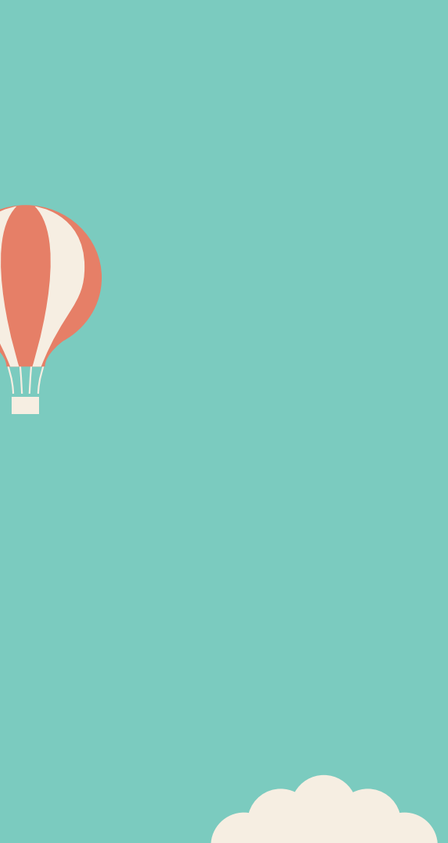

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ANTICIPATING PUBLIC ACCEPTANCE THE HYDROGEN CASE OLGA DI RUGGERO

# ANTICIPATING PUBLIC ACCEPTANCE

## THE HYDROGEN CASE

OLGA DI RUGGERO

# INVITATION

You are cordially invited
to attend the public defense
of my PhD dissertation

**ANTICIPATING PUBLIC ACCEPTANCE**
THE HYDROGEN CASE

**Friday, 25 April 2014**
9:30 Introductory presentation
10:00 Formal defense

**Senaatzaal of the Auditorium** (Aula)
**Delft University of Technology**
Mekelweg 5, Delft
Afterwards there will be
a reception

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# Anticipating Public Acceptance: The Hydrogen Case

**Olga Di Ruggero**
Delft University of Technology
2014

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**Anticipating Public Acceptance: The Hydrogen Case**

**Proefschrift**

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door
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*To my parents*

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## Summary

Current energy related issues, such as climate change or the oil depletion, demand technological and societal change towards new ways of producing and using energy. One of the challenges coming with the development of these new solutions relates to the impact that these technologies will have on society, and how people will react to these technologies. This phenomenon is often referred to as public acceptance. The relevance of considering public acceptance of emerging technologies is self-evident, especially when thinking of the heavy controversy that surrounded technologies such as nuclear power or CO2 capture and storage.

The focus of this study is public acceptance of hydrogen technologies. Hydrogen (and related technologies) may be used in the future, for example, to heat our houses or fuelling our cars. Some believe that hydrogen may help in developing a more sustainable energy system. Others discuss to what extent this is actually possible. For example, it is unclear in which measure hydrogen may contribute to deal with issues like climate change, energy security or pollution; or whether hydrogen could be successfully stored or transported.

**Summary**

Ever since I started this research, and every time I was explaining that the focus of my work was *public acceptance of hydrogen*, the most frequently asked question I received has been "So, are people going to accept hydrogen yes or no?!". This question is, in my opinion, emblematic of a certain idea of public acceptance that I argue to be technocratic and potentially counterproductive. In this study, it is argued that the technocratic approach to public acceptance implicitly conceptualizes the public as a 'barrier to overcome', putting people either in an active position of rejecting something or in a passive position of 'silently' accepting it.

This study challenges that idea of the public and public acceptance, largely present in the hydrogen literature, and aims at giving voice to the public in a way that citizens may maintain a positive role of 'contributors' to innovation. It is argued that the technocratic approach to public acceptance is inadequate particularly in the hydrogen case. Public acceptance of hydrogen is far too complex to be tackled in a 'yes or no' fashion. The complexity is three-folded. First, we want to know something on public acceptance of hydrogen even though hydrogen is not yet diffused. This issue, referred to as the issue of *anticipation*, poses a methodological and substantial question of how can we study public acceptance of hydrogen, when there is neither hydrogen technology to accept yet nor any "public" concern over a possible hydrogen implementation. Second, hydrogen is not only an element or an application (like a hydrogen bus), but rather an entire infrastructure of many different technologies. For example, some citizens may be in favour of an out-of-sight system where hydrogen is used to store the extra energy of renewables, and being against a system that employs nuclear energy. Third, and related to the previous point, the public is heterogeneous is worldviews, beliefs, values and preferences.

Different disciplines use a variety of methods to engage stakeholders and the public in technology assessment. Based on the lessons learned from these disciplines, this work proposes and applies an alternative approach to identify the voice of the public in a way that may help the anticipation of public acceptance in the hydrogen case. More precisely, this study aims at identifying the perceptions of citizens on hydrogen technologies in the context of the broader energy related issues. Citizens will look at hydrogen technologies in different ways, having different preferences according to how people look at the world, for

example what they consider to be important or what they believe to be an issue relevant to solve. This is a frame, and the frames embed the (possible) preferences towards the different hydrogen systems. Frames define the problems, the solution space boundaries as well as the solutions that might fit those boundaries. In this study, hence, the citizens' frames we aim to define are problems and solution space boundaries from the point of view of the citizens. In this way, we may infer if and how hydrogen may fit those frames. The output of this study is, ideally, a way of mapping the public through a set of frames

A mixture of qualitative and quantitative techniques, namely a combination of focus group technique and the Q method, is used to identify the citizens' frames. This study involved about 120 lay citizens - resident in Italy or the Netherlands – and produced a set of nine frames embedding the preference towards different hydrogen alternatives. The analysis of the frames identified through our Q studies showed shared points of view across our interviewees on what are the problems related to energy that should be addressed and by whom. Each frame represents a problem analysis, defining diverse and, sometimes contradicting, solution space boundaries. From the frame it is deduced which hydrogen systems may fit these boundaries. The results confirm that the public is heterogeneous and that there is no straightforward answer to the question of whether hydrogen will be accepted, yes or no.

For example, it is possible to characterise the frames resulting from this study as *environmental* and *promethean,* although it will be shown that each frame expresses this categorization in different measure, making the distinction not so sharp in certain cases. For instance, it is made plausible through the analysis, that more *radical green* frames may be more compatible with decentralized-renewable hydrogen systems only. At the contrary other *promethean* frames are less compatible with the idea of a decentralized production, or of citizens producing their own energy. From a promethean point of view 'energy' is matter of economic and national interest, not a citizens' responsibility. New technologies like hydrogen should fulfill the economic and strategic requirements beside the environmental ones.

The variety of frames uncovered in this study might help opening-up the idea of the public in the eyes of those professionals who still think of the public as "those who don't know" or "those who care about safety and the environment only". The results also challenge the idea of a

homogeneous risk-adverse public and stimulate the reflection on how do we think about and represent the public in complex issues involving new technologies.

The ramifications of these results are also discussed, and some possible applications of the frames and Q method are proposed. For example, through the frames it would possible to design minipublics, i.e. small groups of lay citizens, potentially heterogeneous in the way of looking at hydrogen technologies. Those minipublics could be involved in deliberative exercises, aimed at reflecting on future technologies like hydrogen from a variety of citizens' point of view, switching the focus from *public acceptance* in the classic (technocratic) sense to co-designing.

This research leaves open a set of practical and methodological questions. For example, what is the effective relation between the frame and the preference, i.e. is the citizens' preference actually determined by their frames in practice? And, what is the added value of discursive representation to select minipublics as compared to conventional methods; and how "generalizable" are the findings?

In conclusion, there seems to be an alternative to the conventional way of anticipating public acceptance, namely, by addressing public acceptance through the frames identifiable through the Q methodology. This path promises practical applications and suggests further lines of research, to anticipate public acceptance better and better in the future.

**Anticiperen op publieke acceptatie: de casus waterstof**

## Samenvatting

Energie-gerelateerde vraagstukken, zoals klimaatverandering of de uitputting van olievoorraden, vragen om technologische en maatschappelijke verandering in de richting van nieuwe vormen van productie en gebruik van energie. Een van de uitdagingen die samenhangt met de ontwikkeling van dit soort oplossingen heeft te maken met de impact die nieuwe technologieën zullen hebben op de maatschappij, en hoe mensen zullen reageren op deze technologieën. Dit verschijnsel wordt meestal aangeduid met de term publieke acceptatie. Het belang van rekening houden met publieke acceptatie van nieuwe technologieën is vanzelfsprekend, in het bijzonder wanneer men denkt aan de heftige controverses rond technologieën zoals kernenergie of $CO_2$ afvang en opslag.

Deze studie richt zich op publieke acceptatie van waterstof technologieën. Waterstof (en gerelateerde technologieën) kunnen bijvoorbeeld in de toekomst gebruikt worden om huizen te verwarmen of onze auto's op te laten rijden. Sommigen geloven dat waterstof kan helpen bij de ontwikkeling van een meer duurzaam energiesysteem. Anderen vragen zich af in welke mate dit mogelijk zal zijn. Het is bijvoorbeeld onduidelijk in welke mate waterstof precies kan bijdragen aan het tegengaan van klimaatverandering, het vergroten van de energievoorzieningszekerheid of het reduceren van vervuiling, en of waterstof voldoende efficiënt en veilig opgeslagen en vervoerd kan worden.

Sinds het begin van mijn onderzoek en iedere keer dat ik uitlegde dat mijn onderzoek ging over *publieke acceptatie van waterstof*, was de meest gestelde vraag: "Dus, gaan mensen waterstof accepteren, ja of nee?!". Deze vraag is naar mijn mening kenmerkend voor een bepaald idee van publieke acceptatie waarvan ik stel dat het technocratisch en mogelijk contraproductief is. De technocratische benadering van publieke acceptatie stelt impliciet het publiek voor als een "barrière die genomen moet worden", waarbij mensen geacht worden ofwel een actieve positie van verwerpen in te nemen, ofwel een passieve positie van 'stil' accepteren.

Dit idee van het publiek en publieke acceptatie is wijdverbreid in de literatuur over waterstof, maar wordt in dit onderzoek ter discussie gesteld. Dit onderzoek beoogt het publiek een stem te geven op zodanige wijze dat burgers een positieve rol kunnen hebben in het 'bijdragen' aan innovatie. Er wordt uiteen gezet dat de technocratische benadering van publieke acceptatie niet geschikt is, in het bijzonder in de casus waterstof. Publieke acceptatie van waterstof is veel te complex om op een 'ja of nee' manier aangepakt te worden. De complexiteit kent drie kenmerken. Ten eerste, we willen iets weten over de publieke acceptatie van waterstof terwijl de diffusie van waterstof nog niet heeft plaatsgevonden. Dit kenmerk, *anticipatie*, leidt tot de methodologische en inhoudelijke vraag hoe we publieke acceptatie van waterstof kunnen onderzoeken, als er nog geen waterstof is om te accepteren. Ten tweede, toepassing van waterstof bestaat niet alleen uit een element of een specifieke toepassing (zoals een op waterstof rijdende bus), maar uit een hele infrastructuur, en kent vele verschillende technologieën. Burgers kunnen bijvoorbeeld voorstander zijn van een niet-zichtbaar systeem zijn waarbij waterstof wordt gebruikt om energie van hernieuwbare bronnen op te slaan, en tegelijkertijd tegenstander een systeem waarbij kernenergie gebruikt wordt. Ten derde, en gerelateerd aan het vorige punt, het publiek is heterogeen in wereldbeelden, opvattingen, waarden en voorkeuren.

Dit onderzoek verkent een manier om de verschillende stemmen van het publiek te identificeren, waarbij rekening gehouden wordt met de hierboven genoemde complexiteitskenmerken. Het beoogt de percepties van burgers ten aanzien van waterstoftechnologieën in de context van bredere energie-gerelateerde vraagstukken te identificeren. Burgers zullen op verschillende manieren tegen waterstoftechnologieën aankijken, afhankelijk van hoe zij de wereld zien, bijvoorbeeld wat zij belangrijk vinden of welke vraagstukken zij vinden dat opgelost moeten worden. Dit is een frame, en de frames bieden het kader voor (mogelijke) voorkeuren ten aanzien van verschillende waterstofsystemen. Frames bepalen zowel wat men als probleem ziet, als de grenzen van de oplossingsruimte en ook de oplossingen die binnen deze grenzen passen. Door dergelijke frames te identificeren kunnen we afleiden of en hoe waterstof bij die frames aansluit. Het resultaat van dit onderzoek is een manier om het publiek in kaart te brengen door middel van een set van frames.

Een combinatie van kwalitatieve en kwantitatieve technieken, namelijk focus groepen en Q methodologie, is gebruikt om de frames van burgers in kaart te brengen. Het onderzoek is uitgevoerd onder ongeveer 120 (leken) burgers, woonachtig in Italië of Nederland. Dit leverde een set van negen frames op die het kader vormen voor de voorkeur voor verschillende waterstofalternatieven. De analyse van de frames op basis van de Q studies resulteerde in gedeelde perspectieven op de energieproblemen die aangepakt zouden moeten worden en door wie. Ieder frame bevat een probleemanalyse die verscheidene, soms tegenstrijdige, grenzen van de oplossingsruimte beschrijft. Uit het frame is afgeleid welke waterstofsystemen bij deze grenzen zouden kunnen passen. De resultaten bevestigen dat het publiek heterogeen is en dat er geen eenduidig antwoord is op de vraag of waterstof geaccepteerd zal worden, ja of nee.

Het is bijvoorbeeld mogelijk om de frames die uit dit onderzoek volgen te karakteriseren als 'milieugericht' en "prometheïsch", hoewel deze indeling op een verschillende manier in de frames tot uiting komt, waardoor het onderscheid niet in alle gevallen zo scherp is. De analyse suggereert bijvoorbeeld dat de meer *radicaal groene* frames beter aansluiten bij decentrale, hernieuwbare waterstofsystemen. *Prometheïsche* frames daarentegen sluiten minder aan bij het idee van een gedecentraliseerde productie, of van burgers die hun eigen energie produceren. Vanuit een prometheïsch perspectief is 'energie' van economisch en nationaal belang, niet een verantwoordelijkheid van burgers, en dienen nieuwe technologieën zoals waterstof naast de milieueisen aan economische en strategische eisen tegemoet te komen.

De variëteit aan frames die in dit onderzoek zijn blootgelegd kan helpen om professionals die nog steeds denken over het publiek als "zij die het niet begrijpen" of "zij die alleen om veiligheid en het milieu denken" de ogen te openen. De resultaten tonen daarnaast de onjuistheid aan van het idee van een homogeen, risico-avers publiek en stimuleren reflectie op hoe we denken over het publiek en de vertegenwoordiging ervan in complexe vraagstukken die betrekking hebben op nieuwe technologieën.

De consequenties van deze resultaten en enkele mogelijke toepassingen van de frames en de voorgestelde Q methodologie worden besproken. Het is bijvoorbeeld mogelijk om door middel van de frames 'minipublieken' samen te stellen: kleine groepen van (leken) burgers,

die heterogeen zijn in de manier waarop zij tegen waterstof technologieën aankijken. Zulke 'minipublieken' kunnen betrokken worden bij deliberatieve exercities, die als doel hebben te reflecteren op toekomstige technologieën zoals waterstof vanuit een variëteit aan burgers en hun standpunten. Op deze manier kan het accent van *publieke acceptatie* verschuiven van de klassieke (technocratische) benadering naar een bandering van gezamenlijk ontwerpen.

Het onderzoek roept een aantal praktische en methodologische vragen op, waaronder de werkelijke relatie tussen het frame en de praktische voorkeur: wordt de voorkeur van burgers in de praktijk inderdaad bepaald door hun frames? Ook de toegevoegde waarde van discursieve vertegenwoordiging om 'minipublieken' te selecteren in vergelijking met conventionele methoden dient nog uin de praktijk te worden aangetoond, evenals de bredere toepasbaarheid van de bevindingen.

Samenvattend lijkt er een alternatief te zijn voor de conventionele manier om te anticiperen op publieke acceptatie, namelijk door publieke acceptatie te benaderen door de frames die geïdentificeerd kunnen worden met behulp van Q methodologie. Deze weg belooft praktische toepassingen en leidt tot nieuwe onderzoekslijnen op weg naar het beter anticiperen op publieke acceptatie.

# 1 Public acceptance of hydrogen: introduction to the issue

## 1.1 Introduction

Issues like climate change or the depletion of the current energy resources require a (technological) shift towards new ways of producing and using energy (and not only). When thinking of which alternatives might be implemented, e.g. new technologies like renewable energy sources or hydrogen as an energy carrier, policy makers and technology developers are challenged also with how people might react to these alternatives, or, in other words, they might be interested in the public acceptance of these alternatives. Some may argue that the point of view of the public should be accounted for in order for the future energy system to reflect the societal values. Others may argue that considering public acceptance has the strategic purpose of gaining consensus. Some may think that the public does not care about what will be the technology of the future or does not have the choice anyway.

Nonetheless, the relevance of considering public acceptance becomes self-evident when thinking of emerging technologies like CO2 capture and storage, or shale-gas (or nuclear energy decades ago). These are just some examples of emerging technologies surrounded by a heavy controversy and intense public debates, leading sometimes to the abortion of the implementation.

Hydrogen technology is one of the possible alternatives that, for reasons that we will see in detail later (§1.2), may contribute to preventing climate change and urban pollution as well as contribute to energy security. Hydrogen is a chemical element that can be found in various substances, like water (H2O) or Natural Gas (e.g. Methane CH4). Hydrogen can be extracted from these substances and used as an energy carrier. For example hydrogen can be used to fuel our cars, heat and power our homes or store the electricity produced by different renewables (like wind) compensating the intermittency of these sources. Some scientists, companies in the energy sector, technology developers and policymakers consider hydrogen technology as a promising way to realise a more sustainable energy system (e.g. European Commission 2008).

The concern of the hydrogen advocates about public acceptance, emerges through many different types of papers (e.g. McDowall and Eames 2007; Eggerston 2003; Mercuri et al. 2002; European Commission 2008; Dunn 2002; Crabtree et al. 2004; Cherry 2004; Bayakara 2005; Smit et al. 2007, Edwards et al. 2007). In those papers, public acceptance is considered as one of the uncertainty factors related to hydrogen, a barrier to overcome, in order for hydrogen technologies to diffuse. In these papers public acceptance is often associated with risk and environmental perception. Some authors (e.g. Cherry 2004) even mention as a source of concern for public opinion the

Hindenburg accident, where a hydrogen zeppelin caught fire causing the death of many passengers; an incident that occurred in 1937. As we shall show in section 1.4, several studies have answered this call by monitoring and exploring public acceptance of hydrogen in relation to safety and environmental perception.

However, there are other elements beyond safety, which makes it interesting and relevant to study public acceptance of hydrogen. As we shall show in sections 1.2 and 1.3, hydrogen is not only an element or an energy carrier; 'hydrogen' is a complex (policy) issue, which includes several technologies, socio-political aspects, conflicting visions and unclear, if not contradictory, knowledge. Moreover, the fact that hydrogen is not yet diffused poses the question of how to study public acceptance of hydrogen when there is yet no hydrogen implementation to accept (§1.3).

In this first chapter we will explore the challenges that the study of public acceptance presents in the hydrogen case. To the best of our knowledge, these challenges have had little attention in the hydrogen literature, and will be the focus of this study. In particular this study challenges the idea of public acceptance that transpires from many studies on public acceptance in the hydrogen literature, which we will classify as technocratic (§1.4).

In order to build up this study we considered an alternative branch of the literature, which cuts across several disciplines, and whose aim is in general to deal with innovation, technology and policy problems through the engagement of different stakeholders. Based on the lessons learned from these other disciplines (§1.5) we design the theoretical framework and the set up of this study (§1.6). The research questions 1.7 emerge from the theoretical framework. Finally section 0 resumes the structure of the book.

## 1.2 Hydrogen as a complex system and a controversial issue

We are interested in knowing more about public acceptance of hydrogen, but what is hydrogen? Isn't that simply a chemical element? As we shall see, the word 'hydrogen' hides much more than that.

Hydrogen is a gas, which can be burned (like natural gas) or used in a fuel cell. For example hydrogen could be used in a car with an internal combustion engine (basically a normal car) or in a fuel cell car (somewhat like an electric car). A fuel cell could also have a domestic application for the cogeneration of heat and power, which means that a hydrogen fuel cell may work instead of a conventional heating system, with the addition of giving also electricity for light and appliances. Moreover at the application level, hydrogen has virtually none or low emissions. For characteristics like these, some consider hydrogen as a possible alternative for the reduction of urban- and local air pollution (see e.g. Adamson 2004, Schindler et al. 2008, European Commission 2008).

Hydrogen is an energy carrier, which means that it cannot be found in nature unlike for example natural gas. Hydrogen instead has to be produced, or extracted, for example from water. In order to be extracted it needs a source of energy, for example wind power. Once it is extracted hydrogen 'conserves' a certain amount of energy that can be used, as we said above, to fuel a car or heat a house. In this sense it stores the energy from a primary energy source in a way that it can be transported where it needs to be used. Hydrogen can be produced by virtually any primary source (such as renewables, various types of gas or nuclear energy), and (potentially) it can be used in many different appliances. For these reasons hydrogen has the advantage of being a flexible energy carrier. Moreover, when used as a storage-means of renewable energy sources, it may be used to give energy when the

renewable sources are not producing any or not enough, for example when the wind is not blowing or during peaks of energy demand. In this way, hydrogen could potentially compensate the intermittency of the renewable energy sources. These are some of the reasons why hydrogen may contribute to tackle the issues of energy security.

At this point, one may think that hydrogen is a panacea, which is, of course, not the case. Before stepping into the issues hiding behind hydrogen, we shall draw the first conclusion regarding hydrogen. Namely that with the word hydrogen we intend a complex *system of technologies* -from production, to end-usage- or as some others refer to, a *hydrogen economy* (e.g. Clark and Rifkin 2006, Crabtree et al. 2004). All these different technologies could be combined in different ways, to design different hydrogen systems. For example, hydrogen could be produced in a centralized nuclear power-plant (e.g. Penner 2006), transported in liquid form to a refuelling station and the liquid hydrogen could then be used in hydrogen cars (McDowall and Eames 2007). Hydrogen could also be produced at home through renewables and used to heat and power an off-grid house or fuel the house car.

When we consider hydrogen as a system of technologies, public acceptance is not only about being pro or against hydrogen; as one might be pro or against nuclear. Moreover, if we consider hydrogen as a system, public acceptance of hydrogen it is not only a matter of where to implement the technology, as one may be pro windmills but being against having them in his neighbourhood. If there are many possible hydrogen systems, in fact, it is possible that one may like a hydrogen car but only if hydrogen is produced through renewables and not if hydrogen is produced through fossil fuels. Therefore, when hydrogen is considered as a system of technologies, public acceptance may also be

about how citizens envision hydrogen, which system might be more acceptable than others and under which circumstances.

Interestingly, other authors (Eames et al. 2006, Sovacool & Brossmann 2010, Cuppen 2010, Hisschemöller & Bode 2011) uncovered a variety of hydrogen visions among different stakeholders, such as scientists and decision makers (but not lay citizens). The authors disclosed how diverse and sometimes conflicting these visions are. For instance, some see hydrogen as a way to radically change the energy production and usage. This vision pictures a future where, for example, energy is produced locally through renewables, and hydrogen allows to have a stable supply. In these ecological utopias, energy is produced in small communities or individually, and hydrogen becomes a means to democratize the energy production. On the contrary, others envision hydrogen as a sort of technical fix, where hydrogen is a way to maintain the status quo without relying on imported oil (Eames et al. 2006, Sovacool & Brossmann 2010). In this line of thinking, how the hydrogen economy looks like reflects why we want hydrogen and how we want to live.

Another element that might be relevant to take into consideration is the possibility that the implementation of any of the hydrogen systems will need investments and regulations addressing for example safety, tariffs, or emissions. Hydrogen may also require a considerable effort of both public and private actors in order to be implemented, for example because it requires a new infrastructure, because the technologies are still costly, or because research is needed to solve the issue of the hydrogen storage. Therefore any of the alternative hydrogen systems may require measures such as feed-in tariffs, tax exemption or public investment (e.g. European Commission 2008).

Through the word 'hydrogen' thus, we refer to a system in which technical and socio-political aspects are entangled with society. Hydrogen hides different alternatives, whose choice depends also on what we want and what we need as a society.

Adding complexity, the viability and suitability of the implementation of hydrogen is still under discussion. For example, since the CO2 footprint of hydrogen depends on how hydrogen is produced and transported, it is, to the best of our knowledge, still under discussion whether hydrogen could really positively contribute to the environmental cause (e.g. Cherry 2004, Dunn 2002). Moreover, hydrogen may require a new infrastructure, for example new pipelines or a new network of refuelling stations. A new infrastructure would increase the costs and the decrease the feasibility of hydrogen economy. For example, it might be difficult to sell hydrogen cars without a network of hydrogen refuelling stations; at the same time, the willingness to invest in the implementation of a diffused network of refuelling stations will be low if there are not a lot of hydrogen cars in the streets. This is known as the Chicken and the Egg problem and it is considered as one of the main 'stumbling blocks' to the future of hydrogen (e.g. Adamnson 2004).

The above mentioned are just examples of the elements that characterize the discussion on hydrogen, which is sometimes so exacerbate to divide those who believe in the added value of hydrogen from those who consider hydrogen more as an utopia (Dunn 2002). Without entering in the merit of this discussion, what is relevant to underline is that this divergence and conflicting visions (McDowall and Eames 2007; Sovacool & Brossmann 2010) and the knowledge conflict (Hisschemöller & Bode 2011) colour the hydrogen issue with controversial traits, which may permeate the public discussion on hydrogen and consequently affect public acceptance. For example, if

developers support hydrogen as a green alternative, how would people react if the CO2 footprint of the whole hydrogen system is under discussion? If hydrogen is proposed as a way to decrease fossil fuel reliance, how would people react if hydrogen is produced using oil or natural gas as some considered (e.g. Dunn 2002, Cherry 2004, McDowall and Eames 2007)?

To sum up, when thinking of 'hydrogen' one may not only consider it as a chemical element or an energy carrier, but also as a variety of alternative technological systems, whose feasibility and positive contribution to several energy related issues is discussed in the decision arena. In the hydrogen issue, we are interested in exploring the public acceptance of hydrogen. If hydrogen would be only a car, exploring public acceptance could almost be reduced to measuring how many people buy it. However, we showed that 'Hydrogen' is not such a simple thing as being a car. It is the complexity of hydrogen and its potentially controversial nature that makes the study of public acceptance of hydrogen so relevant, challenging and interesting.

### 1.3 The issue of anticipation

Hydrogen is still in a relatively early stage of its development, at least if we compare it with other alternative technologies like wind or solar energy, which are now a days quite diffused (at least in the Netherlands or Europe in general). Hydrogen technology instead has only been implemented in few pilot projects across the world, implementing e.g. a hydrogen bus line (Accept$H_2$ – accepth2.com) or a wind-hydrogen facility (PURE project). Therefore, hydrogen still remains prevalently in the niche of the hydrogen advocates, researchers and developers.

Consequently hydrogen is not only largely unknown to the broad public, –as unanimously revealed by several reviews of the public acceptance

literature (Ricci et al. 2006 and 2008; Roche et al. 2010, Altmann et al 2003)-; hydrogen is not a public concern or a problem either. As a matter of fact, citizens are not alarmed at the prospect of a hydrogen implementation. In other words, there is not a problem with public acceptance yet, or perhaps ever.

Nonetheless, public acceptance is often rised as an issue in the technical community. As we mentioned previously (§1.1), the concern on public acceptance of hydrogen often emerges in the (technical) literature as a possible barrier to the hydrogen diffusion (e.g. McDowall and Eames 2007; Eggerston 2003; Mercuri et al. 2002; European Commission 2008; Dunn 2002; Crabtree et al. 2004; Cherry 2004; Bayakara 2005; Smit et al. 2007, Edwards et al. 2007).

In these papers public acceptance is often associated with risk and environmental perception, for example hydrogen might be perceived by the public as unsafe, due to the risk of explosions. Environmental and safety risks have been crucial in other cases, such as the Nuclear energy or the $CO_2$ capture and storage. Those technologies have been rejected and their implementation blocked by the public in many instances worldwide. Perhaps, since the hydrogen transition may require a high commitment and investment to be realized, stakeholders and developers might be concerned of a similar prospect for their project. After all, considering that some of the possible hydrogen scenarios include the abovementioned technologies, this prospect might be more than a simple concern.

This interest in public acceptance in such an early stage of hydrogen development might have both strategic and normative ramifications. A proactive approach could help in preventing public acceptance problems to explode, supporting the transition to a more sustainable energy

system and allow the development of technologies that express societal values.

The roots of such a proactive approach can be found perhaps in the long tradition of technology assessment literature and, as we will see in the next sections (§1.4 and 1.5), it has been addressed in the hydrogen case through different types of studies.

Whatever reasons and objectives lie behind the concern over public acceptance, the approach of public acceptance in such an early stage of hydrogen development implies that public acceptance is anticipated rather than observed or dealt with.

The challenge that comes with the study of public acceptance of hydrogen, therefore, is to answer this need of anticipating public acceptance despite the citizens' lack of knowledge on hydrogen, the lack of a problem and the lack of a hydrogen implementation. This is what we refer to as the *issue of the anticipation.*

Anticipating public acceptance of hydrogen poses a set of both methodological and substantial questions: how can we study public acceptance of hydrogen, where there is no hydrogen to accept yet? Furthermore, how can we study public acceptance of hydrogen when there are so many heterogeneous future hydrogen economies that can possibly be accepted (or not)? We are in an early stage of technology development and in a long-term time-frame. The interest of the advocates is to somehow anticipate public acceptance, long before a specific hydrogen project is decided to be implemented somewhere.

Before trying to answer these questions, we will show how previous studies dealt with this issue.

## 1.4 Public acceptance as a technocratic concept

"*Awareness is, and will continue to be, the major barrier to public understanding and acceptance of renewable energy hydrogen*" (Eggerston 2003).

Many authors often associate and reduce public acceptance of hydrogen to safety perception (e.g. Shulte et al 2004; Dunn 2002, Crabtree et al. 2004, Cherry 2004, Bayakara 2005, Smit et al. 2007, Edwards et al. 2007). In this linear way of looking to public acceptance, when hydrogen safety is technologically ensured and the public educated about hydrogen safety, public acceptance will be achieved and hydrogen will enter the market and diffuse. As a matter of fact, it is not unusual to read recommendations suggesting "education campaigns on hydrogen" to achieve acceptance (Heinz and Erdmann 2008; Zachariah-Wolff et al. 2006; Eggerston 2003; O'GArra 2005; Accepth2 2005). From this point of view, public acceptance is seen as a potential barrier to be overcome, and knowledge and safety as the factors to influence.

This idea of the public and public acceptance is widespread in the hydrogen public acceptance literature. This stream of literature usually employs quantitative techniques, seeking for the variables influencing the attitude towards hydrogen and its applications –such as buses or refuelling stations (e.g. see e.g. Tarigan et al. 2012; Haraldsson et al.2006; Van den Bosh 2004; O'Garra et al. 2008, O'Garra et al. 2007; O' Garra et al. 2005, Molin 2005, Huijts et al. 2012; Zachariah-Wolff et al. 2006; Saxe et al. 2007). The main variables explored in those studies are knowledge, safety and environmental perception. We briefly summarise that those studies show that people (i) are substantially positive or neutral with respect to hydrogen despite the lack of knowledge, (ii) are not a priori concerned with hydrogen safety, although more information is requested to formulate a more final

judgment, and (iii) have scarce knowledge on hydrogen. Finally, across these studies, the relationship between environmental concern and hydrogen attitude is unclear. For an extensive review of these studies, we refer to the work of Ricci et al. (2008), Roche et al. (2010) and Altmann et al. (2003).

We argue that this type of approach to public acceptance is of limited use, especially in case like hydrogen. The first set of arguments concern the methodological limits of quantitative tools, such as questionnaires or opinion pools, in a case like hydrogen. The second set of arguments is more substantial and it concerns how this approach of public acceptance implicitly conceptualizes the public and public acceptance and how this conceptualization is useful in the decision making process. Let's start with the methodological arguments.

First, there is the problem of knowledge. As mentioned above, quantitative research on public acceptance showed that hydrogen is largely unknown to the public. When exploring public acceptance of new technologies it is important to apply methods that overcome the lack of knowledge of the respondents on the subject of enquiry. Arguably, questionnaires may not be the most appropriate research tools (Ricci 2006, Roche 2010; Assefa & Frostell 2007).

Second, there is the problem of complexity. We have shown in 1.2 that hydrogen is not only an element, but a complex system of technologies, from production to end-use, that (may) imply a shift in habits, lifestyle, policies and ultimately values. In this light, what does a questionnaire focusing on specific hydrogen *applications* (such as a hydrogen bus) tell us about the rest of the hydrogen *system*? On the other hand, how is it possible to squeeze the complexity of (multiple) hydrogen systems into a questionnaire or a phone-call (Mayer 1997)?

Third, and encompassing the previous two points, we have the issue of anticipation. We have seen (§ 1.3) that there might be a shared wish to anticipate public acceptance, before hydrogen is implemented and diffused. Quantitative tools are snapshots at a specific point-time of people's opinion of specific hydrogen technologies, technologies that they barely know (if not at all) and that are far from their daily life. How reliable and in which way could these data be used to decide about the (possible) future hydrogen implementation? If, as shown in several of these studies, environmental attitude corresponds to a positive attitude towards a hydrogen bus, does it mean that we can implement an entire bus-fleet, build the refuelling station, lay the hydrogen pipelines and finance the project with public money as far as hydrogen is green? And how would hydrogen be green?

The fourth and last argument concerns the process. Public acceptance may evolve with the hydrogen diffusion, in a process that involves many different actors interacting over time. 'The citizens' are also actors in this process. Who will implement hydrogen, where and how? In this process expectations and negotiations, local and national, will evolve in a dynamic process. Once again, how does a questionnaire relate to that kind of process?

The latter methodological critic leads us to another set of arguments criticizing the quantitative approach to public acceptance. This second set of arguments is more substantial and it refers to the way the public and public acceptance is implicitly conceptualized in the quantitative abovementioned studies. Let us explain.

A linear concept of acceptance emerges in between the lines of many of the quantitative studies on public acceptance of hydrogen. In line with the scientific goals of psychology, these studies seem to be aimed to predict public acceptance, together with its determinants (e.g.

knowledge and beliefs), almost as if they were trying to answer the question "if public acceptance is a barrier, which buttons should be pushed to overcome it?". In those studies, hence, the anticipation of public acceptance is addressed by predicting determinants, with the scope of influencing acceptance. Quantitative tools, like attitudes scales and questionnaires were mainly used to identify these public acceptance determinants.

The representation of the public and public acceptance of new technologies as a barrier to overcome has its roots in the so-called "deficit model" of the public (Sherry-Brennan et al. 2007, Flynn and Bellaby 2007). According to these authors, some scientists and policy-makers mistrust the public, believing that "…the public tends to misunderstand new technologies and to amplify the risks". In the deficit model, the public is "ignorant" or too emotional. People don't know and therefore they make the wrong judgment about the technology (Horlick-Jones 2007).

When this concern is shared by people who believe to have "the solution" to the problem at hand, it is quite automatic to perceive the public as a potential obstacle to the successful implementation of "their" solution. In this sense, public acceptance is a technocratic concept, seeded in the mind of these scientists and developers who want to implement, from the top, the technologies that they have in their hands.

We believe the term "public acceptance" contains in itself the seed of this technocratic view. First of all, public acceptance contains the concept of "the public" which reminds of an indistinct mass of people, as other authors already underlined (Ricci et al 2008; Haggett 2011). The risk is to attribute only one voice to the public, no matter if this voice represents a minority, a majority or one of the hundreds of points of view diffused among the citizens. Therefore, sentences occur like "the

public doesn't care" or, "the public is scared" or, "people don't want it in their back yard". Suddenly, the public is identified with "the blockers", which often represent only a minority of the population (Bell 2005 in Haggett 2011). One public, one voice, it is certainly reductive.

Second, public acceptance contains the idea of "acceptance", which is characterized by a somewhat passive connotation. As a matter of fact some dictionaries define "acceptance" as the act of taking or agreeing to use something that is offered, or as the fact of getting used to a situation and recognizing that it cannot be changed or avoided (Collins English Dictionary, 10th Edition). Hence, something is acceptable when "people generally approve of it or allow it to happen" or when "it is considered good enough" (Collins English Dictionary, 10th Edition). Moreover, the etymological root of this word can be found in the Latin words of *accipere*, namely "receive," and *ad-capere*, namely "to take". In this light, "acceptance" puts people in a passive position of receiving something and consenting. Acceptance reminds of something that has already been decided somewhere else and people just have to react to that decision with a "yes" (or nothing) or a "no". This dichotomised connotation of public acceptance is reflected for example in the work of Heinz and Erdman (2008), which represents the dynamic of public acceptance as the percentage of people switching from supporters to blockers. This dynamic is actually rather simplistic, putting on stage developers and citizens as antagonists, the first proposing and the latter either being passive-and-accepting, or active-and-rejecting.

This dichotomy between the developers/proponents and the citizens/opponents emerges also between the lines in a study by O'Garra et al. (2008). In this study, the authors attempted to calculate the possible social cost of a refuelling station. The social cost accounts for the compensation to the possible opposition of the citizens living

near the planned hydrogen refuelling station. The social cost has been assessed by the authors to be £100,000 (see O'Garra et al. 2008). What we find interesting of this study is that the authors implicitly anticipate the opposition between the two parties, and reduce the solution to nothing else but monetary compensation. Trying to overcome the citizens' opposition through a monetary compensation might be felt as bribing by the citizens (Haggett 2011) or even interpreted as an attempt to pricing people's safety. As a reaction, the opposition might even increase, with the monetary compensation eventually provoking the opposite reaction that was expected, in a sort of self-fulfilling prophecy.

The strategy of compensation, the idea of educating and convincing people of hydrogen benefit, suggests that a decision about hydrogen has already been taken somewhere else, and citizens can either accept or oppose it.

This rather technocratic approach to public acceptance aims at predicting and influencing acceptance. If used improperly it may however reduce the actions that the citizens can take to contribute to the hydrogen development. In the complex case of a societal transition towards innovative technologies, framing the complexity in a yes/no situation is not helpful, especially when the situation really turns into an active rejection campaign of the citizens (e.g. think of the 'NO campaign' against nuclear energy). In a yes/no situation, there is no room for negotiation with the result that only one of the two parties, if any, can win.

At this point we remain with the question: what is a meaningful and useful way to anticipate public acceptance of hydrogen technology? Before dealing with this question (§1.6) we will look at another branch of the literature focusing on the interaction between technology and society.

## 1.5 Lessons learned from the alternative approaches to public acceptance.

A number of studies can be found in the hydrogen literature, taking a different stand when exploring public acceptance of hydrogen.

Flynn and Bellaby (2007) edited a set of these studies in a book dedicated to public acceptance of hydrogen. One of these studies, for example, applies the focus group technique to elicit the citizens' points of view on different hydrogen alternatives. Results show that the interviewees were not only concerned about safety and economical aspects, but also interested in understanding what hydrogen would mean for their daily life, and which changes hydrogen would require. Moreover, the interviewees raised the critical issue of which trustworthy actors they could rely on (Flynn et al. 2006; Ricci et al. 2009).

As the authors underline, this type of results suggest that citizens have a multitude of points of view on hydrogen and that they are capable of discussing their perspectives when put in the condition of doing it, in contradiction with the idea of the 'deficit public' discussed in section 0 (Flynn and Bellaby 2007, Flynn et al. 2006; Ricci et al. 2009, Dryzek & Goodin 2009).

Other studies focused on emotions, lay and expert knowledge, and social representations (Sherry-Brennan et al. 2009; Sherry-Brennan et al. 2011; Sherry-Brennan et al. 2007) as well as on the role of expectations in community acceptance of hydrogen (Raven et al. 2009a and 2009b). Interestingly, in this latter study, the focus is on the process and the many actors involved with their different views. These authors see public acceptance as the result of a well-managed process through a set of well-defined steps.

McDowall and Eames (2007) conducted a participatory hydrogen scenario appraisal, involving stakeholders ranging from the private sector, to the policymakers and (environmental) NGO's. These actors were asked to identify a set of criteria to assess a set of hydrogen scenarios. The scenarios varied from decentralized to centralized hydrogen scenarios, where hydrogen is used only as a fuel or also as a general energy carrier. The stakeholders identified different criteria such as environmental criteria (e.g. visual amenity and air pollution), economic criteria (e.g. feasibility, upfront capital cost or fuel cost), social criteria (e.g. public acceptance, control of energy or need for government intervention) and energy security criteria (e.g. resource scarcity, diversity of supply). Interestingly, some stakeholders assessed centralized *out-of-sight* scenarios as more acceptable for the public, while others assessed the least polluting or the ones needing the least interference by the state as more acceptable. In general however, the stakeholders weighted the social criteria as the least important. McDowall and Eames conclude that 'If hydrogen systems develop, there is a significant potential for conflict and disagreement over the shape and direction that those systems take' (McDowall and Eames 2007).

What do these studies have in common and how are they related to the technocratic approach previously discussed?

This type of studies can be contextualized in a set of disciplines focusing on innovation and participation. Please note that, rather than reviewing the great amount of work done in these disciplines, our goal here is to sketch an overview of this type of literature, focusing on these elements that were fundamental to develop the idea behind our study on public acceptance of hydrogen.

We could say that this literature generally attempts to answer questions such as 'where do we implement this technology (siting issues)?' or 'Is

that technology safe or green enough (technology assessment)?' or 'How the future may look like and how do we get there (strategic planning and policy design)?'

This literature includes qualitative studies that, with various methods and objectives engage different types of stakeholders to reflect on new technologies. According to the literature the term 'stakeholder' usually refers to "… any group of people, organized or unorganized, who share a common interest or stake in a particular issue or system" (Grimble and Wellard 1997). This definition includes therefore actors such as the private companies, the government, the normal citizens, as well as their representatives –such as an association representing a specific citizens' or societal interest, e.g. an environmental association or an association of citizens producing energy on their own. Further categorizations of the stakeholders include their saliency, power, whether they are affected by or affect the decision or even their *latency* - i.e. whether they might be salient or active in the future. As we will explain later (§1.6) for us it is relevant to distinguish between the citizens - which are the common, lay people- and their representatives. Citizens' representatives include the official institution (e.g. the Municipality) or groups who may represent a specific citizens' interest (e.g. an environmental association or a consumer association).

The objectives of these studies aiming at the stakeholders' participation are diverse, from normative to strategic (Arnstein 1969). Mayer (1997) identifies 8 types of objectives among which 'Eduaction and Information', 'Consultation', 'Anticipation', 'Mediation', and 'Co-ordination'. Mayer (1997) gives an overview of the methods and how they evolved in the last decades, from the first forms of participation to the modern ones. Beyond the above-mentioned studies applied in the hydrogen case, common methods for stakeholders' participation include

for instance citizens juries (Crosby, 1995), the Danish consensus conferences (for a complete description see Mayer 1997), Deliberative Polling® (Fishkin 1991), back-casting (Dreborg 1996), Gaming simulations (Duke 1974), stakeholders dialogues (Van de Kerkhof and Wieczorek, 2005) the Constructive Conflict Methodology (Cuppen 2010) and other policy exercises aimed at assessing and developing policy alternatives and technologies.

In the public and stakeholders' engagement approach some issues remain open, such as which stakeholders to engage, how, when and with which expertise; what is the contribution of these methods to the process; how to evaluate the participatory processes and their effects (e.g. are they useful and for what?); the difficulties in communicating with lay citizens about difficult technical aspects of emerging technologies; the risk of manipulation; the fact that not all the citizens want to participate; the openness of the technology developers to the outcome of a participatory process, whatever that might be, including the rejection of the technology (e.g. Mayer 1997, Gastil 2000, Cuppen 2010, Flynn et al. 2011; Haggett 2011, Dryzek and Niemeyer 2008, Dryzek and Goodin 2009, Huitema et al. 2007).

From the different disciplines dealing with stakeholders' participation we can identify four lessons that are particularly relevant in the setup of our study:

1. Stakeholder's participation literature is process oriented, namely it focuses on the issues and the alternatives from the perspectives of the stakeholders, and their interactions over time. In relation to our case, it represents an alternative way to look at public acceptance of hydrogen, where the dynamic of public acceptance is not a shift from no to yes, but rather an evolution of opinions on issues and

alternatives from the point of view of the public. Moreover, the process includes the interactions between the public and the decision arena.

2. Stakeholder's participation literature generally challenges the idea of the 'deficit public'. It proposes instead the idea that the inclusion of the diversity of societal actors can positively contribute, normatively and strategically, to the design, development and implementation of innovation. In the same way the public can contribute positively instead of being a 'barrier to overcome';

3. Stakeholder's participation literature implicitly pictures the public as heterogeneous in points of view and actively looks for methods to elicit and include this diversity of views;

4. Stakeholder's participation literature intends anticipation as inclusion of values, namely what matters from the point of view of the stakeholders (e.g. the environment). Decisions and technology should represent the variety of values and therefore the acceptance of these decision and technologies is a consequence of a good process rather than of a 'good public'.

These four lessons are central in the approach we take in our study of public acceptance of hydrogen, which will be described in the next section (§1.6). In our study we attempt to concretize this idea of 'technology reflecting values' namely, which values? How to find them? How to include them? And which hydrogen technologies are we talking about precisely?

## 1.6 Using frames to anticipate public acceptance of hydrogen: our approach and theoretical framework

This work starts with the question of what is a meaningful way of "anticipating public acceptance" of a technology (hydrogen) that does not exist yet in people's life.

In section 1.4 we have seen that one line of research attempts to anticipate public acceptance through prediction, namely trying to grasp the variables that lead to acceptance. We criticized this approach to public acceptance through five main points, namely (i) often, the implicit goal of public acceptance studies is to predict how to steer public acceptance; (ii) Quantitative methods are often used to explore variables to predict acceptance such as environmentalism or safety perception. These conventional quantitative methods (e.g. questionnaires) are of limited use in a case such as hydrogen where the respondents have scarce knowledge on the technology, (iii) this approach to the public is reductionist and often disregards the variety within the public; for example when it is assumed that only environmentalism could be a driver for acceptance (iv) in parallel the very same concept of 'public acceptance' is reductionist, by limiting the complexity of the public acceptance issue into a matter of safety, costs and environmentalism (v) this approach to public acceptance ultimately carries the risk of dichotomizing public acceptance in a yes/no or acceptance/rejection situation, in which the public is a barrier to overcome. For these five reasons, the conventional way of anticipating public acceptance through "prediction" is of limited use in a case such as hydrogen.

In section 1.5 we showed that the stakeholders' engagement literature has a pluralistic vision of the public(s). People can positively contribute to the technology implementation, rather than constitute a barrier. In

**Text box 1.1: Three dimensions of public acceptance to better understand the focus of our study.**

Wüstenaghen et al (2007) introduce three dimensions generally explored in the public acceptance studies of renewable energy technology, namely, (i), the socio-political acceptance, which is the most general level of acceptance, with respect to both technology and policies, and takes into account the perspectives of policymakers, key stakeholders and the citizens; (ii), the community acceptance, which refers to the specific acceptance of siting decisions and renewable energy projects by local stakeholders, particularly residents and local authorities, this is the arena where the debate around NIMBYism unfolds; (iii), the market acceptance, with respect to the adoption of innovative products by consumers. According to the authors, the market acceptance is by far the least explored in the renewable energy technologies.

Interestingly, citizens cover different roles in each of the three levels of acceptance, namely citizens, consumers and residents, and their point of view on the same topic may change according to which of the roles they are asked to give their perspective from.

In this study we are interested in the most general level of acceptance, the socio-political acceptance. As a matter of fact, the contribution that the hydrogen technologies are expected to give to a set of issues with a great societal interest (the energy issues), the heterogeneity of the shapes that the hydrogen economy might assume, the possible need of a considerable institutional effort to realize a hydrogen future, makes the "common good" dimension of the hydrogen issue particularly relevant together with the citizens' point of view on that same matter.

this approach, the anticipation is realized through the engagement of the public. The engagement of the public since the early stage allows the inclusion of the citizens' values and preference in the implementation of the technology, before a decision is taken. In this way, public acceptance is anticipated by normatively and strategically 'matching' societal values and technology.

In our case we are interested in exploring possible ways of anticipating public acceptance of hydrogen out of the context of a specific project, i.e. when the hydrogen technology is not implemented yet. In this situation therefore there is no hydrogen, no public acceptance problem, low knowledge and no specific points of view diffused in the population.

A possibility could be that of exploring the consumer's acceptance angle of hydrogen (see text box 1.1 for an overview of the dimensions of public acceptance). Consumer's acceptance studies may focus for

example on the usability or attractiveness of specific hydrogen appliances, like a hydrogen car, a refuelling station or a home system. In this line of reasoning, anticipating public acceptance is aimed at designing "competing" hydrogen products, i.e. products that people will be willing to buy and use.

This line of research is certainly interesting and useful, and it is likely to be explored for example by companies willing to sell hydrogen products. From our point of view, and as we have stressed in section 1.2, hydrogen is much more than only a chemical element, a fuel or a car. Hydrogen is a set of different systems, arguably implying different meanings and values. It is these values and meanings that we are interested in grasping, from the perspective of 'the public'. A consumer acceptance approach could hardly get the type of insight we are interested in.

In line with the public engagement literature, instead, we take a pluralistic approach to the public, and we attempt to anticipate public acceptance through the acknowledgement and the inclusion of this variety of values into the hydrogen development. But, in concrete terms, what does it mean and how can we include the public values into the hydrogen reflection at this stage of the hydrogen development, namely before hydrogen is implemented somewhere? In order to answer this question we need to take a step back first.

We are interested in emerging technologies, and how they interact with society. In this process, public acceptance represents how people look at hydrogen and it manifest itself at a discursive level, for example in the public debate that might surround hydrogen, as it surrounded nuclear energy or $CO_2$ capture and storage. Beyond the specific arguments (which at the moment we cannot foresee) at a certain level this public debate may question why we want hydrogen and how we

want it. In this public debate there might be competing views shared by the citizens and represented in the arena by a variety of actors. Let's bear in mind that there are many possible hydrogen systems and that as other authors underlined (Ricci et al. 2008) when talking about public acceptance of hydrogen it becomes relevant to distinguish between "which hydrogen" we are considering. Hence, we are interested in identifying the variety of views, or *frames*, held by the citizens, taking, at the same time, the variety of possible hydrogen systems into account.

A *frame* (Schön and Rein 1995; Fischer 2000) could be defined as a constellation of beliefs, containing worldviews, assumptions, and underlying values, which act as a filter in selecting and constructing information and driving individual behaviour. A belief is an opinion on a certain topic. A belief therefore, as opposed to a "fact" and "knowledge", is subjective and discussible. The beliefs are combined to represent reality, to explain how reality works. These beliefs can be based on facts and knowledge, but also on feelings, experience, traditions, assumptions, social environment, culture, religion and values. In the literature, a combination of beliefs can be called a perspective, frame or a belief system, depending on the field we are moving in. In text box 1.2 we give some more definitions that will (hopefully) help in orientating the reader.

Returning to our frames, we will describe them, through the words of van Eeten (1999), as "a line of reasoning that connects a description of the problem situation with an answer to the question of what, if anything, needs to be done". Frames define the problems, the solution space boundaries as well as the solutions that might fit those boundaries. In our study, hence, the citizens' frames we aim to define are problems and solution space boundaries from the point of view of

**Text box 1.2 Clarifying the terminology:**

Values, beliefs, norms, attitudes, perceptions and frames are all ways in which we make sense of the word around us and guide our behaviour. These concepts are used in different research fields, from psychology to policy analysis, and the terms have sometimes overlapping and slightly different meanings. Moreover, many of these terms are of common use in our daily vocabulary. Here we try to clarify how the terms are used in this book.

We adopt the Schwartz (1977, 1992, 1996) definition of **values.** In Schwartz theory, *values* have an adaptive function for human beings, i.e. they help humans to survive by driving our behavior towards the fulfillments of our basic needs, such as the biological needs we have as living organisms, the social needs of organized interactions and the survival and welfare of the group. Schwartz identified 10 basic values, shared by more than 68 cultures. These values are of relative importance for each individual. For example "*I believe that all human beings are equal and should have equal opportunity*' is an example of the value of *Equality*. Values help humans in making sense of reality, in judging situations and events. Values motivate behavior, and are linked to emotions. For example people giving high priority to the value of Equality may have an emotional response and act in a situation of social class injustice. Values transcend particular situations, they are always valid, so to say. Therefore values differ from norms and beliefs as we will describe them below. We could say that values are near the core of our personality.

Similarly to values, the **beliefs** help us in making sense of reality and drive behavior. However, unlike values, beliefs are linked to specific situations, and they may change and evolve for example based on events. Beliefs could be more or less general, such as "I believe that restaurant has good stakes" or "I believe that climate change is an issue", the latter being an example of a belief as it is used in this book. As opposed to a "fact" and "knowledge", a belief is subjective and discussible. Beliefs can be based on facts and knowledge, but also on feelings, experience, traditions, assumptions, social environment, culture, religion and values. Three classes of beliefs are relevant for this research: the worldview, the awareness of consequence and the ascription of responsibility as defined in section 1.6.

A **norm** refers refers to an expectation about a behavior, an action or an event as it should be or happen. A personal norm refers to how a single individual expects from himself to act in a specific situation. For example in the Netherlands it is a norm for people to hold the door for the person that is walking behind us, or to pay taxes. The former is a social norm, i.e. a norm generally shared by the group 'Dutch society', and particularly it is a norm of politeness; the latter is both a social and legal norm.

In the literature: A **discourse** is a set of categories and concepts embodying specific assumptions, judgments, contentions, dispositions, and capabilities. A discourse is a representation of reality. At a basic level, any political discourse will normally feature an ontology of entities recognized as existing or relevant. Among these entities, some (e.g., individuals, social classes, groups, or states) will be ascribed agency, the capacity to act, while in competing discourses the same entities will be denied agency (e.g., liberal individualists deny the agency of classes). For those entities recognized as agents, some motives will be recognized, others denied (Dryzek and Niemeyer 2008).

A **belief system** is a set of causal and normative assumptions about reality that filter perception and drive policy actions. The beliefs are of different type, from deep, core, fundamental beliefs, to normative-empirical beliefs, regarding for example what is an effective solution or the distribution of authority between the market and the government (Sabatier and Jenkins-Smith 1993, 1999)

A **perspective** is the integrated whole of beliefs, values and presumptions that a person, or group of persons, uses to get grips with a particular problem. A perspective shapes people's perceptions and determines how someone perceives a particular problem and its solution. As such it represents a way of making sense of and acting upon reality. Unlike worldviews or values, perspectives are dynamic. People can take on multiple perspectives, dependent on the specific situation one is in (Cuppen 2009).

A **point of view** (or viewpoint), accordingly to Watts and Stenner (2012), determines our way of perceiving, feeling and behaving. A point of view is strictly linked to the "object of observation" and is dynamic, changing over time, according to our experience, the situation, knowledge, etc.

A **frame** is the way of perceiving and making sense of social reality, by selecting and organizing an information-rich situation. Those who construct the social reality of a situation through one frame can always ignore and reinterpret the "facts" that holders of a second frame present as decisive counterevidence to the first (Schön and Rein 1995).

**In this work** we consider as equipollent and interchangeable the concept of perspective, frame, discourse and point of view, as all those concepts are characterized by being dynamic, subjective and discussible representation of reality, which drive behaviour. They are holistic constructions of beliefs, norms, and underlying values.

the citizens. In this way, we may infer if and how hydrogen may fit those frames. In other words, citizens' will look at hydrogen in different ways, having preferences for this or that system (or none).

This preference will depend on how people look at the world, for example what they consider to be important or what they believe to be an issue relevant to solve. This is a frame, and the frames embed the (possible) preference towards the different hydrogen systems.

For example, if some advocates will propose hydrogen as a way to achieve a green economy (as showed in Eames et al. 2006, Sovacool & Brossmann 2010), would a nuclear-hydrogen system or a decentralized-solar-hydrogen match this frame from the perspective of the public? Would there be other frames beyond the environmental one embedding the different hydrogen systems? Moreover, taking a pluralistic approach to the public, would a different share of the public support different frames and different hydrogen systems?

In this study, hence, we are interested in identifying the citizens' problem analysis in order to understand which hydrogen system(s) fit(s) their solution space boundaries. However, asking the citizens about their problem analysis and their solution space boundaries may be too vague, or too far from citizens life. For the purpose of the data collection it would be useful to fain-grain the concept of frames. For this purpose we use the VBN theory.

Stern and Dietz (Dietz et al. 1998; Stern et al. 1999) developed a theoretical framework - the Values, Beliefs, Norms (VBN) theory - to explain how citizens are activated to support a specific party in a public controversy, namely through a chain of values, beliefs and norms. For example, the VBN theory (Dietz et al. 1998; Stern et al. 1999; Stern 2000; Steg et al. 2006) links environmentally significant behaviour back to personality through a chain of beliefs and personal norms.

Throughout the different studies, the environmentally significant behaviour has been defined for instance as supporting an environmental movement e.g. by signing a petition, sorting waste for recycling, or willingness to pay for an environmental tax. The personality instead is defined by core fundamental values (Schwartz 1973 and 1992, Schwartz & Huismans 1995, Schwartz et al. 2001), and particularly altruism and openness to change in the environmentally significant behaviour. The beliefs that link behaviour back to fundamental values are defined in the theory as,

1. the general worldview that defines the object of value or what is at stake - in the environmental example the nature, how the humans relate to nature, or what technology can or cannot do,
2. awareness of adverse consequences (AC), namely the belief that the object at value is threatened – in the environmental example, nature is threatened e.g. by human behaviour such as littering,
3. the ascription of responsibility (AR), namely the belief that a personal action may or may not alleviate the threat – e.g. the person may contribute by sorting the trash for recycling.

The VBN theory might be a way to operationalize the values that the different hydrogen systems implicitly express. However, in line with everything we have being arguing so far, in this work we are not interested in quantitatively linking the values, beliefs and norms to the hydrogen preferences. Once again, we are interested in embedding or framing the preference for the different hydrogen systems in these beliefs and values. The preferences towards the different hydrogen systems, embedded in their frames, are the substance of public acceptance.

Through the VBN theory, we can further refine the hydrogen frames as a constellation of beliefs on what are the issues related to energy that should be addressed (Awareness of Consequences), who is responsible to do something about those issues (Ascription of Responsibilities) and what, if anything should be done (including what should *I* do, i.e. Personal Norms, and what the *others* should do –Norms)[1]. As we will see later on (Chapter 3) in our data collection we will look for these three types of beliefs as possible building blocks of the citizens' frames. Moreover, we are interested in grasping the citizens' perspective on hydrogen as a system, including the production ways and the different shapes, for example small or large-scale hydrogen systems. We argue that the frames might be used to anticipate (but not predict) public acceptance of hydrogen. Since hydrogen is largely unknown to the citizen, we expect those frames to be somewhat general and perhaps also undeveloped, "in an early stage", somewhere back in the mind of people (see text box 1.3 for a brief discussion about the latent nature of frames).

**Text box 1.3 Short discussion on the latency of the frames**

The *latency* of the frame is implicit in the definition of Schön and Rein (1994) as, according to these authors, frames are unconsciously used by people to filter and make sense of reality. Because of the latent nature of frames, these authors retain that one of the goal of stakeholder participation is making stakeholders aware of their own and others frames.

From another point of view the latency means something that is there in the back and it is made explicit. Therefore it wouldn't make sense to talk about latent frames in the hydrogen case, as hydrogen is largely unknown to the public, and therefore there is nothing to make explicit but rather something to construct (see for example Warren 2009).

The frames may be also latent as Sabatier intended the actors to be (1988). For the author, latent actors are "dormant", namely they are not involved in the policy process, but they are ready to become active when excluded or if they are not represented in this process. In a similar way a latent frame might be activated, for example in case of a public discussion on hydrogen. In this case, the frames are latent with respect to hydrogen

[1] Note that the goal of this research is not to combine these theories, we are not interested to understand to what extent the VBN may define a frame, i.e. verifying whether the frames are composed of these beliefs falls beyond the scope of this research

At this point one may wonder why focusing only on the citizens when the topic is societal acceptance of hydrogen. In order to answer this question we remind the distinction we made when talking about 'stakeholders' between the lay-citizens and their representatives (section 1.5). There are already a few studies aiming at eliciting the experts and citizens-representatives points of view on hydrogen (see for example Cuppen et al 2010; McDowall and Eames 2007). Logically, when the goal is including the public, representatives are needed, if not only for practical reasons that you cannot bring the 'whole public' around a table. In these studies, environmental and consumers' associations have been involved to represent 'the public' and the 'broader societal interest'; we can say that these are in fact the 'usual suspect' in a participatory exercise.

Interestingly, in the hydrogen case we don't know what the citizens' frames are, we can only assume what the spectrum of points of view is with respect to hydrogen preferences and consequently we can only guess which actors can represent the public. Therefore, instead of assuming which frames might be diffused in the public, we focus specifically on the citizens and their views on hydrogen.

In conclusion, we use the VBN theory to fine-grain the concept of frames in order for us to know which beliefs we should look for to identify the hydrogen frames and drive the data collection of this research.

## 1.7 Research questions

Given the research focus, the approach and the theoretical framework introduced in the previous sections we derive the following research questions and sub-questions, which will drive this study:

**Research question 1**: What frames on hydrogen can be found across the lay citizens?

**Sub-question 1**: What are the beliefs on energy, responsibilities and hydrogen?

**Sub-question 2**: How are these beliefs organized in frames?

**Research question 2:** What characterizes those frames?

In conclusion, in this study we are interested in identifying and analysing holistic points of view on hydrogen, which we define as hydrogen frames, directly from the perspective of the citizens. We believe that by answering these research questions we will have a clearer picture of how 'the public' may approach hydrogen while respecting the complexity of both the hydrogen case and the public. We believe the results may eventually lead to a better understanding of public acceptance and possible ways to anticipate it. In the last chapter we will propose possible ways to use the results of this research to anticipate public acceptance, in cases like hydrogen.

## 1.8 Book structure

In this first chapter we defined the focus, the approach and the questions driving this research. Data collection, data analysis, interpretation and conclusion will follow.

In the next chapter, chapter 2, we will describe and discuss the methodological approach to answering the research questions, arguing the choice of a qualitative study, the selected research methods and the choice of collecting the data in two countries, namely Italy and the Netherlands.

Chapters 3 and 4 are dedicated to the data collection and data analysis, and they will answer the first research question and its sub-questions, by delivering nine frames on hydrogen and related technologies.

In chapter 5 (some of) the frames will be interpreted and analyzed, by backing up the empirical results with existing literature and answering the second research question.

Finally, in chapter 6, we will draw conclusions from the study. Starting from the answers to the research questions, we will reflect on possible uses of the frames in the hydrogen process, discuss the methodological challenges that should be addressed by further research and finally come back to the concept of public acceptance and the issue of anticipation with the gained insight.

# 2 Methodology

## 2.1 Introduction

In chapter 1 we discussed both the concept of public acceptance itself, as well as how it emerges from previous studies (sections 1.4 and 1.5). We proposed a different approach, namely to identify hydrogen frames as a constellation of beliefs, worldviews and values as they can be found in lay citizens. These constellations of beliefs embed the preference towards different hydrogen systems (see section 1.6). In this way, we aim to ideally "map the public" by identifying shared frames among the citizens and trying to understand what characterizes them. Arguably, this path may lead to anticipate public acceptance of hydrogen in a meaningful and possibly useful way (see chapter 1, sections 1.3 and 1.6).

While the majority of the studies exploring public acceptance made use of (quantitative) tools such as opinion polls, interviews, and questionnaires, in this chapter we argue that the combination of the qualitative techniques we have chosen, in which the Q-methodology is central, provides us with an asset to identify a variety of citizens' points of view on hydrogen.

We will proceed by first discussing which requirements the research methodology should match in this study (section 2.2). Successively we will describe what the Q Methodology is and how it works (sections 2.3 and 2.4). With this knowledge we will discuss how the Q Methodology meets the methodological requirements we set (section 2.5). Furthermore we will discuss the challenges coming with the implementation of the Q Method in our research case (section 2.6) and we will explain how we overcame these challenges (section 2.7). Finally we will describe the research set up (section 2.8).

## 2.2 Methodological requirements for this study

As explained in chapter 1, the goal of this study is to identify holistic points of views embedding the possible hydrogen preferences. In the complexity of the hydrogen case however, the methodology implemented should enable the researcher to overcome three main issues linked to the hydrogen case.

First, since hydrogen is not diffused yet, most citizens do not know much about this technology. In this situation, as other authors argued before (see e.g. Ricci et al. 2006 and 2008), quantitative methods such as questionnaires are not indicated to explore the citizens' points of view on hydrogen technologies. Therefore, as a first requirement, the methodology should offer the possibility to explore the citizens' points of view despite their likely lack of knowledge on the subject of the study.

For example, the research tool could offer stimuli that might help the citizens to reflect and generate insight. Moreover, the citizens should be put in the conditions to generate this insight. For instance, sitting alone compiling a questionnaire might not offer the best conditions for a citizen to generate insights on hydrogen, as compared to a face-to-face interview; as, in the context of an interview, the respondents may have for instance the time to reflect, the questions may be adjusted, and so forth. In other words, the methodology should allow an in depth exploration of the citizens' points of view, rather than an extensive exploration as in the case of a questionnaire.

Second, many of the above mentioned studies are based on the researcher's assumptions of which variables are relevant for the citizens when assessing a technology, e.g. pro-environmental attitude or safety perception. As we argued in section 1.4 these assumption may reflect an idea of the public that disregards the heterogeneity of the citizens' points of view. Hence, as a second requirement, the methodology we need should allow the heterogeneity of points of view to emerge, even though the researcher has no idea a priori of what this variety consists of. In other words, the methodology should allow the exploration, rather than the verification of a hypothesis.

Third, as we extensively discussed in chapter 1, our goal is to consider hydrogen as a system of technologies from production to end-use. Previous studies mainly focused on particular parts or implementation of the hydrogen system, like on the hydrogen bus, or the refuelling station. In our study instead we need a methodology that may handle the entire hydrogen system, i.e. the full hydrogen chain, the other technologies linked to hydrogen (like the primary energy sources) the variation in application of the hydrogen technology, and possibly also the policies related to the hydrogen implementation.

All these requirements point towards the Q methodology. The latter combines qualitative and quantitative techniques to identify holistic points of view. As we will explain in section 2.5, the Q methodology allows the exploration of the personal points of view, enriching the results with in depth qualitative information. At the same time, the results (the points of view) emerge from the data, reducing the bias of the researcher. Moreover, as we will see in the next sections (2.3 and 2.4), the Q methodology allows dealing with complex and multifaceted topics. We will provide more details in that respect in section 2.5. For those readers unfamiliar with this methodology, we will give a short introduction to the Q methodology in the following two sections.

## 2.3 Reducing complexity through the Q methodology

The Q-methodology was developed by Stephenson (1935), with the aim of capturing and enhancing subjectivity rather than misrepresenting it with conventional methods using statistics (often referred to as R methods, as we will do in this research). In the following decades, Brown expanded and promoted the application of the Q methodology in political sciences, namely to explore the political subjectivity (Brown 1980). Since then, the Q methodology has been further applied in a variety of fields, such as education and communication, and today it is increasingly used as a stakeholder-analysis tool used to identify the stakeholders' perspectives around policy problems. Examples of this application can be found for example in Cuppen 2010; Ockwell 2008, van Eeten 1999; Ellis et al. 2007; Hobson& Niemeyer 2011.

The example of a talk-show situation is perhaps a good way to explain how the Q-Methodology works. Imagine that different stakeholders are invited into a TV-program to talk about the hottest issue of the moment, say the regulation of Genetically Modified Organisms (GMO). Eight

guests are invited to the show: two researchers, a doctor, a couple of policymakers, a representative of Greenpeace, a representative of the consumers' association, of the agricultural association and one of the FAO (Food and Agriculture Organization). All the guests have been selected to bring a different perspective in the discussion: what do you think the show might look like? The discussion develops in a sequence of arguments and counterarguments but after a while it gets stalled (especially if it is an Italian talk show!). Just because of their different perspectives everybody is saying something on the same topic, but there is no common discussion: different levels, different meanings. In such a situation what can you conclude? How are the single guests thinking? Where are their points of view overlapping and where are they disagreeing? Are they disagreeing because they say so, or because there are fundamental differences in their perspectives? For example GMO can be natural for somebody, non-natural for somebody else and some others don't care about GMO being natural or not. The point is, that in the different perspectives the same adjective "natural" has different meanings: everybody is saying something on the same topic, but there is no common discussion: different levels, different meanings.

At this point, the conductor of the program wants to unravel the discussion: clarifying to the audience what the main perspectives are, pointing out the conflicting and consensus points, and showing to the audience which of the guest are actually more or less thinking in the same way.

The TV conductor could then resume everything that the guests have been saying so far in a set of sentences and write each of them on a card. He could then ask each guest to sort the cards according to how much they agree/disagree with the sentences. This is done by disposing the cards in predefined grid that contains the same number of cells as

there are cards: part of the cells have a value such as "I disagree", another part has the value "I agree" and the rest will have a neutral value (fig 2.1). The proximity and the distance among the cards should represent the logic structure underlying the perspectives. This is called a Q-sort and it portrays the individual's opinion in a way that facilitates the conductor to group the similar Q-sorts together. Say that in our case, the researcher, the doctor and Greenpeace representative sorted the cards in a similar way and thus share one perspective; the other researcher and the representative of the FAO share another perspective; the consumer association is the voice of another perspective while the policymaker is somehow in between the three perspectives. In this way the eight points of view of the guests are reduced to three shared perspectives, which are formulated in such a way that it is easier to compare them. At this point it is easier for the TV-show conductor to show to the public where the guests are really disagreeing. Through the comparison it becomes clear that some guests disagree because, for example, they mean different things. It is at this point that the audience can better understand what the discussion is about. The TV conductor just completed a Q-study.

## 2.4 A methodology in three phases.

In a Q-study quantitative techniques, such as correlation and factor analysis, are used to reduce a variety of points of view into a limited number of shared perspectives on a defined topic of interest. In practice a Q study is realized in 3 phases, namely (1) definition the concourse and Q sample selection, (2) identification of the perspectives and (3) interpretation of the results. Let's discuss the phases in more detail.

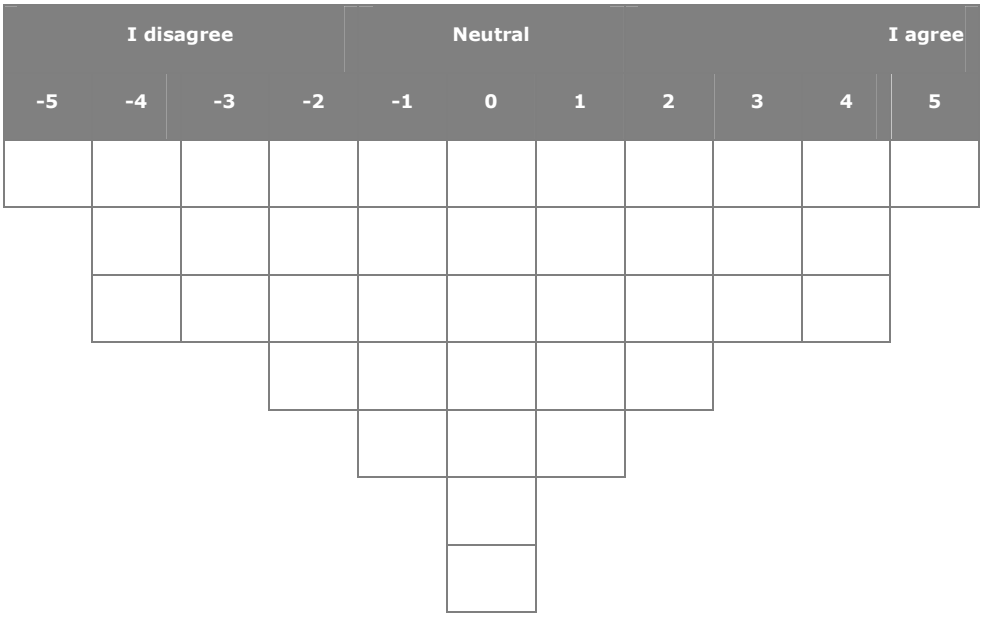


Figure 2.1. Q grid. The interviewees are asked to sort the statements in a grid, like the one here above, according to how much they agree or disagree with the statements. The statements are written on cards, and there are as many cells as there are cards/statements. The right side of the grid is for the statements they agree with, the left side for the statements they disagree with and the central area or for the statements that are either not relevant, with respect to the other statements, or on which they do not have an opinion. Hence the cells at the extremities are used for the statements that generate more agreement/disagreement. According to Brown (1980, pg. 201 and 289) the shape of the grid is statistically irrelevant.

Phase (1), the so-called "concourse" is defined as the flow of communicability about a topic as it is in "the ordinary conversation, commentary, and discourse of everyday life" (Brown 1980 and 1993). Hence the concourse sources are usually newspapers, magazines or documents containing e.g. people said about the topic "Genetically Modified Organisms". The concourse is successively reduced into a more limited set of statements, the so-called Q sample. The Q sample is selected in order to represent in small the complexity of the concourse. In other words the Q sample is representative for the flow of communication. The set of sentences is written on cards, each card a statement. A grid is designed with the shape of a quasi-normal distribution (fig 2.1), with the same number of cells as there are cards.

The second phase, aims at collecting the variety of perspectives on the topic. Firstly a limited number of participants is selected to sort the Q statements (Figure 2.2), this is called the P-set. The participants however, should be diverse in their point of views, as we described in the TV-show example (section 0). This diversity is one of the keys to identify the spectrum of points of shared perspectives. In the context of an interview each participant is asked to rank-order the set of cards under a certain task, e.g. "agree-disagree" from a +5 to -5 scale and to explain his choices. In principle, the cards are sorted in the grid in a way that represents the individual point of view, which is called a Q sort. Hence in a Q sort, each statement on the cards will get a certain value according to each participant, for example in the grid showed in Figure 2.**1**, the statements can have a value from +5 to -5. Through the Q sorts the individual points of view became quantitatively comparable.

Figure 2.2 Interviewee sorting the Q statements in the Q grid

The Q sorts are first correlated and factor analyzed, so that similar Q sorts are grouped into a limited number of factors. Each factor is successively translated through a weighted average, into a new Q sort, so that this new Q sort represent a sort of ideal point of view that expresses the points of views (Q sorts) grouping in that factor. There is no single rule indicating how many factors to select and how, but rather a set of potential criteria that can be used according to the goal of the study. Brown (1980) suggests some, which we apply and discuss in appendix C: quantitative data analysis. For instance, as we will also see in the chapter dedicated to the data analysis (chapter 4), we followed the criteria of saliency, relevance and variety.

Each factor represents a common sequence or, in other words, a pattern of distributing the cards on the grid. As Brown (1980) demonstrates, since there are theoretically infinite ways of distributing the cards, when patterns are disclosed these are likely due to an underlying logic. The factors hence, represent a "shared logic" behind a constellation of beliefs. Moreover, since each factor-perspective is the combination of the same cards, but with different values, the comparison among the perspectives is much easier.

Last, the interpretation takes place. The perspectives around the factors are reconstructed, retrieving the qualitative information collected during the interviews. The qualitative information helps the researcher to find the logic connections between the statements in each factor, using directly from the perspective of the interviewees, rather than from the perspective of the researcher.

In the third phase the factors resulting from the data analysis are further interpreted, based for example on the existing literature, with the aim of better understanding the results and their implications.

## 2.5 Matching the methodological requirements through the Q method

With the assumption that there is a limited number of ways to think about a certain topic, and given the nature of the statistics used, the Q-methodology doesn't require big samples, as far as the sample guarantees a sufficient variety of perspectives. The Q method hence does not aim to give a representative distribution of the opinions among the population (such as an opinion poll) but rather aims to disclose the variety of perspectives on a certain topic (Brown 1980; van Exel and de Graaf 2005; Webler et al. 2009). Through a Q study it is possible to identify a limited set of perspectives, e.g. four or five, each representing

a dimension of the topic of study. Each single point of view (expressed in form of a Q sort) will somehow relate (e.g. be closer or completely different) from each of these perspectives (expressed as factors). We could say that the perspectives identified through the Q method are some sort of cardinal points, or reference points, through which the researcher can organize, represent and grasp the variety of the opinions on the topic of interest.

A Q study aims at identifying shared perspectives in a way that the perspectives can be holistically collected, compared and analyzed. The Q methodology therefore, should be an appropriate tool to grasp the frames, which we defined as the holistic rationale embedding the preference towards hydrogen. More precisely we defined the frames as composed of different beliefs. Hence, in practice, we can use the Q methodology set up to let the citizens build their own frames (in the form of a Q sort), and we will compare and analyze the frames in order to find shared ones, as in the Q manner. Therefore the Q methodology offers the set up and the tool to answer our main research question.

In a Q-study quantitative techniques, such as correlation and factor analysis, are used to reduce a variety of points of view into a limited number of shared perspectives. However, contrary to a conventional quantitative analysis, the perspectives are enriched with useful qualitative data about "how" and "why" certain variables are linked. This is due to the fact that the interviewees are asked not only to sort the statements according to how much they agree and disagree; but also to comment the statements and explain why they sorted them in a certain way. This set up may offer the right conditions for citizens to reflect on hydrogen and generate the insights we are looking for. The statements may work as stimuli, citizens may react and reflect on a statement despite their possible lack of knowledge on the topic. The Q method

offers the possibility to include these reflections and insights in the analysis. Moreover, in a Q study the variety emerges from the data, rather than from the pre-imposed categories of the researcher. This is due to the fact that 1) the set of stimuli (the statements) are interpreted by the people that are sorting them, 2) the factors emerge from a quantitative analysis, and 3) because the logic connection between the statements, i.e. the reconstruction of the shared perspective, is done based on these comments collected during the sorting exercise, hence the shared perspectives are interpreted from the point of view of the interviewees and not from the free interpretation of the researcher. Last but not least, the setup of the Q may be able to handle the complexity of the hydrogen case, as a Q sample is designed to reproduce the complexity of a topic in a relatively small number of statements.

For all these reasons we believe that the Q methodology may match the methodological requirements we discussed in section 0, allowing the intensive exploration of the points of view of the citizens on the topic 'hydrogen' and through the identification of shared frames embedding the hydrogen preference. Through a Q study in fact, instead of finding factors leading to acceptance or rejection (e.g. a pro-environmental attitude) as is done conventionally in quantitative research, we may understand the points of view. Here it becomes evident the difference between Q methodology and conventional quantitative studies, defined by Brown (1993) as the difference between "intensive" and "extensive" studies. In other words, the study of an emerging technology such as hydrogen requires an intensive exploration of the relevant perspectives, which are not well understood. Whereas in the standard quantitative approach, the understanding of the perspectives is assumed and their prevalence ascertained through the exploration.

The application of the Q method to our case however, poses some challenges; mainly because we are applying the Q method in an *anticipatory* way. Namely, we are applying the Q methodology to a topic, hydrogen, which is not present yet in people's life. For example this means that we will most likely use the Q to construct a point of view rather than elicit an existing one. This translates into a set of practical challenges in the application of the method, which will be discussed in the next section.

## 2.6 Challenges in the application of the Q methodology in our case

Brown (1993) defines the concourse as the flow of communicability about a topic as it is in "the ordinary conversation, commentary, and discourse of everyday life" around an issue of interest. In our TV show example in chapter 2 (§ 2.2), the issue of interest was the genetically modified food. Doctors, scientists and policymakers, as well as any citizen, were offering different points of view on the issue.

Hence often the Q set is retrieved from "everyday life" sources, such as newspapers, magazines or documents containing what lay citizens or politicians said about the topic of interest. The concourse sources are used accordingly to the topic of interest and the Q set is selected in order to represent the main points of the concourse. In other words the Q set is representative of the flow of communication around a certain issue.

In 2008 we reviewed the internet-database of the two main Italian newspapers, and we could find not much more than a handful of articles about the hydrogen car in the "science and technology" column. This was not surprising, given how many studies showed that hydrogen is yet largely unknown to the citizens (see for example Ricci et al. 2008,

Roche et al. 2010 and chapter 1 in this book). Hence, when this research begun, hydrogen could not be defined as an "everyday life" topic.

Certainly hydrogen was an everyday life topic for an elite of scientists, policymakers and entrepreneurs working on hydrogen. Some authors studied the perspectives on hydrogen diffused among these "hydrogen experts" (Sovacool and Brossmann 2010, Eames et al. 2006, van de Kerkhof et al. 2009). While these studies grasp the essence of the discussion and the variety of experts' perspectives on hydrogen, we doubted whether such a specific set of discourses would represent the citizens' perspectives, since the discussion on hydrogen that experts have, might be too specific and therefore far from the citizens point of view. As we argued before, the citizens' perspectives could have been more general, unspecific and, perhaps, even more varied than the perspectives of experts (§1.6).

In order to avoid possible bias, we were particularly interested in letting citizens talk about the subject, instead of looking for written sources from the perspective of the researcher. Moreover, it was important to formulate the beliefs in a familiar style, in order for the interviewees to better recognize the sentences when Q-sorting. Yet we needed a way to generate and observe the flow of communication on the above-mentioned topics. Varied, familiar, unbiased, focused, and "lay". These are the characteristics of the flow of communication we were looking for. How did we get it?

## 2.7 Overcoming the challenges

In order to have a varied, familiar, and lay concourse, we needed to involve citizens directly, namely we needed to let citizens generate the concourse in a semi-controlled environment. We needed a context like

an interview, in order to explore the citizens' points of view through open questions. We also needed a group situation, in order to overcome the possible lack of knowledge, as in a group situation anybody could react on somebody else's point of view, while in a one-to-one the interview may get stalled if the interviewee doesn't have an opinion.

With these requirements in mind, we opted for the focus group technique. As Kitzinger (1995) describes:

"The idea behind the focus group method is that group processes can help people to explore and clarify their views in ways that would be less easily accessible in a one to one interview. Group discussion is particularly appropriate when the interviewer has a series of open ended questions and wishes to encourage research participants to explore the issues of importance to them, in their own vocabulary, generating their own questions and pursuing their own priorities. When group dynamics work well, the participants work alongside the researcher, taking the research in new and often unexpected directions."

In a focus group, a set of participants is gathered to discuss and interact on a certain topic, the focus. The focus group method originated as a market research technique in the beginning of last century and was lately used in many social science studies (Basch 1987; Bogardus 1926; Merton et al. 1956, Kitzinger 1994 and 1995). The peculiarity of the focus group, compared to a group interview, is the importance of the interaction among the participants, so that the role of the researcher is limited as much as possible to being the observer. We expect the focus group the be the appropriate methodology to obtain a dynamic and genuine discussion, rich of varied, familiar, unbiased, focused, and "lay" beliefs as we are looking for.

We determined the boundaries and the salient points of the concourse through the theoretical framework we described in chapter 1 (§1.6).

Namely, we were interested in the citizens to generate a variety of beliefs concerning energy related issues, underlying causes, distribution of responsibilities, and possible solutions that the different actors should undertake. Among the solutions we were particularly interested in hydrogen, considered as a system, i.e. including the different level of the chains, the production technologies and the different scales of production (for example large scale centralized systems or small scale decentralized ones) to the end-use applications (for example transport or domestic usage). We thought these beliefs could be the building blocks of the frames. The established boundaries were not particularly strict, but were meant to help the researcher to keep the group on focus, for example by avoiding the participants discussing topics unrelated to energy and hydrogen. As the reader can imagine, a group of 10 people discussing 'off-leash' may lead very quickly the discussion off topic leaving the researcher with a lot of useless data.

In this research we used the focus groups with lay-people as a sort of "beliefs generator". In the next chapter we will see how we realized that in detail.

## 2.8 Research design: implementation of the Q study in 3 phases

Parallel to the 3 phases of the Q-methodology we divided the research work in 3 phases:

Phase 1: concourse and Q sample (chapter 3). We used the focus groups, organized with both Dutch and Italian lay-citizens, as a sort of "beliefs generator". As defined by the theoretical framework, the beliefs focused on the energy related issues, distribution of responsibilities and solutions, including hydrogen and hydrogen related technologies. As we will see in the next chapter, we used a combination of questions and hydrogen scenarios (in form of drawings) to stimulate the discussion.

These beliefs were extrapolated from this discussion, used to pool a representative set of statements, which were then sorted in the following phase of the Q study, as described in the next paragraph.

Phase 2: the Q factors (chapter 4). We got the opportunity to conduct the Q study both in Italy and in the Netherlands. In both countries we followed the same procedure to select the participants (P-set) and conduct the interviews. As we will thoroughly discuss in section 4.2 (chapter 4) identifying a diverse P-set was challenging, but we managed, as shown by the results of the Q study, i.e. a variety of frames diverse in content. Each participant sorted the same set of statements (translated in their own language) in the context of an interview. The limitations of using the same set of statements in two countries is discussed in chapter 6 (sections 6.6 and 6.7). After the data collection, the data are quantitatively and qualitative analysed as described in the Q fashion (§2.3). As the analysis will show (§4.5), the factors and narratives elicited with the analysis are frames as we defined them in chapter 1.

Phase 3: interpreting the results (chapter 5). The frames are further analyzed and interpreted on the base of the existing literature, with the aim of better understanding and characterizing the frames. In this way we will answer the second research question and we will lay the foundation of our reflections and conclusions over the possible uses of the frames (and the Q methodology) to anticipate public acceptance.

The sequence of research steps, from the focus groups to the Q study, is summarized in figure 2.3 in the following page.

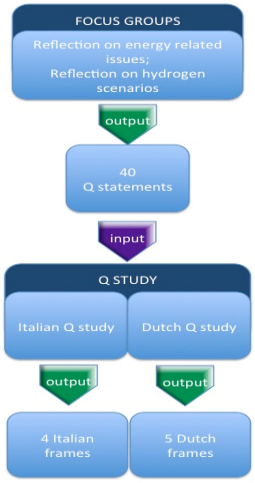


Figure 2.3 Sequence of research steps. The focus groups are implemented in order for the citizens to reflect on the energy related issues and a set of possible hydrogen scenarios. The output of the focus groups is a list of 40 statements, further implemented in two parallel Q studies, one in the Netherlands and one in Italy. The result of the Q studies is a set of 9 frames.

# 3 Concourse and sample of statements

## 3.1 Introduction

We described the Q method as composed of three phases (chapter 2, § 2.4). The first phase aims at defining the set of statements representing the issue of interest – the so-called concourse, in our case the energy issue and the hydrogen technologies. In our TV show example in chapter 2 (§2.3) the concourse was defined in the discussion on genetically modified food during the TV program, and the Q study participants were the variety of guests of the show. Successively, a smaller number of statements are sampled from the concourse, in order to be sorted in the following phases of the Q study.

We chose the focus groups technique to generate the concourse. We used the theoretical framework described in section 1.6 to guide the data collection. In sections 3.2 and 3.3 we describe how we applied realized the focus groups. In 3.4 we give an overview of what has been discussed by the research participants. We will see that the results show

a variety of citizens' beliefs on energy related issues, on the distribution of responsibilities, on solutions, on hydrogen and on related technologies. The uncovered variety supports the idea behind this study, namely that other (combinations of) beliefs exist, besides the environmental concern and safety, largely explored in the hydrogen acceptance literature (chapter 1, §1.2). These combinations might embed different visions of the future hydrogen system. We defined these combinations of beliefs as hydrogen frames (chapter 1, §1.6).

In §3.5 we will describe how we passed from the raw data of the focus groups, to the concourse and then the Q sample. We will conclude the chapter with the discussion on the concourse (§ 3.6).

In sum, this chapter represents the first step to answer our first research question (chapter 1, §1.6). Specifically, this chapter will answer the first sub question:

What are the beliefs on energy related issues and hydrogen?

## 3.2 The beliefs generator

The focus group design in our study contained 2 parts. The first part focused on the energy issues, while the second focused specifically on hydrogen. When the participants felt comfortable with a non-native language, the discussion was held in English, otherwise in Dutch or Italian. The focus groups lasted approximately two hours. The interactions were taped and successively transcribed.

In the first part of the meeting, after a brief introduction, we introduced and defined the topic through a brainstorming activity. The brainstorming was used mainly as an icebreaker and secondarily to define the focus of the discussion.

After the brainstorming, we fed the discussion asking the participants three open questions, in the following order:

1. from your point of view, which issues related to energy should have to be addressed nowadays?
2. from your point of view, who is responsible to do something about these issues?
3. from your point of view, what actions should have to be undertaken?

As the reader may recall from our theoretical framework (chapter 1), the above questions cover the beliefs on issues, responsibilities and norms of the VBN theory that we used to refine the concept frames.

In the second part of the meeting, the common activity was focused on hydrogen. Participants were confronted with a set of drawings representing possible hydrogen systems. The aim of the drawings was, first, to concretize a vague concept such as "hydrogen technology" by a visualization of the entire chain; second, to confront people with a variety of hydrogen ideas, for example by presenting different system concepts, from the "invisible hydrogen" (hydrogen is used to store extra energy coming from a huge wind farm somewhere in the North Sea) to the "business as usual" (energy is centrally produced through a nuclear power plant and liquid hydrogen is used in cars) to the very small scale (where hydrogen is produced and used at a very local level –in a village or at home). Figure 3.1 shows two examples of the scenarios we presented.

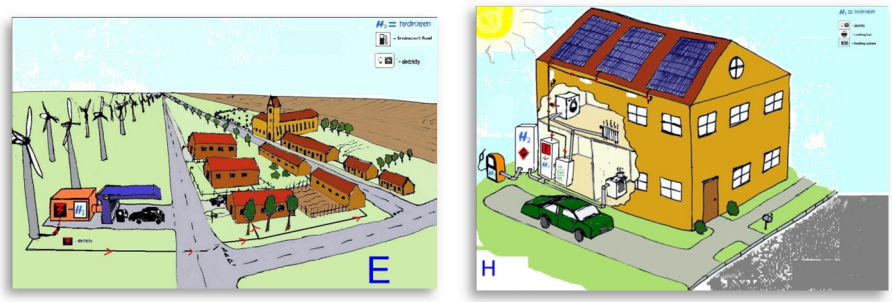


Figure 3.1 Two possible hydrogen systems. One of the focus group participants named these systems the *little utopias*. The drawings are aimed to describe how hydrogen is produced and used. The systems vary in scale, e.g. here we have a household system and a local system. Other drawings included other energy sources, like nuclear power, biomass from waste, or natural gas. We thank Pauline de Heer for the help in creating the drawings.

The drawings are based on existing hydrogen scenarios found in the literature (see for example van de Kerkhof et al. 2009; Mcdowall and Eames 2007). Drawings of the systems, as the ones showed above, were both projected on a screen and printed in hard copies.

## 3.3 Data collection

As mentioned above, we are interested in observing an interaction as natural as possible, such as discussion of friends or colleagues around a dinner table. Therefore, like in other studies we aimed to work with pre-existing groups, i.e. people that knew each other already, such as group of friends or colleagues (e.g. Kitzinger 1994). For example, focus group number 9 was some sort of 'book club' that one night agreed to answer our questions instead of doing their normal activity. To achieve this goal, we tried to access different networks by worth of mouth, asking few persons to gather each a group of 8 to 10 people. However, gathering 8-10 people to discuss about energy and hydrogen was not an easy task, since often one person alone could not bring a sufficient number of participants. Therefore, given the time and resources

available, in some cases we were forced to mix participants from different networks in order to achieve a minimum number of participants (five). When doing this, we tried to combine groups with a certain grade of homogeneity (e.g. age, social background) and to create a comfortable context. By creating such a familiar setting, as similar as possible to a chat-among-friends situation, we aimed at facilitating people to just say what they think despite a topic that might be perceived as rather "technical".

Table 3.1 Overview of the participants of the two rounds of focus groups.

| Round 1 | | | | | |
|---|---|---|---|---|---|
| Focus group | females | males | Age range | Type of group | Language |
| Group 1 | 2 | 3 | 20-30 | natural group | English |
| Group 2 | 3 | 4 | 20-30 | mixed | English |
| Group 3 | 4 | 5 | 20-70 | natural group | Dutch |
| Group 4 | 2 | 3 | 30-40 | mixed | English |
| Group 5 | 3 | 3 | 30-60 | natural group | Italian |
| Group 6 | 2 | 3 | 20-30 | mixed | English |
| Group 7 | 3 | 4 | 20-30 | mixed | English |
| Round 2 | | | | | |
| Focus group | females | males | Age range | Type of group | Language |
| Group 8 | - | 5 | 20-50 | mixed | English |
| Group 9 | 3 | 4 | 60- up | natural group | Dutch |
| Total N. of focus groups 9 | | | Tot. N. of participants 56 | | |

As a result, we organized 9 focus groups, with 56 people participating, in a time frame of about 3 months. With the collected sample, we covered a wide range of ages (from 18 to over 60) and different social backgrounds (i.e. education, profession, nationality), although the males, the under 30s and the highly educated are overrepresented, with about the half of the participants having an university degree or higher. Table 3.1 shows the socio-demographic background of the participants. There might be multiple reasons for this overrepresentation; perhaps the kind of topic was more attractive for male and literate people; or the focus group were conducted mainly in the Delft area, which is a small town with a fairly large number of people working or studying at the local technical University; or because we accessed the different networks through people having themselves an high educational level (i.e. people having an university degree).

The data collection took place in two rounds. In the first round we organized 7 focus groups, after which we gathered already a great variety of beliefs. These beliefs were already enough to be able to continue with the Q study. Given the time and resources available we decided to proceed on two parallel tracks (1) to continue with the following phases of the Q study, i.e. selecting the sample of beliefs and starting collecting the Q sorts; (2) to organize a second round of focus groups, in order to check whether possibly new, relevant beliefs would emerge from other discussions. In this way we would get a better impression of the quality of the beliefs sample we were using in the Q study.

In the second round we organized two more focus groups using the same recruiting method/criteria of the first round. Comparing the data collected in these two additional groups, we concluded that the focus groups were not adding anything substantial to the beliefs we already

had and used to extrapolate the sample. The participants of the last two focus groups were discussing mainly the same things we observed in the first seven focus groups, and no different beliefs were emerging from the new groups.

As we will further discuss in section 3.6 we concluded that saturation was achieved for the sampling method or, in other words, we concluded that we had a small chance of finding new beliefs, at least when using the same method for recruiting the focus group participants. For reasons that we will explain, the ambition of the study was not to be representative but rather to collect variety. We concluded that the raw material obtained with the first round of focus groups was vast enough, and therefore could be considered satisfactory. Therefore, we decided not to organize other focus groups.

### 3.4 Overview of the discussions held in the focus groups

The questions and the hydrogen drawings we designed stimulated hours of discussions in the focus groups. From these discussions we extrapolated the concourse and successively the Q statements necessary to implement the Q study. Before stepping into the phase of selecting the set of Q-statements from the concourse we will give an overview of the content of the focus groups discussion. Each of the next subsections (from 0 to 0) is dedicated to one question we posed and highlights some of the answers the research participants gave. This division is somewhat artificial, and does not reflect the "unity" of the discussion as it evolved during the meetings. As a matter of fact, often it was not necessary to ask all the questions we envisaged in the setup of the focus group. In many cases the discussion naturally evolved from the first question, covering all the topics of interest.

### 3.4.1 Question 1: What are in your opinion the issues related to energy?

Some of the groups focused and explored in depth one or two issues, while others touched on more topics without entering in the details. In order to give an idea of what has been discussed in the groups and how, we selected some examples from the raw data.

For example, the following exchange developed in answer to the first question –from your point of view what are the issues related to energy?- in the focus group number 8:

Male 1: "The problem with energy is that every day we consume more oil than what is available, if we don't find an alternative we will run out of energy" opened one of the participants.

Male 2:"But if you consider coal, we still have enough energy for hundreds of years. The problem, I think, is that this oil comes from some countries I would not like to depend on because of their political situation "

Male 3: "Well, I am a fan of the climate crisis. I think it is really happening and we should do something about it"

Male 4: "And not only! I don't know how is it for you, but I live in Rotterdam and I go jogging in my neighborhood from time to time and I am not getting any healthier!" (referring to the traffic emissions).

In just one round, the participants disclosed four different issues, from the environment to the energy security. The same topics emerged in other focus groups. Some groups discussed more about one topic than another. For example, the Italian focus group talked longer about urban

pollution. Here is a discussion between two of the participants, a middle-age man and a young woman[1]:

Male 1:"In Italy we increasingly have a problem with respiratory diseases [due to air pollution caused by traffic]. I myself suffer of asthma, which I never suffered before! I think pollution is a problem of today, not a problem of tomorrow."

Female 4:"In Germany they don't let you go in the centre with the car, and if they catch you doing it, they give you a fine! In my town you are stuck in the traffic and you just close the window and suck it up! [i.e. the citizens just live with the pollution]"

The production of the second focus group contains more sentences on climate change; here is a snapshot of an interaction between three participants in group 1:

Male 3: "With environment you do not see it and you do not think about it"

Female 1:"That's true, if you read a newspaper, but in my daily life I do not feel it!"

Female 2:"I feel the climate changing and it alarms me [...] It is getting warmer, there are strange things happening with the climate and this is a signal."

Interestingly, the same discussion about feeling climate change and the environmental threat has developed in another group (n. 7), but from another angle:

[1] The conversation was held in Italian, the translation in English here is edited by the author. The text between brackets is added by the author in order to help the reader in understanding the meaning of the conversation.

Male 2: "The biggest issue is that we're causing damages to the environment that can't be held back. We can't time travel to restore the environment, and we're continuously damaging it."

Male 1: "The environment is our responsibility now, and it's happening now, but we don't feel it yet. It happens in really small steps. It's our problem as well, but the results will be there in the future"

Male 3: "I don't know, there are scientists saying that the climate change is a normal process. The humans are maybe contributing to the climate change, but the time period is too small to really judge."

Male 2: "Maybe we should go for sustainable energy, but there will be trade-offs. Ecosystem matters less compared to humans, we are on top. We should satisfy our needs, but not completely disregard the ecosystems."

Male 3: "Yeah, we are a part of nature, it's like a survival of the fittest."

Male 1: "The problem is that you're depending on these resources...we consume too much..."

Male 3: "We rely too much in general on energy. The problem is not that we consume too much, but that we consume!! We are completely dependent on energy for everything. We cannot go back in time and consume less... we cannot go back to the Stone Age!"

As we can see from this last example, the discussion on issues quickly shifts to an exchange of views on the causes of these issues and worldviews in general. However, in this exchange a different worldview emerges than in group number 4, talking as well about consumption:

Female 1: "I think that we consume too much, in general. Every summer you say: "Now I need another pair of shoes" while my grandparents used their shoes until they were broken. It doesn't make

sense that I can buy for 2 Euros a pair of socks that come all the way from China, it is crazy! And by the way, after 2 days they are broken."

Other problems that have been discussed are the oil dependency and the energy dependency in general. Some groups discussed the possibility of the Middle East "closing the tap", some found it an unrealistic option, some others envisage wars to ensure energy supply and some others even "wishing at this possibility": "If Saudi Arabia closes the tap, then we might change faster!" (Male 2 – group 4)

As we can see from these snapshots of the conversation, the discussions across the focus groups cover a variety of topics, which were both recurring and described from different angles. The picture that emerges is varied, described in familiar words and coloured with personal experiences and emotions.

As the reader can imagine from the examples we gave, the discussion often easily evolved from problems and causes to responsibilities and solutions. We have observed in the discussion that the definition of the problems indeed contains the seeds of this so called normative leap, namely of what should be done to address these issues and by whom. We report examples of this leap in the next sections.

### 3.4.2 Question 2: Who is responsible to do something about these issues?

The attribution of the responsibilities generates quite some discussions among the participants, unfolding fundamental divergences in the worldview of the people. In general the responsibilities of the abovementioned issues have been distributed by the participants between three main actors: the citizens, the government, the industries and science. The latter is considered as the institution that should both find solutions and suggest (or better tell) society what to do.

Logically, the responsibility was attributed differently according to the problem that was taken into account. For example some stated that the oil dependency is a governmental issue, as it is necessary to strategically consider "[...] in the long term in which direction the country should go and what is convenient" (Male 2 – group 5). Concerning the environment instead, some clearly stated that the environment is a responsibility of the people, "ours" to be more precise. Therefore each person should contribute individually to safeguard the environment. Others pushed this belief further, wishing the government to push, steer and even force the consumers and the industries, which otherwise would not think about the environment on their own. Some reacted to this consideration fearing that constraining the industries would affect the competitiveness:

Female 2- group 5: "from your perspective this would be right because you are an environmentalist, but we have to pay attention to the economy".

This dynamic of putting the economic interest above the environmental one is a well-known phenomenon in the environmental discourses (e.g. Dryzek 1997, de Geus 1999). Through the above-mentioned example we can see how the acceptability of the distribution of responsibility depends on the problem definition on one side. On the other side it depends on the general worldview, as this exchange in focus group 2 shows:

Male 1: "The government should do something, they know what to do and they are the only one to have enough power to do something"

Male 2: "The government is there to support and it is not responsible for everything, for a lot of things the market in itself can accomplish things".

Under the surface of these discussions many other important topics hide themselves, such as trust and fairness. Trust and mistrust in the government, politics and the institutions, emerged for example in focus group 4:

Male 1: "The government? The last persons I trust are the politicians!"

Male 3: "Well not the politicians, but I do have some trust in the system-government"

Fairness in distributing the burden of responsibility emerges in focus group 7:

Female 1: "Is a shared responsibility, everybody should do his piece, people too."

Male 3 "But aren't the industries using most of the energy? A small city uses as much energy as a big train when it accelerates!"

Or in group 3:

Female 3: "We should consume less, and we should start, us, the citizens, I ...We should understand that what we do as single persons is not a drop in the sea ..."

Female 4: "But the government should start. They should give the good example and do things first, like having solar panels on public buildings".

The beliefs on the responsibility are the link between the beliefs defining the problem, and the beliefs on the kind of solutions that should be undertaken, to overcome these problems. In chapter 5 we will better see that it is possible to identify through the Q method distinct perspectives among the citizens. These distinct perspectives are structured as systems of beliefs on problems, responsibilities and solutions consistently linked. For example, when the problem at stake is

the environment and the citizens, "us" are considered responsible for the environment, decentralized energy systems better fit the solution space boundaries, as they make "us" more responsible. On the contrary, when the government is held responsible for the protection of the environment, centralized energy systems are preferred over the decentralized ones, as in that view the management of energy is not a thing the people should be responsible of.

Let's have a closer look at the beliefs on solutions as they emerged in the focus groups in the next section.

### 3.4.3 Question 3: What should be done to address these issues?

The discussion on what to do contains three main elements in all focus groups: technology, policy and behaviour.

Technology is seen by many as a key in solving the issues related to energy, whatever these might be (environment, oil dependency, energy depletion, energy needs, climate change, price, competitiveness, sustainability and so forth).

Many underline that a change in people's behaviour is also central in overcoming the issues related to energy: a change in people's current life style, in the products and technology in use. A change in how much is used as such.

The relationship between technology and behaviour emerged as tense in group 4:

Male 1: "When I think about solutions I think about alternative energy. But I also think about the structure of society. There is so much industrialization. People do not use their hands anymore, even though people that use their hands are much happier. Perhaps it is too much!

Maybe we should create more space for craftsmanship, this makes you happier, you do things… maybe we could come back in doing things locally"

Male 3: "I do not agree… I think that with technology you are not going backwards, you are improving! People want to have more and more, not to go back"

Male 2: "Yes but you can see this in cars: you can improve the safety of the car with all these ABS devices but then people drive faster!"

Female 1: "The profit of a new technology never goes to the environment but is used for personal gain: I have efficiency bulbs: I can have 3 lamps instead of 1! I have a safe car I drive faster, I have a fast train I live 100 km further from my work."

This discussion expresses the tension between the technical fix and the societal change, the trust in progress and technology and the critic on it.

The third element discussed, was about the governmental policies and their objectives. It was discussed whether the policies should be pushing or pulling people and industries to change their consumption patterns, to consume less or to change products, e.g. for more sustainable products. According to where the responsibility was shifted, these policies should either push or pull citizens or industries towards new behaviour and technologies. Push policies constrain the subjects targeted by policy. Examples of push policies proposed in the focus groups are "Include the environmental cost on grey energy" (Male 3- group 4) or "pushing industries to consume less" (Male 2- group 1) (e.g. by making them comply to certain targets). Pull policies aim at making the alternative more attractive, for example subsidizing certain products, like PV panels.

A discussion that emerged in more than one focus group is the question of price vs. awareness. Some supported the thesis that people's behaviour is money-driven. An increase of price (for example directly or indirectly resulting from a governmental regulation), some argued, might push people to switch to other new technologies as "people think with their wallet" as many stated. On the other side, others replied that a change due to price is not substantial: "It is a matter of awareness. Changing only for price does not make me aware of what I am doing. Changing without awareness does not lead anywhere" (Female 1 – group 5). A female participant explained her differentiation of an 'empty change' as opposed to a 'deep change' discussed in other focus groups too. Moreover, some find price policies unfair, as "people who have the [financial] possibility will keep on doing what they want".

The timeframe of the solution is also different, short term, long term and even postponed solutions to the next generations. This is especially the case when people mentioned education in primary school as the only way to solve things, so that the next generation would be fully aware and act consequently.

### 3.4.4 Question 4: What do you think about hydrogen?

After a break, in this second part of the focus group the participants have been confronted specifically to hydrogen. In order to stimulate the discussion, several drawings of possible hydrogen configurations have been projected and used as example to talk about the future possibilities of hydrogen.

In this phase, the discussion was not as fluid and rich as in the previous one. From the coding of the raw data we deduced a categorization in 4 families of statements.

I. Questions on hydrogen. First, participants tried to understand what hydrogen is and how it works. Other questions concerned safety: "how dangerous is it compared to gas [Natural Gas]?". This topic was further explored in 3 other focus groups, and people divided between two parties; those who would not like the idea of having gas at home or in a car, and, those arguing that "it is just a matter of habits". Interestingly enough, people often used known technologies to make a comparison and better understand hydrogen. Other questions were very practical, enquiring for example the dimensions of the home system.

II. Appraisal of practical aspects of the system. In the more productive focus groups, participants came to the point of commenting aspects of the system that they found interesting. People were capable of foreseeing advantages and disadvantages of specific systems. "Another reason to fight with your neighbours" commented 3 persons in 3 different focus groups, looking at the system where the solar-hydrogen refuelling station is shared by the neighbours. Others even discussed the potential of new employment possibilities in a decentralized energy system (Figure 3.1), like in focus group 2:

    Male 1: "I like the idea of producing energy on my own"

    Female 1: "I don't. It doesn't make me feel secure. What happens if there is no sun, or if the panel breaks?"

    Male 1: "There will be new companies compensating for that, the market will adapt."

III. Comments on the technologies used in the systems. Many debates developed around nuclear energy, and whether it is or it is not polluting. Windmills were also quite discussed, the

possibility of having them onshore, or offshore, if they are ugly, noisy or not. Two examples of comments expressing this perceptions' divergence: "Nobody wants to live in a forest of windmills" (Male 2- group 4) and "I look at the windmills and I feel good" (Female 1- group 5). The use of waste as a possible energy source received some attention as well. Many found it a good idea, as it solves two problems in one: getting rid of waste and producing energy. The use of sun (solar panels of PV) received also positive comments, "because they [the panels] are less visible" (Male 1 – group 3) or even "I have solar panels at home (in Italy) and when I take a hot bath I don't feel guilty anymore!" (Male 4 – group 5)

IV. Concern over hydrogen in general. People expressed concerns on the efficiency of the chains, as well as doubts on the convenience of hydrogen compared to other technologies. Some people wandered about the feasibility of such a big change, when a new infrastructure is necessary, or whether it is possible that the energy is produced in decentralized systems.

### 3.5 Concourse and Q- sample: procedure.

During the focus group we observed that once the discussion started, it went smoothly in all the focus groups we conducted. People manifested interest in the discussion, for example by staying longer than the two hours previously agreed, or by giving positive feedback to the mediator even in the following days. The informal atmosphere of the focus groups allowed everybody to express their own point of view, questions and doubts.

At the end of the data collection, a set of audio records and transcripts were ready to be transformed into usable data. As a first step, the

transcripts were "cleaned" of all the sentences out of focus, such as general jokes or comments on the coffee. The conversation was transformed into lists of sentences, one list for each focus group. In total, these lists contained more than 220 sentences. Together, these sentences form the concourse.

From the concourse we extrapolated a smaller sample of statements, i.e. the Q statements that will be transcribed on cards and will be successively sorted in the Q grid in following steps of the Q study. Generally, the set of Q statements should be representative of the concourse, namely a small amount of statements should represent the extent of the concourse. Therefore, the set should be composed of statements very different from one another "more nearly approximating the complexity of the phenomenon under investigation" (Brown 1980 p.189). The procedure usually includes the researchers giving a structure to the concourse, arranging the statements according to this structure and then selecting the most different statements from each category.

We proceeded for the selection of the statements in a team of three researchers. Two researchers individually and in parallel selected their own sample of cards from the concourse. Each researcher proceeded by giving her own structure. The sentences were selected not for their relevance (i.e. number of times they have been repeated) but rather in order to cover what had been discussed and the maximum variety of perspectives. The sentences were selected such that they cover different topics, avoiding overlaps among sentences and trying to keep them as near as possible to the original formulation.

Afterwards, with the help of the third researcher, the two parallel samples have been compared and merged into one list. When more sentences covered the same topic (e.g. climate change), but had

different nuances in meaning, it was chosen to use either the broader sentence or to pick one of the two randomly.

Particular attention was given to the hydrogen statements. Only the statements with the highest level of abstraction have been chosen, in order to be comparable with the beliefs on the energy issues in the level of abstraction. The comparability in the abstraction level is important because a Q-sort is intended to grasp holistic points of view, and it would be strange to combine in the same discourse, for example, a statement on the "gravity of the environmental issue" together with the "concern over the size of a fuel cell". Moreover, previous studies on hydrogen narratives have been used as reference point for the selection (Sovacool et al 2010, Eames et al 2006). For example, one of the narratives identified in these studies describes hydrogen as a way to be competitive with other countries. Therefore we selected from the focus group the sentence "Countries like Japan and US are investing in hydrogen and so should we".

Among the sentences on hydrogen collected through the focus groups there were no strong positions against hydrogen. We were concerned that the lack of at least one statement against hydrogen might have hindered the emergence of a point of view. For this reason we added one sentence, namely "Hydrogen is not a solution for the environmental issue". In this way we aimed to give more space to these Q interviewees that might possibly be against hydrogen. If not relevant or disagreeable, the participants could always sort the statement in the central or negative area of the grid, with no influence on the output of the study. Last, we took care of including a sentence expressing a judgment for each kind of energy primary source possibly associated with hydrogen, especially if controversial. For example we included nuclear energy, wind power and biomass.

Since our objective was to involve in the Q study very different lay people, with different education level, age, and knowledge, we needed to propose them a doable task. However, sorting a variety of cards on our topic might not have been such an easy task for lay people. Perhaps, the people we aimed to involve have never thought about these issues before. The pre-tests showed that, while people easily sorted 20 sentences, some interviewee could not complete the task of sorting 60 sentences. Therefore, we reduced the final set of statements to 40. We concluded from the pre-test that 40 cards would be a compromise between richness of data and feasibility of the task.

In a Q study, the selection of the Q sample is always somewhat subjective and arbitrary. Perhaps for this reason the selection of the statements is considered by some more of an art than science (Brown p.186), and it is often the main source of discussion in a Q study (see for example Neff and Cohen 1967, in Brown p 188). In our case, the first selection of statements was done by two researchers in parallel, who applied different categories and selection strategies to the same pool of statements. We argue that this team effort helped to overcome possible personal biases and enabled the design of a more complete Q sample that reflects the complexity of the concourse from which the Q sample is extrapolated. However, because the Q sample is originated from the concourse, we believe that the discussion over the quality of the Q sample depends to a large extent on the quality of the concourse, which is discussed the next section.

### 3.6 Discussion on the concourse

We were aiming at generating a concourse varied (in terms of topics and points of view), focused (on energy and hydrogen technology) and

familiar (i.e. the statements should have been formulated in a familiar jargon for the persons who would need to sort the statements later on).

As briefly mentioned in the previous section, we implemented a pre-test Q study before the focus groups. In this Q study we assembled a concourse based on our hypothesis, retrieving the statements from newspapers, Internet blogs and forums, scientific literature and so forth (Brown 1980, Barry and Proops 1999, Webler et al 2009). From this concourse we extrapolated two Q samples of 20 and 60 statements. The pre-test concourse/Q sample will be used as a reference point to compare the quality of the final concourse derived from the focus groups.

In section 0 we gave an overview of the variety of topics discussed in the focus groups. The conversations between the participants were rich, especially in the first and more generic part of the focus group, which was focusing on the energy issues. The beliefs represented a variety of points of view over a set of topics. Previous literature focused on environmental benefits and safety as drivers to acceptance. The participants of the focus groups showed to be not only concerned with the environment, but also with a variety of other issues. The topics discussed covered, for example, many problems related to energy and the underlying causes, such as pollution, climate change, consumption and consumerism, lifestyle, but also energy security and oil independency and energy need. The beliefs also covered the way in which the responsibilities for these energy issues are distributed among the different societal actors, and the contribution that these actors can offer to address these issues. The identified actors were citizens and single individuals, the governmental institutions, the private sectors (e.g. industries) but also science as the institution of knowledge and innovation.

When confronting the participants with the hydrogen systems in the second part of the focus groups, safety was one of the subjects of discussion. The participants asked questions to understand how hydrogen works, or what the added values are (like benefits over the environment or the efficiency). Short discussion elaborated into the possible changes that some of the hydrogen systems might have brought into the daily life, like fights with the neighbors, changes in the energy services, problems with energy shortages. Safety was addressed by comparing hydrogen with existing technologies, like appliances or cars running on natural gas. We also observed the conversation drifting over very concrete aspects of hydrogen, such as the size of the fuel cell. Consequently, the discussion about hydrogen was more fragmented than the discussion about the energy issues. Nonetheless we can conclude that the focus groups participants elicited a variety of topics when discussing about energy and hydrogen technologies. When we confronted the concourse generated through the focus groups and the pre-test concourse (the one assembled by the authors based on literature and other written sources), it was evident that they were overlapping, but the former was more extensive than the latter. Moreover, the focus group concourse was richer in points of view, as the participants offered different points of view on the topics. For example, when discussing climate change, there were those who believed it to be an important issue, and those who, at the contrary, believed it to be an overrated issue.

The atmosphere of the focus groups was informal, allowing everybody to express their own point of view, questions and doubts. As a result, the beliefs, spontaneously produced in the course of the interaction between the participants, were formulated in the words of the lay citizens. For instance, let's consider the following statements, the first derived from the pre-test concourse –i.e. the one assembled by the

authors-: "*The current model of exponential growth and over-consumption characterizing our society is incorrect*" and the second is derived from the focus group and it contains the exact words of a focus group participant: "37. *Consumers should be more responsible. We should understand that we can do a lot for decreasing consumption in our daily life. What a single person does is not a drop in the sea*". Both statements are about over-consumption, but they are formulated in very different ways. For example, the second statement contains simpler words and a figure of speech. In general we can conclude that the statements derived from the focus groups are formulated in a more familiar way than the statements we assembled in the pre-test concourse.

Interestingly, the above-mentioned focus group statement is (spontaneously) formulated in a way that appeals for actions, i.e. taking responsibility and decreasing consumption, while evoking directly to the values of "Being Responsible" and "Being Helpful" (i.e. *what we do is not a drop in the sea*). These two values are described in the Schwartz theory of Values, on which the VBN theory is based (Schwartz 1973; Schwartz 1992; Schwartz & Huismans 1995; section 1.6 of this book). Table 3.2 gives an example of the statements we used in the study, classified per type of belief as in the VBN theory. The complete overview of the 40 statements can be found in Appendix E: categorization of the statements. Table 3.3 shows an example of the statements used in previous studies to explore how the VBN theory may explain pro-environmental behaviour (Stern et al. 1999; Stern 2000; Steg et al. 2006). As you might notice, the statements in the two tables are formulated in different ways, the former (the Q-statement) being more general and ambiguous, as in the Q manner (Brown 1980) and the latter (the so called R-statement – see also §2.2) being sharper as required in a questionnaire (Webler et al. 2009).

Table 3.2 Overview of some the 40 statements collected in our study. The statements are classified as in the VBN theory, section 1.6 chapter 1.

| Statement type | Statement Example |
|---|---|
| General world view | 38. Companies like Shell already have the new technologies but they are postponing their use. If they will push the new products the consumers will buy them. |
| | 36. Energy problems have social grounds. The technical progress will not solve the problems |
| | 13. People only care that energy is available: they turn on the switch and the light works; this is what people care about |
| Awareness of consequences | 12. Pollution is a problem of today: the respiratory diseases are increasing because of the bad air quality |
| | 28. I am a climate-skeptic. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption |
| Ascription of responsibility | 5. A single person does not think about energy, the environment or efficiency. The government should tell me what to do, they should oblige me! Even if I have to change my habits, I would vote for such a party, because in this way I will have no other choice than do the right thing |
| | 37. Consumers should be more responsible. We should understand that we can do a lot for decreasing consumption in our daily life. What a single person does is not a drop in the sea. |
| Norms | 31. Hydrogen is a reality in US and Japan. We should not stay behind and invest on hydrogen too: hydrogen is the future and we should go for it. |
| | 34. People are more important than nature, we are at the top of the natural chain. We should satisfy our needs, but not completely disregard nature |

Table 3.3 Example of statements as in the VBN theory, used in the questionnaire by Stern et al. 1999; Stern 2000; Steg et al. 2006)

| Statement type | Statement Example |
|---|---|
| Worldview | 1. Technology will solve many environmental problems |
| Awareness of consequences | 2. Global warming is a problem for society. |
| Ascription of responsibility | 3 Not only the government and industry are responsible for high energy consumption levels, but me too |
| Personal norms | 4. People like me should do everything they can to reduce energy use |

However, despite the differences in the formulation, we can see how the two types of beliefs (the one used in a Q study and the ones used in the questionnaires) are similar in the content and type, compare e.g. for example among the 'worldview' type of beliefs the Q statement 36 (Table 3.2) and the R-statement 1 (Table 3.3). On the other hand it is important to notice that, because of their different formulation, it is more difficult to sharply distinguish the Q statements into one of the types, e.g. whether the Q statement 37 '*Consumers should be more responsible. We should understand that we can do a lot for decreasing consumption in our daily life. What a single person does is not a drop in the sea*' is an 'ascription of responsibility' or a 'norm' type of statement.

In general, we can deduce two things; first that the statements generated in the focus groups are not only different in topics (e.g. climate change or energy security) but also express different types of beliefs (ascription of responsibility, norms, etc. similarly to the VBN theory); second, that these statements do not only make use of familiar, or lay words, but are also formulated as Q statements should, i.e. they are interpretable and debatable.

Since the questions in the focus groups were designed based on the VBN theory, we can also conclude that the VBN theory was helpful in generating a variety of beliefs. The support of the theoretical framework in this phase of the data collection was three folded. First it helped to design a set of questions that generated a broad discussion. Second, it helped the focus group mediator to keep the focus of the discussion, setting the boundaries of the focus and avoiding the group discussion to wander on out of focus. Third, it helped in structuring the selection of the statements. As we will see later on in this book (chapter 4), the beliefs resulting from this data collection worked as building blocks for the frames.

At this point one may wonder to what extent the beliefs collected through the focus groups (concourse) were representing the beliefs of the general population. Certainly, which beliefs we collected depends on the persons that participated to the focus groups, and therefore the way participants are selected biases the concourse. The fact that we used a convenient sample of focus group participants reduces our capability of saying it is an unbiased set of beliefs. If we had used a random sampling for the focus group participants we could have been safer in arguing that the concourse is, at least in theory, unbiased. However, having an unbiased concourse would have not necessarily meant a better quality of the results (i.e. the concourse) for at least three reasons. First, for practical reasons; given how hard it was to gather participants, a randomly selected group of participants would have been not only outside the resource constraints of this research, but also potentially unsuccessful. For instance we might not have had enough people to conduct a focus group; or not enough material from the focus groups to assemble a concourse. Second, any sampling method potentially generates bias. In fact, one may argue the beliefs could have been biased anyway because only a certain type of people might have agreed to take part to the focus groups. Third, it was more important to have a varied, extensive and well-formulated concourse than a representative one. This is because a concourse (and consequently the sample of statements) that excludes part of the topic, reflects only certain points of views, or contains statements that are not formulated well enough, would affect the way people sort the cards, potentially reducing the possibility for certain perspective to emerge from the Q study, with a sort of garbage- in garbage-out effect.

Certainly we have no way to say that the concourse we obtained is exhaustive in absolute terms, in other words, at the time we didn't know what we missed. However, as we showed above, the concourse derived

from the focus groups was more varied, more exhaustive and better formulated than the pre-test concourse we assembled on our own. Hence, we can conclude that through the focus groups we obtained a better concourse than what we would have without the focus groups. Perhaps, organizing other focus groups, recruiting the participants in different ways may change the concourse and consequently the factors. As we will discuss in the conclusive chapter (§6.7) this is a methodological issue that remains open. In our case, since organizing new focus groups was not adding relevant content, we considered that, given the time and resource constraints, the concourse was wide enough to keep on with the Q study. Later on there would have been the possibility to understand to what extent the concourse was complete, by asking the Q interviewees if important beliefs were missing from the Q statements. As we will see later on, the participants of the Q study did not report any relevant missing statement. Moreover, we will also see that we were able to elicit a variety of frames through the Q study. That confirmed that both the concourse and the Q sample were indeed good enough to generate a variety of points of view.

In order to conclude the discussion on the quality of the concourse we draw the attention of the reader to a last issue. As we mentioned before, the focus groups were divided in two parts, first a general discussion on energy and then a discussion focused on hydrogen, based on the hydrogen drawings. We already mentioned that the discussion in the first part was generally richer and smother than the discussion on hydrogen. As a result, the two sets of beliefs (the beliefs deriving from the first part and the beliefs deriving from the second part of the focus groups) seemed to be independent from each other, as if they were two separated concourses.

At this point we had to choose, whether to keep the two sets separated or rather to select and merge the two sets into a unique homogeneous concourse. However, the second set of statements on hydrogen was not rich enough to be one stand-alone concourse. Moreover, we were interested in the construction of a unique hydrogen frame, namely a system of beliefs containing hydrogen beliefs in the context of the broader energy issue. For these reasons we chose to merge the two sets of statements, confident that the interviewees would fill the blank spots during the Q sorting, linking the general beliefs on the energy issues, responsibilities and norms with the beliefs on hydrogen, while sorting the statements. If not, the Q grid has space for those statements that are not relevant for the interviewee. Therefore, if the interviewees would not have linked the hydrogen beliefs with the rest, they might have put the statements in the central-null area. In one or in another way, the hydrogen statements would have found their place in these belief systems. We believed that through the Q method it would be possible to construct a frame as a holistic combination of a hydrogen preference and the embedding reasons for that preference. As a matter of fact, that was the goal of the research in the first place. As results will show, this didn't happen to the extent we expected. Namely most of the hydrogen statements were sorted in the central area of the grid, leaving hydrogen in the shade. In chapter 6 (sections 6.6 and 6.7) we will reflect, in hindsight, on the choice of merging the two sets of beliefs (on hydrogen and energy).

In sum, we merged the two sets of beliefs, derived by the focus groups, creating the concourse for the Q study. The concourse covered the type of beliefs we defined through our theoretical framework. The beliefs covered a variety of topics, broader than the hydrogen literature. The concourse contained different points of view on the topics, offered by the focus groups participants. The hydrogen beliefs, as derived by the

focus groups, were not directly related to the beliefs on energy and responsibilities. However we thought the context would be found during the Q interviews.

We conclude that the focus groups worked as beliefs generator, and the VBN theory helped in designing the questions that stimulated the generation of a variety of beliefs. We assessed the collected beliefs to be heterogeneous and varied enough to allow variety of frames on hydrogen to possibly emerge. The collected beliefs can be considered a suitable concourse from which to select a representative set of Q statements.

# 4 The Q factors

## 4.1 Introduction

Our approach to the study of public acceptance of hydrogen (chapter 1 and 2) foresees the exploration of shared laypeople perspectives on the issues related to energy that should be addressed, by whom and how. The underlying idea is that these perspectives, or frames, will embed in different ways the preference towards hydrogen technology.

In the previous chapter we have seen how we collected, through the focus groups, a variety of lay beliefs on energy related issues, responsibilities, and possible solutions, among which hydrogen and related technologies. In this second phase we are interested in identifying a set of shared constellations of these beliefs, always from the perspective of lay citizens.

In this chapter we will show how we identified four and five shared perspectives, respectively in two groups of lay citizens, Italian and Dutch. We will make plausible that, despite the difficulties present in our case, the interviewees we purposively selected offer a sufficient variety of perspectives as required by the Q Methodology. We will also argue that the perspectives resulting from the data analysis meaningfully represent the perspectives of these interviewees.

In chapter 3 we answered the first research sub-question (SQ), at the base of this study (see also § 1.7 chapter 1), namely:

(SQ1) What beliefs on energy, responsibilities and hydrogen can be identified among lay-citizens?

Through this part of the study we will answer the second research sub-question, namely:

(SQ2) How are these beliefs organized in citizens' frames?

Hence, in this chapter we will be able to answer the first research question (RQ) (see also §1.6 chapter 1), namely:

(RQ1)What frames on hydrogen can be found across the lay citizens?

We will start by describing and discussing the challenges of the data collection and the procedure we followed (§4.2). We will continue with the data analysis, both quantitative and qualitative (§4.3). After presenting the results of this analysis, namely the nine Q factors (§4.4), we will make plausible that these factors represent frames (§4.5). These frames, as we defined them in our theoretical framework (§1.6 chapter 1), are belief systems, which embed the preference towards hydrogen. Finally, in order to gain more insight on our results, we will explore the relation between the frames and the VBN theory we used in our theoretical framework.

## 4.2 Data collection, challenges and procedure.

The basic idea behind the Q methodology is to correlate the constellations of beliefs (i.e. points of view) rather than having single beliefs correlated. The correlation indicates similarities in the points of view. The factor analysis clusters similar points of view into groups, or factors. Since each point of view obviously corresponds to one person, the Q method requires as many persons as necessary to establish the existence of a factor. Brown (1980 p. 192) explains that five or six persons sharing more or less the same view are sufficient to define a factor. This is because factors are generalized abstractions of similar points of view. These abstractions are calculated as weighted average of these similar points of view. Five or six points of view significantly similar are usually sufficient to produce a quite reliable abstraction (or factor) so that adding other similar points of view to that factor would be redundant.

For this reason, in the Q methodology, a limited number of persons (the P-set) are necessary to identify the perspectives as far as the P-set guarantees a broad variety of points of view. In a P-set, therefore, the persons are purposively selected to offer their point of view. The P-set collects persons who are "relevant for the problem under consideration" (Brown p.192) and who are "expected to define a factor. Whether they in fact do so or not is an empirical matter brought to light by factor analysis." (Brown 1980 p. 194)

For instance, if we take again the case of the TV-talk show on GMO (§2.3 chapter 2) we can imagine that the eight guests invited (representative of the research field, medicine, environmentalist and agriculture) would be already sufficient to represent a broad variety of points of view. Their affiliation to certain institutions and organizations could be a sign of their point of view. Following this principle, the Q

methodology is used in policy analysis to identify the perspectives of a variety of stakeholders, when the variety is defined by the actor type[1] (e.g. government, NGOs, this or that company). Examples of these Q studies are numerous (see e.g. Ellis et al. 2007, Ockwell 2008 Kroesen & Bröer 2009, van Baren 2001 in Hoppe 2007, Ashworth et al. 2012, Van Eeten 1999 and Cuppen 2010)

In our case however, we are interested in exploring the perspectives of the citizens directly, without passing through the formal and informal institutions and groups (stakeholders) that are supposed to represent the citizens perspectives in the hydrogen case (if a variety of representatives exists yet). In such cases, Brown (1980 p.192) reports the example of Thompsons's study on public opinion on land use. Thompsons (1966) defined a set of categories to be a priori relevant for land use attitude. For instance, he distinguished the experts (e.g. architects), the authorities (e.g. journalists), the special interests (e.g. the builders) and the class interests (e.g. middle class, working class). Thompson further defined these categories according to gender (male or female) and the geographical area of residence. A balanced P-set would consist of a mixture of persons representing a variation of these a priori defined categories. In the above-mentioned example, the P-set would include for instance a male-working class of the south and a female-journalist of the north.

In our case we focused only on the lay-citizens' point of view. Hydrogen and the energy issues concern everybody; hence 'everybody' is relevant for this topic. Therefore, identifying which criteria define differences in the points of view on energy and hydrogen was quite challenging. For example, would "people that like dogs" and "people that don't like dogs"

1 Despite Cuppen (2010) shows that actor type is not necessarily a good proxy for identifying a variety of perspectives, as sometimes people with different affiliation may share the same point of view. With the Q methodology the variety emerges from the data rather than from a priori categories imposed by the researcher. This is at the same time the added value and the challenge that comes with the implementation of this methodology.

be a relevant criteria to identify people that think differently about the energy issue and hydrogen? Probably not. Would then income, education or possessing a certain type of car be more relevant criteria to identify different points of view on hydrogen? Difficult to say a priori, i.e. without knowing what these points of view are. In principle, that is why we conducted this research in the first place.

Inspired by the literature (e.g. Williams & Millington 2004) we could expect that a "strong environmental concern" and a 'weak environmental concern" could be a relevant criterion, but what else? We had no idea of which factors could be found beyond the environmental one (that is why we did this study) and therefore we had no indication of which persons might have helped in defining these factors. Our theoretical framework suggests us that values, as defined in the VBN theory (Stern et al. 1999, Stern 2000, Diets et al. 1998), might underlie different frames. But screening participants based on their values would have been too complex and too costly. Political preference was the only category we thought might be relevant, as a possible indication of a general difference in the belief systems. To this we added age, as a possible generational gap in the points of view. We also tried to balance age and education level, in order to avoid having a P-set of mainly men or mainly highly educated people, although we believed that gender or education are not much more relevant to indicate differences in the point of view than the colour of the eyes or being a dog-lover.

Last, but more importantly, we relied on the interviewees to indicate different points of view, throughout the snowball method. The snowball method, as used in other Q-studies (e.g. Venables et al 2009) consists of asking each participant that completed the Q-sort to identify other possible participants. More precisely, each participant is asked to indicate somebody who may think similarly and somebody who may

think differently with respect of his own point of view. Through the snowball method, the participants are indicating to the researcher where to find variety in points of view.

We proceeded in a similar way in both Q-studies, in Italy and in the Netherlands: we started with different people, following different snowball paths. We started with people that we expected or we knew to have an environmentalist or a non-environmentalist perspective, as we just discussed to be the more relevant criterion we could think of, at least better than the "dog-loving" one. After collecting their Q-sorts we asked them to put us in contact with at least one other person they thought to have either a similar or a different point of view.

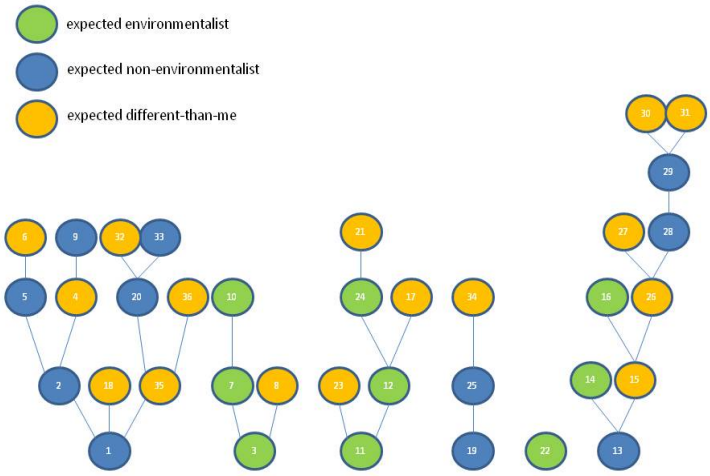


Figure 4.1. Recruitment of the interviewees for the Italian Q study by means of the snowballing technique. Each circle represents a person. Circles in the first row are the persons that have been contacted directly by the researcher (number 1, 3, 11, 19, 22, 13). Each of them indicated one or two other persons, which they thought might have a similar or different points of view (indicated in the schema by the same or different color).

For example, figure 4.1 shows the snowball structure of the Italian P-set. The first interviewee, the blue circle number 1 (bottom left of the figure) was contacted as she was expected to have a non-environmental point of view. The interviewee indicated three subjects to further involve in the study. Subject number 2 was expected to think alike, while subjects 18 and 35 where expected to think differently (represented as blue and yellow circles in second line, left of the picture). In the next chapter we will see the effective differences and similarities between the interviewees' points of view as revealed by the data analysis (see sections 5.3 to 5.5 of the next chapter).

In this way, we involved in our Q studies 36 people in Italy and 37 in the Netherlands, whose characteristics are resumed in tables 4.1 and 4.2. The unbalances of the two P-sets in gender, education and political preference, as well as the incomplete branches in the snowball structure (visible in Figure 4.1), reflect the difficulties encountered in recruiting participants.

Table 4.1. Characteristics of the Italian P-set. The subjects are divided per political preference (rows). Within each political cluster, we distinguish the gender, education level and average age (columns). For example the Left cluster (a) includes 7 subjects, of which 5 males and 2 females, one with high school or less education level, 2 with bachelor level and 4 with master or higher education level. The average age of the (a) cluster is 29.

| POLITICAL PREFERENCE | Tot | Males | Femal. | EDUCATION | | | Age |
|---|---|---|---|---|---|---|---|
| | | | | Basic | Med. | High. | |
| (a) Left (PC, 5Stelle,SeL) | **7** | 5 | 2 | 1 | 2 | 4 | 29 |
| (b) Center-Left (PD) | **8** | 4 | 4 | - | 1 | 7 | 46 |
| (d) Center-Right (PDL-UDC) | **8** | 3 | 5 | 1 | - | 7 | 41 |
| (e) Right (FN, exAN, LN) | **7** | 6 | 1 | 3 | 1 | 3 | 39 |
| (f) No preference | **6** | 3 | 3 | 3 | 1 | 2 | 39 |
| TOTAL | 36 | 21 | 15 | 8 | 6 | 22 | 39 |

Table 4.2. Characteristics of the Dutch P-set. The subjects are divided per political preference (rows). Within each political cluster, we distinguish the gender, education level and average age (columns). For example the D66 party (n) includes 3 subjects, of which 2 males and 1 females, one with HBO education and 2 with university education or higher. The average age of the (n) cluster is 35.

| POLITICAL PREFERENCE | Tot | Mal | Fem. | EDUCATION | | | Age |
|---|---|---|---|---|---|---|---|
| | | | | Basic | Med. | High | |
| (g) Christelijke Partij (SGP) | **1** | - | 1 | 1 | - | - | 45 |
| (h) Cristian Union | **2** | 1 | 1 | 2 | - | - | 40 |
| (i) PVV | **1** | 1 | - | - | 1 | - | 46 |
| (j) CDA | **1** | - | 1 | - | 1 | - | 24 |
| (k) VVD | **8** | 5 | 3 | 1 | 5 | 2 | 33 |
| (l) Socialist party SP | **2** | 1 | 1 | - | 2 | - | 55 |
| (m) Groen Links | **8** | 3 | 5 | 1 | 2 | 5 | 33 |
| (n) D66 | **3** | 2 | 1 | - | 1 | 2 | 35 |
| (o) PvdA | **7** | 4 | 3 | 1 | 4 | 2 | 39 |
| (p) No preference | **4** | 3 | 1 | 1 | 2 | 1 | 41 |
| TOTAL | 37 | 20 | 17 | 7 | 18 | 12 | 38 |

We asked the participants to complete the Q sorts in the context of single interviews. The interviews were usually held in a familiar place for the participant (like home or workplace) and lasted 30 to 90 minutes, according to the availability and interest of the interviewees. The task was to dispose the cards into the grid (figure 2.1 pg. 39), ranking the statements in an 11-points scale from "strongly disagree" (-5) to "strongly agree" (+5). In some cases, we allowed the interviewees to dispose the cards out of the grid in order to help them in completing and feeling comfortable with the sorting task.

During the interviews, the Q sorting was enriched by comments, given by the interviewees, explaining their personal interpretation of the

statements. We stimulated the discussion with the interviewee through simple questions, in order to make explicit the logic behind the interviewees' personal sorting pattern of the cards in the grid. These comments were taped and used later on by the researcher to reconstruct the narratives behind the factor (see § 4.4 and appendix D: Qualitative analysis of the Q-factors)

Finally, in order to assess the representativeness of the sample of statements and hence of the concourse (sections 3.7 and 3.8 chapter 3), at the end of the interview we asked the interviewees whether the cards were covering the different aspects of the topic or if something was missing.

### 4.3 The quantitative and the qualitative data analysis

Once that all the Q sorts were collected during single interviews, we had in our hands two kinds of data: quantitative and qualitative. The quantitative data are the sorting patterns of the statements. The qualitative data are the interviewees' comments. As a first step we analysed the quantitative data, performing the conventional Q methodology routine, consisting of first, the correlation of the Q sorts and second, the centroid factor analysis, which identifies and groups the more similar Q-sorts in the cloud of data (Brown 1980). We used one of the programs conventionally used with the Q-methodology, the PQ method.

For those readers who are not familiar with this methodology (or statistics in gneral) we sketch the fundamentals of the Q method analysis, referring to the appropriate literature for deeper information (e.g. Brown 1980, Barry and Proops 1999, Webler et al 2009). In simple words, in a Q analysis the correlations compare all the single Q sorts in pairs; the factor analysis groups these Q sorts that have higher

correlations (i.e. the most similar Q sorts); the varimax rotation maximises the variation that can be explained through the factors. Each factor is a vector, and each Q sort will (cor)relate to a certain extent to that vector. That (cor)relation is expressed by the so-called loading. The higher the loading the more the factor expresses that specific Q sort, i.e. the point of view of that person (or the other way around, how much that person could be considered as a sort of 'spokesman' for that group of people sharing that point of view). Above a certain threshold (see Brown 1980) it is possible to identify loadings with statistical significance. Each Q sort will load to a certain extent in each of the factors. For example, if a Q sort has no significant loading in any of the factors, it could be interpreted as a person having a point of view that agrees a little bit with all of the main views on the issue[2]. A pure loading indicates a Q sort that is significantly correlated to one and only one factor. In other words, a *pure loading* indicates a well distinctive point of view that is different from all the other views in the other factors and very similar to the average point of view for that factor.

As described and discussed in Appendix C: Quantitative analysis we follow one of the normal procedures for the data analysis with the Q methodology, employing the centroid factor analysis and orthogonally rotating the factors through the varimax rotation. We explored different factorial structures (see for example figure C-2, apeendix C), with the objective of identifying a balanced number of unique, diverse and reliable factors. We used as proxy for those criteria the number of pure loadings, the Eigenvalues, the Humphrey's rule and the correlation between the factors. Eventually, we selected a 4 factors structure for the Italian case and a 5 factors structure for the Dutch case. Six of the nine factors selected contain at least five pure loadings, as suggested by

[2] It could also be interpreted as a person having a very peculiar point of view, or a possible new factor that would emerge with more data.

Brown (1980) whereas the other three factors only had three or four pure loadings.

For each factor it is possible to calculate an "ideal Q sort", representing a (weighted) average of the all the Q sorts grouped in that factor. In this way the complexity of all the Q sorts in the P-set is represented by a limited number of (shared) ideal Q sorts. These ideal Q sorts give information on how the statements are rank-ordered in each factor. Through the Q analysis it is possible to have quantitative information of how different the factors are, for example by looking at the differences in the rank order of the single statements.

As shown in Appendix D: Qualitative data analysis of the Q-factors, the logic behind these shared Q sorts is reconstructed retrieving the qualitative information collected during the interviews. It is possible to make sense out of the quantitative information (the shared way of ranking the statements) by means of the comments and the explanations given by the participants during the interviews. In this way, the logic behind the factors is reconstructed, like a puzzle, directly from the perspectives of the interviewees. This puzzle has the shape of a complete narrative, representing a common point of view. The researcher is not filling the gaps among numbers according to her personal logic, but rather to the logic of the participants directly.

Section 4.4 describes the nine narratives corresponding to the nine Q factors identified in the Italian and Dutch Q studies. In the next chapter we will discuss to what extent these factors correspond to the frames we defined in our framework (chapter 1, §1.6).

## 4.4. Nine Q-factors, nine narratives

Following the analysis and interpretation procedure, shortly described above (§4.3), we reconstructed the nine perspectives corresponding to the nine Q-factors identified through the quantitative analysis. Hereby we sketch the essence of each one of the nine perspectives while the complete description can be found in Appedix D: Qualitative data analysis. We describe the perspectives with a "first person" narration, as a person would describe his own point of view.

*Four Italian factors*

The mistrusting environmentalism – Italian factor 1

The energy issue is very important, and I care to know about what's going on. We all know what the problems are but the real problem is that newspapers don't talk about it. People don't care enough and the government holds back in tackling the issue. If we would use renewable technologies there could be enough energy for everybody. Hydrogen is one of the many possible alternatives. However, as it is not in the interest of the big companies, we will stick with the current system or worse, we look back at nuclear! I wish it would be possible to be off-grid, to produce energy at home, or nearby, through renewable technologies.

The market-driven sustainability – Italian factor 2

I see the problem with energy coming. As citizens we should all care more about it, because nowadays everything is decided by the market. The technologies are developed by the market and the consumers choose them. Hence technology changes and develops according to our consuming pattern and the government should not interfere. I don't know if the technologies like renewable are ready yet to compete in the market, but we need to be independent with the energy and we should

not destroy our environment for that. Personally, I don't know if gas is good or if hydrogen is efficient and it is worth to invest in it. Certainly if hydrogen helps the diffusion of renewables and improves energy security it would be good even if I don't know whether I would like to have it at home. Relying locally on renewable is unrealistic and besides, I don't want to be constrained in producing energy on my own. Energy is an important national matter and citizens should not be held responsible for that.

The technocratic outlook – Italian factor 3

The real issue with energy is not the environment, I don't know if our lifestyle has something to do with it. In fact, I don't think there is something really wrong with our lifestyle at all .The real issue with energy is at the geo-political level. For our energy supply we are in the hands of foreign countries that are politically instable. This is unacceptable and inconvenient for the economy. We need to have cheap and reliable energy. The stakes are so high that the citizens should not interfere. The government should take the lead and tell people what to do otherwise people may block technologies like hydrogen because they are afraid of it. There is always an excuse to block a new technology, this is why in Italy we do nothing and we lag behind the other countries, which invest in new technologies and become richer and more powerful. Technological progress can bring good things, but we should invest in it.

The ecotopian outlook – Italian factor 4

The environmental problems are caused by our lifestyle and in our way of looking at nature, as if we were not part of it. It is a societal issue; technology can help us very much but no technical fix is possible. We need to change mentality and take our responsibilities. We should stop blaming China or the industries for polluting, or the corporations for lobbying or the government for not caring and doing nothing. It is a

shared responsibility and we, the citizens, should be the first to do something. We should change our way of thinking and living. For instance we should consume locally. This doesn't hold only for seasonal-local food but also for the energy sources. We should understand that burning waste for energy may be an alternative to oil for now, but in the future we should produce less waste. We should understand that having cheap energy is not more important than knowing from where it comes from; we shouldn't keep harming the environment for the economic benefit, for example using nuclear energy. For these reasons, education on sustainability is so important.

*Five Dutch factors*

The liberal environmentalism – Dutch factor 1

Energy shouldn't only be cheap. Energy should be CO2 neutral and we should become independent from oil and from the politically unstable countries that export it. Technology is needed to solve the problems but technology alone can't solve it, we need to make some changes in our way of living. We can't point the finger and blame the others. It is a shared responsibility between the private sector, citizens and the institutions. It must be a common effort. I think that people don't care enough yet. Price is a good way to make people aware. We all know that people think with their wallet. Kids should be educated in school about sustainability, that's the best way to change society. I think there are many alternative technologies that could be used already, such as wind, biomass and also nuclear energy. Hydrogen is one of the many alternatives but I don't know much about it. I don't know if going local with energy is a good or bad idea, but I would not like to have to produce energy on my own.

The practical environmentalism - Dutch factor 2

We cannot do very differently from how we do now, as we need to satisfy our needs, and we need energy for that. I am worried, because the energy costs everyday more and more. Energy should be cheap, but not at the detriment of the environment, because we are already polluting the environment where we live. We are putting our health at risk. For this reason we should prefer local natural sources like wind or sun, which are better than burning waste or corn, to have energy; although these are better than nuclear energy. There's not much that people could and should do. The last thing the government should do is to increase the price of energy even more.

The liberal outlook – Dutch factor 3

I think that the environmental issue has been overestimated. I am not sure whether we should pay more taxes, in name of the environmentalism, and certainly I don't want the government to tell me what to do. If you want to find a problem with energy, there is the fact that we all base our economies on oil, which comes from politically instable areas. In that respect, I don't think there is much more to do than what we are doing now. New technologies need to be developed to make us oil independent, technologies like hydrogen. However, switching to new technologies is very costly. Have, for example, a look at wind energy, which is still on the market just because the state is supporting it. I think it would be better if the government stays as much as possible out of the market game. The technologies will be developed by the scientists and the market, and the consumers will select the best.

The prescribed environmentalism - Dutch factor 4

Energy shouldn't be only cheap. Energy should be CO2 neutral and we should become independent from oil and from the politically unstable

countries that export it. There is the risk that energy will become less and less available, although I think it is hardly possible that one day we don' t have energy for our things. We all know that, but the institutions that are responsible to do something about it, instead of taking the lead, are hesitating, playing political games. Environmental costs should be added into the price of the products, we should invest in renewable technologies; find innovative, efficient and safe ways of producing energy and increase energy security. For example by wind or biomass or hydrogen rather than nuclear energy, gas or use agricultural products; in the end there must be an alternative to using food for energy. Maybe we should go back to doing things more locally and produce energy on our own.

The mistrusting environmentalism – Dutch factor 5

I am not sure about what is going on with this energy issue. I can see that things are changing, but the newspapers don't talk about it. Is it really a problem to be dependent from the Middle East for oil? Is Climate change really dangerous and due to us? I can see that we consume a lot, more and more, and that we are exploiting nature to satisfy our societal needs. The government should do something, but it holds back. Instead they should focus on education so that consumers in the future could become more responsible and buy alternative products, use alternative technologies. However it is important that the companies do not hold back these alternative technologies for their own interests. Like hydrogen, why isn't it in the market yet? Isn't hydrogen a good alternative? Maybe using local energy sources is not a bad idea. I don't know if I would like to be off grid but I wouldn't mind to have hydrogen at home, or driving a hydrogen car and certainly I don't think that it might threaten our national security. There are many technologies available; we just need to invest on them.

## 4.5 Are the factors frames?

The goal of this study was to identify a set of hydrogen frames. We defined a frame as a problem analysis containing the definition of what are the relevant issues to consider and what should be done to address these issues. A hydrogen frame would have been a more specific problem analysis of the issues related to energy, embedding the preference towards the different hydrogen systems. At this point the question is whether the factors we identified through the Q methodology are actually hydrogen frames as we defined them. More precisely, we need to verify whether the factors are structured as a combination of problem definition and solutions space

Table 4.3. Correlations between the nine factors. The correlations indicate how similar the dispositions of the statements are across the factors.

| | NL 1 | NL 2 | NL 3 | NL 4 | NL 5 | IT 1 | IT 2 | IT 3 | IT 4 |
|---|---|---|---|---|---|---|---|---|---|
| NL 1 | 100 | | | | | | | | |
| NL 2 | 23 | 100 | | | | | | | |
| NL 3 | 42 | 15 | 100 | | | | | | |
| NL 4 | 39 | 23 | 24 | 100 | | | | | |
| NL 5 | 55 | 33 | 45 | 48 | 100 | | | | |
| IT 1 | 38 | 34 | 19 | 50 | 65 | 100 | | | |
| IT 2 | 64 | 17 | 38 | 19 | 56 | 48 | 100 | | |
| IT 3 | 52 | 10 | 33 | 44 | 42 | 45 | 32 | 100 | |
| IT 4 | 49 | 24 | **13** | 45 | 40 | 55 | 48 | 37 | 100 |

Table 4.3 shows the correlation between the factors, indicating to what extent the factors are similar to each other. The Dutch factor 3 (Liberal frame – NL3) and the Italian factor 4 (Ecotopian frame – IT4) have the lowest and statistically insignificant correlation of 0.13, indicating that these factor are the most far apart points of view we identified. As we

are about to show, these factors have the same structure of problem definition and solution space but differ substantially in content.

Table 4.4. Some of the key statements used by the interviewees to define the Italian factor 4. The combination of these statements reflects the structure of a problem definition and the consistent solution space.

| Factor structure | Q statements used in this Q study | Rank IT4 |
|---|---|---|
| Problem definition | 34. People are more important than nature, we are at the top of the natural chain. We should satisfy our needs, but not completely disregard nature | **-4** |
| | 28. I am a climate-skeptic. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption | **-3** |
| | 2. We consume too much in general. I think we should live very differently. | **4** |
| | 36. Energy problems have social grounds. The technical progress will not solve the problems | **0** |
| | 37. Consumers should be more responsible. We should understand that we can do a lot by decreasing consumption in our daily life. What a single person does is not a drop in the sea | **3** |
| | 5. A single person does not think about energy, the environment or efficiency. The government should tell me what to do, they should oblige me! Even if I have to change my habits, I would vote for such a party, because in this way I will have no other choice than do the right thing | **-1** |
| Solution space | 8. The government should add environmental costs to products and use this money for the benefit of the environment. I think it is fair that people pay an extra tax proportional to what they consume | **3** |
| | 16. Maybe we could go back to doing things locally, also with energy. It would be nice to produce energy locally without having to transport it | **3** |

Table 4.4 lists some of the key statements used by the interviewees to define the Italian factor 4. The combination of these statements reflects the structure of a problem definition and the consistent solution space. In factor 4, the environmental issue is considered to be relevant, with the statements 2 on overconsumption and 28 on climate change sorted at the extremities of the grid. In combination with statements 36 on the role of technology and 37 and 5 on the distribution of responsibilities, we obtain the following problem definition for this factor:

> "The environmental issue has its roots back in our lifestyle, in our way of looking at nature, as if we were not part of it. It is a societal issue; technology can help us very much but no technical fix is possible. We need to change mentality and assume our responsibilities. It is a shared responsibility and we, the citizens, should be the first to do something."

Consistently to this problem definition, the solution space is defined for example through the statements 8 and 16 (Table 4.4):

> "We should change our way of thinking and living. For instance, we should consume locally. This doesn't hold only for seasonal-local food but also for the energy sources. We should understand that burning waste for energy may be an alternative to oil for now, but in the future we should produce less waste."

Table 4.5 shows instead some of the key statements used by the interviewees to define the Dutch factor 3. Some of the statements are the same as used in the above-mentioned ecotopian frame, but they assume very different meaning being ranked and combined with other statements, as usual in the Q methodology (Brown 1980 pp. 248). As we did for the Italian factor 4, we can see how the Dutch factor 3 expresses concern over the oil dependency rather than climate change, through the statements 6 and 28. Statements 17 and 38 explain why it is difficult to solve this problem, while statements 10 and 5 clarify the distribution of responsibilities of this problem. As a result, here is the different problem definition for the Dutch factor 3:

> "The environmental issue has been overestimated, while the real problem with is the fact that we all base our economies on oil, which comes from political instable areas. Although technology can do much to solve this problem, there are not yet any alternative technologies that we can use to be energy independent. The alternative technologies are still under development, but they are not yet competitive, they cost too much. Science will find the solution, and the market will do the rest."

and the consistent solution space:

" To solve the energy dependency issue, I don't think there is much more to do than what we are already doing. New technologies need to be developed in order to substitute oil. Technologies like hydrogen may be the solution. It is better to invest in developing these new technologies because it will endorse our economy. Focussing on small scale energy production is not convenient if it will make the energy production less competitive and more costly."

Table 4.5. Some of the key statements used by the interviewees to define the Dutch factor 3. The combination of these statements reflects the structure of a problem definition and the consistent solution space.

| Factor structure | Q statements used in this Q study | Rank NL3 |
|---|---|---|
| Problem definition | 6. The majority of oil comes from political unstable countries. We will have serious problems if the Middle East decides to close the oil tap. We should not be dependent of these countries | **4** |
| | 17. It is difficult to change from old to new technologies, because it costs too much | **4** |
| | 28. I am a climate-skeptic. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption | **0** |
| | 36. Energy problems have social grounds. The technical progress will not solve the problems | **-4** |
| | 10. Science has the responsibility to find solutions for the environmental issues related to energy | **5** |
| | 38. Companies like Shell already have the new technologies, but they are postponing their use. If they would put the new products on the market consumers would buy them | **-3** |
| | 5. A single person does not think about energy, the environment or efficiency. The government should tell me what to do, they should oblige me! Even if I have to change my habits, I would vote for such a party, because in this way I will have no other choice than do the right thing | **-4** |
| Solution space | 22. I wish it would be possible to be completely independent of the electricity grid. I would prefer to produce energy myself at home | **-3** |
| | 30. Hydrogen is not a solution for the environmental issues. | **-5** |
| | 39. Becoming a leader in these new technologies means becoming a leading economy in the world. | **3** |
| | 2. We consume too much in general. I think we should live very differently. | **-1** |

We can deduce that in both factors and, in a similar way in all the other factors we identified, the statements have been sorted reflecting the same structure of problem analysis and the solution space, despite the differences in content. We conclude that the factors are frames.

However, we were expecting slightly more specific hydrogen frames, containing more information about how people envision hydrogen. Instead, in the formulation of the solution space, the technologies, and especially hydrogen, remain in the back, with most of the statements on hydrogen being sorted in the central area of the grid. The participants focused their attention on the other statements, more relevant for them than the hydrogen statements. These hydrogen statements, and the other statements on technology, that did receive attention (i.e. sorted outside the central, neutral columns of the Q grid) have been interpreted, consistently with the rest of the point of view, as expressing a more general point of view, rather than a specific preference towards the technology itself.

Perhaps the statements on hydrogen and related technologies were too fragmented with respect to the other statements, or perhaps they should have been formulated differently. We already discussed in chapter 3 (§3.6) how the statements derived from the two parts of the focus groups (the general discussion and the comments on the hydrogen scenarios) were somehow disconnected, not homogenous. We hoped that Q study participants would find this connection while sorting the statements, which they did, as we have a variety of frames that are logic, but not as we hoped.

Perhaps the fact that we didn't identify the frames as we expected them may be also related to what can be expected from the Q methodology. For instance, let us consider statement number 3 expressing an opinion on one of the possible sources from which hydrogen could be produced

–biomass from waste- and how it has been ranked in the Italian factors (the rankings per each factor are between brackets, in order corresponding to the Mistrusting, Market-driven sustainability, Technocratic, Ecotopian frames):

"3. Using biomass from waste to produce energy is dangerous and inefficient" (-2, **-5**, -3, 0)

Interpreting the ranking of these statements as a pure preference, for example concluding that the Market-driven frame prefers biomass more than the Ecotopian, might be misleading. The participants that sorted statement 3 in position -5, intended to express the idea that the technologies that are "efficient" should be promoted not feared, while those who ranked the statement -3 commented that, although it is a good idea to be efficient, if we want to be really sustainable there should be less waste in the future. In the Q methodology the statements are interpreted, and acquire different meaning in the context of the whole point of view. For this reason the Q methodology may not be the right tool to identify preferences for this or that technology. Hence, in retrospect, perhaps the statements on hydrogen and related technologies should have been formulated differently, or perhaps it would have been necessary to organize the focus groups in another way, in order to have a more homogenous concourse; or we should have used two different methods to capture the frames and the preferences. We will discuss this further in chapter 6 (§6.7).

Nonetheless, as we will see in the next chapter, it is possible to deduce which hydrogen systems may be more or less compatible with the frames. For example, we will see that the Ecotopian frame might be more compatible with decentralized hydrogen systems using renewable energy sources, while some other frames might be more compatible with centralized systems where the hydrogen production is out of sight.

Therefore, although the frames are not as specific as we expected, they are still useful to identify, even if indirectly, a variety of points of view on hydrogen.

Before digging into that, it is interesting to look at the factors we identified in light of the VBN theory, which was part of the theoretical framework we used in this study.

### 4.6 Factors and the VBN theory

In our theoretical framework (chapter, section 1.6) we further defined a frame through the VBN theory (Dietz et al. 1998; Stern et al. 1999; Stern 2000; Steg et al. 2006), as composed by the following type of beliefs:

(i) the general worldview (WW) that defines the object of value or what is at stake - in the environmental example the nature, how the humans relate to nature, or what technology can or cannot do,

(ii) awareness of adverse consequences (AC), namely the belief that the object at value is threatened – in the environmental example, nature is threatened e.g. by human behavior such as littering,

(iii) the ascription of responsibility (AR), namely the belief that a personal action may or may not alleviate the threat – e.g. the person may contribute by sorting the trash for recycling,

(iv) norms (N), and, more specifically in the VBN theory, personal norms pushing the individual to comply to the behavior – e.g. if I can do something to protect the environment I should do it.

As we have seen in the previous chapter (section 3.6) the VBN theory was helpful in driving the data collection during the focus group and ultimately in designing the sample of Q statements used to elicit the frames. At this point it is interesting to see to what extent the frames

we identified reflect this structure of worldview, awareness of consequences, ascription of responsibility and norms. Notably, we are not trying to verify a hypothesis, which would be out of the scope of this research and outside the boundaries of the Q methodology, but rather analyzing the factors through our theoretical framework, in order for the reader to get more acquainted with the factors and, perhaps, get more insight on the theoretical framework we designed. For this analysis, we will use the same frames we considered in the previous section, namely the Ecotopian (IT4) and the Liberal frames (NL3).

Table 4.6 shows some examples of the statements used in the literature to test the VBN theory for pro-environmental behavior, the statements are classified as AC, AR and N as above described. In table 4.7 we list the statements used in the Italian factor 4 for the problem definition, classifying the statements according to the belief type defined by the VBN theory.

Because of the way the Q statements are formulated the distinction between belief types is not so sharp. For example, statement 37 expresses both a norm and an ascription of responsibility. Nonetheless, the statements of the factor 4 (considered together with the way they have been ranked) resemble the content and the classification of the statements used to test the VBN theory. For example the reader may compare the statement 1 table 4.6 with the Q statement 36 (and its ranking) in table 4.7; or statement 4 'people like me should do everything they can to reduce energy use' (table 4.6) and statement 37 (table 4.7) '… we can do a lot to decrease energy consumption in our daily life, what a single person does is not a drop in the sea'. Despite the difference in the research methodology, the beliefs in the Italian factor 4 have been sorted in way that reflects the VBN structure of pro-environmental behavior elicited in previous quantitative studies. It is fair

Table 4.6. Examples of the statements used in the literature to test the VBN theory for pro-environmental behavior.

| Belief type as in the general VBN theory | Application of the VBN on environmental behavior | Example of statements used in the questionnaire |
|---|---|---|
| **Worldview** | Ecological worldview | 1. Technology will solve many environmental problems |
| **Awareness of consequences** | Environmental concern | 2. Global warming is a problem for society. |
| **Ascription of responsibility** | Personal ascription of responsibility | 3 Not only the government and industry are responsible for high energy consumption levels, but me too |
| **Norms** | Personal norms | 4. People like me should do everything they can to reduce energy use |

Table 4.7. Statements used in the Italian factor 4 for the problem definition, classifying the statements according to the belief type defined by the VBN theory

| Belief type according to VBN | Q statements used in this Q study | Rank IT4 |
|---|---|---|
| **(Biocentric) Worldview** | 34. People are more important than nature, we are at the top of the natural chain. We should satisfy our needs, but not completely disregard nature | **-4** |
| | 36. Energy problems have social grounds. The technical progress will not solve the problems | **0** |
| **Awareness of consequences** | 2. We consume too much in general. I think we should live very differently | **4** |
| | 28. I am a climate-skeptic. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption | **-3** |
| **Ascription of responsibility and Norms** | 37. Consumers should be more responsible. We should understand that we can do a lot for decreasing consumption in our daily life. What a single person does is not a drop in the sea. | **3** |
| | 5. A single person does not think about energy, the environment or efficiency. The government should tell me what to do, they should oblige me! Even if I have to change my habits, I would vote for such a party, because in this way I will have no other choice than do the right thing | **-1** |

to think that the ecotopian frame might be linked to pro-environmental behavior as well. Perhaps, this pro-environmental behavior might consist of, for example, the preference for a hydrogen system perceived as green, or the support for an actor that oppose hydrogen when not perceived as green or sustainable.

Does the liberal frame contain a specific worldview, awareness of consequences, ascription of responsibility and norms as well?

Table 4.8 shows a possible classification of the statements used for the problem analysis in the Dutch factor 3. This factor identifies as threatening the oil dependency, hence statement 6 could be considered as a sort of AC. Statements 36, 17 and 38 express the worldview underlying the AC. In the next chapter we will characterize this worldview as anthropocentric (§5.2). Statement 5 could be considered as a norm, as in this frame citizens should not expect the government to tell them what to do, but rather the citizens, as consumer, and the market, will determine the direction of change (as a matter of fact we named this frame as Liberal, as opposed to other frames that instead expect more intervention from the government). The responsibility is shifted to a large extent to the research institution and therefore further in the future, while at the moment people can't do much. Hence the NL3 have some similarity with the VBN structure, although the factor does not give any specific indication of how this frame would translate into an action (obviously, this frame is not likely to be translate into a pro-environmental behavior).

For example, previous studies (Attari et al. 2009) showed that respondents sharing an energy security frame justify their preference towards green energy policies with the need of reducing the foreign oil dependency rather than the need for environmental protection. We could hence hypothesize that the Dutch factor 3 might relate to a

preference towards new technologies, among which hydrogen, if these technologies are perceived as reducing the oil dependency.

Table 4.8. Possible classification of the statements used for the problem analysis in the Dutch factor 3 according to the VBN theory.

| Factor structure | Q statements used in this Q study | Rank NL3 |
|---|---|---|
| **Worldview** | 36. Energy problems have social grounds. The technical progress will not solve the problems | **-4** |
| | 17. It is difficult to change from old to new technologies, because it costs too much. | **4** |
| | 38. Companies like Shell already have the new technologies, but they are postponing their use. If they would put the new products on the market consumers would buy them | **-3** |
| **Awareness of consequences** | 6. The majority of oil comes from political unstable countries. We will have serious problems if the Middle East decides to close the oil tap. We should not be dependent of these countries | **4** |
| **Ascription of responsibility and Norms** | 10. Science has the responsibility to find solutions for environmental issues related to energy. | **5** |
| | 5. A single person does not think about energy, the environment or efficiency. The government should tell me what to do, they should oblige me! Even if I have to change my habits, I would vote for such a party, because in this way I will have no other choice than do the right thing | **-4** |

However, in this factor it is central that the technologies are competitive and convenient for the consumers, we could say that self-gain seem to be more important that the common good. The VBN theory explains behaviors that are socially significant. In other words the main concern is about the threat of the 'common good' and the behavior expresses altruistic values. The threat identified by the Dutch factor 3 (oil dependency) also concerns the common good. However, unlike the Italian factor 4 (and the VBN literature), in the Dutch factor 3 there are no clear personal norms, i.e. there are no clear expectations on the personal contribution that the single person, *I*, could do to reduce the threat (AC). This is consistent with the fact that the Italian factor 3 does not attribute the responsibility of the energy security issue to the

citizens or to the government, as technology will fix the problem and the solution is postponed to the future, to the 'next generation' as 'not me'. We have insufficient data to hypothesize if and how this constellation of beliefs would translate into a behavior and there is, to the best of our knowledge, no other example than 'pro environmental behavior' in which the VBN has been tested. Therefore, there is no reference point in the VBN literature to which we can compare the Dutch factor 3.

In conclusion, the frames reflect to different extent the structure of the VBN theory. The fact that some frames are so similar to the VBN theory endorses the idea that the frames might be effectively linked to behavior, and especially to the preference towards different technologies (hydrogen in our case) when perceived as consistent to the frames. Perhaps the VBN theory could be extended to explain other types of behavior, other than the pro-environmental one. Or the VBN might not apply to some of frames we elicited because of the different values and worldviews that compose these frames. We would need further data, in order to explain and understand the nature of the differences between the frames we identified and the VBN theory.

## 4.7 Conclusion

In this study we are interested in identifying and analysing, through the Q methodology, a variety of holistic points of view on hydrogen, which we define as hydrogen frames, directly from the perspective of the citizens. The data analysis revealed two sets of factors in the two data sets. The factors represent shared points of view among the interviewees.

These factors underlie patterns in the combinations of different beliefs and norms, collected during a set of focus groups, and proposed to the participants of the Q study as statements to sort. The analysis reveals that these factors are structured as a variety of problem definitions and

consistent solution space, in other words frames, as defined in the first chapter. Some of the factors are remarkably similar to the VBN-theory we used to structure the Q sample. This similarity supports the idea that frames (including the ones we uncovered) drive people's behaviour, or at least their intention of it. In other words, we are encouraged in thinking that the different frames we uncovered might effectively lead to a preference of different hydrogen alternatives, as we will argue further in the next chapter. Interestingly, this similarity emerges despite the great difference in the research methodology employed (Q methodology vs. conventional questionnaires and statistics used in the VBN literature).

The frames are different in content. In both studies, the frames focus on different issues, such as the environment, the economy, the security. The frames show the heterogeneity of the concept of sustainability in practice.

However, the nine frames we elicited, do not express any specific vision of the future or preference towards particular technologies. The relationship between the frames and the (technologies in the) solution space is more indirect. As we will discuss in the last chapter, this is probably due to a combination of the nature of the methodology, which is not apt at identifying preferences, the nature of the topic, hydrogen, which is not an on-going discussion, and how the methodology has been applied.

In the next chapter, we will see how we can still infer how the different frames may match (and mismatch) possible hydrogen scenarios.

# 5 Interpretation of the results

## 5.1 Introduction

The data analysis revealed nine Q factors in our Q study, five in the Dutch data set and four in the Italian, whose narratives are described in Chapter 4. In that chapter we also argued that the factors we identified represent frames, namely belief systems where the beliefs on problems and solutions are entangled.

In this chapter we will dig into the variety of frames, by looking at similarities and differences, in order to understand what characterizes each of the frames. We will show that we didn't find only green frames across the citizens we interviewed, but also promethean kind of frames (§5.2), which, according to the literature, seem to be more typical of policymakers, rather than of the lay public (Dryzek and Goodin 2009). We will also show that different types of environmentalism emerged through our frames, underlining the danger of generalization over the

public "environmental concern" (§5.3). Furthermore, we will show how the distinction between the green and the promethean frame is not so sharp, with many intermediate frames. Through a reflection on the solution space boundaries defined by the frames, we will make plausible that different frames embed hydrogen preferences in different ways (§5.4). Finally in section 5.6 we will discuss the relevance of the frames when dealing with public acceptance of hydrogen technologies.

## 5.2 Not only environmentalism in the public: the promethean points of view.

During one of the focus groups, one participant stated that "[…] nowadays it is politically correct to be an environmentalist". By looking at the factor arrays, however, we can see how in some of the frames, especially the Dutch frame 3 and the Italian frame 3, the environmental issue[1] is secondary. Let's go a bit deeper into this.

Previous literature reveals the existence of alternative perspectives on the environmental issue, characterized by the minimization of the problem, the anthropocentric vision of nature, the priority of economic growth over the other issues, and the trust in the market and in technology (e.g. Adger et al. 2001, Williams and Millington 2004, Dryzek 1997). Dryzek (1997) defined these alternative perspectives as promethean, after the myth of Prometheus, who vastly increased the human capacity to manipulate the world, by stealing the fire from Zeus.

[1] We use the term 'environmental issue' (or issues) as a general container, which may hint to several issues such as climate change, urban pollution and so forth. Notably, in this study we let the citizens define what they understand to be an environmental issue, through the focus groups, the Q statements and finally through the frames identified in the Q study. These definitions are described and discussed in section 0. There we argue that because of the plurality of the interpretation of the 'environmental issue' and the different approaches to tackle them, it is possible to identify different *environmentalisms*.

Some of the frames we identified in our Q study are also characterized, to different extent, by the minimization of the environmental issue, the anthropocentric vision of nature, the priority of economic growth over the other issues, and the trust in the market and in technology. Table 5.1 shows the statements in our Q sample that express the above-mentioned promethean characteristics, together with the ranking per each factor. We remind that, as foreseen by the Q methodology (Brown 1980), is the combination of the statement, the ranking and the interviewees' comments that expresses the presence and strength in the frames of these promethean characteristics. Also the interpretation of what the ranking means depends on different parameters, for example on how the statement is ranked with respect to the other statements within the same factor, how the same statement is ranked by the other factors, or how the statement has been interpreted by the people grouped in the same factor.

For instance, statement 12 (Table 5.1) expresses the concern over urban pollution, one of the possible environmental issues. In the technocratic frame (Italian factor 3) the statement is ranked in the central area of the grid with the value of 2. This is the lowest that the statement has been ranked, considering that in other factors the same statement has been positioned in the most extreme area of the grid (value 4 and 5). The ranking of this statement has been accompanied by comments of the interviewees such as "*I think that decades ago the air was much more polluted than now, it is just that now we talk more about it*" (Italian interviewee num. 27). The combination of ranking and comments, suggests that in this frame the pollution is not only perceived as unproblematic, but also that there is an active effort of minimizing the importance that the issue has been given by others. A similar reasoning holds for statement 28, expressing the lack of concern over climate change, another possible environmental issue. Dryzek

(1997) attributes the minimization of the environmental issue, to a fundamental optimism, that any (environmental) issue can be solved by technological development. This same optimism is expressed in our study through the ranking of the statements 10 and 36, and it is well expressed in the words of two interviewees grouped (or loading) in the Italian factor 3: "[...] progress increased our quality of life, and so it will in the future. Therefore it shouldn't be hindered". In a promethean mind-set, progress brings society forward, which is natural; while a simpler lifestyle implies "going back in time", as explicitly commented by some of the interviews dealing with the statement 2 on consumption. Going back in time would be unnatural. According to Dryzek (1997) a Promethean worldview, in opposition to the ecological perspective, is not concerned with the limit of growth or the limit of nature, believing that eventually technology will compensate the lack of nature. Similarly, Adger et al. (2001), in their analysis of some global environmental discourses (e.g. about deforestation and climate change), identified a set of less dominant discourses denying the gravity or the existence of the environmental issue supported instead by the dominant discourses.

At the same time, more importance is given to "be a leading economy", through the sorting of statement 39. In this frame, investing and switching to new technologies has primarily an economic and security purpose (statement 39 and 6, Table 5.1) and only secondarily an environmental one. In the Dutch liberal perspective (Dutch factor 3) we can find the same characteristics of minimization of the environmental issue and importance of the economy we highlighted in the Italian technocratic frame.

Table 5.1. Characteristics of the promethean frames. The left column shows the promethean characteristics as defined by the literature. The second column shows the Q statements that express these promethean characteristics. All the other columns show the ranking of these statements for each of the factors, both Italian and Dutch. The combination of the statement, the ranking and the interviewees' comments expresses the extent to which the promethean characteristics demarcate the frames.

| Promethean characteristics in the literature | Q statement | Ranking Dutch factors | | | | | Ranking Italian factors | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 |
| Minimization (Adger et al. 2001; Dryzek 1997) | 12. Pollution is a problem of today: the respiratory diseases are increasing because of the bad air quality | 1 | 5 | -1 | -1 | -1 | 2 | 4 | 2 | 5 |
| | 28. I am a climate-skeptic. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption | -4 | -2 | 0 | -4 | -1 | -2 | -2 | 0 | -3 |
| Focus of the energy issue other than the environment | 6. The majority of oil comes from political unstable countries. We will have serious problems if the Middle East decides to close the oil tap. We should not be dependent of these countries. | 4 | -1 | 4 | 4 | 2 | 2 | 4 | 5 | 0 |
| Anthropocentric vision of nature (Dryzec 1997, Williams and Millington 2004) | 34. People are more important than nature, we are at the top of the natural chain. We should satisfy our needs, but not completely disregard nature. | -2 | 3 | -1 | -1 | -4 | 2 | -2 | 2 | -4 |
| Importance of economy (Dryzec 1997, Williams and Millington 2004) | 39. Becoming a leader in these new technologies means becoming a leading economy in the world. | 3 | 1 | 3 | 2 | 3 | 0 | 0 | 4 | 1 |
| Trust in the market (Dryzec 1997, Williams and Millington 2004) | 9. The government is responsible to do something about the issues related to energy. They have enough power to do something about them | 2 | 3 | 0 | 5 | 2 | 0 | -1 | -1 | -2 |
| | 37. Consumers should be more responsible. We should understand that we can do a lot for decreasing consumption in our daily life. What a single person does is not a drop in the sea. | 5 | 0 | 2 | 0 | 4 | 4 | 5 | 0 | 3 |
| Trust in technology (Dryzec 1997, Williams and Millington 2004) | 36. Energy problems have social grounds. The technical progress will not solve the problems | 1 | -1 | -4 | -5 | -1 | -1 | 1 | -3 | 0 |
| Aversion to safety and environmental concern (Dryzek and Goodin 2004) | 25. I think it is morally incorrect to use energy produced from food. I would not buy biodiesel produced from corn or sunflower oil. | -2 | 2 | -4 | 3 | -3 | -4 | 0 | -4 | 1 |
| | 3. Using biomass from waste to produce energy is dangerous and inefficient. | -3 | -1 | -3 | -2 | -3 | -3 | -5 | -3 | 1 |
| No need for radical change (Williams and Millington 2004) | 2. We consume too much in general. I think we should live very differently | 3 | 0 | -1 | 1 | 3 | 3 | 3 | 1 | 4 |

Moreover, the data suggests that the above-mentioned frames reflect a substantial satisfaction with status quo. Hence not only is there no need of a societal change (statement 2, Table 5.1), but also society should evolve following the current line. The problems, if any, will be solved, through innovation. Technology will emerge according to the market rules; what consumers will ask and find convenient will survive and develop. The rest will become old. There is no need for the government to intervene in this natural process (statements 9, 5, 37 of the liberal perspective -Dutch factor 3). The statement 34 "People are more important than nature, we are at the top of the natural chain. We should satisfy our needs, but not completely disregard nature" is about the relationship between humans and nature, central to any ecological thought. The formulation of statement 34 expresses an anthropocentric vision of nature. In the anthropocentric outlook, nature exists and it is valued to satisfy the needs of humans. For example nature gives humans resources, like water, that shouldn't be polluted. But nature can be valued also for its beauty, or because it offers leisure activities. Hence, nature should be safeguarded in order to avoid dangers for the human beings. Moreover, in an anthropocentric view of nature (see also §5.3), nature exists because (and is valued if) it fulfils human needs. Therefore no intervention of the government is needed for the environmental matter, as technology, science and the market are sufficient. Similar concepts are also described as central in the so-called weak sustainability discourses described by Williams and Millington (2004). Weaker sustainability discourses give less importance to the need of radical change and are more inclined to the status quo.

The Italian and Dutch frames 3, hence, have many common points with the above mentioned literature, and for this reason we characterised them as promethean. Interestingly, the distinction between the promethean and the non-promethean frames (which will be analysed in

the next section) is not so sharp. The ranking of the statements shows variation over the promethean theme. For example, the Italian factor 3, takes an authoritarian stand, wishing the government to take the lead and strive for innovation. For this reason we named the Italian factor 3 the technocratic frame. The Dutch factor 3 instead maintains a typical (promethean) liberal stand, expecting the government to stay out of the market, gaining the name of liberal frame.

As we will see in the next section, the variations over the promethean theme have commonalities with the non-promethean frames, such as the Italian factor 2 (I2) and the Dutch factor 1 (N1). These factors ranked in a comparable way many of the statements characteristic of the promethean frames. For example, I2 and N1 minimized respectively the climate change and the pollution aspect (statements 28 and 12), and believe in the consumers' power to drive innovation (9 and 37 table 5.1). These similarities reflect also in the relatively high correlations among those factors (table 4.3 pg. 97). The factors have been named "the market-driven sustainability" (Italian factor 2) and the "liberal environmentalism" (Dutch factor 1), and will be analysed in the next section (5.3) as variations of environmental frames.

In sum, the literature indicates alternative perspectives, characterized by specific themes, alternative to the environmental discourses. Dryzek (1997) defined these alternative perspectives as promethean, suggesting that the promethean outlook is more characteristic of the political elites (policymakers) rather than the lay public (Dryzek et al. 2008).

However, our data show traces of the promethean outlook in some of the frames we identified across our group of lay citizens. The liberal and technocratic frames can be both characterised as promethean. However, as we will see in the next section, there is no sharp distinction between

the promethean and non-promethean frames, as these converge in several middle ground positions. The implications of this finding will be discussed in the last section of this chapter.

## 5.3 Environmentalism or environmentalisms?

Some of the sentences of the sample offered the interviewees the opportunity to reflect on their environmental stand. Table 5.2 gives an overview of the environmental statements, comparing how they have been sorted in four selected factors. As with the promethean frames, the interpretation, ranking and combination of some of the Q statements allowed different green thoughts to emerge. These Q statements are resumed in Table 5.2 together with the ranks for each selected factor.

The first statements are obviously the ones directly expressing the environmental concern (statements 12 and 28). The environmental concern, either due to climate change or urban pollution, or both, is a common trait of the factors we selected. Another common trait is the belief that something should be done to compensate the environmental damage, such as adding the environmental cost to the product and using the money "for the benefit of the environment" (statement 8). According to some authors the need for compensation is a normative consequence of a biocentric outlook (Des Jardins 1997). The bio-centric outlook conceives humans as part of nature and not "inherently superior to other living things" (Taylor 1986 in Des Jardins 1997 pg. 138).

Table 5.2. Environmental statements of our Q sample classified accordingly to the central elements found in the green literature. The table shows the ranks per each of the selected factors. We remember that conventionally, the differences between the rankings are relevant when higher than 2 ranking points (Brown 1980), and that the interpretation is based on the combinations of beliefs and the comments of the interviewees.

| Central elements of environmentalism | Factors | Italian | | Dutch | |
|---|---|---|---|---|---|
| | Q statements | I4 | I2 | N1 | N4 |
| Environmental concern | 28. I am a climate-skeptic. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption . | -3 | -2 | -4 | -4 |
| Environmental concern | 12. Pollution is a problem of today: the respiratory diseases are increasing because of the bad air quality . | 1 | -1 | 5 | 4 |
| Relationship with nature – ethnocentric/biocentric outlook | 34. People are more important than nature, we are at the top of the natural chain. We should satisfy our needs, but not completely disregard nature | -4 | -2 | -2 | -1 |
| Overconsumption and call for a simpler lifestyle | 2. We consume too much in general. I think we should live very differently | 4 | 3 | 3 | 1 |
| Compensation | 8. The government should add environmental costs to products and use this money for the benefit of the environment. I think it is fair that people pay an extra tax proportional to what they consume | 3 | 2 | 3 | 4 |
| Dilemma economy ecology | 39. Becoming a leader in these new technologies means becoming a leading economy in the world. | 1 | 0 | 3 | 2 |
| Role of technology | 36. Energy problems have social grounds. The technical progress will not solve the problems . | 0 | 1 | 1 | -5 |
| Self-sufficient economy | 16. Maybe we could go back to doing things locally, also with energy. It would be nice to produce energy locally without having to transport it . | 3 | -3 | 0 | 3 |
| Self-sufficient economy | 22. I wish it would be possible to completely independent from the electric grid. I would prefer producing the energy at home on my own. | 2 | -4 | -3 | 1 |
| Sustainable use of resources | 3. Using biomass from waste to produce energy is dangerous and inefficient | 1 | -5 | -3 | -2 |
| Ascription of responsibility | 37. Consumers should be more responsible. We should understand that we can do a lot for decreasing consumption in our daily life. What a single person does is not a drop in the sea | 3 | 5 | 5 | 0 |
| Ascription of responsibility | 5. A single person does not think about energy, the environment or efficiency. The government should tell me what to do, they should oblige me! Even if I have to change my habits, I would vote for such a party, because in this way I will have no other choice than do the right thing. | -1 | -4 | 0 | 2 |

**Interpretation of the results**

In our study, the relationship with nature emerges through statement 34. As we have seen before (§5.2), the statement expresses an anthropocentric vision of nature. The results show strong disagreement of the Italian factor 4 with the anthropocentric vision. Two of the interviewees loading in this factor justified the disagreement with their strong belief that "humans are part of nature, we forgot that. Somehow we believe that everything is allowed to satisfy our needs … and for this reason we grew apart from nature".

Many interviewees, whose Q sorts were grouped in other factors, instead found the statement double, disagreeing with the first part and agreeing with the second. As a reaction this statement was sorted in the middle position (e.g. -2). We deduce that the biocentric outlook is more a characteristic of the Italian factor 4 than of the other factors. We can also deduce that, no matter if some people found the statement double, this statement was relevant for those who either strongly agreed or strongly disagreed with it. Hence the formulation of this statement had an important role, as it allowed the stronger promethean views to emerge and, in opposition, the stronger green views such as the ecotopian frame. Notably, statement 34 was literally taken from one of the focus groups participants and was one of the statements that was not present in the pre-test Q study. In other words, we could have never come up with a statement like this without the focus groups.

In the perspective defined by the Italian factor 4, the anthropocentric vision of nature is at the basis of the environmental issues, together with overconsumption (statement 2, Table 5.2) Consumerism as a source of fake happiness is central in the ecological thought, together with the concept of simplicity, the retour to a simpler lifestyle and austerity (de Geus 1999, pg. 211 and 273). Simplicity, explains de Geus, combined with trust in technology (statement 36 in our study),

creates the necessary conditions to believe in the ecological utopias of living in decentralized self-sufficient communities, where goods (in our case electricity) are produced and used in the vicinities, avoiding useless transport. Statements 16 and 22 clearly express this ecotopia (de Geus 1999) in the Italian Factor 4. Moreover, through statement 3, which concerns the uses of waste to produce energy, the Italian factor 4 encompasses a broader idea of sustainability. A sustainable and ecologically sound society does not only use its resources responsibly, e.g. by recycling waste to produce energy, but also produce less waste (as described for example in Dobson 1990, or de Geus 1999). Hence, we retain the ecological utopias to characterize the Italian factor 4, a deep green point of view, which we named the ecotopian frame.

Through the same statements but different ranking, the Dutch factor 4, expresses another green stand. As a matter of fact the judgment over consumerism distinguishes the Dutch factor 4 from the rest of the factors. Contrarily to the other factors, the Dutch factor 4 does not focus on changing the consuming pattern. This point of view makes sense especially in combination with the strong disagreement with statement 36. "Energy problems have social grounds. The technical progress will not solve the problems". Why should society moderate consumption if a technical fix is possible? As we have seen before, the technology-positivism is more typical of the promethean frames. Moreover, in this frame, minor importance is given to the personal ascription of responsibility of the citizens, which should recognize that "What a single person does is not a drop in the sea", statement 37. The rationale behind the Dutch frame 4 can be better understood through the agreement with statement 5 "The single person does not think about energy, the environment or the efficiency. The government should tell me what to do […]". Here however, the authoritarianism is not intended in the more classic ecologic view as a way to limit growth

and enforce an ecologically sound society (as described for example in Dobson 1990, or de Geus 1999), but rather as an expectation about authoritarian governance to steer technological development. In this type of authoritarian governance, described by Hisschemoller et al. (2006) as the "Governance by Government", the government focuses its policies on specific technologies, for the sake of an overriding common good, such as security. The Governance by Government is seen as a possibility to realize the transition towards hydrogen but its first limitation is the need of a large consensus, a consensus that seems to be shared by the Dutch factor 4 only. As a drug is prescribed by a doctor for the good of the patient, so technology should be prescribed by the government for the environmental benefits. For this reason we named the Dutch factor 4 the prescribed environmentalism.

Milder ranking of the same statements distinguish the Dutch factor 1 from the two previous frames. The starting point to understand the Dutch factor 1 is the ranking of the statement 39 (Table 5.2). The Dutch factor 1 solved the fundamental conflict between environment and growth central in any deep-green thought. Dutch factor 1 sees the environmental technologies development as beneficial for the economy. According to some authors (e.g. Dobson 1990, de Geus 1999, Dryzek 1997) this belief distinguishes the environmentalist from the ecologic point of view. The Dutch factor 1 seems to have, with respect to the ecotopian frame, a more specific idea of sustainability, which focuses more on climate change, technological development and the economy.

Other differences between the environmental and the ecotopian stand emerge when identifying the path towards a sustainable and ecologically sound society. On the one hand the ecotopian frame calls for decentralization and societal change. On the other hand the Dutch factor 1 rejects the burden consequent to the decentralization of energy

production and delegates the responsibility to the concerned institutions. "It's not practical" or "It's something that should be done professionally", commented some interviewees. Last but not least, differently from the other two factors taken into account, the Dutch factor 1 is characterized by liberalism: the less intervention of the government the better. Green technologies will be driven by the market and green behaviour will come with people's awareness. All this considered, the Dutch factor 1 has been named the liberal environmentalism.

In sum, some of the statements of the Q set offered the possibility to define different environmental stands. The stands emerged by combining different gradation of environmental concern, anthropocentric and biocentric outlook, and expectations about simplicity, societal change, governmental role and technical fix. In this way, we distinguished between a deep ecological frame, the ecotopian, and milder environmental frames, the liberal environmentalism, which bridges the green frames towards the promethean and finally a technology focused frame, the prescribed environmentalism. While previous literature on public acceptance of hydrogen refers to "one environmentalism", our results show rather multiple forms of environmentalisms. The substantial difference among the environmentalisms suggests how misleading generalization can be.

## 5.4 Perspectives and solution space

The frames we found in our studies are belief systems where the beliefs on problem and solutions are entangled. In our analysis we can distinguish these two levels, looking for the problem definition and the solution space boundaries. As we shall argue, the problem definition,

and especially the distribution of responsibilities, seems to define the boundaries of the solution space.

As we mentioned in section 4.5, the Q methodology is not suitable to establish people's preferences (for that conventional statistics are needed) and a clear and coherent picture of hydrogen did not emerge from the ranking and interpretation of the hydrogen statements. Nonetheless, we can still reflect and speculate on the solution space boundaries, inferring how hydrogen might be envisioned compatibly with each frame. For this exercise we select four frames, which, as we shall show, will be of interest, namely the ecotopian, the prescribed environmentalism, the technocratic and the liberal. The first two express two different environmental points of view (§ 5.3) and the latter two represent two promethean points of view (§5.2). Table 5.3 shows some of the statements that we will take into account to conduct our reflexive exercise[2] on the solution space boundaries. We start with the ecotopian frame.

In the ecotopian frame, small energy communities are the future of energy production (statement 22 and especially 16). Decentralization fits the bigger picture of sustainable communities, were the responsible use of local resources does not only refer to energy, for example through renewables (statement 1), but also to other products in general, such as shorter supply chains for food. In these communities, energy could be produced by groups of people, but "…it doesn't have to be people, it can also be the municipality or a local company (to manage the energy production). The important thing is that it is near

[2] We remind the reader that the differences in ranking value of a statement between an Italian and a Dutch frames –visible in tab. 5.3- does not say anything about possible difference in the sorting of the statement, because the factors belong to two different data sets, which have been analyzed independently from each other. For example statement 5 has been ranked as 2 by the Dutch factor 4, and 4 by the Italian factor 3. In both cases, the ranking value was the highest within each of the data sets, with a statistical significance exceeding 0.01.

people. In this way people become more responsible for the energy they use" (interviewee n.6).

Table 5.3. Statements expressing the solution space boundaries. The liberal and prescribed environmentalism are Dutch frames while the ecotopian and the technocratic are Italian.

| Central elements of environmentalism | Factors | Italian | | Dutch | |
|---|---|---|---|---|---|
| | Q statements | I4 | I2 | N1 | N4 |
| Environmental concern | 28. I am a climate-skeptic. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption . | -3 | -2 | -4 | -4 |
| | 12. Pollution is a problem of today: the respiratory diseases are increasing because of the bad air quality . | 1 | -1 | 5 | 4 |
| Relationship with nature – ethnocentric/biocentric outlook | 34. People are more important than nature, we are at the top of the natural chain. We should satisfy our needs, but not completely disregard nature | -4 | -2 | -2 | -1 |
| Overconsumption and call for a simpler lifestyle | 2. We consume too much in general. I think we should live very differently | 4 | 3 | 3 | 1 |
| Compensation | 8. The government should add environmental costs to products and use this money for the benefit of the environment. I think it is fair that people pay an extra tax proportional to what they consume . | 3 | 2 | 3 | 4 |
| Dilemma economy ecology | 39. Becoming a leader in these new technologies means becoming a leading economy in the world. | 1 | 0 | 3 | 2 |
| Role of technology | 36. Energy problems have social grounds. The technical progress will not solve the problems | 0 | 1 | 1 | -5 |
| Self-sufficient economy | 16. Maybe we could go back to doing things locally, also with energy. It would be nice to produce energy locally without having to transport it | 3 | -3 | 0 | 3 |
| | 22. I wish it would be possible to completely independent from the electric grid. I would prefer producing the energy at home on my own. | 2 | -4 | -3 | 1 |
| Sustainable use of resources | 3. Using biomass from waste to produce energy is dangerous and inefficient. | 1 | -5 | -3 | -2 |
| Ascription of responsibility | 37. Consumers should be more responsible. We should understand that we can do a lot for decreasing consumption in our daily life. What a single person does is not a drop in the sea | 3 | 5 | 5 | 0 |
| | 5. A single person does not think about energy, the environment or efficiency. The government should tell me what to do, they should oblige me! Even if I have to change my habits, I would vote for such a party, because in this way I will have no other choice than do the right thing. | -1 | -4 | 0 | 2 |

The importance of responsible use of resources emerges also through the low agreement shown with the possibility of using of waste of agricultural products to produce energy (statements 3 and 25, Table 5.3). Notice that since no technical fix is possible in an ecotopian perspective, the technology supports the change towards a more sustainable society, but the change is societal rather than purely technical.

The ranking of the statements shows that the prescribed environmentalism defines comparable boundaries to the ecotopian ones. The difference that we highlight is the expectation of a more active role of the government in leading society towards a sustainable society (statement 5, Table 5.3). Interestingly, the same expectation is shared by the technocratic frame, with the difference that instead of striving towards an environmentally sustainable society, the transition should lead to an energy independent and a technologically advanced society. Hydrogen may be applied in both ways and perhaps the advocates (e.g. policymakers, technology developers, lobbyists, experts) willing to steer the transition towards hydrogen may find the necessary public support in those types of frames.

Last but not least we consider the solution space defined by the liberal frame. On the one hand, the liberal frame seems to have wider boundaries. In the end, any technological system is suitable for these frames we classified as promethean, as they do not show any preference for one technology over another (see statements 14, 3 and 25). On the other hand, the liberal frame has a constraint that might be fatal for hydrogen, namely the lack of governmental support for the technology take-off. As often discussed in the literature, the transition towards hydrogen may need a private-public partnership and

commitment from the public institutions (e.g. Hisschemöller et al. 2006, Clark and Rifkin 2006, Agnolucci 2007).

Yet, the scope of this exercise was not to predict hydrogen acceptance through the frames (we will come back to this point in section 5.5 and in chapter 6), but rather to make plausible that different frames embed the hydrogen visions in different ways. Hence, the abovementioned considerations, far to be conclusive, help us in making a step further in the reflection on the added value that the frames could have in the field of public acceptance (of hydrogen specifically or new energy technologies in general).

### 5.5 So what? Relevance of the results.

Through the Q methodology, we were able to elicit a set of heterogeneous lay-citizens frames. In order to better understand the nature of the difference among these frames we characterized them into promethean and environmentalist frames. The analysis suggests that there are fundamental incompatibilities in the points of view of the citizens. However, our analysis also showed that, despite the incompatibilities there are also many possible middle ground positions. In this chapter we have also seen that the heterogeneity of the frames is reflected in different definitions of the solution space boundaries. The data suggests that through these frames, citizens may differently approach the hydrogen issue, which translates into divergent public opinions on how hydrogen should be realized, why and under which conditions. Hence what we propose here is a method (the frames and the Q method) to identify people possibly having different hydrogen preferences, because of their different worldviews.

The implications and relevance of these results are multifaceted, but depend to a certain extent on whether the results could be somehow

extended outside the group of participants. In other words, to what extent are the frames we found representing the frames of the public (Italian and Dutch)?

In principle, it is plausible to think that a thorough Q study could represent a defined population of points of view (we stress that in the Q methodology, the term population refers to the points of view, to the opinions, not to the actual people). The idea that the results of a relatively small qualitative study could be generalized, is based on the assumption that, given a defined topic, there is not an infinite number of points of view on that topic, but rather only a limited set of ways of thinking about it. Moreover, as Brown (1993) underlines, the factors are already generalizations of an individual's point of view, because each Q factor represents an ideal point of view shared by several individuals. The Q factors we selected in both studies represent points of view shared by at least three participants each. In both Q studies, the factors group people that didn't know each other. We can demonstrate this by looking at Figure 4.1 pg. 86. This figure shows the relationships between the participants in the Italian Q study. Each branch shows how the interviewees have been involved by being introduced by another participant. If we take for example, the ecotopian outlook (Italian factor 4), which groups participants 6, 12 and 22 (table C-8 Appendix C: Quantitative data analysis), we can see that these participants belong to three different branches of the sampling process. Hence, the question is, were we so lucky to find the only three persons in town to share an ecotopian outlook or is the ecotopian outlook somehow so diffused among the citizens that it can be so easily found? Although we can't exclude the first situation, we consider the second more plausible.

However, it is hard to establish the 'boundaries' of the population (of frames) that we are talking about. Are we talking about some local

frames? Italian? European? How extended is the whole variety of the frames? Are there other frames? How diffused are these frames, are these minor or dominant points of view? Finally, we don't know in which way these frames may change over time, when people are exposed to new information and new events or when the frames interact. Hence we argue that the frames we elicited can most likely be found in the larger population, and therefore represent *a* variety of the citizens' frames. Nevertheless, we are not able to say whether these frames are exhaustively representing the whole variety of frames, to what extent are they shared by the other citizens, and how stable they are over time.

If we agree on the idea that the frames we identified say something about the general public, the first consideration on the relevance of our results links us back to the beginning of this study. We showed that the majority of the studies on public acceptance of hydrogen are focused on the environmental, and safety perception, and on the willingness to pay for hydrogen. We argued that this approach assumes what is 'relevant for the public', reduces the public to a homogenous voice and dichotomized acceptance as something that either is there or not. The variety of frames we identified instead suggests there is not one homogenous public, as there is not one way of envisioning hydrogen technologies. Our results invalidate the idea of the public as a 'barrier to overcome' and we advance the hypothesis that, in the process, the actors may seek support of the possible subgroups constituting the public and use this in the arena.

The variety also suggests that identifying the whole public with one part of it (e.g. the environmentalist) may be misleading. For example, we have seen that there are different environmental frames, which may embed the preference towards different hydrogen systems. Also,

disregarding the other points of view may lead the experts to favour only part of the public over the other, with the result of creating a feeling of exclusion and potentially resulting into unpractical decisions. Moreover, we learned that people have different ideas of the role that the government should take and therefore of the way the public money should be spent. All these differences and fundamental incompatibilities between the frames might fuel a public discussion, as well as a political debate and/or a decision making process. For all these reasons, it is more appropriate to consider "the public" as a multi-actor context rather than a single voice.

The presence of the promethean frames in the public deserves some more consideration. Dryzek and Goodin (2008) show that, when called to deliberate on delicate technological issues, the public often converges into risk-adverse positions, evoking the precautionary principle, which the elites do not share due to their promethean point of view. The authors show that the contrast between precautionary publics and promethean policymakers may result into stall, de-legitimating of the decision or bypassing the recommendation of the public. Looking at our promethean frames, we ask ourselves whether the convergence of the public into a risk-adverse position is for instance due to a deliberative dynamic (as proposed by Dryzek and Goodin 2008) or to the fact that promethean citizens, somehow, have not been involved in the deliberative process (for example because they are a minority and therefore hard to find, or because they are less willing to participate). Moreover, Dryzek and Goodin (2008) show that this impasse between public and elites might be overcome through intermediate worldviews, called in their work 'ecological modernization outlook'. These intermediate worldviews we find back in our work, for example through the market driven sustainability or the practical environmentalism

(sections 4.4 and 5.2). Would they have a similar role also in a possible deliberation process on hydrogen technology?

Our approach might also have more practical applications. For example further research may observe how the frames change over time. In this way it is possible to observe the process and understand the changes. In this sense the added value is that the frames potentially allow a richer picture of public acceptance, compared to opinion polls and other quantitative methods, which focus on variables rather than on the big picture. In Chapter 6 we will more extensively discuss possible applications of the frames.

In sum, the variety of frames opens up (Stirling 2010) the idea of the homogenous public and public acceptance in the eyes of these professionals that still think of the public as "those who don't know" or "those who care about safety and the environment". Through this study we arrived to a more nuanced and more extensive picture than the one emerging from the previous studies on public acceptance of hydrogen. Here we proposed a method, the idea of frames and the Q methodology, which allows identifying and mapping this variety of the public. Such a more nuanced and more extensive picture may be normatively and strategically relevant when dealing with public acceptance of hydrogen

# 6 Conclusions and Afterthoughts

## 6.1 Introduction

In this conclusive chapter, we will draw our conclusion with respect to the research questions we posed at the beginning of this work (chapter 1) by answering and discussing the questions and relative sub-questions one by one (§ 6.2 trhough 6.4). Successively, we will discuss possible uses of the frames (§ 6.5). Furthermore, starting from the conclusions of this study, we will look in retrospect what could have been done differently and we will propose some further research steps (§ 6.6). Finally we will reflect on the methodological issues that are left open after this study (§6.7).

## 6.2 Conclusions with respect to the research questions.

The exploration of public acceptance of hydrogen carries three problems; first, hydrogen is such in an early stage of development that citizens don't know much about it. This poses the substantial and methodological question of how to explore the acceptance of a technology (hydrogen) that is not implemented yet. Second, being an energy carrier, the implementation of hydrogen will require many other technologies such as the primary energy sources used to produce hydrogen, the way in which hydrogen is transported or applied. There are many different ways in which hydrogen could be implemented, and these ways should be accounted for when thinking of public acceptance. It doesn't make sense to talk about acceptance of hydrogen in general, either you talk about specific parts of the systems (e.g. a bus, the car fuel, the refuelling station) or you have to somehow acknowledge the variety of technologies related to hydrogen. For example some citizens may be in favor of an out-of-sight system where hydrogen is used to store the extra energy of renewables and being against a system that employs nuclear power. Third, and related to the previous point, the public is heterogeneous in preferences.

The incipit of this study was the critic towards a substantial deal of previous literature, which explored public acceptance of hydrogen by focusing on specific parts of the system, based on the only assumption that safety perception and environment matter. This approach results in a reductive and technocratic idea of acceptance and the public, and did not deal with the complexity of the case, as we illustrated above.

We argued that the first step to grasp public acceptance of hydrogen technologies while respecting this complexity of the case is to understand how lay citizens frame their preference towards hydrogen in the broader context of the energy issues. Through the frames, we aimed

at identifying a variety of problem analysis, defining the solution space boundaries in which the specific hydrogen systems might have fit or not. In this way, the frames would give an indication on the possible preference towards hydrogen while respecting the complexity of the case.

We operationalized this objective into two research questions and relative sub-questions, namely:

**Research question 1**: What frames on hydrogen can be found across the lay citizens?

**Sub-question 1**: What are the beliefs on energy, responsibilities and hydrogen?

**Sub-question 2**: How are these beliefs organized in frames?

**Research question 2:** What characterizes those frames?

The first research question will be answered and discussed in the next sub-sections 0 and 6.2.2 by addressing sub-questions 1 and 2; a brief discussion on the first research question will follow in section 6.3; while question 2 will be addressed in section 6.4.

### 6.2.1 Sub-question 1: What beliefs on energy, responsibilities and hydrogen can be found among lay citizens?

We collected the beliefs in two rounds of focus groups, with a convenient sample of lay citizens, with no or little previous knowledge on hydrogen (Chapter 3). Seven focus groups were organized in the first round and two others in the second round, for a total of fifty-six participants of different age, gender, education, profession and nationality (Italian and Dutch). The males and the highly educated and the Dutch were over-represented. Since the second round of focus

groups was not generating additional (different) beliefs than the ones we already collected in the first round, we assumed saturation and we decided not to organize any more focus groups. In the focus groups we, first, asked the participants opinion on what are the issues related to energy, who is responsible to do something about them, and what should be done. In the second part of the focus group meetings, we asked the participants' opinion on hydrogen by confronting them with a set of hydrogen scenarios.

The participants of the focus groups showed to be not only concerned with the environment, but also with a variety of other issues. The topics discussed covered, for example, many problems related to energy and the underlying causes, such as pollution, climate change, consumption and consumerism, lifestyle, but also energy security and oil independency and energy need. The beliefs also covered the way in which the responsibilities of these energy issues should be distributed among the different societal actors, and the contribution that these actors can offer to address these issues. The identified actors were citizens and single individuals, governmental institutions, the private sectors (e.g. industries) but also science as the institutions of knowledge and innovation. The participants articulated different expectations on what these actors should do, for example some discussed to what extent the government should intervene to steer the technological transitions, or whether technology could be a solution alone or whether citizens or industries could do something to reduce energy consumption, whether it would be fair to pay carbon taxes and so forth.

When confronting the participants with the hydrogen scenarios in the second part of the focus groups, safety was one of the subjects of discussion. The participants asked questions to understand how

hydrogen works, or what are the added values (like benefits over the environment or the efficiency). Some discussions elaborated into the possible changes that some of the hydrogen systems might bring into the daily life, like fights with the neighbors, changes in the energy services, problems with energy shortages. Safety was addressed by comparing hydrogen with existing technologies, like appliances or cars running on gas. We also observed the conversation focusing over very concrete aspects of hydrogen, such as the size of the fuel cell. More in general, the participants discussed about the added value and shortcomings of centralized and decentralized systems. They also focused the discussion on specific parts of the hydrogen systems, such as the primary energy sources used to produce hydrogen or the distribution infrastructure (e.g. hydrogen pipelines).

From the focus group discussion we extrapolated a set of more than two hundred beliefs, which we resumed into a representative set of forty beliefs listed in Appendix B: Q statements - English. These forty beliefs (translated in Italian and Dutch) have been used as the sample of Q statements used in the Italian and Dutch Q studies with the aim of eliciting a variety of frames on hydrogen and answering the second research sub-question.

**Intermezzo: discussion on the answer to sub-question 1**

The focus groups allowed the collection a vast number of beliefs, varied in terms of types of beliefs (problems, responsibilities, norms, etc. with some similarities to the VBN theory) as well as problems (e.g. climate change or energy security are two problems). The group discussion also allowed different points of view to emerge. For example, the climate change issue has been discussed from both the 'believer' and the 'sceptical' point of view. Moreover, the beliefs, spontaneously produced in the course of the interaction between the participants, were

formulated in the words of the lay citizens. When we compare the beliefs collected through the focus groups to the pre-test Q sample we assembled on our own we can see that the focus group statements were more varied and better formulated. For instance we have seen (in §3.6) how certain statements were articulated with simpler words and figures of speech, or how they evoked certain values (we made the example of "Being Responsible" and "Being Helpful" with statement 37) described in the Schwartz theory of Values (Schwartz 1973; Schwartz 1992; Schwartz & Huismans 1995; section 1.6 of this book). We have also seen the example of statement 34 (§5.3), which had an important role, as it allowed the emergence of the stronger promethean views as well as the stronger green views such as the Ecotopian frame. We have argued that, in many cases, we could have never come up with statements like those we used without the focus groups.

For these reasons we can conclude that the focus group was an appropriate means for lay people to discuss about energy and hydrogen technologies, despite the lack of knowledge or the possible perception of the topic as 'technical' and 'distant from their daily life'.

However, given the way participants have been selected, the set of beliefs we collected may not be representative of what the wider population thinks of the same topic. For example, one may argue that males and/or highly educated citizens may have more knowledge on hydrogen or on the energy issue, while the wider population is less aware –as the quantitative studies on hydrogen suggest (section 1.4 chapter 1). However, the goal of this data collection was not to gather a representative picture of the level of awareness of these issues in the population, but rather, to collect a set of beliefs as varied, extensive and diverse as possible. In this line, if it is true that the focus groups participants were more knowledgeable, it had a positive effect on the

study, as it allowed gathering a more useable set of statements for the Q study. Extensiveness, variety and diversity of the Q sample is important in order to allow different points of view to emerge through the Q study.

On the other hand, it is hard to assess whether the focus groups' participants generated a complete variety of beliefs or whether they overlooked important beliefs; although any type of participant selection would hardly eliminate this doubt. In our case, we compensated this uncertainty by asking the participants of the Q study to mention if important aspects were missing when sorting the Q statements, and nobody mentioned relevant statements.

Furthermore, one may argue that the sample of beliefs used in the Q study might have been culturally biased, due to the relatively low number of Italian focus groups. Also, it is an open discussion whether it is meaningful to converge in the same sample Q statements from different countries. By merging the two sets of statements we assume that first, the two concourses (i.e. the two discussions on hydrogen and energy) are comparable (not different culturally) and second, that the two discussions are overlapping.

Denying that there might be cultural differences in the Italian and Dutch discussion would be absurd, but, based on the observation of the focus groups, we question whether these differences would be at the level of the single beliefs – for example in the way the beliefs are formulated- or rather, at the point of view level – namely in the way the beliefs are organized into perspectives.

Based on the focus groups observation, we have seen that the Italian beliefs overlapped with the Dutch in content. Moreover, neither the Dutch nor the Italian interviewees report important statements missing. On the other hand, we did not merge the Q sorts, keeping the cultural

distinction in the data analysis. In this way we allowed possible cultural differences to emerge through the way the beliefs are organized into perspectives. We conclude that, despite the limitations of the research, the focus groups allowed to achieve the goal of stimulating the discussion on energy, responsibilities and hydrogen technologies. The material collected was sufficient to gather an adequate sample of Q statements, where the adequacy is defined by the extensiveness, variety, diversity and formulation of the beliefs.

### 6.2.2 Sub-question 2: How are these beliefs organized in frames?

We employed the sample of forty beliefs selected from the focus groups data, as Q statements in two Q studies, involving Italian and Dutch lay-citizens (other than the focus groups participants). We interviewed and collected thirty-six Q sorts for the Italian Q study and thirty-seven Q sorts for the Dutch.

Through the quantitative data analysis we elicited four factors in the Italian data and five in the Dutch. Through the qualitative data collected during the Q sort interview we reconstructed the narratives behind the factors.

The four Italian Q factors are:

1. *The mistrusting environmentalism*, which sees the lack of societal interest in the environmental cause as a major barrier for renewable energy takeoff and wishes decentralization as a possible way out for the energy issue;
2. *The market-driven sustainability*, which encompasses energy sustainability in a broader sense, including energy security and environmental protection, believes that sustainable technology

will emerge from the market only and sees decentralization as an inappropriate responsibility for citizens;

3. *The technocratic outlook*, which focuses on energy security and independency, wishes the authorities to take the leadership and direct society towards progress and technological development.
4. *The ecotopian outlook*, which roots the environmental issues into the societal way of thinking, and evokes the need of radical societal change, pushing for a personal take of responsibilities from all the societal actors, first of all the citizens, and wishes for the diffusion of small renewable energy communities.

The five Dutch Q factors are:

1. The *environmentalist frame*, which focuses both on the environmental and the energy security issue, calls for a shared responsibility and envisages that technologies like hydrogen will contribute to solve these problems.
2. The *practical environmentalist frame*, which is substantially satisfied with the status quo, except for the fact that energy should cost less and should pollute less. This issue is not a concern though, because renewable technologies will solve this.
3. The *liberal frame*, in which the environmental issue is not important and whose main focus is energy security. However, there is not much that can be done yet about energy security and oil dependency. Technologies will be developed and will emerge through the market. The government should interfere as little as possible.
4. The *prescribed environmentalism*, which expresses the disappointment in the institutions. The institutions fail to take the lead in the energy issue. Drastic measures should be adopted,

such as adding taxes and switching to renewable technologies, especially those that are using local energy resources.

5. The *mistrusting environmentalism*, which postpones the solution to the environmental issue to the future generations, because today nobody cares.

The Q factors are structured in terms of their problem definition and solution space. The problem definition and the solution space boundaries are defined in each frame by combining the norms and beliefs on issues, responsibilities, attitudes and expectations on technologies. Hence the Q factors can be defined as *frames* (chapter 4, §4.5) as we defined in chapter 1 (section1.6).

In the frames, hydrogen remained in the background, mainly as one of the possible technological alternatives to the ones we currently use.

As we showed in section 4.5 (chapter 4), all the frames we identified are logic and internally consistent. All the frames show the same structure of problem definition and solution space. We showed that the frames, and the Ecotopian frame to a greater extent, reflect the structure of Awareness of Consequences, Ascription of Responsibility and Norms of the Value-Beliefs-Norm theory; the theory we used to better define which type of beliefs might compose the frames and to drive the data collection during the focus groups. Based on these observations we are confident that the selected factors are a good representation of the points of view of the interviewees.

Moreover, previous literature (e.g. Diets et al 19998, Steg et al. 2006) shows that the VBN theory can explain pro-environmental behaviour, or, in other words, that a specific chain of values, beliefs and personal norms drives pro-environmental behaviour. If we consider a preference towards a certain hydrogen system as a behaviour, the similarity

between the Ecotopian frame and the VBN chain suggests that the frames we identified could indeed indicate different preferences. This finding supports the idea of using the frames to identify a set of people with different preference towards whether and how hydrogen could be implemented, as we will propose in section 6.5. On the other hand, the fact that other frames do not reflect the VBN theory as well as the Ecotopian could be due to the fact that we designed the Q-statements according the theory, but the interviewees interpreted and sorted them in their own way. This doesn't exclude the relationship between the frames and the VBN theory, but we have insufficient data to confirm it.

### 6.3 The representativeness and exhaustiveness of the frames

As we have seen in the previous section (6.2.2), we identified four frames in the Italian group of interviewees and 5 frames in the Dutch group of interviewees. In order to answer the first research question, namely ' what frames can be found across the lay citizens' we will have to discuss to what extent the frames we found may represent the frames in the wider population of citizens.

As we argued before (section5.5) we have reasons to believe that the frames we elicited in this study are not only limited to the group of participants, but that they might be found also in the wider population. These reasons are of two types, namely a) statistical/probabilistic and b) content related.

The Q factors we selected in both studies represent points of view shared by at least three participants each. In both Q studies, the factors group people that did not know each other. We can demonstrate this by looking at Figure 4.1 pg. 86. This figure shows the relationships between the participants in the Italian Q study. Each branch shows how the interviewees have been involved by being introduced by another

participant. If we take for example, the ecotopian outlook (Italian factor 4), which groups participants 6, 12 and 22 (see table C-8 in Appendix C: Quantitative data analysis), we can see that these participants belong to three different branches of the sampling process. Hence, the question is, were we so lucky to find the only three persons in town to share an ecotopian outlook or is the ecotopian outlook somehow so diffused in the population that it can be easily found? Although we cannot exclude the first situation, we consider the second more plausible.

Content-wise, as we showed in chapter 5 and as we will better see in the next section, the frames contain elements that are known to the literature, such as the different ways of envisioning nature (see e.g. des Jardin 1997), the ecological utopias (de Geus 1999), weak and strong sustainability visions (Williams and Millington 2004), or the promethean outlook (Dryzek 1997, Adger et al. 2001). All these themes have characterized the political discussion on the environment in the last twenty years at least, hence it wouldn't be so surprising to find them as widely in the larger population as we did in our group of participants.

What we are not able finally establish, based on our results, is whether there are other frames diffused in the wider public that we weren't able to grasp due to insufficient data, namely if we overlooked fundamental statements and/or participants.

In conclusion, if not the complete variety, we elicited *a* variety of frames. These frames are likely to be shared to a certain extent by the wider population. This variety can be used in many ways to contribute to both research streams dealing with the anticipation of public acceptance of technologies, like hydrogen, that are not yet present in citizens' life (streams we illustrated in Chapter 1). We will show and discuss these possible contributions in section 6.5.

## 6.4 Research question 2: what characterizes these frames?

We characterized the frames either as promethean or as environmental (chapter 5). However, we have shown that each frame expresses this categorization in different measure, making the distinction not so sharp in certain cases.

For example, the environmental frames cover very different gradations of green, environmental thought, making it more appropriate to talk about "environmentalisms" rather than generalising to one general category. The frames we uncovered vary from deep green frames, like the ecotopian, to the mild liberal environmentalism or the authoritarian prescribed environmentalism. The *ecotopian* frame has a general ecological outlook, characterised by a biocentric outlook, the call for simplicity and the belief in ecological utopias, such as small sustainable energy communities. The key for radical change is the personal ascription of responsibility of the effects of human behaviour of nature, such as (energy) consumption. Technology may help in supporting a change that needs to be societal. The *prescribed environmentalism* envisions the same direction of change but encompasses the possibility of a technical fix and expects a clear governmental intervention to guide the technological innovation. Finally the milder environmental frames, like the *liberal environmentalism*, are more cautious than the greener in wishing radical change. The conflict between human activity and nature, between economy and environment (Dryzek 1997) has been solved in the *liberal environmentalism*. Pragmatism and moderation characterises these types of frames.

The promethean frames (Dryzeck 1997) differ substantially from the environmental frames (chapter 5, §5.2). As in previous literature, the promethean frames are characterised by the minimisation of the environmental issues, the anthropocentric vision of nature, the priority

of economic growth over other issues, and the trust in the market and in technology (Adger et al. 2001; Dryzek 1997; Dryzek and Goodin 2009; Williams and Millington 2004). Notably, we found the promethean frames across the lay-citizens, while literature suggests the promethean outlook to be more typical of the policymakers than lay citizens (Dryzek and Goodin 2009). The promethean frames, as we found them in our data, are substantially satisfied with status quo, and do not feel the need of a societal change. The problems, if any, will be solved, through innovation as it always happened. The *liberal* and *technocratic* factors best fit the promethean frames. However, the distinction between the promethean and the non-promethean frames is not as sharp as it might appear. The ranking of the statements shows variation over the promethean theme, such as for the technocratic frame, which unlike the *liberal* frame, expects the government to take the lead and intervene in the market. Further variation over the promethean theme can be found in the *market-driven sustainability* (Italian factor 2) and the *liberal environmentalism* (Dutch factor1). The ranking of the statements as well as the correlations show that these four factors present many similarities.

Finally, knowing that the Q methodology is not apt to identify preferences, we reflected and speculated over the different solution space boundaries, identified through each peculiar problem definition (chapter 5, §5.4). We made plausible that hydrogen may fit as well as clash with these solution space boundaries. For instance, hydrogen could be framed as an ecotopian technology. Hydrogen produced through fossil fuels is considered as an option in the first phase of the hydrogen transition (e.g. Clark and Rifkin 2006, Agnolucci 2007). However, fossil-hydrogen might be deceiving from an ecotopian point of view. Taking another example, the transition towards hydrogen may need a public-private partnership and commitment from the public

institutions (e.g. Hisschemoller et al. 2006, Clark and Rifkin 2006, Agnolucci 2007). The hydrogen advocates might find public support to endorse the governmental commitment in the authoritarian frames (e.g. prescribed environmentalism or the technocratic) as well as opposition in the liberal frames (e.g. liberal and liberal environmentalism).

In conclusion, after this study, we arrived to a more nuanced and more extensive picture than the one emerging from the previous studies on public acceptance of hydrogen. We can picture a heterogeneous image of the public, were people have different and somewhat elaborated points of view. These points of view suggest different ways of envisioning hydrogen, indicating which hydrogen system may be more or less acceptable, by whom and why. The variety of frames, especially the promethean ones, invalidate the idea of a unified risk-adverse public and of the public as 'a barrier to overcome'.

Acknowledging the variety of frames could be normatively and strategically relevant when dealing with hydrogen and other emerging technologies, as opposed to the tendency sometimes diffused in certain policy, politics or research environments to treat the public as homogeneous. It might help avoiding reductionism and misleading assumptions. For example, assuming that the public is 'green' may be a misleading generalization because there are different environmental frames, which may embed different hydrogen systems. Moreover, disregarding the other points of view may lead the experts to favour only part of the public over the other, with the result of creating feelings of exclusions and potentially resulting into unpractical decisions. Hence being aware of the variety of frames in the public may allow inclusion and increase the fairness of the process. Last but not least, the actors may seek support of subgroups in the public and use this in the arena.

These could be some of the advantages of looking at the public as heterogeneous instead of an indistinct unified mass.

In conclusion, as we argued in chapter 1, hydrogen is an unstructured problem that requires the exploration of the stakeholders' values in order to find a common solution space. Here we proposed a method, the frames and the Q methodology, we explored these values in the public and we showed the results.

## 6.5 Possible uses of the frames

The results of this study show that the citizens share different worldviews, beliefs and values identifiable in distinguished and coherent subgroupings, defined in this study as frames. Through the citizens' frames, we identified different problem analyse, which define diverse and sometimes contradicting solution space boundaries. The variety of the hydrogen systems may fit to different extent these boundaries. The frames confirm that the public is heterogeneous and that there is no straightforward answer to the question of whether hydrogen will be accepted, yes or no. In chapter 1, we criticized a certain deal of the public acceptance literature in the hydrogen case, which had reductive assumptions on the public. Our findings confirm that there is much more in the public, and that it might be relevant to consider it when exploring public acceptance of hydrogen.

We suggest three ways in which the frames could be used, and we will now elaborate on them.

**Generate new hypothesis and finding robust alternatives through the frames.** The frames we found don't give specific indications on the citizens' preferences towards hydrogen. However, the

frames are still useful to indicate the people that might look at hydrogen differently because of their worldviews, beliefs, and values.

We explained above (and in Chapter 1) that the complexity of exploring public acceptance in the hydrogen case is three-folded, due to 1) the lack of knowledge of the citizens; 2) the lack of a public alarm on hydrogen 3) the absence of hydrogen implementations as well as the variety of possible implementations of hydrogen; and 4) the heterogeneity of the public. Assuming that there is a relation between the frames and the actual preference towards hydrogen applications, through the frames we can generate new, more specific hypotheses on those preferences. The frames could be used for example to generate new hypotheses on which (sets of) beliefs are connected with intention of behaviour or hydrogen preference. For example beliefs on progress, energy security, or an anthropocentric outlook could be somehow linked to willingness to pay, certain risk perceptions of hydrogen or to the preference towards specific hydrogen scenarios. Hence the frames may help in designing more detailed models of drivers for acceptance or rejection of hydrogen options.

Moreover, the frames could be used to identify a common solution space. Hydrogen scenarios could be designed in order to fit this common solution space. In other words, the frames could be used to design robust hydrogen scenarios, namely scenarios that are 'acceptable' (at least in theory) by the public, despite their differences in points of view. Before being used, however, the link between frames and hydrogen preferences should be tested through quantitative tools.

However it is still to be explored to what extent research on *expressed* preferences may shed light on the *effective* preferences that the citizens may have on hydrogen when faced with actual implementations. Moreover, the problem remains for these type of studies, to deal with

the other two complexity dimensions of the hydrogen case, namely how quantitative tools 1) may deal with the respondents' lack of knowledge; 2) how the variety of hydrogen technologies may be *squeezed* in a quantitative research tool (like a questionnaire).

We can think of two other ways to use the frames.

**Anticipatory mini-publics and discursive representation through the frames: direct engagement of the citizens.** Decision processes concerning new technologies (especially controversial technologies) often make use of deliberative exercises involving directly lay-citizens. Citizen juries, consensus conferences, citizens panels are just a few examples of such deliberative exercises. In general, these exercises involve a small number of lay citizens, namely citizens that are not necessarily knowledgeable on the topic of discussion, or professionally involved or have a history of political activism. These are known as mini-publics, and they are gathered in order to be informed, reflect on specific topics and generate a set of recommendations to decision-makers.

Some authors (Warren 2009, MacKenzie and O'Doherty 2011) suggest that mini-publics could be particularly useful to get insight in the potential political dimension of future issues. Future issues are issues that are potentially controversial but not yet present. Warren defines these as anticipatory mini-publics. What distinguishes the 'conventional' mini-publics to the anticipatory ones is that the public does not have an interest yet in the issue and public opinion is not yet organized (Warren 2009).

MacKenzie and O'Doherty argue that mini-publics are particularly indicated, or even normatively required when technical issues affect values maintained by the citizens (as we argued to be in the hydrogen

case, see chapter 1). Mini-publics applied to future issues offer the opportunity formulating "… policies that are more sensitive to a wider range of public concerns, and thus help to decrease the likelihood that potentially controversial issues will become politically explosive" (MacKenzie and O'Doherty 2011)

Hydrogen and its acceptance has the characteristics of a future issue. Hence it would be interesting to employ mini-publics to anticipate which issues might arise with hydrogen from the point of view of the citizens. For example, we can think of confronting the mini-publics with the hydrogen scenarios, a little bit as we did it in the focus groups but in a more structured way, for instance having experts and advocates discussing pro, cons and risks and answering questions. Such mini-publics could offer insight of 'what public opinion would look like, if it were informed and deliberatively developed' (Warren 2009), and in this sense, this type of mini-publics have the potential to anticipate public acceptance of hydrogen.

In mini-publics, the citizens are often assembled from a pool of randomly selected participants, and selected according to their socio-demographics (e.g. age, education, gender, ethnic group, etc) as indeed, miniature (mini) publics. The socio-demographics selection aims at representing as much as possible the diversity of the social characteristics and plurality of initial points of view (Goodin and Dryzek 2006).

Arguably, our conceptualization of the frames, as well as the methodology we used to elicit them, may serve the goal of identifying the variety of points of view (or discursive representation as defined by Dryzek and Niemeyer 2008), better than the socio-demographic characteristics. For example, in the hydrogen acceptance case, frames could help in designing anticipatory mini-publics, constituted by citizens

with different views on hydrogen technologies. We consider this to be one of the main contributions of our work.

In these studies where discursive representation has been actually applied, it is shown that discursive representation allows the participation of stakeholders beyond the usual suspects, giving voice to minority points of view (Cuppen 2009, Cuppen 2012; Cuppen 2012b; Cuppen et al. 2010). With the appropriate adjustments, which will be more elaborately discussed in sections 0 and 0, the concept of the frames and the Q methodology could be used to ensure the necessary variety in mini-publics addressing the future of issue of public acceptance. The frames and the Q methodology would allow the selection of citizens covering a certain variety of worldviews, despite the lack of organized public opinion as typical in future issues like public acceptance of hydrogen.

Discursive representation might be more interesting than a randomly selected sample of participants for a set of reasons, such as a) when the frames correspond to different preferences towards the hydrogen systems, then discursive representation may allow a 360 degree confrontation on hydrogen; b) when the goal of the mini-public is to anticipate issues linked to public acceptance beyond safety, such as why hydrogen should be realized how and by whom, or trade-offs between costs and benefits, the frames may help in bringing a diverse set of values into the discussion; c) perhaps the frames may allow to follow the dynamic of public acceptance, defined as how the frames change and evolve when they interact or when new information and arguments appear; d) in line with point c, it could be interesting to observe whether the frames have roles in the discussion, or if they change the power balance in the actor arena. For example, could it be that the ecotopian frames push towards change and innovation by setting higher standards

and discussing the fundaments of our society? Or that the promethean frames are those who support the (promethean) decision-makers? And more, could it be that, as proposed by other authors (de Geus 1999, Dryzek 1999), the possible tension between the ecotopian and the promethean frames is solved by the intermediate positions, such as the practical environmentalism?

We can think of a process-oriented approach to the anticipation of public acceptance, where several deliberative exercises are organized over time, and structured accordingly to the stage of the discussion and the development of hydrogen and structured accordingly, for example from a general anticipatory discussion in the very early stage to planning and risk assessment in a later stage.

Nonetheless, it is still a matter of further research to prove the usefulness and added value of the frames and Q methodology to select participants of anticipatory mini-publics in cases like public acceptance of hydrogen. We will come back to this discussion in the section dealing with further research propositions (section 0). Before that, we will propose another possible use of the frames and Q methodology in a qualitative approach of public acceptance.

**Stakeholders' processes that represent the frames of the public: indirect engagement of the citizens through representation.** If, for any reason, the direct involvement of the citizens is not an option, there might be two other ways to bring the voices of the public into the process since the very early stage of hydrogen development.

As we explained in chapter 1 (section 1.5) other deliberative methods can be used to engage stakeholders in reflective exercises on technology. We have two examples in the hydrogen field, namely the work of McDowall and Eames (2007) and Cuppen (2009) van de Kerkhof

et al. (2009) who used respectively the scenario appraisal technique and the repertory grid to assess stakeholders' perspectives on a set of hydrogen scenarios. The difference here is that the stakeholders are 'professionals' rather than lay citizens. Citizens are also stakeholders, but the difference we stress here is between a citizen having a stake in an issue because he is affected by it, for example because he may one day drive a hydrogen car; and a stakeholder who is involved in the issue because of its profession for instance, somebody representing the interest of a company producing hydrogen cars; but also, we stress the difference between a normal citizen and somebody whose profession is to represent the citizens' interest, like somebody belonging to a consumer association or an environmental NGO's.

We can find many other examples in the literature of similar deliberative exercises, involving professional stakeholders. It is common practice in this type of exercises to involve professional stakeholders according to the actor type (for example, 'governmental institution 'or 'knowledge and research') or to their interest in the issue. The goal of the stakeholder selection is usually to grasp and represent variety. However, when it comes to represent 'the public' or the broader 'societal aspect', researchers often opt for a set of NGOs, e.g. an environmental and a consumer association, the usual suspects.

We already mentioned the case of Cuppen (2009) who used discursive representation to select participants instead of the conventional selection criteria. When, like in Cuppen's case, only professional stakeholders are the targets of the deliberative exercise, we propose our frames as a way to indirectly bring the voice of the public in the process. Our study offers the means to grasp the variety of public perspectives. The frames and the Q methodology represent a way to map the public voices. This map could be used as a reference point to

select participants in a stakeholder dialogue. In this way, the representation of the public voices could be another criterion for stakeholder selection, to complete the criteria of *diversity* and *balance*, defined by Cuppen's approach (2009 and 2010). For example, based on our results, we know that an environmental NGO would potentially represent only one type of frame of the public - the environmental frames and not the promethean. To be more precise, an environmental NGO may only represent a limited set of environmental frames, for example only the ecotopian – it would probably depend on which environmental NGO is considered. Our results may help in finding which other stakeholders may represent the other citizens' frames.

The frames could be used to discursively represent the public in a professional stakeholder dialogue. However, in this case, discursive representation is stretched a step further, not with lay-citizens representing lay-citizens' points of view e.g. in a consensus conference, but with professional stakeholders representing citizens' points of view e.g. in a back-casting exercise.

Another way in which the frames and Q methodology could be used is that of setting the discussion agenda; in other words, the content of these stakeholder dialogues may be organized in a way that it represents the variety of perspectives of the citizens. The idea is inspired by the work of van Eeten (1999) who proposed that including a variety of perspectives and matching solution alternatives may help in overcoming policy deadlock. In other words, even when there are fundamental incompatibilities in the perspectives, still there is a chance to agree upon intermediary solutions. In this line several authors (like Dryzek and Goodin 2008; Stirling 2008) argue that intermediate positions may help in *opening up* the discussion and find middle ground in controversial issues. For example, the frames could be used to design

robust hydrogen scenarios from the perspective of the citizens and the scenarios could be used in a back-casting exercise. Or, in a multi-criteria appraisal, the criteria could be chosen also in order to represent the citizens' frames, because each frame has its own. Sure enough, in order to do that, it might be useful to first test the hypothesis of the actual link between frames and preferences towards the hydrogen scenarios (in the next section we propose solutions for that).

Using the frames to structure the content of a stakeholder process is once again a way to stretch the concept of discursive representation of Dryzek and Niemeyer, by applying it to the content of the deliberation rather than the participants.

## 6.6 Afterthoughts on the conclusions and suggestion for further research.

The first conclusion we draw is that, if not the complete variety, we elicited *a* variety of frames, which are likely to be present in the wider population. In order to definitively answer this question it would be necessary to conduct a quantitative study, with a statistical representative sample of respondents, inquiring in which measure the frames we identified are diffused in the population. This could be done in different ways. Example of this type of study can be found in Niemeyer 2010, Danielson 2009, Baker et al. 2010 and Kroesen et al. 2011.

With this type of quantitative study however, we still wouldn't be able to say whether there are other frames diffused in the wider public that we weren't able to grasp due to insufficient data, namely if we overlooked fundamental Q statements and/or participants. In order to address this important issue it would be necessary to first, conduct other focus groups, this time balancing both Italian and Dutch participants, and

perhaps trying other sampling methods (e.g. randomly selected participants or pool participants from different geographical areas) and second, to conduct several Q studies in each country, rather than only one in each country.

Having more Q data, would also allow a more meaningful cross-cultural comparison between the countries. As a matter of fact, we chose not to elaborate on the intercultural comparison as now we have insufficient data to conclusively attribute the difference in the frames to a cultural disparity.

Nontheless the comparison of the two sets of results offers some interesting inputs for further cross-cultural research. For example if we compare the greener of the Italian environmental frames, i.e. the Ecotopian and the greener of the Dutch environmental frames, i.e. the Prescribed environmentalism, we can see that both promote the achievement of a sustainable energy system, for example through the decentralization of energy production, i.e. local production and usage of local energy sources. Interestingly, however, while the Italian Ecotopian frame is more focused on societal change, (e.g. consume less) the Dutch frame is more focused on technological change (impose the transition to new technologies). Are these frames two culturally different expressions of the 'ecological utopias' (de Geus 1999), or are these two fundamentally different frames? For example are these frames the reflex of two national environmental discourse, the Italian being still centred around the dilemma between technology and nature, economy and environment, and the Dutch environmental discourses being passed that point by recognizing the economic benefit of green technology (de Geus 1999, Dryzek 1999)? Or is an Ecotopian frame also diffused in the Netherlands but we just didn't find it in our data set? Also, the Ecotopian frame put the responsibility on citizens, which should on their own push

for the change and take responsibility for the energy production. The Dutch prescribed environmental frame instead, charges the government for the responsibility of the transition, the government should steer the change (that is why it is 'prescribed' environmentalism). Would this difference reflect a different level of trust in the government, with the Italian citizens being so distrustful of the institutions to feel the need of taking things in their hands, unlike Dutch, who are so trustful and satisfied with the institutions to have no problem in delegating? These are just examples of what kind of questions could be tackled by collecting more data.

As we suggested before, future research should also address the issue of quantitatively linking frames and hydrogen preferences, since a lack of correspondence between the two may affect the extent of the contribution of this study and the possible applications of the frames and our methodological approach. Also it might be interesting for future research to explore how stable the frames and preferences towards hydrogen are and how they evolve when people are confronted with new information, events or with other frames.

We proposed a set of possible contributions of this study to the study of public acceptance of hydrogen. Based on the richness and quality of insights that the focus groups and the Q methodology were able to give on the citizens' points of view, we advance the hypothesis that the implementation of qualitative-intensive research tools could be more fruitful to anticipate public acceptance than the conventional quantitative-extensive tools, such as questionnaires or opinion pools (see also § 0). We mentioned the anticipatory minipublics and deliberative exercises as example of these qualitative-intensive research tools. We propose discursive representation through the frames as a way to structure them.

One may argue that the results of the anticipatory mini-publics may be confined only to the context in which they emerged and therefore hard to generalize; or that mini-publics pose the issue of intergenerational justice (how can present generations fairly deal with issues that regard future generations?), or one may think that deliberative processes are costly and work only an ideal world. These remarks are important and debatable.

However, when the goal is to anticipate public acceptance before the occurrence of a public acceptance issue, still the question remains whether quantitative methods are more reliable in giving insights (§ 0). Considering this unreliability, rather than employing quantitative methods, perhaps it would be more convenient to simply treat public acceptance as an external, uncertain factor.

We proposed three possible applications of the frames to realize discursive representation by a) citizens discursively representing citizens in anticipatory mini-publics b) 'professional' stakeholder discursively representing citizens in reflective processes c) setting the process agenda in order to discursively representing citizens in stakeholders' reflective processes. It would be important for future research to address the effectiveness of these three forms of discursive representation, as well as of the added value of deliberative processes in dealing with future issues like public acceptance of hydrogen or other potentially controversial future technologies. Would it work? And how? Would it be cost effective? Future research could employ for example longitudinal studies as well as comparative studies, as sort of quasi-experimental design to compare outputs of different deliberative processes (e.g. engaging lay citizens and professional stakeholders) using different selection methods (e.g. discursive or demographic representation) and with respect to extensive quantitative studies.

The reflection of the application of the Q methodology to elicit frames deserves some more space and it will be treated separately in the next section.

## 6.7 Methodological issue: Q methodology out of its comfort-zone, more questions than answers

This section is dedicated to the application of the Q methodology in this study, giving particular attention to the methodological aspects that remained open after this study and, in our opinion, deserve future research.

In this study, we stretched the boundaries of the Q methodology in at least two ways.

Q methodology is usually employed to identify discourses in an ongoing discussion. As we explained in chapter 3, the researcher retrieves the concourse from different sources, such as newspapers, meaning that the discussion is 'present in society', it is 'happening'. In an ongoing discussion, the researcher has more indications of the content of the discussion, what might be the relevant perspectives, who to include in the P-set and whether these persons have sufficient insight in the topic to offer a relevant point of view. For example, Watts (e.g. Watts and Stenner 2005), who was interested in having more methodological insights in the Q methodology, chose to explore people's perception of love. 'Love', Watts[1] explained during a workshop, is a 'safe topic' from a Q methodological point of view, as everybody is likely to have a subjective idea of love. This could be defined as the comfort zone of the Q methodology. In its comfort zone, the quality of a Q study is then ensured by the representativeness of the sample of statements and by

[1] Q methodology workshop at the Q methodology conference 2011 in Birmingham.

an adequately varied set of participants (P-set) that will sort the statements.

In this study instead, we applied the Q methodology to a discussion, energy and hydrogen, which is not yet 'present' in the public sphere. Therefore, in this study we applied the focus groups and the Q methodology to construct a concourse and points of view. We had few indications of the extent of the topic, which people might have been relevant for the P-set, whether we would have had consistent points of view and whether we would have obtained relevant and meaningful results.

Second, we attempt to elicit a latent frame defined as a problem definition and a solution space, in the context of the same Q sort. We had on the one hand multiple hydrogen scenarios and on the other hand the set of reasons and arguments embedding the preference towards these scenarios. Instead of keeping the preference and the arguments separated, we chose to merge the two types of statements into one concourse and conduct one Q study. However, as Brown (1980) explains, the Q methodology is not apt to elicit preferences. Preference identification is the territory of conventional statistical, quantitative studies.

Because of these two choices in this study we pushed the Q methodology outside its comfort zone. What did we learn from this stretching of the methodology?

We were able to elicit a certain variety of viewpoints. These viewpoints are consistent, usable and offer insights on the possible preference towards the hydrogen systems. Many participants reflected on the statements while Q sorting. For example one participant, at the end of the sorting exercise, commented "thank you, I didn't know that this was my point of view!". Arguably, it is possible for the participant to

construct his own point of view through the Q methodology, provided the statements are formulated in such a way that one can reflect and give an opinion on them while Q sorting. Therefore, in principle it is possible, although complex, to apply the Q methodology to construct points of view that are not yet 'present'. The complexity is due mostly to the lack of 'reference points' in the definition of the concourse and in the selection of the P-set.

The relation between the preference towards the hydrogen systems and the embedding frames is instead less convincing. The Q statements were designed in order to reflect on the one hand the hydrogen systems and the variety of related technologies (e.g. primary energy sources necessary to produce hydrogen, or centralized/decentralized systems) and on the other hand the underlying beliefs embedding these systems. We were expecting to identify, through the Q method, specific hydrogen frames. Instead we elicited a set of more general frames, in which the relationship between the hydrogen preference and the underlying beliefs can only be inferred and hypothesized. One of the reasons why we did not meet these expectations could be attributed to the fact that, perhaps, we stretched the Q methodology too much, passing the limits of its applicability. When a statement such as "Nuclear energy is a good solution for the environmental issue" results in a 'most agree' order in a Q factor, we have no way to establish whether nuclear energy is the most preferred technology for these people grouped in that factor, compared to other technologies, such as solar, mentioned in the other statements. This is why it might be difficult to elicit through the Q method a frame with a specific preference, especially when applying the Q methodology to a discussion that is not yet present in people life, such as we did with hydrogen.

Hence, in retrospect, we expect it would have been better to distinguish between the preference (the hydrogen scenarios) and the embedding discourse. For example, in his work, Niemeyer (e.g. Niemeyer 2011, Niemeyer and Dryzek 2007, Ashworth, Littleboy, Graham and Niemeyer 2010) proposes to the participants two sets of stimuli, the Q statements to sort on one hand, and a set of alternatives to rank-order according to the preference on the other hand. Successively both the Q sorts and rank-ordered preferences are correlated, establishing statistical relationships between the two. This type of method would have been possible and perhaps more appropriate in our case too. We could have used the Q sort and the set of drawings representing the hydrogen scenarios asking the participants to rank order them. On the other hand, this approach would have required more attention to the visual representation of the scenarios, in order to have more control over the ranking of the drawings, e.g. avoiding that participants rank order the scenarios because of the nice colours or because they like the drawings rather than what they represent.

Another way to elicit more specific hydrogen frames could be that of organizing another set of focus groups or, more interestingly, an anticipatory mini-public more directly focusing on hydrogen. In both ways the conversion would be more structured and even more focused on hydrogen than how we did in our focus group. This would be possible because, thanks to our study, we now have enough information on the more general context surrounding hydrogen as well as enough material (the frames and the Q set up) to structure the discussion and select participants in order to gather a variety of points of view. The discussion of the mini-public could be used to define a concourse, this time more specifically focused on hydrogen and related issues, and hence to assemble a more specific Q sample than the one we gathered in this study. This more specific concourse/sample could be employed in a new

Q study to elicit specific hydrogen frames in the larger population (i.e. citizens who did not participate in the deliberation process).

At a more theoretical level, perhaps it would be interesting for future research to further inquire the link between the frames and core personality traits. For example, Hoppe (2007) and Kroesen et al. (2009b) move towards this direction, linking Q factors to the four cultural theory types (Douglas 1978, Douglas and Wildavsky 1982). In general we find the idea of connecting the Q factors to people more interesting than only describing shared discourses.

A last set of questions, which deserve some attention, relates to the replicability, validity and generalizability of the results of a Q study. When the aim of a Q study is for example, to develop policy alternatives, to select participants of a deliberative process or to structure such a process; it is relevant to consider questions such as, how would the factors change when choosing a different sample of statements, or a different set of participants or when adding new Q sorts to the set of data we already have.

A common way to deal with these issues is to treat a Q study as a qualitative study, which could hardly be generalized and therefore is aiming at giving intensive insight rather than extensive results. However, we think that the Q methodology could potentially be broadly applicable.

In principle it is plausible to think that a thorough Q study could represent a confined population of point of view. Everything starts with the assumption that, given a defined topic, there are not infinite points of views on a certain topic, but rather only a limited set of ways of thinking about it. We offered a set of arguments to support the claim that the frames we identified are likely to be found outside our sets of participants, in the larger population.

Some authors (Brown 1993, Fairweather and Rinne 2012) argue that the factors are already abstractions of individual points of view, as no one person will provide a Q sort that is exactly like the Q factor array, which is the generalization based on the response of several people.

A thorough Q study is defined by a sample of statements and a set of participants that allow the variety of points of view to emerge. Brown (1980) argues that given a theoretical selection of the sample (i.e. a selection dictated by a set of theoretical criteria as we described in section 4.2), any other sample with comparable characteristics should produce comparable factors. Hilden (1958) shows that a sample of 50 statements drawn randomly from a universe of more than 1000 statements will produce the same results, supporting the idea that a Q sample that is representative of a concourse may be as good as any other.

With respect to the set of participants, Brown (1980) argues that when the P-set characteristics are defined, it doesn't matter who is selected as far as it fulfils the criteria and the overall P-set is balanced. Thomas and Baas (1992-1993) showed through two Q studies that variation over the sample of statements and the P-set produces comparable results. To the best of our knowledge, this is the only study that addresses these issues.

It would be interesting to support these encouraging results with more systematic studies. For instance, future research may quantitatively compare the results of different Q studies using similar or different ways to select the P-set.

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# Appendix A: Information sheet for the focus group mediator

RESEARCH GOAL: collect people's opinion on energy, energy issues and hydrogen technology
GOAL PART I: generate opinions and beliefs on energy and sustainability (problems, responsibilities and actions)
PARTICIPANTS TASK: a) discuss on the topic proposed by the mediator, b) give their opinion based on their experience, their norms, their feeling c) there are no correct or wrong answers
PARTICIPANTTION RULES: talk among each other, try to avoid involving the mediator, everybody speaks one by one, do not monopolize the conversation.
MEDIATOR ROLE: a) natural observer = do not correct misinformation, answer direct questions as less as possible (always turn them back to the group) do not give opinions, b) facilitate the conversation (the process, avoid monopolization, disregarding and other inadequate behavior of participants, stimulate the silent persons), c) avoid the group to go out of the focus and explore as much as possible the focus (try to let talk also about secondary topics or topics that proposed by the minority of the group).

**PART I: open discussion on energy**
In the following pages the mediator can find the points that have to be addressed during the focus group (1. 2. 3. 4.) some suggestion of how to address them and

**INTRO:** (5 min max)
(thanks, rules, permission for recording, questions)

**2. WARM UP**: mind map on energy (write on a flipchart or on a whiteboard) (max 3 min)

**3 Question**: (30 min)
if they **mentioned the issues already in the WARM UP** phase: link to them: "before you mentioned X and Y, can you say something more about it"
did not **mentioned the issues already in the WARM UP** phase:
"on the white board are different way to produce and use energy. From your perspective are there any concerns, issues, related to the way energy is used and produced?"
for each issue explore Responsibilities and Possible Actions. If the group does not spontaneously talk about it ask directly:
Responsibilities (ask: who do you think is responsible to do something for this issue?)
Possible Actions (ask: what do you think should have to be done?)
4 **Question** (2 min)

**---BREAK (10 min)---**
**Focus Group Protocol PART II**
**Hydrogen scenarios, questions and opinions**
**1.** INTRO (2 min) explain task

**2. SCENARIO PRESENTATION in the following order (please don't take care of the letters):** (about 15-20 min)
**PICTURE C**

**PICTURE D**

**PICTURE A**

**PICTURE B**

**Picture I**

**Picture J**

**Picture E**

**Picture F**

**Picture G**

**Picture H**

**4. OPEN DISCUSSION** (20 min)

# B

## Appendix B: Q statements - English

1. Windmills are noisy, ugly and bad for the environment.

2. We consume too much in general. I think we should live very differently.

3. Using biomass from waste to produce energy is dangerous and inefficient.

4. There will be less and less energy available, I see that problem coming. If countries like India or China want to live like us, there won't be enough energy.

5. A single person does not think about energy, the environment or efficiency. The government should tell me what to do, they should oblige me! Even if I have to change my habits, I would vote for such a party, because in this way I will have no other choice than do the right thing.

6. The majority of oil comes from political unstable countries. We will have serious problems if the Middle East decides to close the oil tap. We should not be dependent of these countries.

7. Industries consume the most energy. They should do something it, not the citizens!

8. The government should add environmental costs to products and use this money for the benefit of the environment. I think it is fair that people pay an extra tax proportional to what they consume.

9. The government is responsible to do something about the issues related to energy. They have enough power to do something about them!

10. Science has the responsibility to find solutions for the environmental issues related to energy.

11. Price is a good way to make me more aware of something. A significant increase of the price of energy will help me change my way of energy consumption.

12. Pollution is a problem of today: the respiratory diseases are increasing because of the bad air quality.

13. People only care that energy is available: they turn on the switch and the light works, this is what people care about.

14. Nuclear energy is a good way to solve energy related issues.

15. Natural gas is clean and good for the environment.

16. Maybe we could go back to doing things locally, also with energy. It would be nice to produce energy locally without having to transport it.

17. It is difficult to change from old to new technologies, because it costs too much.

18. When you read the newspaper you see that there are all these energy issues, but in my daily life I do not notice it.

19. If you mass produce hydrogen and store it somewhere, that place will make us vulnerable for terroristic attacks.

20. If you look at the amount of people there are and how much energy we consume, I think that energy will become less easily available.

21. I would not like to have a tank of hydrogen gas at home.

22. I wish it would be possible to be completely independent of the electricity grid. I would prefer to produce energy myself at home.

23. I want to have cheap energy. I do not care where the energy comes from; I want it to be cheap.

24. I think it is not safe to drive a car with a tank of hydrogen on board.

25. I think it is morally incorrect to use energy produced from food. I would not buy biodiesel produced from corn or sunflower oil.

26. I believe that the government is reluctant in tackling issues related to energy. Some things are stimulated and some things are not. Politicians choose solutions that are politically convenient.

27. I worry that my electricity bill or refueling my car will become more and more expensive

28. I am a climate-skeptic. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption.

29. Hydrogen is inefficient: it costs a lot of energy to extract it and then to be reused again.

30. Hydrogen is not a solution for the environmental issues.

31. Hydrogen is reality in the US and Japan. We should not stay behind and invest in hydrogen too: hydrogen is the future and we should go for it.

32. Hydrogen is a good way to increase energy security.

33. Hydrogen can stimulate the diffusion of renewable energy sources because it is a good way to store energy.

34. People are more important than nature, we are at the top of the chain. We should satisfy our needs, but not completely disregard nature.

35. Government should really focus on education concerning sustainability and it's important to focus on the right things. Change starts with education.

36. Energy problems have social grounds. The technical progress will not solve the problems.

37. Consumers should be more responsible. We should understand that we can do a lot by decreasing consumption in our daily life. What a single person does is not a drop in the sea.

38. Companies like Shell already have the new technologies, but they are postponing their use. If they would put the new products on the market consumers would buy them.

39. Becoming a leader in these new technologies means becoming a leading economy in the world

40. A big advantage of hydrogen is that you can produce it directly where you want to use it.

# Appendix C: Quantitative data analysis

## C-1 The Dutch Q study

### C-1.1 The P-set:

We defined a balanced P set according to age, gender education and political preference, as much as possible: with respect to the political preference, the P-set is distributed with 14 participants voting for the 2011 governmental coalition, 18 participants voting for the opposition, 2 external, 5 participants with no political preference.

**Table C- 1 Characteristics of the Dutch P-set.** The subjects are divided per political preference (rows). Within each political cluster, we distinguish the gender, education level and average age (columns). For example the D66 party (n) includes 3 subjects, of which 2 males and 1 females, one with HBO education and 2 with university education or higher. The average age of the (n) cluster is 35

| Political preference | total | males | females | Basic education | Medium | with higher education | Average age |
|---|---|---|---|---|---|---|---|
| (g) Christelijke Partij (SGP) | 1 | - | 1 | 1 | - | - | 45 |
| (h) Cristian Union | 2 | 1 | 1 | 2 | - | - | 40 |
| (i) PVV | 1 | 1 | - | - | 1 | - | 46 |
| (j) CDA | 1 | - | 1 | - | 1 | - | 24 |
| (k) VVD | 8 | 5 | 3 | 1 | 5 | 2 | 33 |
| (l) Socialist party SP | 2 | 1 | 1 | - | 2 | - | 55 |
| (m) Groen Links | 8 | 3 | 5 | 1 | 2 | 5 | 33 |
| (n) D66 | 3 | 2 | 1 | - | 1 | 2 | 35 |
| (o) PvdA | 7 | 4 | 3 | 1 | 4 | 2 | 39 |
| (p) No preference | 4 | 3 | 1 | 1 | 2 | 1 | 41 |
| **TOTAL** | **37** | **20** | **17** | **7** | **18** | **12** | **38** |

## C-1.2 Quantitative Data analysis

In this section we illustrate the data analysis conducted on the Dutch P-set. The peculiarity of the Dutch P-set is that it was collected into two rounds. In the first round we collected 24 Q sorts and in the second round we collected 13 Q sorts, for a total of 37 Q sorts for the Dutch P-set. We extrapolated two sets of Q factors, one from each of the P sets, namely the partial P set of 24 sorts and the complete P set of 37. The comparison of those two sets of factors gives interesting insights on the Q methodology and therefore we will describe in the next subsection the full analysis.

The two sets of factors were extrapolated through the same procedure, which is described in subsection C-1.2.1; while the comparison of the two sets of factors is described in C-1.2.2. In the subsection C.1.2.3 we will draw some conclusions from this analysis.

### C-1.2.1 Extrapolation of the factors: procedure.

We conducted the quantitative data analysis by means of one of the programs conventionally used with the Q-methodology: the PQ method. Through this program we performed one of the conventional routines for the extrapolation of the Q factors. The routine we used consisted in:

I. the correlation of the Q sorts,

II. the centroid factor analysis, extrapolating a certain number of factors

III. the varimax rotation,

IV. the selection of the significant factors

However, the extrapolation of the factors is an iterative process, finalized to find a way to "cut a cake" in the most meaningful way. This means that, in order to find a set of Q factors that adequately represents the variation of the data, we explored different factorial structures, passing through steps II to IV several times.

In practice, we started by extrapolating two factors and progressively increasing the number of factors up to a maximum of seven factors. In general Brown (1980) recommends to extrapolate more factors than necessary, as the variations contained in the exceeding factors can be used for better define the other factors through the rotation. The number seven is conventionally used among the Q methodologists, probably under the suggestion of Brown (1980), who reports that the experience suggests that there are not more than 7 factors to extrapolate in a Q study. As a rule of thumb, in an average set of 35 Q sorts you can possibly find a maximum 7 perspectives (or factors), shared by 4-6 persons each. A factor with 5 loadings would make the results enough "solid". In that respect Brown (1980) argues that the factor analysis clusters similar points of view into groups, or factors. Since each point of view obviously corresponds to one person, the Q method requires as many persons as necessary to establish the existence of a factor (Brown 1980 p. 192). Brown explains that five or six persons are sufficient to define a factor. This is because factors are generalized abstractions of similar points of view. These abstractions are calculated as weighted average of these similar points of view. Five or six points of view significantly similar are usually sufficient to produce a quite reliable abstraction (or factor) so that adding other similar points of view to that factor would be redundant.

In our analysis, we extrapolated successively 2, 4, 5 and 6 factors in the P-set of 24 Q sorts. The number 5 is chosen through the rule of thumb that, with 24 Q sorts there will be a maximum of 5 perspectives shred by 4 – 5 people. The number 6 is chosen following Brown's suggestion of extrapolating more factors than necessary. Following a similar line of thinking, we extrapolated 2, 4, 5 and 7 factors in the P set of 37 Q sorts (5 Q sorts x 7 factors = 35 Q sorts).

In each round, only the significant factors have been selected for further analysis. For example, in the P-set of 24 Q sorts, the extrapolation of 4 factors produced 3 significant factors, the extrapolation of 5 factors produced 4 significant factors, the extrapolation of 6 factors produced

also 4 significant factors, and so forth. The significance of the factors is established on a set of general rules suggested by Brown (1980):

✓ Include only factors that have Eigenvalue (EV) in excess of 1. However Since Eigenvalues are the result of the sum of the square factor loadings, therefore it increases when the number of subject is increasing. Considering the percentage of explained variance (%ex.v.), which is also depending on the number of variables (in our case the number of Q sorts) but in an inverse way in respect to the Eigenvalues, as % ex.v. = 100 (EV/n) where n indicates the number of q sorts;

✓ At least two significant loadings per factor, Brown (1980 pg 280) demonstrates that correlations exceeding 2.58 the standard error (SE) carry a 0.01 significance, while correlations exceeding 1.96(SE) carry a 0.05 significance. The SE is calculated according to the Guilford-Lacey expression (Guilford and Lacey 1947 in Brown 1980 pg 283): SE= $1/\sqrt{N}$; where N is the sample size, i.e. the number of statements in the Q study;

✓ Humphrey's rule, stating that a factor is significant when the cross product of its two highest loadings exceeds twice the SE,

✓ Less strict application of the Humphrey's rule where the significance is lowered to exceed only once the SE,

In order to find the most appropriate factorial structure we compared all the significant factors, as illustrated in the next subsection.

### C-1.2.2 Choosing the factorial structure: comparison of the factors.

Each factor represents an ideal Q sort, resulting from the average of the Q sorts loading in that factor. The average is weighted according to the loadings (Brown 1980). This means that it is possible to reconstruct the factor array (i.e. a Q sort) for each of the factors extrapolated. The factors arrays can be further correlated, to identify similarities across the factors.

Figures C-1 and C-2 show the relationship between the significant factors extrapolated respectively from the intermediate set of 24 Q sorts and the complete set of 37 Q sorts. The arrows indicate the correlations. Note that, according to the above described Brown's rule, in our study a correlation higher than 0,41 has a 0.01 significance. Moreover, Browns (1980) shows that two Q sorts resulting by one person sorting the same set of cards twice, will have approximately a correlation of 0.80 or higher.

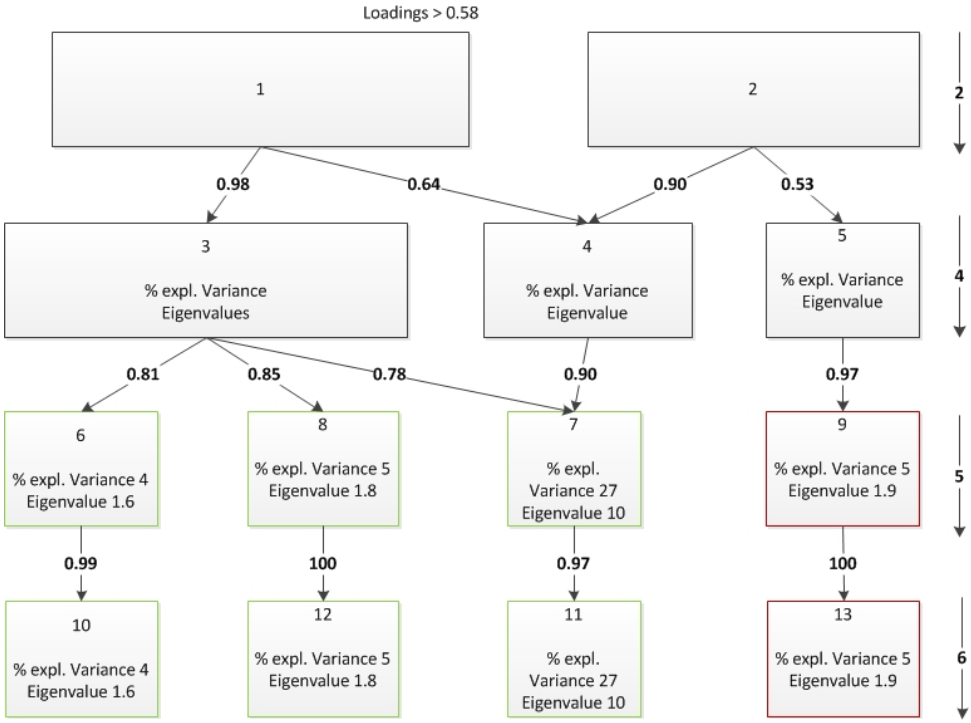


**Figure C- 1 Evolution of the factorial structure in the 24 Q sorts P set.** Each square represents a factor. Each line represents a set of significant factors, extrapolated by performing several centroid factor analyses asking for a progressive number of centroids, namely 2, 4, 5 and 6. The arrows indicate the correlations.

Bearing this in mind, we can consider for example, the first line of figure C-1, which shows a model with two significant factors, extrapolated from the intermediate set of 24 Q sorts. Those two factors are further define in 3 significant factors (factors 3 – 5, second line of figure C-1) extrapolated from the same 24 sorts by asking 4 centroids. Five centroids produced 4 significant factors ( fators 6 – 9, third line of figure C-1). The correlation indicates that factor 9 is practically identical to factor 5. Factor 7 is very similar to factor 4, but takes also variation from factor 3. Factor 3 is further divided in factors 6 and 8. Correlations indicate that the factors 10 – 13 are practically identical to factors 6-9. This data suggests that no further significant factors can be extrapolated from this data set. Notably, factor 13, marked in red, is practically identical to factors 5 and 9, suggesting that this perspective clearly emerges from a 3 factor structure and remain almost unvaried across the different factorial structures.

With a similar reasoning, we can seein Figure C-2, how the factors in the complete P set of 37 Q sorts, evolve from 2 to 5.

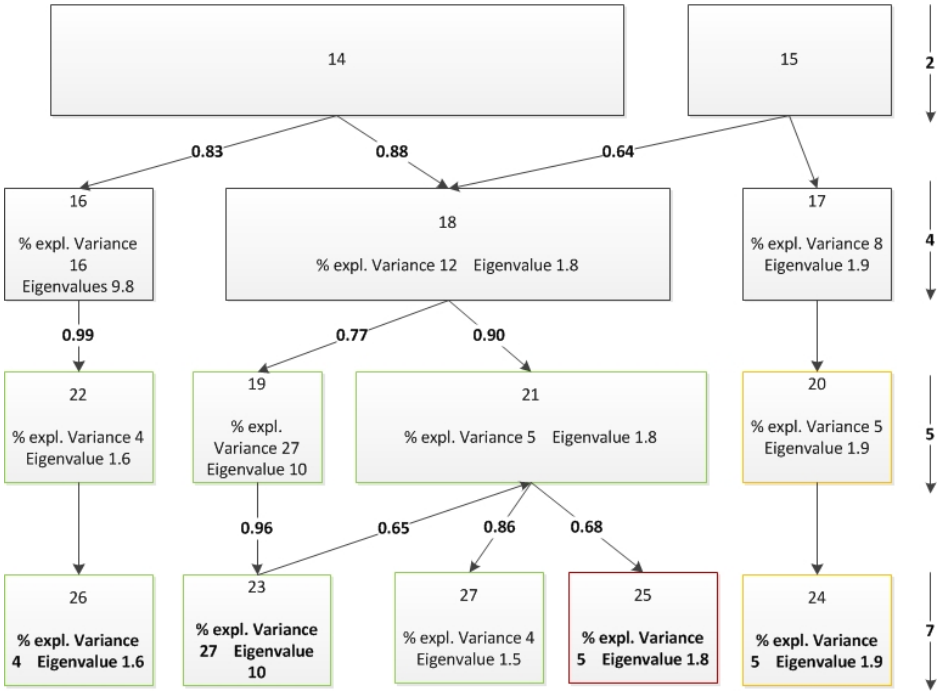


**Figure C-2 Evolution of the factorial structure in the 37 Q sorts P set.** Each square represents a factor. Each line represents a set of significant factors, extrapolated by performing several centroid factor analyses asking for a progressive number of centroids, namely 2, 4, 5 and 7. The arrows indicate the correlations.

The correlations among the different factors extrapolated in the various factor analysis show that one of the two basic factors (15) practically remain the same in all the factorial structures (factors 17, 20 and 24, marked in yellow). The other basic factor (14) instead is further divided in smaller and more defined factors. From the first to the second level factor 14 is divided into 2 factors. In the third level part of the variance given by the many sorts that were not loading in any of the 4 factors is recovered and redistributed so to create a 4 factors structure. At this point extrapolating more factors (7) does not add anything further: the structure stabilizes itself in a 4 factors model, explaining the 41% of the total variance, with Eigenvalues comprised between 1.8 and 10.

As a last step of the analysis, we correlated the four significant factors extrapolated in the 24 sorts P set (factors 6, 7, 8, and 9 Figure C-1) to the five factors extrapolated from the 37 sorts P set (factors 23, 24, 25, 26 and 27 Figure C-2). This correlation will reveal interesting

information about what is actually added and what is missed by having more Q sorts.

Table C-2 shows the correlation between the four significant factors extrapolated from the P set of 24 sorts, and the five significant factors extrapolated from the P set of 37 sorts. We remind that we obtained the more extensive P set by adding other 13 Q sorts to the previous set of 24 Q sorts. The correlations suggest that:

- Three factors remain practically the same in both P-sets, namely factor 23 ≈ 6 (r = 0.93), factor 25 ≈ 9 (r=0.95) and factor 27 ≈ 8 (r= 0.94);
- One factor register a certain variation, namely factor 26 is similar to factor 8, with a correlation coefficient of 0.72; interestingly the changes from factor 8 to 26 concern the "magnitude" of the ranking (e.g. ranking value changes from 1 to 2) but not the direction of the ranking (e.g. no changes from -2 to +5), suggesting that the perspective did not change substantially in content
- One new factor emerges, factor 24, which is particularly dissimilar from the other factors, especially from factors 7, 8 and 9, as indicated by the relatively low correlation coefficients. These data suggest that factor 24 is a new outstanding factor, emerging from a larger data set.

| factors | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|
| 6 | 0.52 | **0.42** | 0.26 | **0.72** | 0.57 |
| 7 | **0.93** | **0.21** | 0.39 | 0.36 | 0.50 |
| 8 | 0.56 | **0.25** | 0.41 | 0.48 | **0.94** |
| 9 | 0.36 | **0.12** | **0.95** | 0.23 | 0.37 |

**Table C- 2 Correlation between the factors extrapolated from the two P sets of 24 and 37 Q sorts.** Factors 6 to 9 are the significant factors extrapolated from the 24 Sorts P set. Factors 23 to 27 are the factors extrapolated from the more extensive P set of 37 Q sorts. We remind that we obtained the more extensive P set by adding other 13 Q sorts to the previous set of 24 Q sorts. The colors of the correlations correspond to the colors in which the factors are marked in figures C-1 and C-2.

Based on those information we can chose and discuss the most appropriate factorial structure to represent the Dutch data set (subsection C-1.2.3)

## C-1.3 The final factorial structure for the Dutch data set: discussion and conclusion

In the previous section we explained that the significance of the criteria is based on the Eigenvalues, the number of significant loadings and Humphrey's rule (more or less strictly applied). When looking at our 5 factors model (Figure C-2) we can see how the Eigenvalues are in all five cases higher than 1, although in 4 factors over 5 they amount up to a maximum of only 1.9. However, the Eigenvalues strictly depends on the number of Q sorts and their loadings. For example, with 37 Q sorts we would have had an Eigenvalue higher than one even when each Q sort was loading as low as ±0.16 in one factor. Based on this information therefore, perhaps an Eigenvalue of 1.6 is not so convincing. Moreover the five factor model is capable of explaining the 45% of the total variance, which is higher than all the other models but still lower than the threshold of 50% recommended by some authors (e.g. Hair et al. 1998, Fornell & Larcker, 1981).

Table C-3 illustrates the significant loadings (r) of each of the 37 Q sorts in all the 5 factors. Since we are looking for disparities in the perspectives however, we consider in our analysis only the pure loadings. A load is pure when a Q sort load significantly only one factor. We repeat that the significance of the loadings is calculated as in Brown (1980) according to the formula:

$r\ (p<0.05) > 1.96\ SE = 1.96\ (1/\sqrt{N}) = 1.96\ (1/\sqrt{40}) = 1.96\ (0.16) = 0.31$

$r\ (p<0.01) > 2.58\ SE = 2.58\ (1/\sqrt{N}) = 2.58\ (1/\sqrt{40}) = 2.58\ (0.16) = 0.41$

**Table C- 3 Q sort loadings.** All the Q sorts will load to a certain extent in each of the factors. In this table however, we show only the significant loadings. The bold indicates the Q sorts that have been used to calculate the factor arrays. Loadings higher than 0.31 are significant with a $p<0.05$. Loadings higher than 0.41 are significant with a $p<0.01$

| Q sort | Factor loadings per factor | | | | |
|---|---|---|---|---|---|
| | 23 | 24 | 25 | 26 | 27 |
| 1 | **0.57** | - | - | - | - |
| 2 | **0.68** | - | - | - | - |
| 3 | - | - | - | - | **0.56** |
| 4 | - | - | - | **0.62** | - |
| 5 | **0.50** | - | - | - | - |
| 6 | - | - | - | - | **0.67** |

| Q sort | Factor loadings per factor | | | | |
|---|---|---|---|---|---|
| | 23 | 24 | 25 | 26 | 27 |
| 7 | - | - | - | - | **0.60** |
| 8 | - | - | **0.32** | - | - |
| 9 | - | - | - | - | **0.67** |
| 10 | 0.19 | 0.20 | -0.11 | 0.19 | 0.21 |
| 11 | **0.58** | - | - | - | - |
| 12 | - | - | - | - | **0.56** |
| 13 | 0.37 | - | - | 0.35 | - |
| 14 | - | - | - | - | **0.48** |
| 15 | - | 0.45 | - | - | 0.51 |
| 16 | 0.37 | - | 0.31 | - | - |
| 17 | - | - | **0.43** | - | - |
| 18 | - | - | - | **0.71** | - |
| 19 | 0.47 | - | - | 0.55 | - |
| 20 | **0.76** | - | - | - | - |
| 21 | **0.69** | - | - | - | - |
| 22 | - | - | **0.71** | - | - |
| 23 | - | 0.53 | - | 0.45 | - |
| 24 | 0.22 | 0.27 | 0.24 | 0.02 | 0.2 |
| 25 | - | **0.56** | - | - | - |
| 26 | - | - | - | **0.57** | - |
| 27 | - | **0.49** | - | - | - |
| 28 | - | 0.39 | - | - | 0.31 |
| 29 | - | **0.72** | - | - | - |
| 30 | - | - | - | - | **0.49** |
| 31 | - | 0.31 | - | - | 0.28 |
| 32 | - | **0.39** | - | - | - |
| 33 | - | **0.50** | - | - | - |
| 34 | - | - | - | **0.60** | - |
| 35 | - | 0.29 | - | - | 0.31 |
| 36 | 0.58 | - | - | 0.42 | - |
| 37 | - | - | - | **0.57** | - |

The table reveals that factors 23, 24, 26 and 27 contain each five to seven pure significant loadings. The same four factors satisfy the

Humphrey's rule, even when strictly applied, as the multiplication of the two highest loadings exceeds twice the standard error (in our case 0.32). Factor 25 contains only three pure loadings, and it satisfies the Humprey's rule less strictly applied, i.e. the multiplication of the two highest loadings exceeds only once the SE.

In conclusion, four of the five factors (factors 23, 24, 26 and 27) satisfy all the significance criteria (Eigenvalues, number of loadings and Humphrey's rule strictly applied). Moreover, these factors remain relatively stable, despite when the number of participants (and therefore the Q sorts) increases.

Factor 25 seems relatively weaker, compared to the other factors. However, factor 25 is the outstanding factor emerging from the additional Q sorts added to the original set of 24 sorts. Perhaps, if more data were added, this factor would stabilize as the other 4 did when new sorts were added. Given the outstanding nature of this perspective, and our interest in variety, we decided to include this factor in the analysis despite the less convincing significance. The outstanding nature of factor 25 is suggested by its low and insignificant correlation with the other factors (see table C-4). The same correlations suggest factor 24 to be other outstanding factor. The qualitative analysis (appendix D: Qualitative analysis) will reveal in which way those two factors are different from the other.

Last but not least, the analysis suggests that in a Q study, when new data are added (in form of Q sorts) the results refine and stabilize themselves.

**Table C- 4 Correlation between the factors**

| | Factor 23 | Factor 24 | Factor 25 | Factor 26 | Factor 27 |
|---|---|---|---|---|---|
| **Factor 23** | 1.00 | | | | |
| **Factor 24** | 0.26 | 1.00 | | | |
| **Factor 25** | 0.38 | 0.12 | 1.00 | | |
| **Factor 26** | 0.49 | 0.30 | 0.33 | 1.00 | |
| **Factor 27** | 0.55 | 0.26 | 0.43 | 0.50 | 1.00 |

# C-2 Italian Q study

## C-2.1 The P-set:

Similarly to the Dutch P-set, we defined a balanced P set according to age, gender education and political preference. Those information are resumed in table C-5

**Table C- 5 Carateristics of the Italian P-set**

| Political preference | Number subjects | Num. males | Num. females | with Basic education | Medium | with higher education | Aver. age |
|---|---|---|---|---|---|---|---|
| (a) Left (PC, 5Stelle,SeL) | 7 | 5 | 2 | 1 | 2 | 4 | 29 |
| (b) Center-Left (PD) | 8 | 4 | 4 | - | 1 | 7 | 46 |
| (d) Center-Right (PDL-UDC) | 8 | 3 | 5 | 1 | - | 7 | 41 |
| (e) Right (FN, exAN, LN) | 7 | 6 | 1 | 3 | 1 | 3 | 39 |
| (f) No preference | 6 | 3 | 3 | 3 | 1 | 2 | 39 |
| **TOTAL** | **36** | **21** | **15** | **8** | **6** | **22** | **39** |

## C-2.2 Data analysis

We performed on the Italian data set the same analysis we performed on the Dutch data set and described in the previous section (sections C-1.2.1). Hence, the extrapolation of the factors was an iterative process in the Italian Q study as well. We extrapolated a progressively higher number of factors and compared them, in order to identify the most adequate set of factors to represent the variation of the data set.

Figure C-3 shows the relationship between the significant factors extrapolated respectively from the Italian P set, composed of 36 Q sorts. The arrows indicate the correlations, while each square represents a factor. Note that, according to the above described Brown's rule, in our study a correlation higher than 0,41 has a 0.01 significance. Moreover, Browns (1980) shows that two Q sorts resulting by one person sorting the same set of cards twice, will have approximately a correlation of 0.80 or higher. Furthermore, we repeat that the significance of the factors is determined according to their Eigenvalues, the number of pure loadings and the Humprey's rule more or less strictly applied, as in the analysis of the Dutch data.

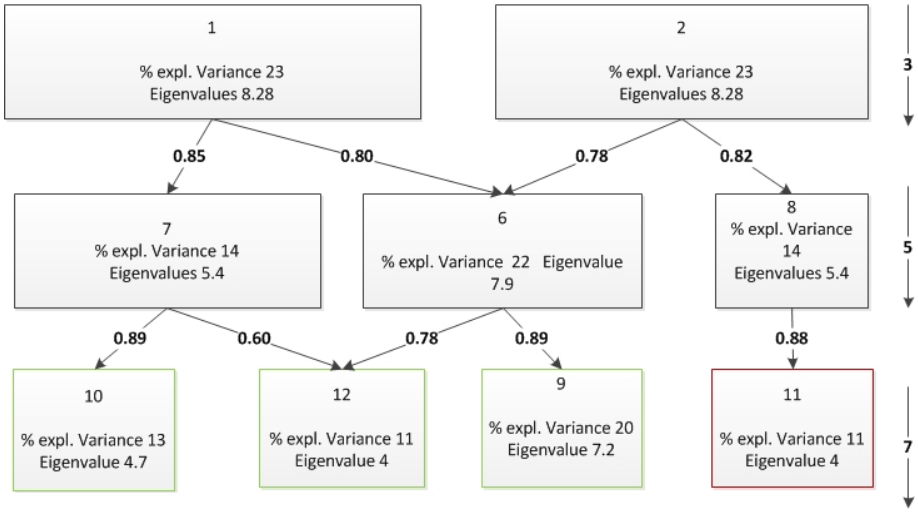


**Figure C- 3 Evolution of the factorial structure in the Italian P set.** The P set contains 36 Q sorts**.** Each square represents a factor. Each line represents a set of significant factors, extrapolated by performing several centroid factor analyses. In each analysis we asked for a progressive number of centroids, namely 3, 5 and 7. The arrows indicate the correlations.

As it is visually showed in Figure C-3, the correlations among all the extrapolated factors are quite high, indicating that the factors are quite similar among each other. As a matter of facts all the subjects load in one or more factors and only few load purely. This might suggest less variety in the Italian P-set than the one we found in the Dutch P-set.

Among all the factor structures, the one with 4 factors (last line of the three in ficure C-3) accounts for the majority of the total variety (55%), exceeding the 50% threshold recommended by some (e.g. Hair et al. 1998, Fornell & Larcker, 1981). Consistently, each factor of this model has Eigenvalue exceeding 1.

Table C-6 illustrates the significant loadings (r) of each of the 36 Q sorts in all the four factors. Since we are looking for disparities in the perspectives however, we consider in our analysis only the pure loadings. A load is pure when a Q sort load significantly only one factor. We repeat that the significance of the loadings is calculated as in Brown (1980) according to the formula:

$r\ (p<0.05) > 1.96\ SE = 1.96\ (1/\sqrt{N}) = 1.96\ (1/\sqrt{40}) = 1.96\ (0.16) = 0.31$

$r(p<0.01) > 2.58\ SE = 2.58\ (1/\sqrt{N}) = 2.58\ (1/\sqrt{40}) = 2.58\ (0.16) = 0.41$

Factor 9 and 10 contain 5 significant pure loadings, factor 11 contains 4 pure loadings and factor 12 only 3. The cross product of the two highest

loadings of Factor 9 and factor 11 satisfy the Humphrey's rule strictly applied (in our case cross products > 0.32) , while the factor 10 and 12 only satisfy the less strictly applied rules (in our case cross products > 0.16)

The selection of the factorial model is subject to the principle of parsimony also known as the Ockham's razor. According to this principle, the selection of the model should result from a tradeoff between the need to explain the data and the need of simplicity, as complexity is not only unnecessary but might leads to attribute meaning to noise (see e.g. Akaike 1974; Forster and Sober, 1994; Chakrabarti et al. 2011) In this light, perhaps only factors 9 and 11 should be selected for further analysis.

**Table C- 6 factor loadings for the Italian Q sorts.** All the Q sorts will load to a certain extent in each of the factors. In this table however, we show only the significant loadings. The bold indicates the Q sorts that have been used to calculate the factor arrays. Loadings higher than 0.31 are significant with a $p<0.05$. Loadings higher than 0.41 are significant with a $p<0.01$

| Q sorts | Factor loadings per factor | | | |
|---|---|---|---|---|
| | 9 | 10 | 11 | 12 |
| 1 | - | 0.66 | 0.47 | - |
| 2 | - | - | **0.52*** | - |
| 3 | **0.50*** | - | - | - |
| 4 | - | 0.47 | - | 0.34 |
| 5 | **0.74*** | - | - | - |
| 6 | - | - | - | **0.59*** |
| 7 | 0.58 | 0.35 | - | - |
| 8 | - | **0.39** | - | - |
| 9 | **0.55*** | - | - | - |
| 10 | 0.58 | - | - | 0.35 |
| 11 | 0.50 | - | - | 0.47 |
| 12 | - | - | - | **0.42** |
| 13 | 0.42 | - | 0.41 | 0.34 |
| 14 | 0.31 | 0.36 | - | 0.47 |
| 15 | 0.55 | 0.48 | - | 0.40 |
| 16 | 0.47 | 0.58 | - | - |
| 17 | 0.60 | 0.36 | - | - |
| 18 | - | 0.60 | 0.46 | 0.41 |
| 19 | 0.67 | 0.35 | 0.31 | - |
| 20 | 0.38 | - | - | 0.44 |
| 21 | 0.51 | - | 0.47 | - |

| Q sorts | Factor loadings per factor | | | |
|---|---|---|---|---|
| | 9 | 10 | 11 | 12 |
| **22** | - | - | - | **0.58*** |
| **23** | - | **0.70*** | - | - |
| **24** | **0.65*** | - | - | - |
| **25** | 0.68 | - | - | 0.34 |
| **26** | 0.63 | - | 0.45 | - |
| **27** | - | - | **0.76*** | - |
| **28** | - | - | **0.53*** | - |
| **29** | 0.44 | 0.42 | - | 0.31 |
| **30** | - | - | **0.53*** | - |
| **31** | **0.60** | **0.38** | - | - |
| **32** | 0.54 | - | 0.50 | - |
| **33** | 0.54 | - | - | 0.60 |
| **34** | - | **0.38** | | - |
| **35** | - | **0.60*** | | - |
| **36** | 0.34 | - | 0.39 | 0.60 |

At this point, the question is whether the restricted variety resulting from the analysis is due to:

1) actual noise (there is not such a big variety of perspectives) or

2) the selected P-set didn't allow this variety to emerge (too homogeneous participants)

3) the sample of statements didn't allow this variety to emerge (e.g. the sentences are formulated in a way that there is only a limited way of sorting the cards).

Looking at the correlation between the Italian Q sorts, we can see that some Q sorts are correlate as little as 0.13. This might answer to point 3, suggesting that the cards could have been sorted in very different ways, and also partly answer point 1, suggesting that perhaps there is variety, is just that we did not find it in the P-set (validating point 2). To clarify those doubts, we would need to increase the variety of the Italian P-set by adding more data. In that case, there would be a chance to encounter the same phenomena emerged in the Dutch P-set, where the smallest factors revealed to be the more stable across data set.

In conclusion, based on those information, considering that (i) the purpose of this study is to identify and represent the heterogeneity of point of views in the public; (ii) the analysis of the Dutch data set

suggested that the factors tend to stabilize and refine when more data are added (section C-1) and (iii) retaining four factors still a manageable number of points of view; we chose for the four factors structure, while postponing to further research the task of extrapolating a "more fitting" factor model.

### C-2.3 Conclusion

We started the analysis questioning how to "cut the cake" in a meaningful way. Which level of detail should be taken into account? Where is the border between the noise ("normal" variability) and real difference?

For example, would have the 3 factors model been sufficient to give an idea of the different perspectives in the Italian case? Arguably, in the case of the Q methodology the selection of the factors depends more on the qualitative analysis and on the purpose of the study (i.e. in which way the results are going to be actually used in the decision making process).

The analysis showed that, once rotated, the smaller factors are more specific, explain more of the variety of the data, are more different among each other and seem to be more reliable. Almost the totality of the rotated factors contained at least 3 or four Q sorts loading with significant loadings ($p > 0.01$), indicating that each perspective was shared by at least three or four people.

In both the Italian and the Dutch case we opted for the more detailed and rich factorial structure: 4 factors for the Italian case and 5 for the Dutch. These factors are a way of representing the different perspectives on energy related issues and hydrogen technology as we found them among the participants of our research.

# Appendix D: Qualitative data analysis

## D-1. Legenda

**Table D- 1 nomenclature**

| | *Appendix C* | *Appendix D & Main text* | | |
|---|---|---|---|---|
| *Country* | *Number* | *Number* | *Code* | *Title* |
| *Dutch* | *Factor 23* | *Factor 1* | *NL 1* | *Liberal environmentalism* |
| *Dutch* | *Factor 24* | *Factor2* | *NL 2* | *Practical environmentalism* |
| *Dutch* | *Factor 25* | *Factor 3* | *NL 3* | *Liberal outlook* |
| *Dutch* | *Factor 26* | *Factor 4* | *NL 4* | *Prescribed environmentalism* |
| *Dutch* | *Factor 27* | *Factor 5* | *NL 5* | *Mistrusting environmentalism* |
| *Italian* | *Factor 9* | *Factor 1* | *IT 1* | *Mistrusting environmentalism* |
| *Italian* | *Factor 10* | *Factor2* | *IT 2* | *Market driven sustainability* |
| *Italian* | *Factor 11* | *Factor 3* | *IT 3* | *Technocratic outlook* |
| *Italian* | *Factor 12* | *Factor 4* | *IT 4* | *Ecotopian outlook* |

## D-2. From the factors to the narratives: Procedure

At the end of the quantitative analysis, the researcher is ready with about 24 pages of numbers to interpret and digest into communicable perspectives.

The quantitative analysis identify per each factor the ideal way of sorting the cards. Since the way of sorting the cards represent the person's point of view, each factor thus represents a shared perspective. The quantitative analysis gives information on how the sentences were

ranked and valued in each factor, as well as the differences of values among factors per each sentence. However our research goal is to understand how people think about the topic of energy and hydrogen.
Therefore we need to translate these factors and numbers into logic perspectives, or narratives. In order to do that, the researcher has to recall the qualitative information collected during the interviews. By using the comments and the explanation given by the participants selves the research can make sense out of the quantitative information. Coming back to what was said during the interviews is necessary to reconstruct the logic behind the factors directly from the perspectives of the interviewees. The researcher is not filling the gaps among numbers (interpreting) according to her personal logic but directly from what the participants told her.
We took the sentences one by one per each perspective, looking at their value and at the consistency with the other sentences. The reconstruction of the narratives starts with the sentences at the extremes, the eight cards with the highest and lowest values: +5, +4, -4 and -5. These are the core concepts of the perspectives. The reconstruction goes on by looking at the sentences that are in the medium and in the central area (from +3 to -3). Why are they there? Do they have a low value because they are not important or because people don't know? As a matter of fact, when a concept is not important, e.g. "climate change", it is a valuable information. How the sentences have been interpreted in the different perspectives? How to they connect with the other sentences?
Let us explain how we proceeded with the reconstruction of the perspectives with some examples.
The first source of information is the "absolute" value that the cards got in each perspective. With "absolute" we mean the value that the sentence got within the perspective, e.g. the highest card (+5) in factor 1. The first absolute values that we looked at are the highest and the lowest. These cards are certainly the core of the perspectives.
For example let's consider statement n. 28 "I am a climate-skeptical. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption." and how it has been ranked in the Italian factors 1 and 4. In factor 4, this statement has been ranked in average with a "-5: I strongly disagree". This means that people in this factor think that climate change is an important issue and that human beings have something to do with it. Consider that he same factor 4 have in position "+5 I strongly agree" the statement n.12 "Pollution is a problem of today: the respiratory diseases are increasing and this is because of bad air quality". This tells us that climate change and pollution are core issue for Factor 4, which as we seen in the main text (chapter 5) is an environmental perspective.

However, not only the absolute value of highest and the lowest cards give useful information for understanding the perspectives. Also the cards that got 0 or +1 give useful information, especially if the qualitative information are used to understand why these sentences went in the central area.
Let's take sentence n. 34 ". People are more important than nature, we are at the top of the chain. We should satisfy our needs, but not completely disregard nature." During the interviews people reacted in very different ways to this sentences: some strongly reacted to the first part of the sentences "humans are more important than nature" and put the cards in the "strongly disagree" part of the grid. These people grouped in factor 2: also an environmentalist perspective, as we will see in section 3. Some other people instead find it contradictory but not false: "we are not more important than nature! we are part of it!" they explained, but they were also giving importance to the second part of sentence "it is true that we have to satisfy our needs without completely disregard the environment". As a result, these people put the sentence in the central area (1 and -2) and grouped into other 2 factors, as we will better explain in the next section. The rest of the people instead, recognized with this sentence and didn't find it double: "that's true!" they commented and valued the card with a +3. These people grouped into the fourth factor. In this example we have seen that the value of the card a) is informative even if it is in the central area and b) is explicative of the perspective when it is used in combination with the qualitative data (i.e. the interpretation that people give to the sentences during the interviews).
Another source of information used to reconstruct the narratives and understand the perspectives was the "relative" value of the sentence. With "relative" we mean the sentences that scored the highest and lowest in comparison with the other factors.
For example if we take sentence n. 2 " We consume too much in general. I think we should live very differently". In all factors this sentence score in the "agree", with a value that goes from 1 to 4, so one might think that everybody more or less agree with it. However, going back to the interviews people reacted into 2 ways: some completely recognized in the sentence and put it in the 4 "strongly agree". These people grouped in to two factors and, as we will see in the next paragraph, the over-consumption is a key concept in these perspectives. However, some others reacted saying "well, it is true that we consume very much, but we cannot go back to stone-age and consume less", and more "It is true but I am glad that thanks to my washing machine I don't have to wash my clothes with my hands anymore!". These people grouped into another factor. Although this sentence still has a positive value ( +1) it is the lowest value that this sentence got in the 4 four perspectives. This relative value together with

the interpretation is another information that help us in understanding this perspective, in our example that the argument of over-consumption doesn't really "convince" people that sare the perspective of factor 3.
In order to better understand the perspectives, the researcher needs to understand as much as possible the differences among the perspectives. The difference among the perspectives is reflected in a difference of at least 2 points between the values that each perspective gave to the same sentence (which usually corresponds to a higher difference in the Z scores, a more reliable way to observe differences in the ranking of the statements across factors).
A further source of information consisted in how the sentences logically linked one to each other within each perspective according to the value and the interpretation.
For example let's look at the above mentioned examples of statements 2 "We consume too much in general. I think we should live very differently" and 34 ". People are more important than nature, we are at the top of the chain. We should satisfy our needs, but not completely disregard nature". In the factor that focuses on over-consumption as an issue sentence 2 got an high score (+4) and sentence 34 ( on nature) consistently got a low score (-4): in this perspective our society consumes too much at the detriment of nature and this is wrong. On the contrary in the factor where sentence n. 2 on over-consumption got the relatively lowest score (+1) the sentence 34 got the relatively highest score (3): in this perspective consuming is not bad because it is a sign of progress therefore human beings need to use nature to satisfy their needs.
In sum, the above examples show which qualitative information we retrieved from the interviews and how we used them to interpret the quantitative data. All the interpretation process was finalized to understand the people's point of views, reconstruct the perspectives and compare them. To achieve this goal we looked at:

1. the value of the sentence in each group, both the absolute (i.e. the highest within the perspective) and the relative (i.e. the lowest across the perspectives);
2. the meaningful differences among the perspectives when the sentences had at least two point difference among the factors (e.g. same sentence has -5 in one factor and -3 in another factor)
3. the way the people in each group interpreted the sentences and the comments that the people gave when reading the sentences;
4. the combination of value and interpretation;
5. the consistency and logic connection between the sentence

**Table D- 2 Ranking of the statements in the Dutch factors**

| N | STATEMENTS | FACTOR NUMBER | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 1 | Windmills are noisy, ugly and bad for the environment. | -5 | -4 | -1 | -4 | -5 |
| 2 | We consume too much in general. I think we should live very differently. | 3 | 0 | -1 | 1 | 3 |
| 3 | Using biomass from waste to produce energy is dangerous and inefficient. | -3 | -1 | -3 | -2 | -3 |
| 4 | . There will be less and less energy available, I see that problem coming. If countries like India or China want to live like us, there won't be enough energy | 2 | -1 | 3 | -1 | 0 |
| 5 | A single person does not think about energy, the environment or efficiency. The government should tell me what to do, they should oblige me! Even if I have to change my habits, I would vote for such a party, because in this way I will have no other choice than do the right thing.. | 0 | -4 | -4 | 2 | -3 |
| 6 | . The majority of oil comes from political unstable countries. We will have serious problems if the Middle East decides to close the oil tap. We should not be dependent of these countries | 4 | -1 | 4 | 4 | 2 |
| 7 | Industries consume the most energy. They should do something it, not the citizens. | -4 | -2 | 1 | 0 | 0 |
| 8 | The government should add environmental costs to product sand should use this money towards something that is good for the environment. I think it is fair that people pay an extra tax proportional to what they consume. | 3 | -4 | -1 | 4 | 0 |
| 9 | The government is responsible to do something about the issues related to energy. They have enough power to do something about them! | 2 | 3 | 0 | 5 | 2 |
| 10 | Science has the responsibility to find solutions for environmental issues related to energy. | 2 | 1 | 5 | 3 | 4 |
| 11 | Price is a good way to make me more aware of something. A significant increase of the price of energy will help me change my way of energy consumption. | 4 | 0 | 2 | 0 | 0 |
| 12 | . Pollution is a problem of today: the respiratory diseases are increasing because of the bad air quality | 1 | 5 | -1 | -1 | -1 |
| 13 | People only care that energy is available: they turn on the switch and the light works, this is what people care about | 2 | 4 | 0 | 0 | 2 |
| 14 | Nuclear energy is a good way to solve energy related issues. | 1 | -5 | 2 | -3 | 1 |
| 15 | Natural gas is clean and good for the environment. | -1 | 1 | 1 | 0 | 0 |
| 16 | Maybe we could go back to doing things locally, also with energy. It would be nice to produce energy locally and to not have to transport it. | 0 | 2 | 1 | 0 | 1 |
| 17 | It is difficult to change from old to new technologies, because it costs too much. | -2 | -2 | 4 | -1 | -2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 18 | When you read the newspaper you see that there are all these energy issues, but in my daily life I do not notice it! | 1 | 4 | 0 | 2 | -2 |
| 19 | If you mass produce hydrogen and store it somewhere, that place will make us vulnerable for terroristic attacks. | -2 | -3 | 0 | -3 | -4 |
| 20 | If you look at the amount of people there are and how much energy we consume, I think that energy will become less easily available. | 1 | 2 | 2 | 1 | 1 |
| 21 | I would not like to have a tank of hydrogen gas at home. | 0 | 0 | -2 | -4 | -2 |
| 22 | I wish it would be possible to be completely independent of the electricity grid. I would prefer to produce energy myself at home. | -3 | -2 | -3 | -2 | 0 |
| 23 | I want to have cheap energy. I do not care where the energy comes from; I want it to be cheap. | -4 | -1 | 0 | 3 | -1 |
| 24 | I think it is not safe to drive a car with a tank of hydrogen on board. | -1 | -3 | -2 | 4 | -4 |
| 25 | I think it is morally incorrect to use energy produced from food. I would not buy biodiesel produced from corn or sunflower oil. | -2 | -2 | -3 | -2 | -3 |
| 26 | I believe that the government is reluctant in tackling issues related to energy. Some things are stimulated and some things are not. Politicians choose solutions that are politically convenient. | 0 | 0 | -2 | -4 | 3 |
| 27 | I worry that my electricity bill or refueling my car will become more and more expensive | 0 | 4 | 0 | -2 | 0 |
| 28 | . I am a climate-skeptic. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption | -4 | -2 | 0 | -4 | -1 |
| 29 | Hydrogen is inefficient: it costs a lot of energy to extract it and then to be re-used again. | 0 | -3 | -3 | -2 | -1 |
| 30 | Hydrogen is not a solution for environmental issues. | -1 | -1 | -5 | -3 | -2 |
| 31 | Hydrogen is reality in the US and Japan. We should not stay behind and invest in hydrogen too: hydrogen is the future and we should go for it. | -1 | 0 | 1 | 1 | 0 |
| 32 | Hydrogen is a good way to increase energy security. | -1 | 0 | 2 | 1 | 1 |
| 33 | Hydrogen can stimulate the diffusion of renewable energy sources because it is a good way to store energy. | 0 | 1 | 1 | 0 | 1 |
| 34 | . People are more important than nature, we are at the top of the chain. We should satisfy our needs, but not completely disregard nature | -2 | -3 | -1 | -1 | -4 |
| 35 | Government should really focus on education concerning sustainability and it's important to focus on the right things. Change starts with education. | 4 | 3 | 4 | 0 | 4 |
| 36 | Energy problems have social grounds. The technical progress will not solve the problems | -1 | -1 | -4 | -5 | -1 |
| 37 | Consumers should be more responsible. We should understand that we can do a lot by decreasing consumption in our daily life. What a single person does is not a drop in the sea. | 5 | 0 | 2 | 0 | 4 |
| 38 | Companies like Shell already have the new technologies, but they are postponing their use. If they would put the new products on the market consumers would buy them | -3 | -2 | -3 | -2 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 39 | Becoming a leader in these new technologies means becoming a leading economy in the world. | 3 | 1 | 3 | 2 | 3 |
| 40 | A big advantage of hydrogen is that you can produce it directly where you want use it. | 0 | 0 | 0 | -1 | 2 |

## Table D- 3 ranking of the statements in the Italian factors

| N | STATEMENTS | FACTOR NUMBER 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 1 | Windmills are noisy, ugly and bad for the environment. | -2 | -4 | 0 | -3 |
| 2 | We consume too much in general. I think we should live very differently. | 3 | 4 | 0 | 4 |
| 3 | Using biomass from waste to produce energy is dangerous and inefficient. | -2 | -5 | -3 | 0 |
| 4 | . There will be less and less energy available, I see that problem coming. If countries like India or China want to live like us, there won't be enough energy | -1 | 0 | 0 | -4 |
| 5 | A single person does not think about energy, the environment or efficiency. The government should tell me what to do, they should oblige me! Even if I have to change my habits, I would vote for such a party, because in this way I will have no other choice than do the right thing.. | 0 | -4 | 3 | -1 |
| 6 | . The majority of oil comes from political unstable countries. We will have serious problems if the Middle East decides to close the oil tap. We should not be dependent of these countries | 2 | 4 | 5 | 1 |
| 7 | Industries consume the most energy. They should do something it, not the citizens. | -4 | -2 | -4 | -1 |
| 8 | The government should add environmental costs to product sand should use this money towards something that is good for the environment. I think it is fair that people pay an extra tax proportional to what they consume. | 0 | 1 | 2 | 3 |
| 9 | The government is responsible to do something about the issues related to energy. They have enough power to do something about them! | 0 | -1 | 0 | -2 |
| 10 | Science has the responsibility to find solutions for environmental issues related to energy. | 1 | 3 | 4 | 3 |
| 11 | Price is a good way to make me more aware of something. A significant increase of the price of energy will help me change my way of energy consumption. | -1 | -2 | 0 | 0 |
| 12 | . Pollution is a problem of today: the respiratory diseases are increasing because of the bad air quality | 3 | 3 | 1 | 5 |
| 13 | People only care that energy is available: they turn on the switch and the light works, this is what people care about | 2 | 2 | 2 | 0 |
| 14 | Nuclear energy is a good way to solve energy related issues. | -4 | 4 | 1 | -2 |
| 15 | Natural gas is clean and good for the environment. | 1 | 1 | -1 | 0 |
| 16 | Maybe we could go back to doing things locally, also with energy. It would be nice to produce energy locally and to not have to transport it. | 4 | -2 | 2 | 4 |
| 17 | It is difficult to change from old to new technologies, because it costs too much. | -2 | -1 | -2 | -1 |

| | | | | | |
|---|---|---|---|---|---|
| 18 | When you read the newspaper you see that there are all these energy issues, but in my daily life I do not notice it! | -3 | -3 | -1 | 0 |
| 19 | If you mass produce hydrogen and store it somewhere, that place will make us vulnerable for terroristic attacks. | 0 | 0 | -5 | -1 |
| 20 | If you look at the amount of people there are and how much energy we consume, I think that energy will become less easily available. | 2 | 2 | -1 | -3 |
| 21 | I would not like to have a tank of hydrogen gas at home. | -1 | 0 | -2 | -1 |
| 22 | I wish it would be possible to be completely independent of the electricity grid. I would prefer to produce energy myself at home. | 3 | -3 | 3 | 2 |
| 23 | I want to have cheap energy. I do not care where the energy comes from; I want it to be cheap. | -5 | -4 | -1 | -4 |
| 24 | I think it is not safe to drive a car with a tank of hydrogen on board. | -2 | -1 | -2 | 0 |
| 25 | . I think it is morally incorrect to use energy produced from food. I would not buy biodiesel produced from corn or sunflower oil. | -4 | -2 | -4 | 0 |
| 26 | I believe that the government is reluctant in tackling issues related to energy. Some things are stimulated and some things are not. Politicians choose solutions that are politically convenient. | 5 | 3 | 4 | 2 |
| 27 | I worry that my electricity bill or refueling my car will become more and more expensive | 0 | 1 | 0 | -2 |
| 28 | . I am a climate-skeptic. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption | -3 | -1 | 0 | -5 |
| 29 | Hydrogen is inefficient: it costs a lot of energy to extract it and then to be re-used again. | 0 | 0 | 0 | 0 |
| 30 | Hydrogen is not a solution for environmental issues. | -1 | -1 | -1 | -3 |
| 31 | Hydrogen is reality in the US and Japan. We should not stay behind and invest in hydrogen too: hydrogen is the future and we should go for it. | 1 | 2 | 1 | 2 |
| 32 | Hydrogen is a good way to increase energy security. | 1 | 1 | 0 | 1 |
| 33 | Hydrogen can stimulate the diffusion of renewable energy sources because it is a good way to store energy. | 0 | 1 | 0 | 1 |
| 34 | . People are more important than nature, we are at the top of the chain. We should satisfy our needs, but not completely disregard nature | -1 | -4 | 3 | -2 |
| 35 | Government should really focus on education concerning sustainability and it's important to focus on the right things. Change starts with education. | 4 | 4 | 1 | 4 |
| 36 | Energy problems have social grounds. The technical progress will not solve the problems | -2 | 0 | -3 | 1 |
| 37 | Consumers should be more responsible. We should understand that we can do a lot by decreasing consumption in our daily life. What a single person does is not a drop in the sea. | 4 | 5 | 1 | 3 |
| 38 | Companies like Shell already have the new technologies, but they are postponing their use. If they would put the new products on the market consumers would buy them | 3 | 0 | -4 | -2 |

| | | | | | |
|---|---|---|---|---|---|
| 39 | Becoming a leader in these new technologies means becoming a leading economy in the world. | 1 | 0 | 4 | 2 |
| 40 | A big advantage of hydrogen is that you can produce it directly where you want use it. | 0 | 0 | -2 | 1 |

# Appendix E: categorization of the statements

Table E-1 Possible categorization of the statements similarly to the VBN theory. The statements are categorized as Awareness of consequences (AC); ascription of responsibility (AR); Norms (N); General world view (WW) and believes on technology (T), the latter not being part of the VBN theory. We remind that the categorization is not in absolute terms, as the statements have been interpreted in different ways by the Q study participants

| N | STATEMENTS | |
|---|---|---|
| 1 | Windmills are noisy, ugly and bad for the environment. | T |
| 2 | We consume too much in general. I think we should live very differently. | N |
| 3 | Using biomass from waste to produce energy is dangerous and inefficient. | T |
| 4 | . There will be less and less energy available, I see that problem coming. If countries like India or China want to live like us, there won't be enough energy | AC |
| 5 | A single person does not think about energy, the environment or efficiency. The government should tell me what to do, they should oblige me! Even if I have to change my habits, I would vote for such a party, because in this way I will have no other choice than do the right thing.. | AR |
| 6 | . The majority of oil comes from political unstable countries. We will have serious problems if the Middle East decides to close the oil tap. We should not be dependent of these countries | AC |
| 7 | Industries consume the most energy. They should do something it, not the citizens. | AR |

**Categorization of the statements**

| N | STATEMENTS | |
|---|---|---|
| 8 | The government should add environmental costs to product sand should use this money towards something that is good for the environment. I think it is fair that people pay an extra tax proportional to what they consume. | N |
| 9 | The government is responsible to do something about the issues related to energy. They have enough power to do something about them! | AR |
| 10 | Science has the responsibility to find solutions for environmental issues related to energy. | AR |
| 11 | Price is a good way to make me more aware of something. A significant increase of the price of energy will help me change my way of energy consumption. | N |
| 12 | . Pollution is a problem of today: the respiratory diseases are increasing because of the bad air quality | AC |
| 13 | People only care that energy is available: they turn on the switch and the light works, this is what people care about | W<br>W |
| 14 | Nuclear energy is a good way to solve energy related issues. | T |
| 15 | Natural gas is clean and good for the environment. | T |
| 16 | Maybe we could go back to doing things locally, also with energy. It would be nice to produce energy locally and to not have to transport it. | N |
| 17 | It is difficult to change from old to new technologies, because it costs too much. | AC |
| 18 | When you read the newspaper you see that there are all these energy issues, but in my daily life I do not notice it! | W<br>W |
| 19 | If you mass produce hydrogen and store it somewhere, that place will make us vulnerable for terroristic attacks. | T |
| 20 | If you look at the amount of people there are and how much energy we consume, I think that energy will become less easily available. | AC |
| 21 | I would not like to have a tank of hydrogen gas at home. | T |
| 22 | I wish it would be possible to be completely independent of the electricity grid. I would prefer to produce energy myself at home. | W<br>W |
| 23 | I want to have cheap energy. I do not care where the energy comes from; I want it to be cheap. | T |
| 24 | I think it is not safe to drive a car with a tank of hydrogen on board. | AC |
| 25 | . I think it is morally incorrect to use energy produced from food. I would not buy biodiesel produced from corn or sunflower oil. | T |
| 26 | I believe that the government is reluctant in tackling issues related to energy. Some things are stimulated and some things are not. Politicians choose solutions that are politically convenient. | W<br>W |
| 27 | I worry that my electricity bill or refueling my car will become more and more expensive | AC |
| 28 | . I am a climate-skeptic. I don't think climate change is an issue. There are even scientists that say that it is a normal process and that it has nothing to do with our energy consumption | AC |
| 29 | Hydrogen is inefficient: it costs a lot of energy to extract it and then to be re-used again. | T |
| 30 | Hydrogen is not a solution for environmental issues. | T |
| 31 | Hydrogen is reality in the US and Japan. We should not stay behind and invest in hydrogen too: hydrogen is the future and we should go for it. | N |
| 32 | Hydrogen is a good way to increase energy security. | T |
| 33 | Hydrogen can stimulate the diffusion of renewable energy sources because it is a good way to store energy. | T |
| 34 | . People are more important than nature, we are at the top of the chain. We should satisfy our needs, but not completely disregard nature | N |

| N | STATEMENTS | |
|---|---|---|
| 35 | Government should really focus on education concerning sustainability and it's important to focus on the right things. Change starts with education. | N |
| 36 | Energy problems have social grounds. The technical progress will not solve the problems | W W |
| 37 | Consumers should be more responsible. We should understand that we can do a lot by decreasing consumption in our daily life. What a single person does is not a drop in the sea. | AR |
| 38 | Companies like Shell already have the new technologies, but they are postponing their use. If they would put the new products on the market consumers would buy them | W W |
| 39 | Becoming a leader in these new technologies means becoming a leading economy in the world. | W W |
| 40 | A big advantage of hydrogen is that you can produce it directly where you want use it. | T |

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## About the Author

I was born the 21st of October 1980 in Italy, in the town of Marino (Rome). In 2005, I obtained my master degree in Psychology at the University of Bologna, with a thesis on Internet-Forums as *empowering* tools for women with maternity issues.

I further developed my interest for empowerment and participation through my post-graduate internship, working in a consulting company specialized both in participatory action research and active training methodology (employing serious games). That enriching experience was fundamental, later on, in the set-up of my PhD.

Between 2006 and 2008 I traveled around Europe and all the way to Mexico. In those months, I had all kind of experiences, from teaching circus arts to handicapped children in Germany, to backpacking in the jungle of Chiapas.

In May 2008 I joined the Policy Analysis section, in the Faculty of Technology Policy and Management, Delft University of Technology. Much of my past research experience converged with the new set of disciplines I have learned in the Faculty. This mélange of disciplines blends in my PhD.

In 2013 I got involved in the observation of a deliberative process in Italy, together with Dr. Simon Niemeyer. In the context of that project I have spent few months as a visiting PhD student at the Australian National University in the group of Prof. Dryzek and Dr. Niemeyer. My first steps into the deliberative democracy field helped me in contextualizing my own work.

In the same year, I was involved in a TU Delft project, a Q study on stakeholder envisioning of the future of gas in the Netherlands. Through this project I gained further insight in the Q methodology, enabling me to refine and conclude my PhD dissertation.

In my free time I enjoy nature, family and friends.

Pelmo Mountain (Dolomiti Bellunesi, Italy), 3123 m. & personal record
September 2013

## Refereed Publications

Di Ruggero, O & Haan, ARC de (2010). A new perspective on public acceptance of hydrogen: which hydrogen future may citizens accept? In s.n. (Ed.), Proceedings of the NHA conference (pp. 1-11). Long Beach: NHA.

Di Ruggero, O. (2011). Energy and Sustainability: public perspectives on what are the issues, who should address them and how. In *World Renewable Energy Congress. Linköping, Sweden (Forthcoming)*.

Di Ruggero, O., Molin, E., & Been, W. (2013). Hydrogen Fuels? Exploring Citizens' Attitudes Towards Alternative Primary Energy Sources. In *Transportation Research Board 92nd Annual Meeting* (No. 13-0666).

Frantzeskaki, N , Haan, ARC de, Di Ruggero, O & Kolfschoten, GL (2009). Lessons learned from a multimodel conceptual modeling course - the "introduction to policy analysis" course's experience as a successful grassroots project of the Delft University of Technology. In D Marti (Ed.), Proceedings of INTED2009 Conference (pp. 4556-4564). Valencia, Spain: INTED

# Propositions

Accompanying the dissertation
"Anticipating Public Acceptance: The Hydrogen Case"
Olga Di Ruggero, 25 April 2014

1. Using frames is a good approach to select participants for an anticipatory* minipublic in cases like hydrogen acceptance (this thesis).

2. When using frames to design anticipatory minipublics reflecting on future technologies it is irrelevant to know which frames are dominant in a statistical sense (this thesis).

3. A well-done Q study can lead to generalizable results, although it employs only a small number of participants (this thesis).

4. Flipping a coin may be as useful as eliciting expressed preferences and sending out questionnaires when attempting to anticipate public acceptance of new technologies like hydrogen (this thesis).

5. There is no such a thing as public opinion. There is only published opinion**.

6. The Italian environmental discourse is 20 years behind the Dutch one.

7. Without ecological utopias*** it will be impossible to realize a truly sustainable society.

8. Humankind will never really adapt to climate change

9. Taste has nothing to do with efficiency, therefore, unlike the Dutch, Italians don't put lasagna and salad in the same plate.

* anticipatory in the sense that they deal with future issues, like in (MacKanzie, M.K. & O'Doherty (2011) Deliberating future issues: minipublics and salmon genomics. *Energy Policy* 34:1236-50

** alleged quote of Winston Churchill according to several website-writers.

*** Geus, M. de (1999). *Ecological utopias: Envisioning the sustainable society*. Utrecht: International Books.

These propositions are regarded as opposable and defendable, and have been approved as such by the promoter Prof.dr.ir. W.H.A. Thissen

# Stellingen

Behorend bij het proeschrift
"Anticiperen op publieke acceptatie: de casus waterstof"
Olga Di Ruggero, 25 April 2014

1. Het gebruik van frames is een goede aanpak om deelnemers te selecteren voor een anticiperende* *minipublic* in gevallen zoals waterstof acceptatie (dit proefschrift).

2. Bij gebruik van frames om anticiperende *minipublics* te ontwerpen die reflecteren op technologieën van de toekomst, is het niet relevant om te weten welke frames dominant zijn in statistische zin (dit proefschrift).

3. Een goed uitgevoerde Q studie kan leiden tot generaliseerbare resultaten, hoewel zij slechts gebruik maakt van een klein aantal deelnemers (dit proefschrift).

4. Het opgooien van een munt kan net zo nuttig zijn als het eliciteren van voorkeuren en het verzenden van vragenlijsten bij een poging om te anticiperen op de publieke acceptatie van nieuwe technologieën, zoals waterstof (dit proefschrift).

5. Er is niet zoiets als de publieke opinie. Er is slechts gepubliceerde opinie**.

6. Het Italiaanse milieu *discours* loopt 20 jaar achter op het Nederlandse.

7. Zonder ecologische utopieën*** is het onmogelijk om een werkelijk duurzame samenleving te realiseren.

8. De mensheid zal zich nooit echt aanpassen aan klimaatverandering

9. Smaak heeft niets te maken met efficiëntie, daarom eten Italianen, in tegenstelling tot Nederlanders, lasagne en salade niet tegelijkertijd van hetzelfde bord .

*anticiperend in de betekenis van omgaan met toekomstige issues, zoals in (MacKanzie, M.K. & O'Doherty (2011) Deliberating future issues: minipublics and salmon genomics. Energy Policy 34:1236-50

**vermoedelijk een uitspraak van Winston Churchill volgens sommige websites.

*** Geus, M. de (1999). *Ecological utopias: Envisioning the sustainable society*. Utrecht: International Books

Deze stellingen worden opponeerbaar en verdedigbaar geacht en zijn als zodanig goedgekeurd door de promotor Prof.dr.ir. W.A.H. Thissen