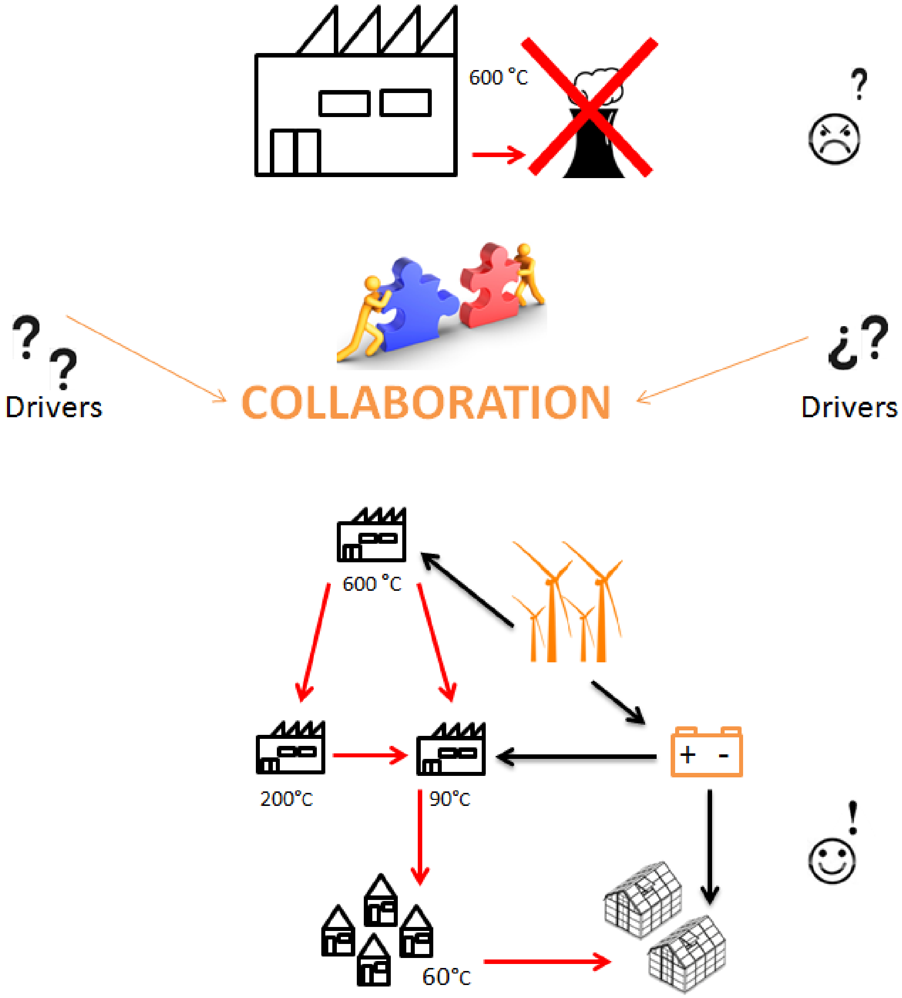
GAINING INSIGHT INTO MESO-LEVEL COLLABORATION BEHAVIOUR IN THE DUTCH HEAT AND COLD ENERGY STORAGE FIELD

Developing a factor framework with Q-methodology to assess the most important drivers for collaboration behaviour



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July 6th 2015.

Master of Science Thesis Systems Engineering, Policy Analysis and Management

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MSc Systems Engineering, Policy Analysis and Management Thesis

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PREFACE

Preface

This thesis is my proof of the final part of my journey at the faculty of Technology, Policy and Management. At this faculty I have spent many hours completing courses for the Master of Science program Systems Engineering, Policy Analysis and Management. I did this with pleasure at the Energy and Industry section. For my thesis I was able to perform an internship at two companies Balance and ING (an interim & project management company and a financial institution in the Netherlands).

This research has the goal to find drivers that are the most important for collaboration behaviour in the Dutch heat and cold energy storage sector. Energy storage is defined in a broad way and therefore also geothermal energy and energy from (district-) heat grids are included in the scope. This thesis provides a recommendation for policy with the framework of drivers for collaboration behaviour for each different perspective in the field.

During my study and the process of my thesis I have had many persons helping me and contributing to my research. Herewith I would like to thank them. Family, friends and my employer for their support; my colleagues at Balance and ING with their access to a wide network of actors in the heat and cold field in the Netherlands; all twenty interviewees from varies companies for their indispensable input; Gijs de Man for his expert validation of the perspectives and their drivers resulting from Q-methodology; the members of my graduation committee for their feedback and powerful discussions: Paulien Herder as chair and as promoter for energy, Gijsbert Korevaar as motivating first TU Delft supervisor, Haiko van der Voort for his TPM reflection style as second TU Delft supervisor. Furthermore I have appreciated to be in the company of and in (sailing) discussions with both Wim Voogd, who made my graduation possible at Balance and gave me the freedom to pursue my academic challenge and Dirk Jan van Swaay as a fantastic supervisor and mentor at ING.

Jorick Willem Florian Weijers

Delft, 2015.

SUMMARY

Executive Summary

There exists urgency in the Netherlands to use heat and cold energy storage, this stems from the directive for heat mapping, a need for heat and cold energy storage, as well as for balancing the electricity grid and the Warmtebrief by the Dutch Ministry of Economic Affairs. This thesis looked at the problem that despite this needs and urgency there is no clear growth in the heat and cold energy storage field in the Netherlands. It was found that specifically collaboration is lacking and with a combined qualitative and quantitative approach this research has led to the conclusion that:

There are four different perspectives for collaboration behaviour: the Early Adopters-, the Policy Sceptics-, the Quid pro quo- and the Second Movers-perspective. These perspectives however are not represented by (in-)formal Dutch institutions, which results in a lack of development of the field. Furthermore four relation diagrams show that each perspective has different (categories of) drivers for collaboration behaviour in the Dutch heat and cold energy storage field (See Figure 13, Figure 14, Figure 15 and Figure 16 on pages 57 to 59 for the best overview). The description of each perspective is important to understandit is provided on the two final pages of this report so it can always be easily consulted while reading the report.

Forming a general conclusion, to the extent in which this is possible provided a disclaimer on generalizability due to the small sample size, it would formulated as to create a policy to change the negative relations of drivers with collaborations values into green positive values, starting with the lower valued negative relations in the most perspectives: <u>Interaction and Information / Knowledge.</u> Combined with the stimulation of the higher valued positive relations in the most perspectives: <u>Price / Cost, Supply / Demand, Image and Risk</u>. Finally, it would be advisable to steer with policy on the Policy Sceptics perspective (for Common goal / Strategy and Image) and on the Quid pro quo perspective (for Time, Information / Knowledge and Supply / Demand) since they have a negative relation with collaboration when the category between brackets has three positive relations the other perspectives.

According to Gijs de Man these four perspectives are seen common in the market. This results in a positive recommendation for the validity of both Q-methodology as a method and the interpretation of the researcher of the Q-sorts and the Principal Component Analysis. No other common perspectives were suggested in the validation-interview.

After an initital literature research a problem statement was developed: 'The heat and cold energy storage field in the Netherlands not developing as expected from the needs and urgencies that are found.' Therefore a systems analysis was performed to see where knowledge gaps are in this field. The Dutch heat and cold energy storage field is a complex socio technical system, which is characterized by long term planning, large investments and interdependencies between actors and other systems.

The hypothesis is that some form of cooperation is needed in this field. That is why three pillars were used to analyse the system from different viewpoints while keeping the structure to see overarching issues: technology, economy and institutions. This was done because the problem analysis showed that economics are important and often driven by the technological choice of a technology while being bounded by the institutional design of the systems (e.g. (in-)formal rules and regulations).

Research showed that the technology is not burdening the development of the heat and cold energy storage field in the Netherlands as techniques are mature and available in the market. The economic analysis has shown that the economics are assumed not to burden the development as energy storage systems have multiple mature markets to sell energy, there is demand for heat and cold energy storage and existing business cases show that the economic side of the field is feasible. From an institutional point of view the Institutional Analysis and Design framework shows that there are much moments of interaction. However, these interactions do not lead to desired outcome: collaboration.

The systems analysis shows that a clear knowledge gap is at hand. "Interaction is not leading to the ideal outcome of development of the heat and cold energy storage field due to a lack of collaboration behaviour (informal) in the Netherlands. This thesis aims to answer that knowledge gap with the following research question:

"*Which are the most important drivers for collaboration behaviour in the Dutch heat and cold energy storage field?"*

Because knowledge is needed about collaboration behaviour from scientific literature, sub question 1 is formulated. Furthermore knowledge is needed to find applicable drivers and statements that make this thesis more applicable to investigated field of research and therewith creating a higher socieatal impact, see sub question 2 below:

SQ1 "Which are the drivers for collaboration behaviour stemming from literature?"
SQ2 "Which are the drivers for collaboration behaviour stemming from the experts in the field?"

The relation between the subquestions is represented by the list of drivers resulting from the first subquestion that are taken into account at subquestion 2. The applicablitity is tested and more drivers are added and translated into statements.

The methodology to perform this analysis is the Q-methodology, which strength is being able to combine quantitative research in a field with a too small sample number for statistical analysis (n<200) with a qualitative richness of information into a combined good overview. Q-methodology creates a set statements specified on collaboration behaviour in the heat and cold energy storage field in the Netherlands, the Q-set, the IAD framework was used to ensure fitment into the system. The P-set, a group of carefully selected participants, performs the Q-sort with the Q-set statements. The Actor analysis was used to create a clear P-set (set of participants) of the field with producers, costumers, grid owners, financiers etc. In the Q-sort the participants have sorted the statements by forming their opinion whether they agree most or disagree most with a statement related to collaboration behaviour.

During the analysis different factors, initially eight factors were found in the set that explain a significant amount of variance while also keeping the statistical requirements in hand. After removing unsuitable factors, a total variance of 68% is represented by the four perspectives. An expert validation confirmed the applicability and rightfulness of the perspectives and the drivers for the field.

As mentioned the Dutch institutional setting does apparently not take all the current perspectives into account. This has an important implication to the field. The natural role has to change if collaboration is the wanted outcome.

At least, the field should put effort in four points according to this research, each taking some of the perspectives into account:

1. Creating more need for heat and cold energy storage, hereto creating the incentive for the loaders in the Early Adopters perspective to start investing more in the field;
2. Setting out a clear and above strict policy around heat and cold energy storage with a focus on the long term usage;
3. Developing more hands-on and concrete sustainability goals on both a national and also important local level. To align with participants from the quid pro quo perspective, since they understand the need for collaboration in this field, but do not see (potential) options at this moment.
4. Taking the first step in a market which is currently known by market failure (see paragraph 1.3 and 2.5) in relation to the infrastructure for heat and cold energy storage. Hence by taking the first step in (socialising) infrastructure the Second Movers come in action

An institution comparible to the Dutch Gasunie (owner of gas grids respectively) would be an example which captures all above point for the gas sector.

Reflecting on the results and the conclusions has shown that both the system analysis and the Q-methodology produced the expected results. However in the case of the systems analysis a more extensive research could improve the knowledge of the field. Further research is recommended in other institutional barriers for more insights into the fields lacking development.

Another recommendation related to the continuity of the collaboration is the continuation of research into collaboration behaviour over time, since this thesis provides only a snapshot. This is interesting to test if future policy for institutional design is in place and to find out of the drivers for collaboration in the Dutch heat and cold energy storage field stay the same over a longer period of time.

Finally it is highly recommended to design a process that leads to the icorporation of the following drivers for collaboration as agenda points on the “Uitvoeringsagenda warmte visie” (implication agenda for the heat-vision) for October 2015:

”Improve stimulation on Price / Cost, Supply / Demand, Image and Risk but distimulate Interaction”

Combined, these implications and recommendations for the field should be taken into account not only by the persons related to the implication agenda of the heat-vision, but also by the local and national regulators, producers, financers, and suppliers, especially because they load the strongest on the perspectives.

Nevertheless for a full development of the heat and cold energy storage field in the Netherlands all stakeholders with decision making power should gather, for instance by gathering knowledge in a model with common viewpoints such as the MAIS model is currently performing.

Glossary and List of Abbr.

1.1.1.1 Glossary

Chemical energy = Energy stored in secondary energy carriers; e.g. H_2, LNG (IEC, 2011).
Energy = Electric energy and other forms of energy such as thermal- and chemical energy.
Energy storage = Energy storage is the storing of some form of energy that can be drawn upon at a later time to perform some useful operation" (Gil, et al., 2010).
Heat and cold = All forms of thermal energy, often mentioned as thermal energy.
Splitsingswet = Law that enforced the split between energy producers and distributors (Rijksoverheid, 2013).

1.1.1.2 List of Abbreviations

BNG	Bank Nederlandse Gemeenten
Cd	Cadmium
RVO	Rijksdienst Voor Ondernemend Nederland
BTW	Belasting Toegevoegde Waarde (Value added taxes).
Bv / Bijv.	Bijvoorbeeld (for example)
Br	Bromine
CO_2	Carbon dioxide
CV	Centrale Verwarming (Central Heating = Household heating system based on natural gas)
Cr	Chromium
CHP	Combined heat and power
CAES	Compressed air energy storage
CSP	Concentrated solar power
DLC	Double layer capacitor
EV	Electric vehicle
EES	Electrical energy storage (contains 5 types of storage including thermal energy)
FB	Flow battery
FES	Flywheel energy storage
Warmtevisie	Heat vision, the Dutch policy/law on heat usage.
HEV	Hybrid electric vehicle
HFB	Hybrid flow battery
H2	Hydrogen
LA	Lead acid
Li-ion	Lithium ion (battery)
MGE	Maatschappelijk Gebonden Eigendom (Regional possibility to ensure houses are kept available for a specific focus group during a longer period. With attractive options for housing corporations).
NEW	Nationaal Expertisecentrum Warmte (National expertise centre for heat)
NiCd	Nickel cadmium
NiMH	Nickel metal hydride
NMDA	Niet Minder Dan Anders principe (Principle Not to sell heat More Expensive than Other alternatives)
PCM	Phase change material
PPS	Publiek Private samenwerking (Public Private Partnership PPP)
PHS	Pumped hydro storage
NaS	Sodium sulphur

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INTRODUCTION

1 Introduction

This chapter provides the reader with an insight into the problem at hand in the heat and cold energy storage field. To achieve this it sketches the market outbound and sets the scope of this research. Analysis will be performed around the current energy storage systems, to identify current problem areas. . These problem areas should help to find knowledge gaps, which can aid in providing solutions to address the identified problems.

1.1 Heat and cold energy storage is hot

The title above is literally true but at the same time it is false. True, because in the Netherlands a lot of energy producing overcapacity is available for 100% of the time to serve as balancing capacity in the energy system. Much of this is capacity based on fossil fuel sources, which have the capability to be able to deliver a more flexible energy output. Patterns of demand and supply are changing during the day and this creates a complex system.

1.2 Variability demand

The demand for heat and cold is not constant but it correlates with the temperature outside (for households and presumably also for other users such as industry and commercial premises). The demand varies widely over the year this is shown in the left part of figure 1 as function of the central heating system for the year 2012. In addition, there are big differences in the demanded capacity per day shown in figure 3. Storage can smooth out this variability and allows for less dimensioning of overcapacity (RVO, 2014).

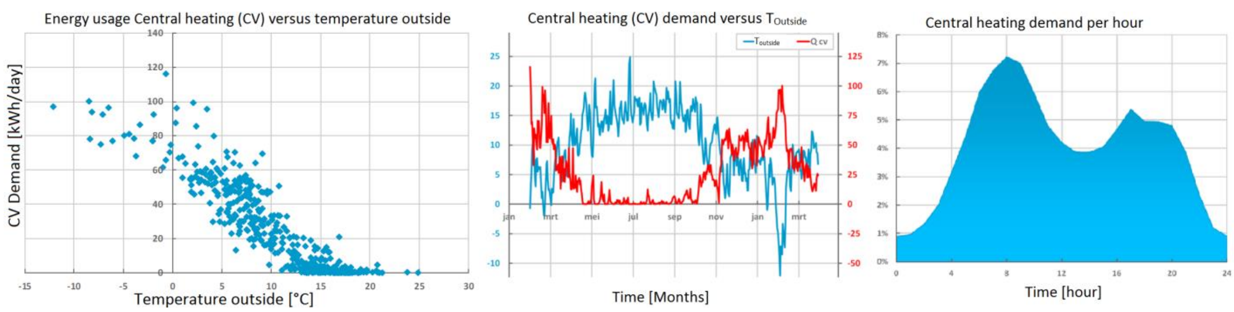

Figure 1 Demand for heat and cold and the outside temperature per month & hour in 2012 (RVO, 2014)

1.2.1 Intermittency

Since intermittent energy production does not have a matching, intermittent demand, there is always a small shortage or surplus of energy. This is costly as the prices in case of energy shortage are high and in case of overproduction they are very low. In central Europe and Denmark this has already led to negative energy prices (Benedettini & Stagnaro, 2014). This shows the need address the issues related to excess and shortage of energy.

Theoretically, storing energy (in the form of heat and cold) could address a part of this capacity delivering function. However, at the same time there are significant limitations. It would be required to store large amounts of energy, for a prolongued time and/or should be able to respond very quickly to changes in demand. For instance gas-fuelled production units can provide these capabilities, but current heat and cold energy storage systems cannot provide these capabilities on a large scale (Beaudin, Zareipour, Schellenberglabe, & Rosehart, 2010).

1.2.2 Regulatory needs

There are also other reasons why energy storage is hot. The Kyoto protocol urged for lower emissions of CO_2. Energy storage can provide this by storing energy from zero or low CO_2 emitting sources. Many more regulations and treaties have followed since Kyoto. More specifically, related to heat there is the obligation to map the heat potential of European Member states in the form of RES directive 2009/28/EC (Steinbach, 2011). This directive has to be implemented into laws in the individual member states of countries in the European Union and therefore also applies to the Netherlands. Next to that, the price of conventional energy sources is expected to rise in coming years and an increasing number of countries realise the critical dependence of national economies on a continuous and undistorted supply of such sources (Hadjipaschalis, Poullikkas, & Efthimiou, 2009).

1.2.3 Decentralisation and spread demand

Decentralisation trends in society lead to local energy initiatives (International Energy Agency, 2015). Parts of the decentralised units are primary heat and cold (end product), while other parts are secondary heat and cold (rest products). New techniques and innovations have lead to less dangerous and less emitting processes (González, McKeogh, & Gallachóir, 2004). However, a highly valuable source of energy remains untouched. This source of energy is heat, which is often cooled away. Heat not only stems from existing man made processes, but Mother Nature is an important source; 99% of the crust of the earth is warmer than 100°C. Nevertheless some parts of the earth are are much more colder so cold could be stored there (TNO, 2013). Next to that also industries have (exothermic) processes that result in abundant heat, which is unused.

Figure 2 Heat demand in the Netherlands in GJ/ ha.year (Nationaal GeoRegister, 2012). Darker red represents a higher demand.

There is a lot of demand for heat and also an increasing demand for cold in the Netherlands of 1324 and 84 PJ respectively (Agentschap NL, 2013; Buck, Valkengoed, & Leguijt, 2009; CBS, 2012). Despite that only, 4% of the Dutch were in 2013 connected to a district heating grid

(Agentschap NL, 2013). In Figure 2 the demand of heat per household per year in the Netherlands is visualised; darker red relates to higher demand.

1.3 Problem statement

Energy storage has been under development ever since electricity was available but became bigger since the second half of the 19th century (David & Bunn, 1988). Given the thermodynamic laws, energy is never lost. This would suggest that energy storage is widespread in the Netherlands, also in the heat and cold field. Despite the before mentioned opportunities, the demand for heat and cold as well as for energy storage, and the untapped resources of waste heat and the pressure from regulatory bodies in different ways, this is however not the case in the current situation. This leads to the following problem statement:

“Different aspects of energy storage in the Dutch heat and cold field are not yet well enough developed or market conditions are not suitable for a large scale development of the field”.

Provided all the above findings, it is not obvious what the exact definition of energy storage is. One broad definition stems from Gil et al. (2010) “Energy storage is the storing of some form of energy that can be drawn upon at a later time to perform some useful operation”. However alternatives exist, (see therefore Appendix A.1 on page 91), the definition by Gil et al is used in this report. In that way also heat grids, heat buffers and geothermal energy are captured in the scope of this research, since they compete with energy storage in the market. Given the definition of energy storage, many different technologies or techniques exist that could fit the definition. This is seen as an argument to create a recent and concise overview (a snapshot) of the current state of energy storage and its applicability in the Dutch energy system. In addition to thermal energy storage many other forms of energy exist. This thesis does not aim to define all of them, but to form an understanding of the reasons behind the lack of development of the heat and cold energy storage field in the Netherlands.

From several parts of the system there is pressure on the heat and cold energy storage field, despite these pressures, e.g. regulatory from the directives (European Commission Directorate-general for energy, 2013; Intelligent Energy Europe, 2011; Steinbach, 2011) and bottom up via the need of system balancing and storing cheap energy (Agentschap NL, 2013; Benedettini & Stagnaro, 2014; Buck et al., 2009) the market is not responding. Steering via the Warmtewet, Electriciteitswet or Mijnbouwet has also not resulted in market development. Assumed is that market failure is the origin of this problem. The market could of course stay the same size as it is currently, hence then no market failure or problems exist in the heat and cold energy storage field in the Netherlands. However, the existence of all this policy from Europe and the Netherlands shows that growth is actually demanded from the field. The heat directive, Warmtebrief and the roadmap for heat (Buck et al., 2009; Kamp, 2015; Steinbach, 2011) are the clearest arguments for that point. So if that is not working another step, individual motivated behaviour; cooperation rather than collective action is assumed to boost the development of the field. In a complex social technical system with a networked strategy, cooperation is documented as a proper steering mechanism (Chisholm, 1989; Dyer, 2002; Ligtvoet, 2013; Raven & Verbong, 2007). The hypothesis is that some form of cooperation is needed in this complex socio-technical field, which is characterized by long term planning, large investments and interdependencies between actors and other systems(Raadgever, Mostert, & Giesen, 2012).

Other options to develop the field such as collective actions or hierarchical steering could also provide a potential solution for the problem defined. Therefore an overview of current energy storage technologies is needed. The institutional perspective determines the environment of the thermal energy storage field and the technological perspective shows which other technologies to store energy are direct competitors of heat and cold energy storage. Next to the institutional and technological systems perspective, the economical design of the heat and cold energy storage field is also needed to understand why and where the field is lacking in its development. For more information on the choices made see pararagraph 2.1 on page 9.

With the problem surroundings not yet clear, this thesis will first describe a systems analysis in chapter two. The research methods that are most fitting to solve the knowledge gap in the heat and cold energy storage field will be described in chapter three. In chapters four the chosen, Q-methodology to find drivers for collaboration behaviour is applied and the results thereof are presented in chapter five. In chapter six an expert validation of the explored drivers is provided and in chapter seven a discussion and reflection are presented on the scientific value and on the results of this thesis. The final conclusions and recommendations are drawn in chapter eight.

SYSTEM ANALYSIS

2 System analysis

"Everything should be made as simple as possible, but not simpler."

Allocated to Albert Einstein

In this chapter the field of heat and cold energy storage is explored into more detail. This chapter is split into three fields of exploration. First a typical systems analysis describes the technical perspective of the energy storage technologies. Given this context, previously developed business cases will be assessed from an economic point of view. Thirdly, a systems overview is presented via the institutionally driven IAD framework (Institutional Analysis and Development). This results in a research question.

2.1 Choice of perspectives

Traditionally many forms exist for a system analysis and systems design and Bots and Daalen (2012) have developed a Technology-, Institutional- and Process design approach. Despite the fact that economics are interwoven in the institutional and technological design of a system, the discussion in the field with experts and scientists (in the running up for this thesis) showed much importance for economics. Therefore and because designing a new system is not the main goal of this thesis, a specific choice was made to use three different pillars; economical, institutional and technological.

2.2 Technological systems perspective

This paragraph provides a desk study and a review of literature into the current stage of energy technology. This is performed as these energy technologies form the direct competition for the heat and cold energy storage technology.

2.2.1 Types of electrical energy storage

There are multiple ways to define energy storage, hence many different types of energy storage exist (explained in more detail in Appendix A.1). All of these types can fulfil a different function, depending on its characteristics. It makes sense and is also common to split energy storage into different types. In literature five types of storage are identified (Chen et al., 2009; DTI, 2004; Gil et al., 2010; IEC, 2011; International Energy Agency, 2014).

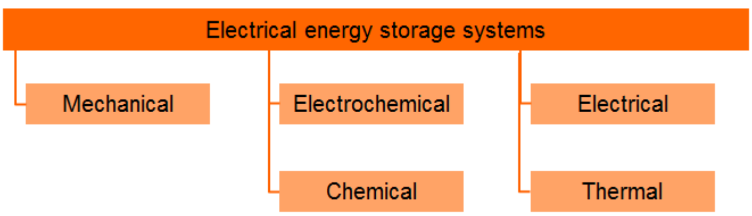

Figure 3 Types of Electrical energy storage systems (IEC, 2011)

- Mechanical: Storing electricity into mechanical movement/motion (e.g. flywheel);
- Electrochemical: Storing electrons in a chemical compound (e.g batteries);
- Chemical: Storing electricity in a chemical energy carrier (e.g. Hydrogen);
- Electrical: Storing electrons in an energy field, no reaction (e.g. supercapacitors);
- Thermal: Storing available heat in an insulated repository (e.g. Geothermal storage).

From all classes a more detailed description of common techniques is provided in A.2 on page 91. Often in discussions in the field confusion was encountered between electrochemical and electrical energy storage. However this is a simple definition question. Next to that also chemical energy is often forgotten.

2.2.2 Characteristics and maturity of the energy technologies

To assess the maturity of the technologies, a clear understanding of the characteristics of different technologies is needed. This tries to assess its maturity in the market, in order to see if that could be the problem for the lack in speed of development. The maturity of the technology is often seen as an indicator if the market is able to develop (Ortt, 2010).

For above mentioned purpose a desk study has been performed to review literature on EES. This has resulted in many papers and scientific articles on the current state of EES, however only those applicable in the Netherlands are researched into full detail. The papers have all shown that characteristics as shown in

1	Discharge Power (W)	9	Charge Power (W)
2	Ramp Up Speed (W/min)	10	Ramp Down Speed (W/min)
3	Energy storage capacity (Wh)	11	Energy Density (Wh/m3)
4	Energy Degradation (%/day)	12	Energy Conversion Efficiency (%)
5	Response Time Discharge (min)	13	Response Time Charge (min)
6	Lifetime (cycles)	14	Min Discharge Time (hours)
7	Discharge Time (hours)	15	Operational Time (min)
8	Max Discharge Time (hours)		

Table 1 have determined the maturity of technologies (Beaudin, Zareipour, Schellenberglabe, & Rosehart, 2010; Black & Vetch, 2012; British Geological Survey, 2008; Chen et al., 2009; DTI, 2004; Ecofys, 2014; EPRI, 2003, 2010; European Commission Directorate-general for energy, 2013; IEC, 2011; International Renewable Energy Agency, 2012; Koolwijk et al., 2010; López-Maldonado, Ponce-Ortega, & Segovia-Hernández, 2011; Pierie, Someren, & Noppen, 2015).

In many cases scientific material differed for each technology regarding the characteristics such as discharge time. This stems from the fact that there are no standardised units of power, volume, density and even less for size if one looks at EES. Therefore this research has adapted averages as distinguishing numbers. These averages are based on the lowest and highest value for each 'characteristic' as found in literature. The average values per technology are shown in Appendix B.1 on page 95 because the overview contains multiple pages.

1	Discharge Power (W)	9	Charge Power (W)
2	Ramp Up Speed (W/min)	10	Ramp Down Speed (W/min)
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7	Discharge Time (hours)	15	Operational Time (min)
8	Max Discharge Time (hours)		

Table 1 Characteristics and units of EES to assess the technological maturity

With the data derived from the characteristics of the technologies on power rating, response time and discharge period, it is now possible to assess the maturity of the technologies in the Dutch heat and cold energy storage system. For the the number of techniques rolled out in the Netherlands (with the focus on heat and cold) see Figure 4. Techniques that are not available on the market or require specific non-Dutch geographical circumstances (height, temperature) are left out of this overview. Despite several different views, the technologies can be separated in their maturity between different levels (Beaudin et al., 2010; Chen et al., 2009). For the purpose of this research the separation of Ortt (2009) has been used because the hypothesis is that technologies are not mature enough for development in larger scale, and this leads to lack of development (Ortt, 2010).

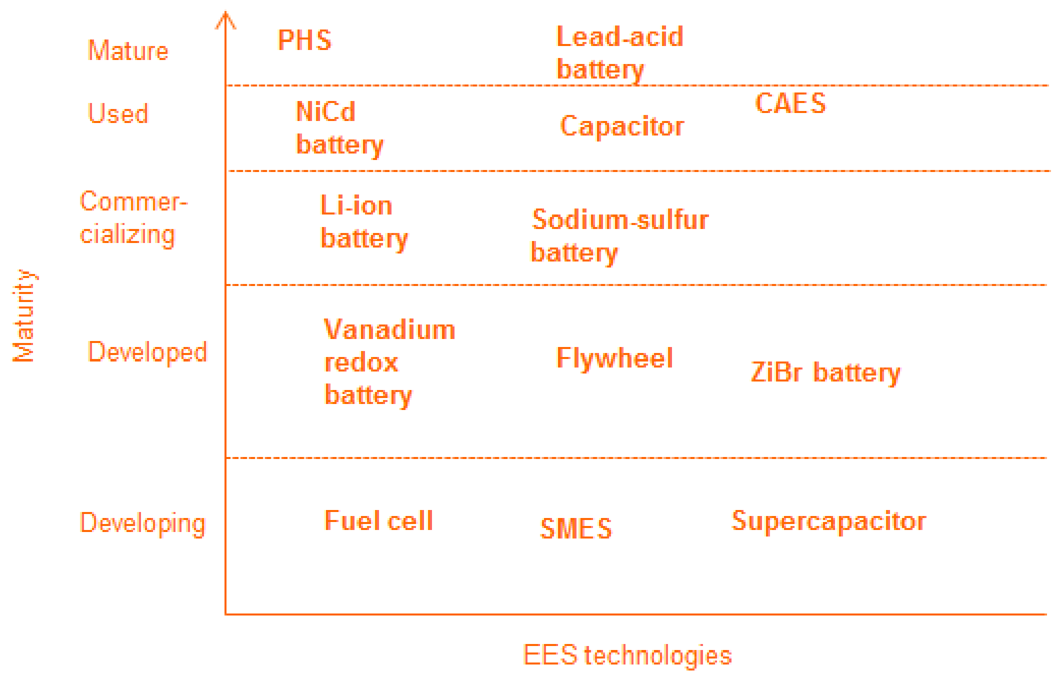

Figure 4 Maturity of energy technologies, adapted from (Beaudin et al., 2010; Chen et al., 2009)

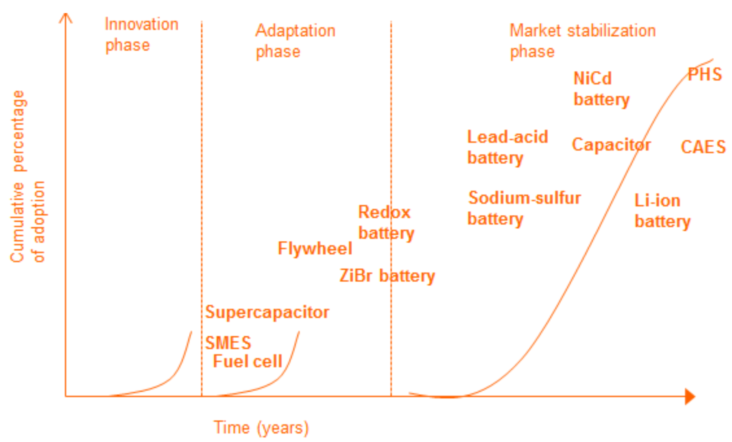

Figure 5 Maturity phase (Ortt, 2010)

The three stages are shown in this figure represent the following thresholds, from innovation to adaptation, if you passed first product launch, this is the case for all technologies, otherwise it is not interesting for this snapshot of the research (in 2015), because technologies are not available freely on the market. The second threshold is from the adaptation phase to market stabilisation and is overcome if industrial production has started. This is not valid for all the technologies as can be seen in Figure 4, which shows the graphical difference between the technological maturities.

As can be seen from Figure 5, many technologies are available on industrial scale in the Netherlands which implies that the technology is not burdening the development of the heat and cold energy storage field in the Netherlands. Therefore a further investigation into the economics is desirable. Especially since Figure 6 shows that the number of households connected to heat grids in the entire Netherlands is still relative low (<4 % in 2012). This is represented by the yellow color in Figure 6. From the same figure can also be derived that heat and cold energy storage technology is not widespread in the Netherlands.

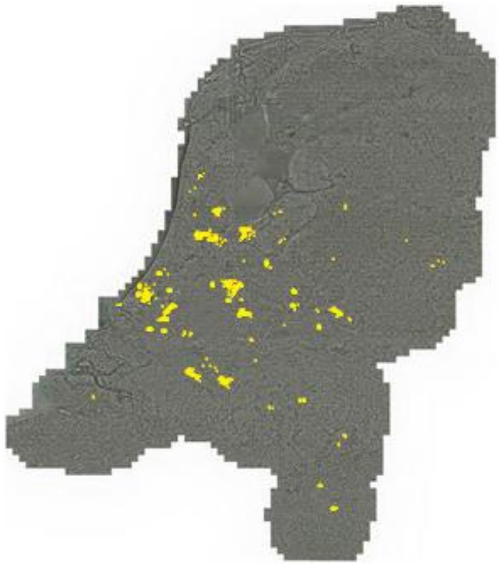

Figure 6 In yellow colour: the number of households connected to a heat grid in the Netherlands (Nationaal GeoRegister, 2012)

Concluding, one can say that at a local level many technologies (adaptation phase (Ortt, 2010)) are implemented, mainly as individual and stand-alone initiatives. However, in general the energy storage infrastructure is not yet implemented on a wider scale or connected to each other and the energy system, especially not in the transmission and distribution chains. The same applies to storage within the heat and cold infrastructure; it is not yet largely implemented, deducting leads to the same conclusion for the entire heat sector, which is not developed widely, especially if you compare it to the other heat provider in the Netherlands, the natural gas sector, which has a full (100 %) coverage of households (Gasunie, 2015).

2.3 Economical systems perspective

Tthe technical part of the TIP design (Bots & Daalen, 2012) seems well developed. The economical part of the field is closely related to the technical design of the system, the assumption should be made while considering at least the combination from the two perspectives. It is also important to keep in mind that the economic design can be argued to relate much to the institutional design given that the institutional design puts a very limiting scope on the business case. More information is provided in paragraph 2.4, from which it will become clear that the institutional design determines the (economic) markets for selling electricity.

2.3.1 Demands for energy storage in the heat and cold chain

Societal demand for (more) heat and cold storage exists for of multiple reasons. Firstly the urge to emit less CO_2 leads to a more sustainable perspective on energy production, heat can be sustainable stored if the heat source is sustainable. Secondly currently sometimes too much energy is produced or energy from fossil sources serves to balance the intermitted energy output from renewable sources. If storage can provide the same balancing function, a reduction of CO_2 emissions from fossil sources can be reached as well as a reduction in the required production capacity for balancing. Because of the Emission Trade System for CO_2–reduction, this forms an economical driver to invest in heat and cold energy storage technologies. Thirdly there is regulatory pressure from the Kyoto protocol. Combined with this regulatory pressure, a European directive obliges the Dutch government to assess the potential of heat in a so called heat-mapping; heat and cold energy storage is part of this heat mapping (Steinbach, 2011). Next to that, the Dutch government has provided the “Topsector Energy” with a delegated assignment to the companies DNV GL, TU Delft and Berenschot to develop a roadmap for energy storage (Energie business, 2014). This is interesting since it needs to be presented on the Energy conference in coming October. Following the policy window-model this provides the possibility for a window in the political- and the problems stream (Kingdon, 1995). Results from this report could provide insight in how collaboration can help set the agenda for growth in the heat and cold energy storage field.

Provided the societal demand as describe above, the expectation is still that the energy storage is suitable to be implemented on a bigger scale currently is implemented (see also chapter 1 Introduction). If an economical perspective is taken, the cost price of storage has declined the last decade to minimal 1 € / kWh stored energy (Barton & Infield, 2004). Sometimes demand is so low, that an energy producer is willing to pay for extra electricity demand (negative energy prices), just to ensure the production capacity does not need to be shut down completely which is very expensive due to extra shut-down and start-up costs. Volatility of high positive and negative energy prices, has already surfaced on the electricity spot markets in Belgium, Denmark, France and Germany and these markets are connected to the Dutch energy market (Benedettini & Stagnaro, 2014). To cope with volatility of the market some companies in California (USA) already provide services to assist big users of energy with the economic most attractive way of their demand load scheduling and balancing (Wang, 2015).

From the business line of heat and cold energy storage in the field as it exists today, several existing business cases with heat and cold energy storage are already implemented. However, specifics of each business case make it difficult to compare them objectively. The choice was made to mention three succesfull projects based on the experience and conversations the researcher had in the field with the ING Bank and with Balance (respectively a Financer and a Project manager heat and cold energy storage projects):

- A geothermal installation was placed by farmers with mostly own capital and in a second project with banks and even installation companies (Vreugdenhill, 2015).

- Secondly banks invest in geothermal projects with local heat grids and this project is back by two major constructers closely related to the Dutch heat and cold field.
- Thirdly a Dutch bank has financed over thirty-five geothermal projects with another bank combined for approximately a hundred million euro.

These examples do not represent all the cases in the field, but shows that most (economic) risks can be leveraged, otherwise banks do not typicially invest. Furthermore this illustrates the state of the field rather than to perform a complete analysis of businesscases.

2.3.2 Value creation in the traditional energy value chain

Another unclear aspect of energy storage lies in the place of the value chain it could be applied to. The value chain of energy is shown graphically in Figure 7. Larger scale energy storage, bigger volumes (MWh size) can be hard to apply on metering and sales level, since this involves many actors before consensus is reached for such a volume, smaller scale storage is more suitable there.

Figure 7 Traditional energy value chain (Enipedia TU Delft, 2014).

Larger scale is therefore most suitable somewhere between Energy source and Distribution (Enipedia TU Delft, 2014). Nevertheless many options and techniques are currently available: A comprehensive and detailed overview of for instance, phase changing materials for thermal storage (which are suitable for transferring heat and cold), is provided by (Zalba, Marín, F., & Mehling, 2003), where already Hundred-thirty materials are identified. Furthermore other types of techniques are available besides thermal storage which are mentioned by Zalba et al. (2003), hence for a good overview of most common techniques for energy storage and their place in the value chain see for instance (EPRI, 2010; Hadjipaschalis et al., 2009).

If one looks at the value chain in Figure 7 it seems revenue can only be created in the wholesale trade with energy (and by selling resources etc.). This is however not the case. The Dutch electricity system is legally a strictly regulated monopoly if looked at the transmission side. Next to that the Splitsingswet prohibits the ownership of both distribution grids and producing capacity (Rijksoverheid, 2013). Therefore this figure does not represent the complete market but mostly the technical design. The complete picture can be seen in Figure 9 (energy sources excluded). The representation in Figure 8 shows the physical layer more clearly.

In order to see whether an economic model is possible and to determine the exact position in the value chain, three criteria are set-up from the characteristics in paragraph 2.2.2. With these criteria the functions can be placed in the value chain. The discharge period is the key indicator in combination with the power rating for the size of the EES. A different size simply means a different the position in the value chain. Furthermore the markets for electricity determine the response time required, hence a position in the technical value chain is determined by an economical point of view and implemented via an institutional artefact (electricity law). A more elaborate motivation per function can be found in B.3 on page 98. Figure 8 shows a limited extraction from the total set to illustrate that energy storage can be applied on multiple positions in the energy value chain.

Criteria
Discharge period
Response time
Power rating

Table 2 Criteria to sort the EES functions in the value chain

EES are known to fulfil a lot of functions (EPRI, 2010; Hadjipaschalis et al., 2009). The most important functions have been identified in previous research by the International Energy Agency in the roadmap for Energy storage (International Energy Agency, 2014). In Table 16 on page 99 the functions of energy storage and a short description are provided. Given the sample of the total set of functions from Figure 8, it is clear that many markets may exist to sell stored energy. The full characteristics of the markets are described in appendix B.5 Energy markets. For now, the only focus is on electrical energy output and not on thermal energy output because this is the bigger system in which the heat and cold energy storage field is embedded in the Netherlands.

Provided the scope of this research and the assumption that technology is not burdening the development of heat and cold energy storage in the Netherlands, a following assumption can be: It is assumed that given the sufficient economic needs, drivers and characteristics of the value chain with many options for EES functions to complete a business case that: the economy is not burdening the development of the heat and cold energy storage in the Netherlands. Therewith effectively assuming that heat and cold energy storage is economically possible, to the extent that this does not influence the results of the research.

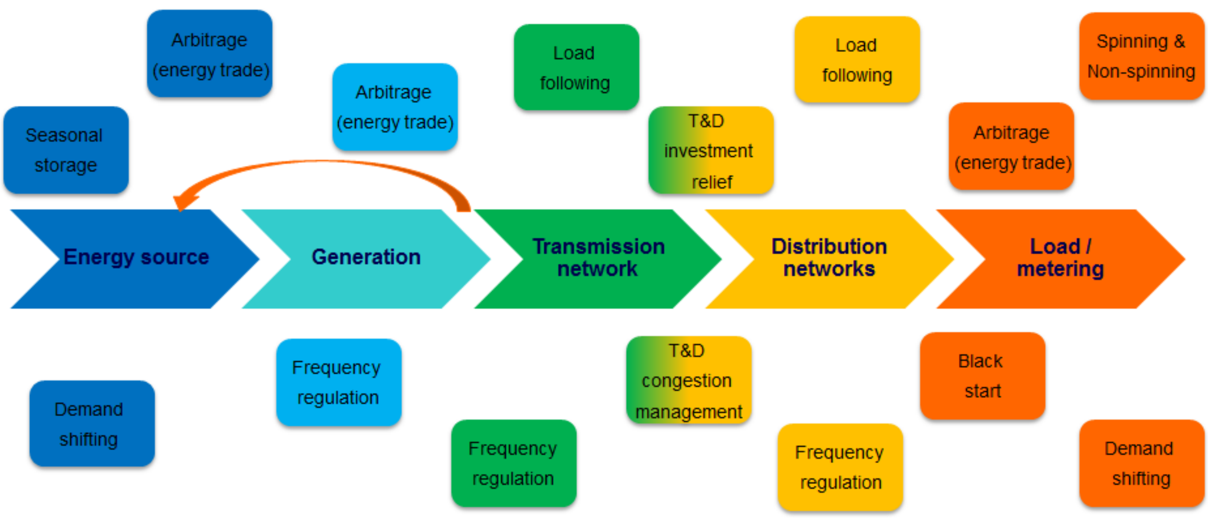

Figure 8 Functions of EES in the value chain

It is unclear why despite this economic urgency and the current state of technologies, this is not leading to growth of the system. To further investigate the field and narrow the scope of this research the next paragraph will analyse the system from an institutional perspective.

2.4 Institutional systems perspective

This section describes the heat and cold energy storage field in the Netherlands from an institutional perspective. To create structure within the relatively capricious and complex field of a sociotechnical system, the Institutional Analysis and Design framework (IAD) from Elionor Ostrom (2011) is used. This structure is needed because of the web of institutions and arenas in the field which has many overlaps with a sector that is more mature, the energy sector (Ostrom, 2011). A strong point of the IAD framework is that it combines the actor analysis with not only the formal but also the informal relations based on the institutions. Despite the strong point, there are other fitting frameworks, however goal of this thesis is not to find the best framework but merely to map the institutional issues incorporated and hidden in the heat and cold energy storage field in the Netherlands. For that reason, formal mapping from Enserink et al (2010) is also used to complete the IAD's analysis. Finally, stakeholder driven actor analysis is also used (Table 2 Enserink et al., 2010, p. 82).

2.4.1 The IAD framework

The main strength and the part the IAD framework will be used for is to identify the way informal and formal rules affect the heat and cold energy field in a collective action dilemma. The hypothesis underlying this part of the desk study is that the heat and cold energy storage field in the Netherlands is not going through a development of growth, because there is a complex field and a lack of collective action therein (despite market failure) e.g. the outcomes of the IAD framework are not satisfactorily for development of the heat and cold energy storage field in the Netherlands.

The IAD framework was first proposed by Ostrom et al. (1994) and is an institution driven tool that enables the researcher to develop a systems perspective on the Dutch heat energy storage system. In short the IAD framework can be divided into three segments; (1) the operational environment; actions and participants, while understanding (2) the underlying structure of the social system and (3) the last segment focusses on observing the interaction patterns and outcomes, given a set of criteria (Ostrom, Gardner, & Walker, 1994). The Development part of the framework (iaD) focusses specifically on new steps to take. As this part focusses on analysing the location of the problem in the heat and cold energy storage field in the Netherlands, rather than developing new institutions the assumption is made that the structure of the IAD framework provides enough knowledge of the institutional setting of the field.

The first sub-paragraph looks at the institutions in the energy value chain, given the economic analysis in the previous paragraph. The second paragraph identifies the action situations (conceptual unit) with that knowledge.

2.4.1.1 Energy value chain heat and cold storage with institutional layer

Multiple articles put emphasis in order to have a proper market design; the market should not only be seen as a pure technical and/or economical design, but more as complex capricious problems and interactions in a system. In the heat and cold field there are also interactions and parties with different goals and (problem) perspectives. The interactions and the articles will be handled in the next sub paragraph.

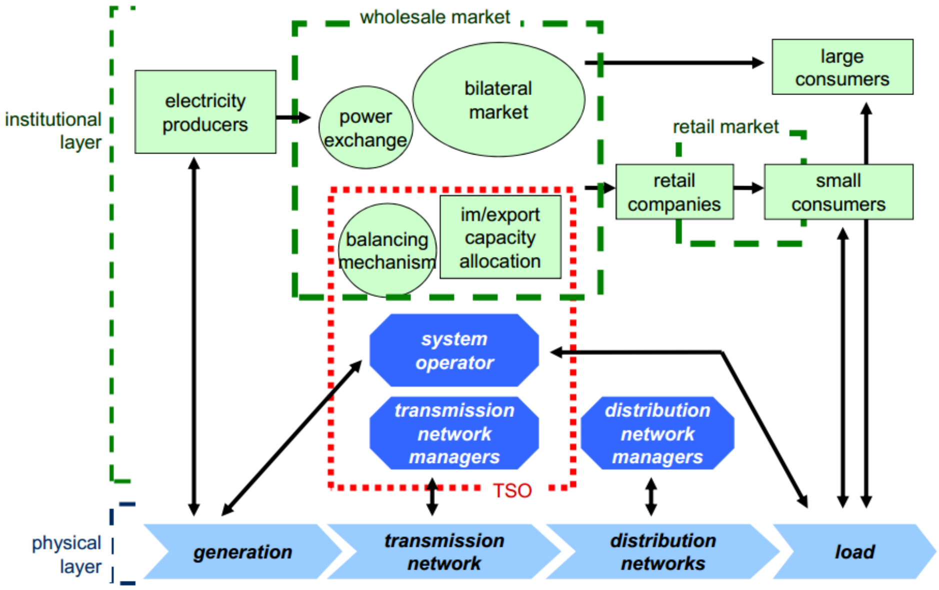

Figure 9 Energy value chain heat and cold storage with institutional layer (De Vries, 2012)

A full formal map can be found in Appendix B.6 on page 102. The most important laws and regulations on the heat and cold energy storage field in the Netherlands are the Splitsingswet, the Electriciteitswet, the Warmtewet, and the newly released Warmtebrief (April 1st 2015)(Kamp, 2015). Municipalities and provinces are very influential, in that they can formulate local spatial plans where heat and cold storage can be applied (Rijksoverheid, 2013). They are also responsible for permits; only for geothermal deep drilling the Mijnbouwet is applicable. As can be seen from Figure 9 there is already a lot of institutional design related tot the energy value chain; however it does not work properly.

If a technology at this moment can reduce energy variations on a small power scale (kWh-size), this means it is interesting to place at the Load/Metering chain of the value chain as was concluded from paragraph 2.3.2 "Value creation in the traditional energy value chain". This means that costs are made by actors in that part of the value chain. However the benefits of the less varying demand are obtained by the Dutch monopolists in the Distribution part of the value chain, one can conclude this results in a split incentive to invest. Before this can be overcome some form of cooperation (i.e. collaboration) between the actors in different parts of the value chain is needed. This again argues for the hypothesis that some form of cooperation is needed in this complex socio-technical field (Raadgever et al., 2012).

2.4.1.2 Action situations

Typically for the IAD framework (Baldwin, 2013) and a system in a networked hierarchy (Chisholm, 1989), the actor analysis is from a networked perspective in the type such as for instance described in (Table 1 Enserink et al., 2010, p. 82 ; van der Lei, 2009). In order to not only dive in the network but to keep a slightly more systems perspective (with the processes design in the back of mind), also some components for a more resource and interdependency driven actor/stakeholder analysis are added via an iterative process, mainly to ensure later applicable drivers, for the lack of desired outcomes, could be obtained (Table 2 second row Enserink et al., 2010, p. 82). For a full implementation see Appendix B.6 on page 102. It is derived that some actors have monetary resources (financers), but there is a lack of (technical) knowledge to perform complex projects on their own (producers/ grid owners). Special attention was already given to the grid owners who are not allowed to feed thermal or electrical energy in on the net as producers (because of the Splitsingswet) (Rijksoverheid, 2013).

2.4.1.3 Patterns of interactions

The patterns of interaction are the second to last set of facets that ought to be explored for the IAD framework. As can be seen in the list below, there are many types of interactions: Inquiring knowledge, finding project knowledge, getting permits and permissions / exceptions, finding financing and connecting with operators and (sub-)contractors.

- Inquiring knowledge;
    - NEW = national expertise centre for heat;
    - TSE = TopSector Energy;
    - BEA = Safeguarding-Comittee of the Energy Agreement;
    - Local initiatives from neighbourhoods or cooperations' (not limited to housing-).
- Finding project knowledge;
- Getting permits and permissions / exceptions;
- Finding financing;
- Connection with operators and (sub-)contractors;
- Finding clients;

Patterns are often recurring, the field is not that wide developed yet, therefore many similar actors are in the rounds. However, this does not result in more development of the field. One seems to work alone, not working on combined goals. Again this provides another argument for the hypothesis that some form of cooperation is needed in this complex socio-technical field.

2.4.1.4 Outcomes

The last iterative step of the IAD framework comprises of the outcomes and the feedback given back to the system to complete the loop in the framework.

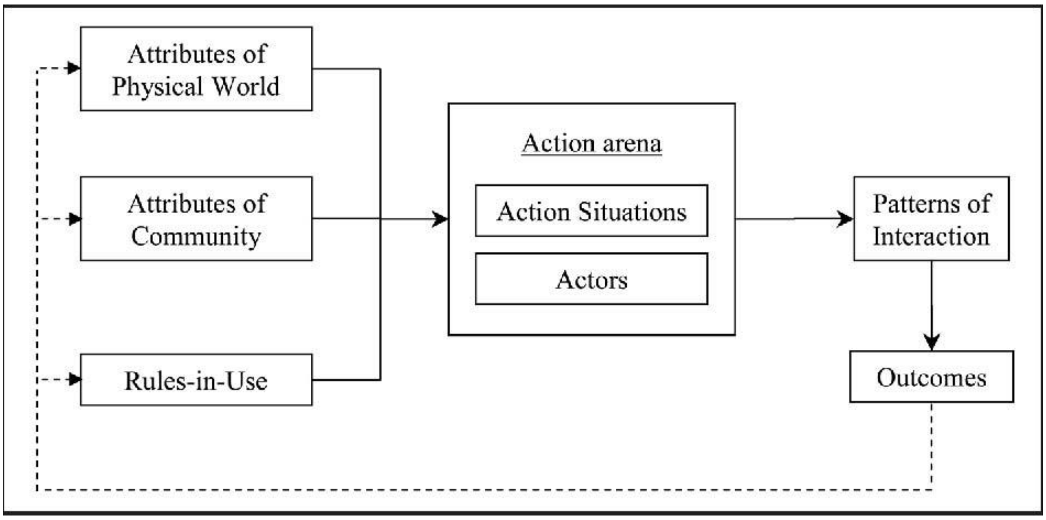

Figure 10 The Institutional Analysis and Design (IAD) framework by (Ostrom, 1997)

District heating provides the best example for this thesis to explain the IAD's results. District heating mainly consists of two common resources; warm water and infrastructure. Here the infrastructure is usually a provisioning problem as there is a need to install and maintain the infrastructure, of which the costs are shared by the users. The warm water needs of end-users trigger appropriation problems, mainly linked to the division of water among the users and to the possible techniques used in order to generate the warm water and the rights to it (Bravo & Marelli, 2008).

Given the Technical and Institutional artefacts in place, the Process design to keep these artefects upto standard or to create new and more artefects seems to be absent in the field. Since in comparison with and concluding from the IAD framework, it seems that this process is not well enough designed yet.

Despite the complexity however in managing two “common pool resources” the Dutch government made it possible to achieve some form of governance. This is mutually exclusive for end-users, the use of the warm water resources for one person at the same time depletes the pool for another user. This is similar for (the construction of) the infrastructure (Bravo & Marelli, 2008; Ostrom et al., 1994)). A couple of credible but also sluggish -the Warmtenet- and cumbersome -local decision making power at municipalities and provinces- institutions were placed. However, the adaption to the informal drive (=to do well for oneself) and the lack of wanted outcomes after interactions (=collaboration) seems not to have been developed. The main argumentation therefore is that “the outcome” is the only arrow of the IAD framework that is not existing in the analysis as performed. The institutions are thus “not well adapted to local physical and social conditions and is not yet able to create the right incentives in order to push the users“ to collaborate so that the fields’ development grows (Tang, 1992). Without stating the process design for institutional artifacts is unfluenced in three ways. The shared values of persons, the worldview persons, by existing networks of social relations and the social characters of the community of users (Auer, 2006). Therefore more research is needed to see which drivers ensure more collaboration in the heat and cold energy storage field in the Netherlands. From problem situation is becomes clear that taking a further step in development with the IAD framework is superfluous since more knowledge is first needed. Two more development steps are discussed in paragraph 6.4.

2.5 Knowledge gaps

This paragraph summarizes the conclusions that can be derived from the technical, economical and institutional analysis that has been performed in the preceding paragraphs. Next it formulates the knowledge gaps and it ends with formulating a specific knowledge gap for this research.

Concluding, one can say that at a local level many technologies (adaptation phase (Ortt, 2010)) are implemented, mainly as individual and stand-alone initiatives. However, in general the energy storage infrastructure is not yet implemented on a wider scale. Nor is it connected to each other and the energy system, especially not in the transmission and distribution chains. The same applies to storage within the heat and cold infrastructure; it is not yet largely implemented, this leads to the same conclusion for the entire heat sector, which is not developed widely, especially if compared to the other heat provider in the Netherlands, the socialised natural gas sector, which is laid out in the entire Netherlands (Gasunie, 2015; Raven & Verbong, 2007).

Provided the scope of this research the assumptions that technology and economy are not burdening the development of the field imply or effectively assume that the expected outcomes for the fields' development are not shown in the Netherlands must come from the instutional perspective.

If one looks at the literature as it is, it is hard to find a set of rules, or a theoretical framework that incorporate both the techno-economical as well as the complex actor perspective of the heat and cold network. This lack of comprehensive theory leads to a gap in scientific literature. Many models are used to develop parts of the heat and cold energy storage field developed by companies such as:

- Frauenhofer ISE; calculation models of the full energy systems (Henning, 2015);
- Quintel: highly aggregated calculation model of Dutch energy system (Energytransitiemodel.nl, 2015);
- Calculation models from single heat providers in specific locations only, such as Eneco and Nuon/Vattenfall (Van de Brug, 2014);
- TU Delft; aggregated differential or agent based models with a too narrow scope for this research (Linny-R, 2015).

Many of these models have a lack of applicability on all fields, they often focus on a full energy system (Frauenhofer), but only specific in a region or some models do incorporate broader regions or even country statistics, but fail to couple that to physical locations (Quintel).

It should be possible to use one main concept to get the entire field on speaking terms with an underlying set of rules and standard data for input upon which to agree with all stakeholders, if the discussion is structured. A first attempt with the IAD framework resulted in a limited institutional scope into the knowledge gap that:

"Interaction is not leading to the ideal outcome of development of the field due to a lack of collaboration behaviour (informal) in the heat and cold energy storage field in the Netherlands."

This research aims to find a solution for this statement, therefor the next paragraph develops the research question and sub questions to come to a sound conclusion.

2.6 Research question

This section translates the knowledge of the gap in into a research question for the purpose of this research.

An insight into collaboration behaviour can ensure that stakeholders in the heat and cold energy storage field combine their efforts to improve the field as a whole and that growth as desired in the Warmtebrief is enabled (Kamp, 2015). Up till now no such effort has been made in the literature focussed on the (Dutch) heat and cold energy storage field.

To conclude from the previous sections in this chapter a research was done into the upper laying structures of the Dutch heat and cold energy storage field. The technological perspective seems not to put a burden on the development of the field. From an economic perspective, the same conclusion was deduced; the economics are not burdening the development of the heat and cold energy storage field in The Netherlands., many business cases exist and hence, there is also no burden on further development. Institutionally the heat and cold energy storage field is a complex system with many different stakeholders. The interactions are there, but resulting collaboration is limited despite the urgency for the economic growth and the interactions. This thesis tries to see whether the insight into drivers for collaboration behaviour can be used in future market design or government policies. The main research question of my thesis therefore is:

"*Which are the most important drivers for collaboration behaviour in the Dutch heat and cold energy storage field?"*

> SQ1: Which are the drivers for collaboration behaviour stemming from literature?
>
> SQ2: Which are the drivers for collaboration behaviour stemming from the experts in the field?

In the next chapter the methodology that is most fitting to solve the research question is elaborated and the framework that will be used therefore will be designed.

METHODOLOGY

3 Methodology and framework design

This chapter describes all the methodologies that have been used to provide an answer to the research question "*Which are the most important drivers for collaboration behaviour in the Dutch heat and cold energy storage field?*" The second part of this chapter is used to describe the design of the steps needed to answer the research question. This while keeping in mind: that the state of current EES in the heat and cold energy storage field in the Netherlands is mature enough for development, secondly that the economic pillar does not put a burden on development and lastly keeping in mind that the heat and cold energy storage field in the Netherlands is a complex and capricious sociotechnical system. Despite that there are many interactions not much collaboration is stemming from the formal and informal institutions in place. The process design is apparently inadequate to stimulate or push this behaviour.

3.1 Grounds for research

The main motivations for this research are two-fold, best described from an academic and a case study related perspective. From an academic perspective, the motivation for this research is to fill the knowledge gap as it has been defined in the previous chapter. This means, that this research will try to find drivers that influence collaboration behaviour.

From a case specific perspective, this research tries to capture a specific case in which these drivers are applicable. This case study is performed with ING and Balance in the Dutch heat and cold energy storage field. As explained in the introduction it is important to find applicable drivers to test, given the usefulness and the relative narrow scope of the research.

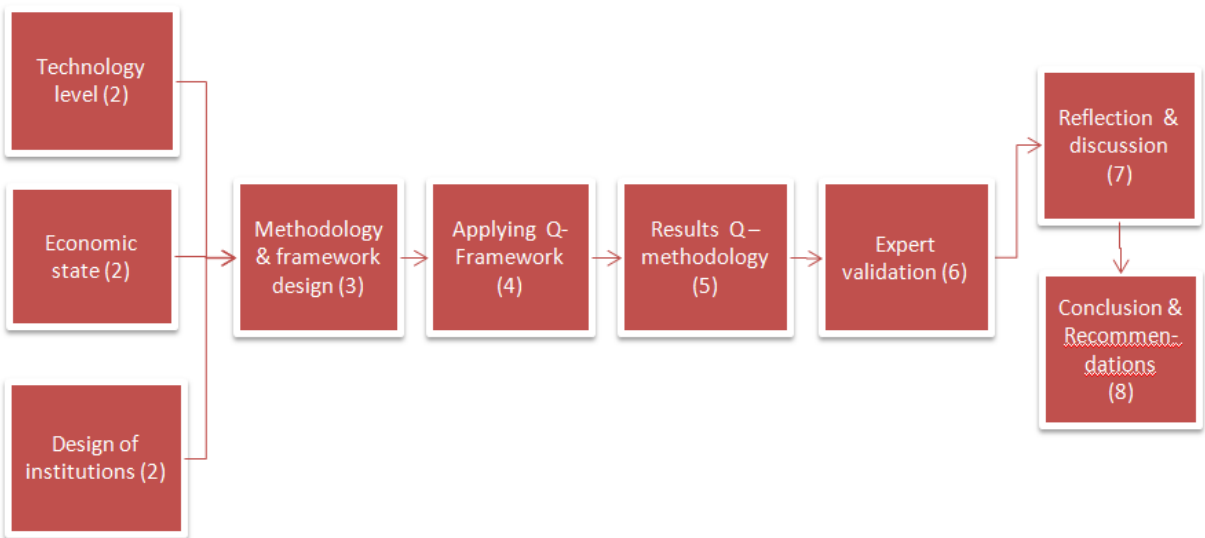

Figure 11 Graphical representation of research approach

3.2 Research approach

Because these research fields (heat and cold- and energy storage fiel) have not been combined so specifically before, this thesis research is from an exploratory nature (Baxter & Jack, 2008). The goal of the research is exploratory: to gather new insights in which drivers that determine collaboration behaviour in the heat and cold energy storage field in the Netherlands. Furthermore Q-methodology is used to structure the current discussion in the heat and cold energy storage field in the Netherlands. Seen in detail the first part of the research is qualitative, which later is quantitative specified in the second part. The research is mainly interpreted, however, with qualitative motivation, since existing literature and a case study with partly quantitative interviews will be used. Because of the low amount of participants in the heat and cold energy storage field in the Netherlands, it is hard to find enough cases to perform a sound standard statistical analysis. Hence, a quantitative and qualitative combination approach is more appropriate and also one of the strong points of Q-methodology (Bravo & Marelli, 2008; Watts & Stenner, 2012). Figure 11 on page 23 provides a graphical overview of the total research. The following tt sub-paragraph shortly set the details for the research related to the literature review as well as the details on the relations between the two sub research questions.

3.2.1 Literature review

The literature review provides a thorough reflection of the current available literature that is relevant to this research. Initially two directions of research have been identified as being most relevant. At first pure collaboration drivers are searched. Secondly also synonyms of collaboration are searched for in a desk study. Later in the search a third and final group of drivers was introduced related to common pool resources. All together these drivers are used to define the collaboration behaviour of the complex and capricious multi-actor context of the heat and cold energy storage field in the Netherlands. These drivers will be clustered by category in the second step after the applicability testing to ensure a reasonable amount of drivers. This is a common technique in Q-methodology, however it does reduce the data-richness of the Q-set (Barry & Proops, 1991; Brown, 1980; Cuppen, Breukers, Hisschemöller, & Bergsma, 2010; Exel, 2005; Gijzel, 2014; Webler, Danielson, & Tuler, 2009). Despite that, for time restrictions of the researcher and the participants in the P-set the choice is made to use categorisation, no specific heuristic was needed for this purpose, much literature already categorised drivers for collaboration and these will be used (Barry & Proops, 1991; Cuppen, 2013; Dyer, 2002; Ligtvoet, 2013). A more technical and economic background research is not performed, provided the analyses from chapter 2.

3.2.2 Relation between subquestions

A discussion and comparison with market parties should lead to more insight into drivers that drive or obstruct the collaboration around energy storage in the Dutch heat and cold chain. This serves partly as a validation for the applicability in the field of the collaboration behaviour drivers as defined in literature. For this part of the research an interview will be developed. This step is very important for the relation between the two subquestions to structure this research. Not only are the theorethical notions taken into account via SQ1, in order to find more applicable drivers two steps are taken. The resulting drivers from the literature will be placed in the context of the IAD framework as well as placed next to the knowledge gained from the systems analysis. As a second step the abovementioned experts will perform a discussion and comparison via a structured interview approach. After this step the statements for the Q-methodology interviews can be created for the resulting categories of drivers.

3.2.3 Q-methodology

The heat and cold field is embedded into the bigger Dutch energy system. This implies that thinking from a systems perspective might be useful, this helps understanding the bigger picture by also looking at interconnections in the sub-systems. The competition in the heat and cold market is not of a high level, but multiple smaller scale projects and networks form a big potential in the entire system, if combined. Because of that assumption, the concourse is defined with the IAD framework and the technical and economical state of the field in mind.

There are several models available to assess a market. This research chooses not to focus on finding the best fitting model to describe the market. It rather uses a proven methodology to analyse the market, knowing that the scientific value lies only in the applicability of the drivers; not on a model from a systems perspective and therefore the IAD framework was used.

If one looks at the literature related to cooperation and actor behaviour sufficient information is also available. The question arises whether a proper market design exists but many efforts are made to strive to the design with the highest possible quality in many types of markets.

The Q-methodology theory developed by Brown (1978) will be used for this stage. This is a more specific version of the Delphi method focusing on the opinion of experts, not necessarily in long-term forecasting (Helmer, 1967). The drivers found in the first stage and refined in the later stages, are developed into the Q-set, this set is than given to the expert stakeholders in the Dutch energy storage system of the heat and cold chain, the P-set. In an interview, stakeholders are asked to rank the statements (the drivers framed in one unambigious direction) in the set. The result of the Q-sort is than tested according to correlation and with a factor analysis of the statements. The experts' opinions about the statements form the N-cases if compared to normal statistical analysis. The perspectivers resulting from the factor analysis are than used to explain the drivers for collaboration behaviour in the Dutch heat and cold energy storage field.

Hence, it is necessary to find more drivers and statements via experts and logical reasoning of the reviewable materials. Next tot that a method must be used to validate these drivers in reality. Given the relative small amount of competitors in the market, it is very difficult to use interviews to create data. On one hand that is because mostly qualitative data stems from interviews but on the other hand, if a more quantitative interview is performed it is hard to find enough cases to have a significant scientific result.

As stated before, other models exist in the field of policy studies, an alternative would be discourse analysis; there focus lies on words, grammar, statements and the analysis thereof related to participants answers (Barry & Proops, 1991). This research has however not been found applied in technical complex fields in scientific literature and the goal of this thesis is not to start a semantic discussion about subject. The Q-methodology technique sorts out a discussion rather than to result in a discussion of subjects. It does not serve as a validation for drivers in the Dutch heat and cold energy storage field; it does however show the discourse of the discussion by showing which topics are important to collaborate in the Dutch heat and cold chain according to the experts (Brown, 1980; Cuppen et al., 2010). Other options of methods could have been to perform a complete interview to create statistical data. This is, as mentioned before, since the field is relative small, to see more validation, see for instance (Van Dijk, 1985; Wodak & Meyer, 2009).

While performing research with Q-methodology the researcher has some steering power. Amongst others the power to frame and steer during and before the interview, as well as during the motivation of the choices made in the Q-sort. To overcome that this power has a big influence on the results, consistent steering is applied if steering is demand by the setting of the interviews, consistency is reached by recording and playing back the conversations. Next to that, an expert validation will be executed after the results of the factor analysis have been calculated. Furthermore these weaknesses are known in the literature, despite that the paradigm in this social science field is that they do not burden the results (Exel, 2005; Watts & Stenner, 2012) in Chapter 7 a reflection is performed on this assumption and the measures taken to overcome highly influenced results.

3.3 Framework design - steps in Q-methodology

Q-methodology is often characterised by the six steps as described below. The Q-methodology that is applied to this research follows these steps from (Brown, 1980). A short description is provided for all of the steps in Appendix C.1 on page 105. The complete design of the Q-methodology framework is provided in the following pargraphs.

1. Define the concourse;
2. Define the Q-set (sample of statements);
3. Create the P-set (set of participants);
4. Q-sort;
5. Analysis (factor rotation);
6. Interpretation.

In the next paragraphs, the set-up and design of the framework is performed by answering the two sub questions. Herewith one defines the concourse (1), the Q-set of statements (2) and the creation of the P-set with participants (3). The framework and the questions for the Q-sort (4) as well as the analysis based on the factor rotation (5) are described subsequently. In the fourth chapter, the framework is applied on the Dutch heat and cold energy storage field. The results are provided in chapter five. To ensure applicability, a review of this framework by an expert to validate the framework is shown in chapter six, a reflection and discussion on the research will be presented in next chapter, 7. Finally, conclusions and recommendations will be drawn in chapter eight.

3.3.1 Formulation of the concourse

In the creation of the concourse it is utterly important that a very wide sample of topics, values beliefs, opinions etc. are taken into account. The previous system analysis has already provided some very important insights into the field and they are taken into account.

To ensure the concourse is structured in the correct manner the sub research questions are used: The first SQ is focussing on literature as source of information for the concourse: *"Which are the drivers for collaboration behaviour stemming from literature?"* In comparison with the main Q-methodological steps, this thesis has an extra iteration in step, field interviews which ensure applicable drivers: *"Which are the drivers for collaboration behaviour stemming from the experts in the field?"*

3.3.1.1 Literature review

By searching for literature on collaboration and also on literature for unsuccessful collaboration, the answer can be found to the first sub research question. Focus in the search is given by three categories of collaboration literature; these categories are the subjective choice of the designer of this concourse by initial scanning trough earlier collaboration research (Gijzel, 2014; Konstantelos, 2014; Kwakernaak, 2014; Van der Voort et al., 2009).

1) At first pure collaboration drivers are searched;
2) Secondly collaboration drivers from networked & interdependency;
3) Later in the search a third and final group of drivers was introduced related to common pool resources and the involvement of the government in this process.

3.3.1.2 Finding and testing drivers for collaboration behaviour in the field

Because the drivers from the literature will be reviewed in the context of the IAD framework as well as combined with the gained knowledge from the systems analysis in chapter 2. As a second step the two experts (Dirkjan van Swaaij (ING Bank) and Wim Voogd (Balance)) will perform a discussion and comparison via a structured interview approach. The approach is showed herunder.

INTERVIEW (TELEPHONE / REAL LIFE)

Interviewee	Name	
	Company	
	Function	
	Notes:	
Interviewer	TU DELFT STUDENT	Jorick Weijers

START OF THE INTERVIEW:

- Explain my situation as a student;
- Can I e-mail you the aspects which are currently being investigated?
- I will write a short report to summarize our conversation and will e-mail this to the interviewee;
- Is it allowed to record this conversation?
-

WHAT WOULD I WANT TO REACH WITH THIS CONVERSATION.

Create more insight into the drivers for collaboration in the heat and cold field;

Update knowledge in the field;

Examples of good collaboration from the field, but preferably out of own experience (to tell about in Q-sort);

Examples of bad collaboration from the field, but preferably out of own experience (to tell about in Q-sort);

Interviewer: *Provide more details here if needed depending on how far I am with the list of statements and the interviewee. Else, show the printed/e-mailed list.*

Add or remove aspects to the created list.(SEND BY E-mail);

SPECIFIC QUESTIONS:

Which of the aspects is most important according to you?

Which the least?

Which parties should be included in most projects around heat and cold?

Which should be excluded?

ROUND OF INTERVIEW

Thank interviewee for the interview, the final product will be sent to you.

Conclude with the procedure that I will send some transcript as promised.

I will create a deadline within 3 days, in order to let the interviewee withdraw his/her statements.

With the information from this step, a full comprehensive list of drivers can be created. They represent the drivers for collaboration behaviour according to experts in the Dutch heat and cold energy storage field. The results of this process are represented in paragraph 4.1.2.

3.3.1.3 Creation of statements

Not all the drivers that are found in literature and in the field will be developed into statements in the first round. A round of revising and checking for overlap will firtstly be performed. The goal of step is to create a full comprehensive set of statements that incorporates both drivers from the field and from literature. However, in order to keep the interview within a reasonable time (thirthy minutes were suggested), a choice has to be made to keep the set between thirty and fifty statements depending on the size of the participants. This resoning stems from the assumption of "finite diversity" which is interpreted in the way that there are in general less topics in consideration in the concourse as there are participants in the field (Watts & Stenner, 2012). A minimum is however defined by only (Barry & Proops, 1991) who state twelve participants are sufficient if one has a minimum of thirty-six statements in the Q-set, hence the bandwith as defined above. Another indicator that is only defined as a heuristic in literature is the ratio "one participant : two statements" with the only explicit notion that the number of participants should not exceed the number of statements in the Q-set (Watts & Stenner, 2012). Only after the creation of the P-set this final number can be checked for in paragraph 4.1.3. A spread sheet file will be used to keep track of each iteration round.

3.3.2 Formulation of the P-set

Now that the set of statements is clearly defined, one must find the correct participants to ensure a proper Q-sort as next step of the method. Finding the correct participants influences the applicability of the results, experts of the field can be more specific and their opinion in the Q-sort is therefore more relevant than the opinion of a layman. Given the actor analysis performed earlier in chapter 2.4.1.2, a clear view of the important players was already envisioned, nevertheless seven iterations have taken place before the P-set was finalised.

The P-set is the group of participants who are interviewed to perform the Q-sort. Next to that they are also subject to a set of questions. They are essential to the succeeding of this research since they have to sort the drivers for collaboration behaviour in the Dutch heat and cold energy storage field.

Despite the importance a clear guideline for the creation, sample size, mix and knowledge of the participants is not so straightforward in Q methodological research. Firstly it must be stated that the p-set is not generalizable to the entire community. This is because the formulation of the P-set serves the goal to find experts in the field of heat and cold energy storage, which do not represent a significant part of the Dutch society. This method of sampling is specified as opportunity sampling (Watts & Stenner, 2012) . Hereby a careful consideration on participants is performed before including them in the final P-set. Some others oppose against the selection of participants via opportunity sampling and suggest to do random sampling (Cuppen et al., 2010). This form of sampling, however, makes the assumption that specific knowledge is not needed in the research. With the opportunity sampling the assumption is made that a group of experts have more than equal knowledge and or expertise over the population. For this research with the specific goal to find applicable drivers in the heat and cold field, the author argues that using opportunity sampling will most likely provide better insights into the drivers of collaboration behaviour in the field. This is because Q-methodology is set up to provide a holistic viewpoint of the drivers that relate all different kind of viewpoints (sets) in its research (Cuppen, 2013). The aim was to include persons from the entire field into the P-set.

An important notion must be made with relation to the names of participants' companies; the opnion of the participant is on a personal title and does not imply or speculate about the viewpoint of their companies. That statement also includes the notion that no mistakes or right or wrong can be deducted from the Q-sort and its statistical results or discussion if related to a participants' opinion. An official statement from the companies involved was also not the goal of this research and then a different set-up for the interviews should have been chosen.

To find the most differing perspectives, it was assumed that a diverse set would be found by taking participants from each chain in the heat and cold energy storage value chain. Despite the efforts hereto, a complete value chain however does not exist following from the IAD research. Therefore and given the limited availability of time, the actor groups from the analyses in chapter 2.4.1.2, were chosen: producers, end-users and installation & project management companies. Because these groups do not possess all aspects of the heat and cold energy storage field, also financing companies were included; due to the size of projects it is often needed to find monetary resources to complete projects.

Each of these groups of participants have an expected pattern of thought, despite their difference, a high expectation for a sort could form to much similar data (Q-sorts) (don't ask a bakery whether or not bread is important). From an academic perspective (the most importat motivation for this thesis) a group of research institutes was added to serve as scientific reference in the P-set. Next to that after reconsidering with both supervisors from ING & Balance as well as both the 1st and 2nd supervisors from the university, another professor of the university was requested to receive a fresh and unbiased input, however due to lack of time, this has not been executed in the report. From the two discussions that followed also the group of close related end-users was added to see a critical opinion towards obligations in the law for the connection to a district heating grid.

Similar to the types of selection method there is no such clear instruction as to the size of the set of participants. An obvious limitation on the size is the time available for this research and the availability of participants (Ostrom, 1997). In principle, Q-methodology does not need a big sample size to perform statistical analysis. This is because Q-methodology is based on the assumption of "finite diversity" which is interpreted that there are in general less topics in consideration in the concourse as there are participants in the field (Watts & Stenner, 2012). A minimum is however defined by only (Barry & Proops, 1991) who state twelve participants are sufficient if one has a minimum of thirty-six statements in the Q-set. Another indicator that is only defined as a heuristic in literature is the connection between the number of participants and the number of statements in the set. However there is no complete consistency about the relation between the exact ratio between them; the heuristic provided by (Watts & Stenner, 2012) states that ideal ratio is "one participant : two statements" with the only explicit notion that the number of participants should not exceed the number of statements in the Q-set.

Since the categories all together produce only seven participants, in the sampling it is argued that to get two or three participants per group (category) enable at least sixteen participants with a maximum of twenty-four participants.

For the purpose of this study, twenty participants in the P-set and the forty-two statements in the Q-set, cover the ratio 1:2 well enough. Next to that the minimum number of participants exceeds thirteen. Hence the concluding assumption is made that the sample size suits the purpose of the research appropriately.

The process of performing this P-set is again as many parts of this methodology subject to much power of the researcher. However a complete solid selection process does not exist in this methodology. It is therefore assumed that the complete set as formed finally has no bad implications on the quality of the research. The final P-set after the iterations as mentioned in this paragraph is presented in the chapter four in paragraph 4.2.

3.3.3 The Q-sort interviews

As mentioned several times earlier in this thesis, the strength of Q-methodology is that it is able to combine quantitative research in a field of few statistical N-cases with a qualitative richness of information into a combined good overview of the heat and cold energy storage field in the Netherlands. The Q-sort combines both this quantitative research with the sorting process of statements by experts and a qualitative follow-up research into motivation for the choices made during the sorting.

3.3.3.1 Distribution in the Q-sort

Before the interview set-up is disclosed, the distribution for the forty-two statements is elaborated upon. The forty-two statements are distributed in an 11 point scale corresponding with a forced normalised distribution, as suggested by Brown (1980) for a set between 40-60 statements. In principle Q-methodology researchers have shown already that a free distribution would also be able to use for factor rotation, but a normalised distribution (up-side-down) has become the standard (Cuppen et al., 2010; Ostrom, 1997; Watts & Stenner, 2012; Barry, Ellis & Robinson, 2007). The main reason for this modelling choice is the limitation on the number of spots to choose from and where to place the statements in the distribution. The time saving aspect and the decreasing level of complexity are used by the researcher to motivate this choice.

The distribution is divided into the columns with the values: -5, -4, -3, -2, -1, 0, +1, +2, +3, +4, +5. This results in the following lengths and places per column: 2, 3, 4, 4, 5, 6 5, 4, 4, 3, 2. This is graphically shown in the set-up for the Q-sort in the next paragraph. The extremes of the distribution are the sides of the distribution upon which the statements are placed where the participants, most agree and most disagree with. The abovementioned approach follows the line of thoughts according to Watts and Stenner (2012), who advocate for a normal distribution with a relative wide middle column, whereas also a narrower distribution was possible, thus steeper. Here again Brown (1980) proved to be useful for this thesis' research, he advocates that it is best to use a steeper distribution in the case participants are less familiar with the topic, since than more statements can be sorted in the less strong motivated middle of the distribution. Related to that a distribution with a more flat distribution is used in the case participants are more familiar with the topic of research. Since the assembly of the P/set has had an extensive preparation and given that the participants are all familiar with the heat and cold energy storage field in the Netherlands, a more flat distribution was chosen.

The results are used anonymously because according to the supervisors of this research (of which one has previous experience with Q-methodology and many other forms of research), this provides much more freedom of speech during the post sorting interview. Also mentioned is the separation into three initial groups of statements. This step was added accordingly with the philosophy of Watts and Sterner (2012) to speed up the sorting process and to decrease the complexity of the research. See paragraphs C.3 and C.4 on page 124 for the step by step procedure of the Q-sort and post sorting questions with the participants

Provided all above formulations the design is assumed to contribute to the research goal. The research continues with the description of the analysis after the Q-sort and the experience and results of applying the framework are found in the next chapter.

3.3.4 Analysing the Q-sort

The analysis of the Q-sort can in theory be perfomed with any statistic calculation program, or by hand if one has a heap of time. Examples of programms are provided by (Exel & De Graaf 2005). Several packages are available on the market for Q-methodology specifically, howver they come with a pricetag connectect to them. For the sake of time and because it was used in multiple theses before, the PCQMethod of Schmolck (2014) was used.

As a first step the correlation between the Q-sort will be identified in order to be able to see if participant indeed correlated between the sorts (sets of answers) that were provided in the interviews. Subsequently a type of factor analysis will be performed with these correlations. A choice can be made between a Centroid Factor Analysis and a Principal Component Analysis. Since the Principle Component Analysis does not require an initial thought for directions of factors and therwith steers the research less than in a Centroid Factor Analysis, this thesis uses a Principal Component Analysis (Gijzel, 2014).

The factors retrieved from the principle component analysis will be analysed for significant results of the eigenvalues of a factor (Watts & Stenner, 2012). If they are sufficient (>1) they are automatically rotated with a Varimax rotation to improve the factor loading ((Brown, 1980). The remaining factors will be analised based on distinguishing statements for each factor as well as by the qualitative date retrieved fromt he specific participants that corralate with the factors. Finally after the description of the factors the different drivers for collaboration behaviour will be deducted from each perspective so that they can be compared between perspectives and specific policy recommandations can be made to improve collaboration within a perspective and thus if perfomed correctly, in the entire heat and cold energy storage field.

Provided all above formulations the design is assumed to contribute to the research goal. Many design information is based on heuristics in literature and hard rules are often not formulated (Watts & Stenner, 2012; Exel & De Graaf, 2005). This provides the researcher with some extend of freedom. The reflection in chapter 7 provides some feedback onto this process. This research continues with the description experience and the results of applying the framework found in the next chapter.

4 Q-methodology applied

In this chapter the results of the application of the Q-methodological framework are described. The steps as designed in the previous chapter will be filled in with the characteristics of the Dutch heat and cold energy storage field, while keeping the information that was gained from the systems analysis in mind. Both the first and the second sub question will be answered in this chapter: “Which are the drivers for collaboration behaviour stemming from the literature?” & “Which are the drivers for collaboration behaviour stemming from the experts in the field?”

4.1 Formulation of the concourse

In this paragraph the results of the literature review and the resulting drivers for collaboration (behaviour) are described. Next to that an overview of the field experts’ opinions on drivers for collaboration behaviour in the heat and cold energy storage field in the Netherlands is created.

4.1.1 Literature

A short side study is performed related to the type of marketed structure and whether it is of influence on the collaboration drivers. The distinction is made between drivers related to networked markets versus the drivers with a strict hierarchy. There seems to be a relation in case of the heat and cold energy storage field in the Netherlands as network market (hierarchy) (Dyer, 2002; Watts & Stenner, 2012; Williamson, 1975). Further literature was searched more in the field of collaboration next to that, earlier theses’ and PhD. theses’ of research around collaboration and Q-methodology were studied for collaboration behaviour. Examples of important sources are (Dittmar & Forsthoffer, 2006; Ligtvoet, 2013; Raadgever et al., 2012; Wagner-Döbler, 2001; Websters Online dictionary, 2015; Wodak & Meyer, 2009).

Another short side study was performed into process design in a complex system. When analysing actor behaviour in design, there is the possibility of strategic behaviour (Bruijn & Heuvelhof, 2010). Their literature provides an in-depth insight into the process that occurs when managing people and projects. Amongst others the principal agent theory, framing and game theory are addressed (Bruijn & Heuvelhof, 2010). Three additional drivers have been extracted from Bruijn and Heuvelhof (2010).

Typically, the government is partly involved in Dutch heat and cold projects, mainly related to finance and subsidies. Related to that is the concept of transaction cost economics. This concept underlines that costs between actors are important in relation to sunk cost of the heat and cold field. Because of large investments in infrastructures (Estache & Martimort, 1999) the assumption is made that collaboration is the correct path to stimulate development of the heat and cold energy storage field. Therefore and because of the economic results from the system analysis, these costs are not extensively included in the research for drivers (hence neither in the statements).

The concourse (of drivers) that has been developed with this literature review (see Table 18) does not ensure the applicability in the heat and cold energy storage field. This step will be taken in paragraph 4.1.2 and 4.1.3 by creating statements and testing those in the field.

4.1.2 Field interviews

Drivers from the field were by using statements as well as separate drivers from the literature and discussing them with two field experts. Furthermore several unstructured interviews with experts from the field have inspired the researcher for for more input in the statements. If this is the case it is mentioned at the statemtent (non-documented).

4.1.3 Final Q-set

A final subjective set of forty-two statements was constructed. The knowledge from a systems perspective of the heat and cold energy storage field in the Netherlands and the state of technology and economy were used as guidance in this reduction process, furthermore categorisation of drivers has helped to reduce the number of statements in the final set. As mentioned before this is a common technique in Q-methodology despite the data reduction in the Q-set (Barry & Proops, 1991; Brown, 1980; Cuppen et al., 2010; Exel, 2005; Gijzel, 2014; Webler et al., 2009). Since much literature already categorized drivers for collaboration no specific heuristic was needed for this purpose (Barry & Proops, 1991; Cuppen, 2013; Dyer, 2002; Ligtvoet, 2013).

In addition, drivers from the field were used. At the start, the seventy-three drivers had been defined by literature. In order to keep the interview within a reasonable time (thirty minutes are suggested by Exel & De Graaf (2005)), eleven categories have been identified. The next step which is taken in this paragraph contains checking the remaining drivers for overlap; double drivers measuring practically the same parts have been removed: resulting into forty drivers.

To test the assumption of paragraph 2.3 regarding the economic maturity of the market, one statement will be added to the final Q-set (statement 31 Table 3). Similarly, a statement related to assumption of the technological readiness of the heat and cold energy storage field (paragraph 2.2) was added (statement 25 in Table 3). The addition of this statement is somewhat uncommon, but serves to test the analysis performed in Chapter 2.

In the complete Q-set, the similar categories are represented. However, because the second sub question searches for data from the experts in the field, the interaction between the two sub questions is brought forward by showing the steps taken in requiring the total Q-set.

1. Firstly, the 73 drivers have been identified via a literature study (SQ1).
2. The drivers have been subdivided in the following categories: Other, Common goal / Strategy, Collective action / Regulation, Interaction, Price / Cost, Time, Risk, Image and Information / Knowledge.
3. The drivers stemming from the literature review list are used to formulate statements. These drivers are represented into 31 of the 42 statements in total Q-set.
4. Next to that, the interviews and own input from the research lead to more drivers for collaboration behaviour from the field (SQ2). As a result 11 more statements were added which sums up to a total of 42 statements.
5. A final category Field was added which makes the total set of drivers, the numbers between (brackets) represent the number of statements per category: Field (11), Other (5), Common goal /Strategy (5) Collective action / Regulation (5), Interaction (4), Price / Cost (4), Time (2), Risk (2), Image (2) and Information / Knowledge (2).

Final Q-Set			
#	**English translation**	**Source**	**Category**
1	Despite the complexity, collaboration in the heat and cold energy storage field in the Netherlands is, in my case, not necessary.	(Chisholm, 1989)	Other
2	At this moment, I do not dispose of the right capacities to collaborate.	(Ostrom, 2007)	Interaction
3	Collaboration is developing because governments facilitate collaboration (-meetings).	(Chisholm, 1989)	Collective action / Regulation
4	Collaboration is developing because governments initiate projects.	(Chisholm, 1989)	Collective action / Regulation
5	For collaboration you need, at first, trust.	(Ostrom, 1997)	Other
6	I collaborate to gain information of third parties in the value chain.	(Ligtvoet, 2013; Ostrom, 1997)	Information / Knowledge
7	I collaborate to improve my image.	(Ostrom, 1997)	Image
8	I collaborate to the principle of reciprocity.	(Ostrom, 1997)	Other
9	I collaborate because of the repeating character of the collaboration.	(Baldwin, 2013; Groenewegen, 2013)	Other
10	I collaborate because it improves the efficiency of projects.	(Ostrom, 1997)	Time
11	I collaborate with other parties to save money for all parties concerned.	(Ostrom, 1997)	Price / Cost
12	By collaborating I can make use of economies of scale.	(Ostrom, 1997)	Price / Cost
13	I collaborate to save time during the project in relation to doing the project on my own.	(Ostrom, 1997)	Time
14	I collaborate with other persons, because they possess more knowledge	(Groenewegen, 2013)	Information / Knowledge
15	Long-lasting (local) government-ambitions result in heat and cold initiatives.	Wim Voogd, Dirkjan van Swaaij	Field (Collective action / Regulation)
16	You cannot compare different types of heat and cold via the tax system.	Dirk Jan van Swaaij	Field (Collective action / Regulation)
17	Delivering heat/cold cannot be compared by CO_2-emission rights.	Dirk Jan van Swaaij	Field (Other)
18	The supply of heat/cold can harm other heat/cold alternatives in the spatial environment.	Wim Voogd, Dirk Jan van Swaaij	Field (Collective action / Regulation)
19	I collaborate to divide the risks of the project in comparison to the situation of doing the project on my own.	(Groenewegen, 2013)	Risk
20	I collaborate to share both profit and loss.	(Ligtvoet, 2013)	Price / Cost
21	The regulatory regime is too individual focussed in relation to collaboration.	Own input	Collective action / Regulation
22	I collaborate to promote the synergy between	Own input	Common goal /

	companies.		Strategy
23	Collective solutions are too complex.	Own input	Collective action / Regulation
24	Because of varying policy of the Dutch government, it is impossible to collaborate on a longer periodical basis.	Own input	Collective action / Regulation
25	The technical design of heat/cold projects is not future proof.	Dirk Jan van Swaaij	Field (Other)
26	The project management of heat/cold projects is not future proof.	Dirk Jan van Swaaij, Wim Voogd	Field (Other)
27	The number of interactions in the heat/cold field is too small.	IAD	Interaction
28	Initiatives for collaboration are split up.	Own input	Interaction
29	Initiatives for collaboration are divided throughout the Netherlands.	Own input	Interaction
30	The (ground) water-system is not suited for lar ge-scale implementation of heat/cold projects.	Own input	Other
31	There is too much competition to be able to collaborate.	Own input, Dirk Jan van Swaaij, Wim Voogd	Field (Interactions)
32	I collaborate to guarantee that supply will be certain.	Dirkjan van Swaaij	Field (supply /demand)
33	I collaborate to guarantee that demand will be certain.	Dirkjan van Swaaij	Field (Supply / Demand)
34	I collaborate in the heat/cold field when infrastructure is available.	Own input, Dirk Jan van Swaaij, Wim Voogd	Field (Collective action / Regulation)
35	I collaborate in the heat/cold field, because I/we facilitate the necessary infrastructure.	Own input, Dirk Jan van Swaaij, Wim Voogd	Field (Collective action / Regulation)
36	I collaborate to put innovations in the market.	Own input	Risk
37	I collaborate in the Dutch heat/cold field to reduce climate changes.	(Ligtvoet, 2013)	Image
38	I collaborate to join new markets, in order to increase my profits.	(Bronder & Pritzl, 1992)	Price / Cost
39	I collaborate to realize a common or equal activity.	(Huisman, 2010; Ostrom et al., 1994)	Common goal / Strategy
40	I collaborate to aim for a common or equal strategy.	(Huisman, 2010; Ostrom et al., 1994)	Common goal / Strategy
41	I collaborate because of common or equal expectations in a project/collaboration.	(Huisman, 2010; Ostrom et al., 1994)	Common goal / Strategy
42	I collaborate because of a common or equal culture in a project/collaboration	(Huisman, 2010; Ostrom et al., 1994)	Common goal / Strategy

Table 3 Final Q-set

This entire process is captured in Appendix C.1.1 in more detail in the form of a table, the rounds of revising are there presented per column. The final Q set is shown in Table 3, but the complete overview with Dutch statements and elaborations on the statements is provided in Table 19 Q-set on page 127.

4.2 Formulation of the P-set

The final P-set (the list of participants) is presented in Table 4. Not all companies have agreed to show their name; in that case a general description of the main activity of the company in the heat and cold energy storage field in the Netherlands is shown. In the second column of the table the job description of the participant has been shown. The last column shows the name as the set was described in the statistical program PQMethod (Schmolck, 2014).

Company(type)	Function description	Description in PQMethod
Ministry of Finance	Direction of International Affairs and Taks on usage.	MinFin
TU Delft	Professor Energy system analysis.	TUDelft
Branch organisation horticulture	Policy specialist Energy and entrepreneurship at industry association of horticulturists.	Branche
Installation company & project manager	Commercial manager installation and project management.	Instal
Ministry of Interior and Kingdom Relations	Direction of spatial environment.	MinBZ
Bank	Renewable energy financer	Bank1
Net owner and production capacity owner	Director (Owner of installations and heat/cold grid).	NetOwn
Bank	Project finance powers and renewables.	Bank2
Close related end-user 1	Inhabitant and participant in a Collective Property Ownership foundation with forty-three households.	Close1
Province of Noord-Brabant	Policy advisor heat Province of Noord-Brabant: Focus on reusing industrial waste heat within households and companies. Usege of heat cold storage.	ProvNB
Producer and distributor heat and cold	Commercial Director (and grid owner).	Produ1
Close related end-user 2	Foundation "Reeshof heat", Organised end-customers in heat grid, who are not fund of the grid.	Close2
Housing cooperation	Director Responsible for finance, administration and sustainability.	HCoorp
Geothermal heat owner and producer	Amongst others: Owner geothermal plant, energy cooperation and paprika farmer.	Geoth
Producer and distributor heat and cold	Sustainable spatial development of customers within a distributor and producer of heat and cold.	Produ2
TKI EnergyGO	1) Chair interest group renewable energy + Chair TKI from the Topsector Energy.	TKI

	2) Domaincoordinator: "heat" of Energydeal.	
Producer and distributer heat and cold	Producer and distributer of heat: Strategic decisions on heat topics.	Produ3
Ministry of Economic Affairs	Senior policy maker of the direction Energy and Sustainability..	MinEZ
Municipality of The Hague	Programme director: strategy and policy on sustainability and heat (= special intra departmental department).	Munici
Installation company & project manager	Director	PBWKZH

Table 4 Final P-set

4.3 The Q-sort interviews

Within this paragraph the results from steps 1 to 8 are described. In step 1-3 the Q-procedure and the implications for the factor analysis and the results of the Q are deduced. Subsequently the main goal of step 4-7 is to be able to answer the second sub research question "Which are the drivers for collaboration behaviour stemming from the experts in the field?" Finally the results of the transcriptions are provided in step 8.

4.3.1 Q-sort: Summary of steps 1-3

Within this paragraph the results from steps 1 to 3 of the Q-procedure and the implications for the factor analysis and the results of the Q are described.

Step 1

Take the set of cards; numbers on these cards are random and their only purpose is to analyse the place you put them in the sorting. Read all of the cards carefully. If you have any questions, please ask them.

Sort the cards into three piles.

1. A pile you tend to agree with;
2. One pile with statements you neither agree nor disagree with or which you find not relevant;
3. A pile of cards you disagree with.

Again no wrong or right answers are possible since the interest of this research is into your opinion.

Step 2

Take the cards from the agree pile and read them all again. Put the two you agree with most on the position of the 'agree with most position'. Fill in the rest of the cards on the deck as you agree with them accordingly. HINT: The distribution is relative, do not spend 10 min. to choose the most extreme statements, this research is looking for the general picture. The position of the statement under the same column does not play any role in the ranking order.

Repeat the step above for the pile of cards you disagree with initially and the pile of cards you neither agree nor disagree with or did not find relevant initially.

Step 3

Review your distribution and shift cards according to your opinion. It is possible to agree with all of the statements; however it is important to make a distinction.

- Cards were used to write down the 42 statements. The points of the distribution (e.g. -5-, -4, -3, etc.) were also printed and laid out in front of the participants.
- All participants have performed the Q-sort with the given Q-set as developed in the previous chapter. Although, the procedure as developed was not always followed exact to the point. In three cases the Q-sorting differed from the rest of the participants:
    - Participant 1 from MinFin did the sort with two persons, given the exact overlap and lack of discussion between participants; both cases were assessed as one entry;
    - Participant 17 from Producers (3) did the sort online; a special design was made to ensure the same set-up as with the other participants was created, but then digitally. It was the online interviewee that expressed his discomfort with the method. It could stem from the lack of face-to-face contact after rescheduling the first meeting due to agenda issues. The full design is in dispose of the researcher and available upon request;

- Participant 2 did Q-sort and the motivation of the most extreme (-5, -4, +4 & +5) up to step 4 of the procedure in a face to face interview. The follow up questions from step 4-8, the motivation for the Q-methodology a day later via telephone interview. In that case both participant and researcher looked at an online version as documented by the researcher instead of the physical cards on the table.

4.3.2 Q-sort: Summary of steps 4-7

This paragraph shortly describes the results from steps 4 to 7 of the Q-procedure. The main goal of this paragraph is to be able to answer the second sub research question "Which are the drivers for collaboration behaviour stemming from the experts in the field?"

Step 4
Can you elaborate on the statements that you assigned to the extreme agree? What do they mean to you? Why you feel so strongly about them? Why do you agree most with the statements on the right?
Step 5
Can you elaborate on the statements that you sorted on the extreme disagree? What do they mean to you? Why do you disagree most with the statements on the left? Why you feel so strongly about them?
Step 6
Do you have any specific comments on the cards in the middle? Or did you struggle with any specific card? Items which you did not fully understand?
Step 7
Why did you shift card # from position X to position Y?

All of the participants had a clear motivation for all of the extreme values and most also for -2 and +2. Participants did struggle to provide motivation for statements in the columns -1, 0 & 1. This does not have an implication for the Q-methodology since the qualitative part serves more as extra information. Regarding the quantitative part, the explained variance does not stem from these columns (Brown, 1980).

4.3.3 Q-sort: Summary of step 8

This paragraph summarises the results of the transcriptions. In the second part of this paragraph the conclusions from the post sorting data are presented.

The participants of the Q-sort were provided with the sheet of paper on A3 size as can be seen in figure 4. This paper was provided for the sorting procedure to see the places of the slots where the statements should be placed. This was derived from a file on the researchers' computer and filled with motivation and the number of the corresponding statement.

Step 8 has been performed by the researcher and he also ensured the transcription of the questions. The results are presented in Appendix C.6 of this report, the readability is limited here due to the size of the tables. The original transcripts are in the disposal of the author of this thesis and can be accessed upon request in anonymised form.

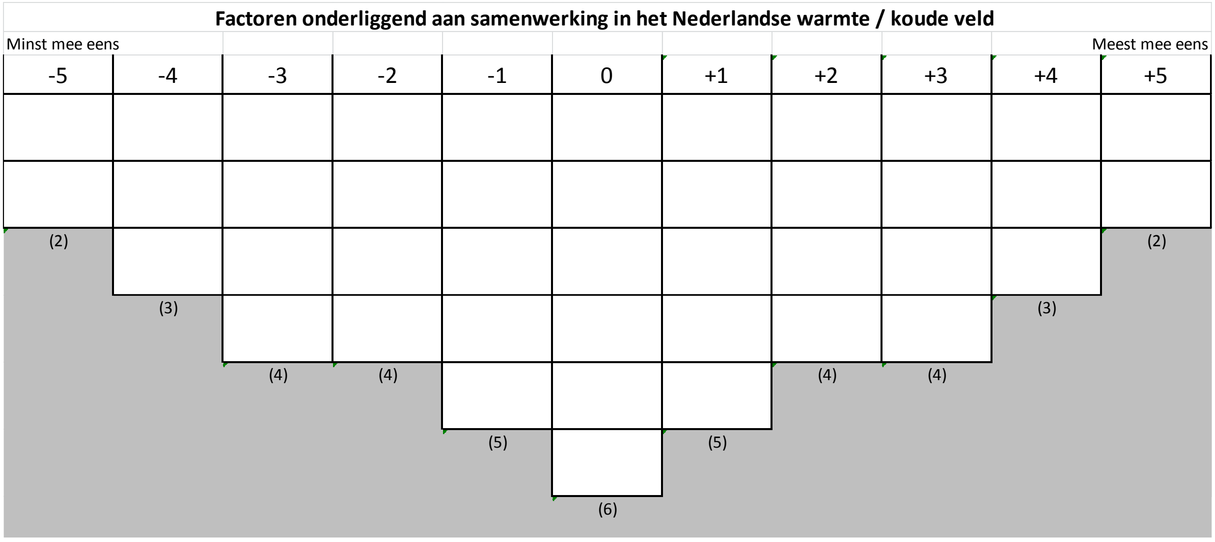

Figure 12 Spread sheet for transcriptions

4.3.3.1 Post sorting questions

Some participants in the P-set used the possibility to expand the Q-set, based on the open questions as designed in paragraph 3.3.3.

- Participant one said: "Cold is not really represented in this set of research statements" and "Sharing costs is missing if you look at the details of the business case" as well as "we do have the right expertise, but not the knowledge". This has no further implications for the research. Cold is explicitly mentioned in all of the statements and in the title of the research question the participants received. Next to that, the goal of this part of the thesis is not to define costs of specific business cases, in that case another type of methodology should be used.
- Participant two mentioned that collaboration is not a goal on its own. This is acknowledged by the researcher, however in this case the goal of the Q-methodology is to see which part of collaboration behaviour is most important and is thus part of the goal. He also mentioned that he is no collaborator in the field research; this was the reason why the participant was asked to join the P-set.
- Participant three mentioned that the horticulture has a separate CO_2 system therefore the statement for CO_2 doesn't apply on her.
- Participant five identified ambiguity in statements (2) & (11). With relation to (2) the definition of capacities as provided solved that issue. Similarly the ambiguity for (11) disappeared after reading the definition provided for saving money. Next to that, he identified problems with the definition of collaboration being a contract between supplier and consumer. This point of view was shared by participant seven.
- Participant ten provided the topic of "rolzuiverheid", which translates into the natural role and notion of a person to keep this role over time. This could be added to the set of important statements on position +3 according to the participant.
- Participant eleven provided the topic of "profileren", Translated into the stimulating the role of heat in the Dutch energy system, or lobbying to overcome the negative views. The researcher acknowledged that this is not in the Q-set, however there is overlap with the statement about image ((7), +1). The participant would place this profiling statement at +4.

- Participant seventeen mentioned the semantic discussion according to his/her point of view. Next to that, a suggestion was done to add the statement: “Concretize the energy taxes to improve collaboration behaviour”. This is relates to the statement about the individualism stemming from / within law (21), but this does not capture the participants point.
- More than one participant has stated the “human factor”, or likeliness of people, the click between partners in a collaboration setting as the most important. Closest to that statement, comes statement forty-two: collaboration from a common or shared culture (speaks the same language). It is not added to the set, because it cannot be concretized.

The acceptance of the Q-set and the additions of the participants during the Q-sort lead to an answer of the second sub-question: “Which are the drivers for collaboration behaviour stemming from the experts in the field?” The total list of the Q-set is therefore expanded with the before mentioned additions that are translated into the following three of statements in combination with table XX they form the answer to the second sub question:

43	*Rolzuiverheid / purity of role*
44	*Profiling*
45	*Concretize the energy taxes to improve collaboration behaviour”*

Table 5 Additional statements from Q-sort

Despite the very useful information in the added statements, this is not generalizable into the field. It does provide insight in which players in the Dutch heat and cold energy storage field have more information than the inspected literature.

Finalising this chapter one could say that the set-up of the framework for the Q-methodology has served its purpose. The process of the Q-methodological research resulted in twenty individual Q-sorts following a replicable process. Furthermore the participants in the P-set have shown to be experts with collaboration behaviour in the heat and cold energy storage field in the Netherlands.

RESULTS

5 Results

This chapter presents the results from the Q-methodological analysis as introduced in the preceding two chapters. The chapter does not focus on the statistical analysis but more on the outcomes.

5.1 Determining perspectives on collaboration behviour

To determine different perspectives on collaboration behaviour in the heat and cold energy storage field in the Netherlands a factor analysis was performed with the final Q-sorts. For this purpose the specialised program PQMethod of (Schmolck, 2014) was used. This program derives the correlation of each Q-sort with the Q-sorts of all the other participants. The next step of the analysis was the factor analysis based on PCA (Principal Component analysis) (Gijzel, 2014). PCA was chosen over Centroid Factor Analysis because there is no sound theory underlying the perspectives in the Q-sorts to be tested upon. Next to that, the research aims to find patterns of similarity among the variables which suits PCA better, see also Appendix D (Watts & Stenner, 2012).

The first output is a table with therein presented all the correlations between all of the participants in the P-set; see Appendix D.1, See Table 20 on page 133 because of its big size. From this table it becomes clear which sets of Q-sorts (participants) have similar viewpoints related to each other's answers. The correlation matrix has provided the insight that indeed multiple participants in the field share the same ranking idea's about the importance of collaboration. The highest positive correlation if found between set seventeen, Producer 3 and set ten, the Province of North Brabant with 71%. The highest negative correlation is found between TKI (set sixteen) and the Ministry of Finance. Furthermore the most interesting result is the correlation of zero, so no correlation at all between the Programme Office South-Holland (set twenty) and the TU Delft (set two) and also between the Ministry of Finance (set one) and the Installation Company (set four).

From the total list of initial drivers resulting into 42 statements that have been investigated by twenty experts in the heat and cold energy storage field, eight factors were determined. Together they explain 62 % of the total variance in the Principal Component Analysis as can be derived from Table 6 on page 48, hower this includes the unroated factor loadings.

The second outcome of the PQMethod is ratings of all twenty participants on statements form the Q-set. These are aggregated for eight higher level distinct (unrotated) factors. The numbers shown represent the factor-loadings of the Q-sorts on the unrotated factors (see Table 6 on page 48). This thesis uses two common conditions to arrive at the final set:

1. A minimum of two Q-sorts should load significantly on the resulting factor;
2. The eigenvalues of the factor scores need to be higher than 1, this is the Kaiser-Gutteman criteria (Gutteman, 1954; Kaiser 1960; Brown 1980).

For more details on the exact calculations see appendix D.

Table 6 on page 48 shows the outcome of the factors that will be used for further analysis with rotation. Five possible resulting-factors remain. From the unrotated factors, all have two significant loadings except factor seven and eight. The unrotated factors 1, 2, 3, 4, 5, and 6 are therefore taken to the next step of checking the eigenvalue.

Q-sorts		Factors							
		1	2	3	4	5	6	7	8
1	MinFin	0.199	-0.368	0.080	0.784	-0.094	0.197	0.145	-0.058
2	TUDelft	0.264	0.305	0.730	-0.041	0.121	0.179	-0.372	0.021
3	Branche	0.664	-0.239	-0.100	-0.318	0.107	0.066	0.269	-0.288
4	Instal	0.711	-0.219	-0.249	-0.262	-0.008	0.015	-0.090	0.352
5	MinBZ	0.641	-0.394	0.241	-0.034	-0.256	0.301	-0.124	0.230
6	Bank1	0.752	0.015	0.308	0.121	0.205	-0.008	-0.059	-0.363
7	NetOwn	0.767	-0.150	-0.175	0.027	0.340	-0.094	-0.047	-0.004
8	Bank2	0.274	0.671	-0.196	0.104	0.179	0.464	0.270	0.100
9	Close1	0.424	-0.314	0.188	0.176	0.503	0.079	0.248	0.282
10	ProvNB	0.855	0.013	-0.093	0.214	0.097	-0.128	-0.094	-0.208
11	Produ1	0.698	0.160	-0.005	0.081	-0.286	0.082	-0.285	0.075
12	Close2	0.450	0.386	0.226	0.386	-0.210	-0.496	0.198	0.094
13	HCoorp	0.693	0.159	0.100	-0.026	0.248	-0.240	-0.182	0.281
14	Geoth	0.795	0.074	-0.257	0.059	0.266	0.043	0.009	0.040
15	Produ2	0.702	0.168	0.000	-0.054	-0.309	-0.192	0.185	0.054
16	TKI	0.401	-0.081	0.614	-0.429	0.038	-0.083	0.346	-0.089
17	Produ3	0.736	-0.019	-0.344	-0.058	0.073	-0.109	-0.305	-0.245
18	MinEZ	0.673	0.354	-0.055	-0.089	-0.200	0.377	0.072	-0.126
19	Munici	0.597	-0.344	0.078	0.032	-0.430	0.099	-0.016	-0.062
20	PBwkZH	0.771	0.057	-0.168	-0.117	-0.293	-0.095	0.212	0.111
Eigenvalues		8.008	1.548	1.538	1.264	1.225	0.942	0.855	0.727
Variance % explained		40.040	7.740	7.691	6.318	6.123	4.710	4.275	3.634

Table 6 Unrotated factors from the PCA analysis

Factor 1, 2, 3, 4 and 5 have an eigenvalue >1 as can be deducted from Table 6 above and continue to the next step, Varimax rotation (factor six does not continue, while factors seven and eight were already excluded because there was only 1 participant loading on the factor, they would be excluded here as well).

Legenda
This table shows the eigenvalues of the initial unrotated factor in the highlighted row. If the eigenvalues are > 1 then they represent a significant result. This means they can explain variance with a 95% confidence interval. They will then be used for further analysis.

These combined already explain cumulative 40+7.7+7.7+7+6.3 =61.7 ≈ 62 % of the total variance.

While performing a Varimax rotation the software aims to rotate the factors in such a way the most variance can be explained with the given factors. Next to that, the Varimax also tries to use rotation techniques in order to let each Q-sort have only one significant factor-loading (Watts & Stenner, 2012).

The matrix generated by the last procedure shows the final factors after Varimax rotation. The Varimax-rotated factor 4 is left out of the total set because it only has one Q-sort as significant composite. Some confounded Q-sorts are found in this case (sorts loading significantly on more than one factor) for that reason they are not taken into account. One Q-sort is a non-loader (sort with no correlation > 0.40 with any of the factors) and is therefore not taken into account for further investigation. The significant loading Q-sorts are used to calculate the final factors: the different perspectives conceived in the Q-sorts of the participants.

Rotated significant factors						
		1	**2**	**3**	**4**	
	Q-SORT					**More information**
1	MinFin	0.1077	-0.0978	-0.0843	0.0865	Non-loader
2	TUDelft	-0.0086	0.1966	0.8188**X**	0.0382	
3	Branche	0.6206**X**	-0.1673	0.1056	0.4052	Confounder 1 and 4
4	Instal	0.6079**X**	-0.1157	-0.0446	0.5271	
5	MinBZ	0.3117	-0.3463	0.2855	**0.5861X**	
6	Bank1	0.5478	0.1509	0.4886**X**	0.3095	Confounder 1 and 3
7	NetOwn	0.8156**X**	0.0839	0.0550	0.2704	
8	Bank2	0.1646	0.7500**X**	0.0087	0.0757	
9	Close1	0.6337**X**	-0.1176	0.2771	-0.1322	
10	ProvNB	0.6447**X**	0.2491	0.1103	0.4810	Confounder 1 and 4
11	Produ1	0.2395	0.2411	0.1400	0.6684**X**	
12	Close2	-0.0133	0.4659**X**	0.2889	0.3968	Confounder 2 and 4
13	HCoorp	0.5585**X**	0.2723	0.33679	0.2799	
14	Geoth	0.7464**X**	0.3043	0.0064	0.3525	
15	Produ2	0.2305	0.2039	0.1664	0.7047**X**	
16	TKI	0.1836	-0.2394	0.7342**X**	0.2362	
17	Produ3	0.6367**X**	0.1608	-0.1146	0.4735	Confounder 1 and 4
18	MinEZ	0.2481	0.3851	0.1617	0.6202**X**	
19	Munici	0.1947	-0.2866	0.0938	0.6912**X**	
20	PBwkZH	0.3637	0.1285	0.0229	0.7583**X**	

Table 7 Factor Matrix with an X indicating a defining sort (=highest scoring) on a perspective

As can be deducted from the table above, factor 1 is specifically loaded by the Q-sorts 3, 4, 7, 9, 10, 13, 14, 17 (marked with X). The second factor has the sorts 8 and 12 significantly loading. Q-sorts 2, 6 and 16 are loading significantly on factor three. The last but not least factor 4 loads with Q-sorts 11, 15, 18, 19 and 20.

It is clear that some participants load significantly (>0,40) on the perspectives, these situations are described as confounding participants, the general rule is that the perspective with the highest significance will use the factor-loading of the participant, see the X behind the participant for which group they belong. Only one participant did not load significantly on one of the four perspectives, this participant is marked as non-loader. Given their truly unique point of view this participant will not be further investigated during this report, With that choice, the toal explained cumulative variance sums up to 68%.

5.2 Extracting perspectives and their meaning

The four left over factors are in fact the "best matching or typical" Q-sorts for their view on collaboration behaviour, wherefrom the viewpoints or drivers stem from in this report. These four factors are called the perspectives. To be able to interpret these results a so called factor array is made for each perspective, presented in Table 22 on page 136 because it takes multiple pages. In essence that is the hypothetical ideal Q-sort best matching the factor as derived from the previous analyses. The distribution is here as well on an 11 point (-5 to +5) point scale similar to the Q research.

The PQMethod reports distinguished statements, these so called distinguished statements are the specific statements that in one perspective are ranked different than in other perspectives (Watts & Stenner, 2012). These distinguished statements present the first option to see which drivers are characterising a perspective, they are presented in the next paragraph 5.3.1, 5.3.2, 5.3.3 and 5.3.4. The first perspective is characterised by the following statements on the most extreme rankings (+5 and -5): 14, 31, 1 & 5 (see paragraph 5.3.1). For factor 2 the statements 1, 5, 36 & 24 received the most extreme ranking (see paragraph 5.3.2), while on perspective 3 the items 5, 25, 41, & 3 are ranked most extreme (see paragraph 5.3.3). Finally for the fourth perspective the statements 1, 15, 23 & 33 received the most extreme ranking (see paragraph 5.3.4). This information is very useful in interpreting the perspectives, combined with other unique items to determine the differences between one and the other perspective. PQMethod uses Z-scores to determine the internal ranking within a perspective. A Z-score also allows for the possibility of cross-factor (perspective) comparing with the goal to make it easier for the researcher to understand the differences between the statements and their valuation in each perspective. See for a full overview of the Z-scores Table 23, Table 24, Table 25 & Table 26, in Appendix D there also the ideal loading per perspective is shown.

5.3 Perspectives on collaboration behaviour

The data resulting from the previous analysis forms the basis for the determination around the perspectives. Next to that in some cases qualitative information from the post-sorting interviews will be used to explain several statements or perspectives in the general field of the heat and cold energy storage field. The approach is to look at the distinguished items (*in italics*) first and then at the lowest and highest valued statements as mentioned in the previous paragraph (see also Table 22 on page 136).

5.3.1 The Early Adopters perspective

The perspectives can be interpreted based on the highest and lowest scores in the perspective. Other aspects did also provide insight; however they are not discussed here in detail but can be found in Table 22.

<u>Early Adopters perspective</u>

Many participants load on this perspective. This results in a less sharp agreement on the reasons for collaboration. Important for them is the sharing of both profits and losses as a starting point for collaboration "this enables bigger projects with in itself more collaboration" (P-17). Next to that a believe is that government ambitions could slightly help to start the first collaboration behaviour but a strong notion in the comments leads to the interviewers interpretation that in the end, the companies will do it themselves. There is an important disagreement that the number of interactions is too low in the heat and cold field, they say there are more than enough interactions which lead to collaboration. Next to that they are hands-on related to infrastructure and backbones. “If it is not there we will make it there” (P-14).

Many loaders are one of the early movers in the field and already own a grid, or produce and supply heat to a heat grid or other interested parties. The most interesting loader is probably the Province of North Brabant, provided that the local governments are not always are first movers. Apparently this is the case in the Dutch heat and cold field. One of the participants who is owner of a heat grid: said: “Collaboration is always needed, for a collaboration agreement I do however put more effort than in the relation between supplier and customer”.

Each perspective is characterised by distinguishing aspects. A distinguishing aspect has a significant different score within this group than in other groups. Table 27 in paragraph D.2 shows the value of the column the statement-group was given in the Q-sort and the Z-score of the statement-group in the perspectives. A statement with both a different Q-SV and a high Z-score can be seen as the distinguishing aspect. Sometimes multiple of these distinguishable aspects exist. Table 8 provides the filtered results on page 51.

Highest (agree) valued aspect by the participants (ranking between brackets)	**Lowest (disagree) valued aspect by the participants (ranking between brackets)**
5: For collaboration you need, at first, trust. (+5) 14: I collaborate with other persons, because they possess more knowledge. (+5)	1: Despite the complexity, collaboration in the heat and cold energy storage field in the Netherlands is, in my case, not necessary. (-5) 31: There is too much competition to be able to collaborate. (-5)
10: I collaborate because it improves the efficiency of projects. (+4) 11: I collaborate with other parties to save money for all parties concerned. (+4) 39: I collaborate to realize a common or equal activity. (+4)	2: At this moment, I do not dispose of the right capacities to collaborate.(-4) *27: The number of interactions in the heat/cold field is too small. (-4)* *34: I collaborate in the heat/cold field when infrastructure is available. (-4)*
Other distinguishable items	
13: I collaborate to save time during the project in relation to doing the project on my own. *15: Long-lasting (local) government-ambitions result in heat and cold initiatives.* *20: I collaborate to share both profit and loss.* *24: Because of varying policy of the Dutch government, it is impossible to collaborate on a longer periodical basis.* *35: I collaborate in the heat/cold field, because I/we facilitate the necessary infrastructure.*	

Table 8 Distinguishable statements Early Adopters’ perspective

5.3.2 The Policy Sceptics perspective

The perspectives can be interpreted based on the highest and lowest scores in the perspective. Other aspects did also provide insight; however they are not discussed here in detail but can be found in Table 22.

Each perspective is characterised by distinguishing aspects. A distinguishing aspect has a significant different score within this group than in other groups. Table 28 in paragraph D.2

shows the value of the column the statement-group was given in the Q-sort and the Z-score of the statement-group in the perspectives. A statement with both a different Q-SV and a high Z-score can be seen as the distinguishing aspect. Sometimes multiple of these distinguishable aspects exist.

Policy Sceptics

These participants are known for their scepticism in relation to changing policy related to energy and the heat and cold energy storage market. In their opinion it burdens development and growth and does not stimulate collaboration behaviour at all "It would be nice if they would be a bit consistent for 10 years or so (P-8, Energy financer at a bank)". These participants do not cooperate to put innovations into the market which suits their profile: banker (risk averse) and a close related end-user (does not have the position to do that). Neither is climate change an important driver for collaboration "there are many other ways to handle that (P-12, a direct related heat customer)". Furthermore these participants are not per se sceptical towards collaboration, but they see hurdles on the road towards the collaboration: "So you must assume that in the future heat will not flow in the nets anymore" and "the costs should go down first before more collaboration will start driven by end-users" (End-customer heat).

Highest (agree) valued aspect by the participants (ranking between brackets)	**Lowest (disagree) valued aspect by the participants (ranking between brackets)**
5: For collaboration you need, at first, trust. (+5) *24: Because of varying policy of the Dutch government, it is impossible to collaborate on a longer periodical basis.* (+5)	1: Despite the complexity, collaboration in the heat and cold energy storage field in the Netherlands is, in my case, not necessary. (-5) *36: I collaborate to put innovations in the market.* (-5)
13: *I collaborate to save time during the project in relation to doing the project on my own.* (+4)	*37: I collaborate in the Dutch heat/cold field to reduce climate changes. (-4)* 31: There is too much competition to be able to collaborate. *(-4)* 20: I collaborate to share both profit & loss. *(-4)*
Other distinguishable items	
35: I collaborate in the heat/cold field, because I/we facilitate the necessary infrastructure. *18: The supply of heat/cold can harm other heat/cold alternatives in the spatial environment.* *15: Long-lasting (local) government-ambitions result in heat and cold initiatives.* *30: The (ground) water-system is not suited for large-scale implementation of heat/cold projects.* *11: I collaborate with other parties to save money for all parties concerned.* *41: I collaborate because of common or equal expectations in a project/collaboration.*	

Table 9 Distinguishable statements Policy Sceptics perspective

5.3.3 The Quid pro quo perspective

The perspectives can be interpreted based on the highest and lowest scores in the perspective. Other aspects did also provide insight, however they are not discussed here in detail but can be found in Table 22.

Each perspective is characterised by distinguishing aspects. A distinguishing aspect has a significant different score within this group than in other groups. Table 29 in paragraph D.2

shows the value of the column the statement-group was given in the Q-sort and the Z-score of the statement-group in the perspectives. A statement with both a different Q-SV and a high Z-score can be seen as the distinguishing aspect. Sometimes multiple of these distinguishable aspects exist.

Quid pro quo

Just like in other perspectives, the participants in this perspective put trust on the most agree position as a condition before collaboration can start. Distinguishable for this perspective is the importance they put in a collective agreement or expectation in collaboration or a project. The expectation or gain from a perspective seems important "It is per se about getting the entire field towards sustainable heat, from my perspective also the parties should gain in order to get them moving (P-15)", also participant 2 commented "collaboration is time consuming, the negotiations etc, it might be much better for individuals to get a heat pump up and running, this would probably not develop the fields faster though" Despite the complexity in the field they do not agree (most disagree) that the complexity puts a burden on collaboration, "especially for that reason I would collaborate (P-5)". Next to that they do relate a lot of value to the repeating character of the collaboration "If you already know the other parties, you can save an enormous amount of time (P-2)". They are also sceptical with relation to the inter comparability of heat and cold via different tax regimes within the Netherlands and put that on +4 in the ranking. In similar agreement they expect that more sustainability ambitions by the local government could create more collaboration. One of the participants commented that "heat should be the choice; however gas can still be lying next to it in the ground" (TKI). Herewith referring to the complexity of the market, but this can be bridged with collaboration.

Highest (agree) valued aspect by the participants (ranking between brackets)	**Lowest (disagree) valued aspect by the participants (ranking between brackets)**
5: For collaboration you need, at first, trust. (+5) *41: I collaborate because of common or equal expectations in a project/collaboration.* (+5)	*3:* Collaboration is developing because governments facilitate collaboration (-meetings). (-5) *25: The technical design of heat/cold projects is not future proof.* (-5)
8: I collaborate to the principle of reciprocity. (+4) *15: Long-lasting (local) government-ambitions result in heat and cold initiatives.* (+4) *16: You cannot compare different types of heat and cold via the tax system.* (+4)	13: *I collaborate to save time during the project in relation to doing the project on my own. (-4)* 20: I collaborate to share both profit & loss. *(-4)* 30 The (ground) water-system is not suited for large-scale implementation of heat/cold projects. *(-4)*
Other distinguishable items	
9: I collaborate because of the repeating character of the collaboration. *23: Collective solutions are too complex.* *36: I collaborate to put innovations in the market.* *33: I collaborate to guarantee that demand will be certain.* *19: I collaborate to divide the risks of the project in comparison to the situation of doing the project on my own.*	

Table 10 Distinguishable statements Quid pro quo perspective

5.3.4 The Second Movers perspective

The perspectives can be interpreted based on the highest and lowest scores in the perspective. Other aspects did also provide insight; however they are not discussed here in detail but can be found in Table 22.

Second Movers

This perspective is known for a second-mover perspective, this cannot be generalized to risk aversive, but they do not take the first action in the market for collaboration and economic growth. It looks like they wait until goals are set by amongst others the government or they do not wait, but do see it as a task of the government to set goals and ambitions related to heat and cold. The distinguishing statements fifteen (Sustainable (local) government ambitions enable heat and cold initiatives (*+5*) and three (Collaboration exists because governments organise collaboration (-meetings) (*+3*) confirm that. Next to that the collaboration serves to ensure the recipients of heat. They do also have sustainability as a high aspect to collaborate. But most important is that they tend to wait to collaborate until the moment that infrastructure is provided by other parties.

Highest (agree) valued aspect by the participants (ranking between brackets)	**Lowest (disagree) valued aspect by the participants (ranking between brackets)**
15: Long-lasting (local) government-ambitions result in heat and cold initiatives. (+5) 33: I collaborate to guarantee that demand will be certain. (+5)	1: Despite the complexity, collaboration in the heat and cold energy storage field in the Netherlands is, in my case, not necessary. (-5) *23:* Collective solutions are too complex. *(-3)* *3: Collaboration is developing because governments facilitate collaboration (-meetings).* (-5)
5: For collaboration you need, at first, trust. (+4) 12: By collaborating I can make use of economies of scale. (+4) 37: I collaborate in the Dutch heat/cold field to reduce climate changes. (+4)	2: At this moment, I do not dispose of the right capacities to collaborate. *(-4)* 18: The supply of heat/cold can harm other heat/cold alternatives in the spatial environment. *(-4)* 31: There is too much competition to be able to collaborate. *(-4)*
Other distinguishable items	
13: I collaborate to save time during the project in relation to doing the project on my own. *20: I collaborate to share both profit and loss.* *27: The number of interactions in the heat/cold field is too small.* *34: I collaborate in the heat/cold field when infrastructure is available.*	

Table 11 Distinguishable statements complexity leads to Second Movers perspective

One participant (P-20) commented: "The government is locally very much responsible for setting a goal for the region. This is needed for sustainability but also for companies in the region and economic growth, initiatives around heat and cold can create collaboration"

Each perspective is characterised by distinguishing aspects. A distinguishing aspect has a significant different score within this group than in other groups. Table 30 in paragraph D.2 shows the value of the column the statement-group was given in the Q-sort and the Z-score of the statement-group in the perspectives. A statement with both a different Q-SV and a high Z-score can be seen as the distinguishing aspect. Sometimes multiple of these distinguishable aspects exist.

5.4 Summarizing the perspectives

Concluding a total of four main perspectives are found in the literature and via experts which explain a significant amount of variance while also keeping the statistical requirements in hand.

The above mentioned results in paragraphs 5.1 and 5.2 started with a quantitative comparison of the Q-sorts from the twenty participants that were selected for the P-set. The output as provided by the Principal Component with the PQMethod has been interpreted with the second part of data, the post-sort interviews with the motivation and explanations of the participants. This resulted in eight initial unrotated factors. Due to the low eigenvalues, the unrotated factors six, seven and eight have been excluded from further analysis. Next to that factor 7 and eight had been excluded from further research because they had only one significant (unrotated) factor-loading. The resulting factors have been rotated with a Varimax rotation. Quantitatively, four perspectives have been found performing PCA with PQMethod. Not each perspective was evenly distributed with sets of participants. Perspective one has eight participants loading significant, whereas perspective two has two, perspective three has three loaders and the fourth perspective has six participants loading significantly on the perspective.

Factor Characteristics per Perspective	1	2	3	4
Number of Defining Participants	8	2	3	6
Average Rel. Coefficients	0.800	0.800	0.800	0.800
Composite Reliability	0.970	0.889	0.923	0.960
Standard Error of Perspectives' Z-Scores	0.174	0.333	0.277	0.200

Table 12 Factor characteristics of the perspectives

5.5 Extracting categories of drivers relating to collaboration from the perspectives

This paragraph provides important information on which categories a steering mechanism should address. Two strategies for finding steering mechanisms are provided. With the use of the z-scores that are shown appendix D.2 and the ranking per perspective that shown in appendix D.3 a deepened analysis of the results is performed. For each perspective the relation between a category and collaboration is calculated in paragraph 14.4, the results thereof are represented in this paragraph by means of relation diagrams per perspective.

From

Table 13 which is graphically represented by Figure 13 until Figure 16, one can deduce that the categories are variating positive or negative. A disclaimer should be provided with these data. Despite the well designed set of participants in the P-set, the data is not generalizable to the entire population because of the small size of the set (twenty). Furthermore the data here is not 'hard'; to get this 'hard' data a survey would be more suitable. A survey on the relations between the found drivers in paragraph and collaboration under more participants could be used to create a generalizable dataset and (in theory) significant causal relations. Since it would not be able to identify perspectives this has specifically not been the purpose of this research.

Relationship values between drivers and collaboration					
Categories:	Statements per category	Early Adopters	Policy Sceptics	Quid pro quo	Second Movers
Other	8	-0.29	-0.18	-0.31	-0.54
Interaction	5	-1.06	-0.42	0.00	-0.79
Time	2	0.86	1.15	-0.39	0.51
Price / Cost	2	1.71	-0.67	-0.33	0.89
Common goal / Strategy	5	0.84	-0.05	0.54	0.30
Image	2	0.43	-0.92	0.21	0.46
Collective action / Regulation	10	-0.72	0.17	0.31	-0.11
Information / Knowledge	2	0.88	0.87	-0.32	-0.06
Risk	2	0.78	-0.27	-0.57	0.76
Supply / Demand	2	0.69	0.89	-0.27	1.36

Table 13 Average Z-score values of the relation between categories and collaboration per perspective

To get a clear overview of all the statements in a category see

Table 13. On the following pages each figure shows the relation between each category in a perspective and the collaboration in the Dutch heat and cold energy storage field. The width of the arrows corresponds with the value of the Z-scores as can be seen in

Table 13 and next to the arrows. Because the Z-scores are used, the values can be compared between the different perspectives. Information is lost about the difference between categories due to this normalisation into Z-scores, however because the relations can now be compared, more information ca be retrieved from the diagrams. More information on the absolute difference can still be deducted from Table 22, but not compared between statements.

One can say that if a policy has to be developed to stimulate the growth of the whole field, there can be multiple strategies. Due to limited time for testing strategies two lines of thought are presented here.

The first line of thought is developing policy that discourages negative relations between several categories and collaboration within all perspectives in the field. A fruitful example strategy would be to tackle the Interaction category in combination with the Risk and Price / Cost categories. Similarly the strategy to stimulate the positive relations would have a big impact; in such case policy should be developed that intervenes on the Image, Information / Knowledge and Supply / Demand categories.

A second line of thought is to steer more specific on groups of participants that have been identified in the field within the mentioned four perspectives. Since the Other-category as mentioned before is hard to simplify, further research is needed and is not taken into account in this part of the research. The explanation of this strategy is provided per perspective with the help of the relation diagrams.

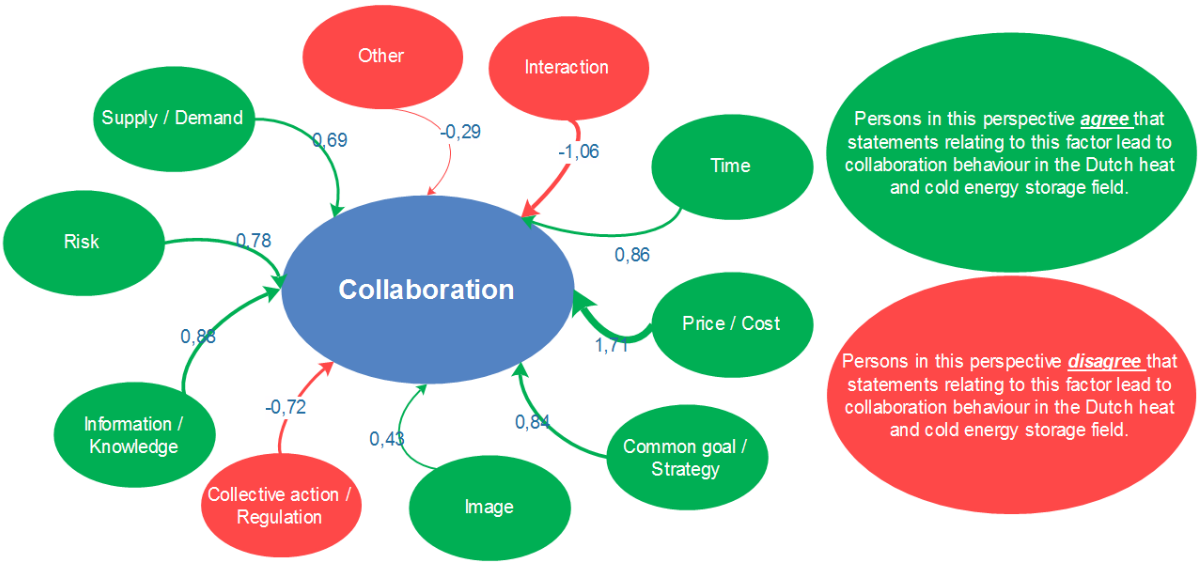

Figure 13 Relation diagram Early Adopters perspective

For the first perspective, see Figure 13, it is clear that the categories Collective action / Regulation and Interaction have a negative relation with collaboration. Thus a policy focussing thereon would be able to bend these relationships positive or a discouraging policy would be of similar effect. Looking at the other categories in this perspective, the Price / Cost category has a high value in the relation and steering with price or cost on interaction and collective action / regulation might therefore have a high effect. Again the notion must be made that this perspective is not generalizable to the entire field.

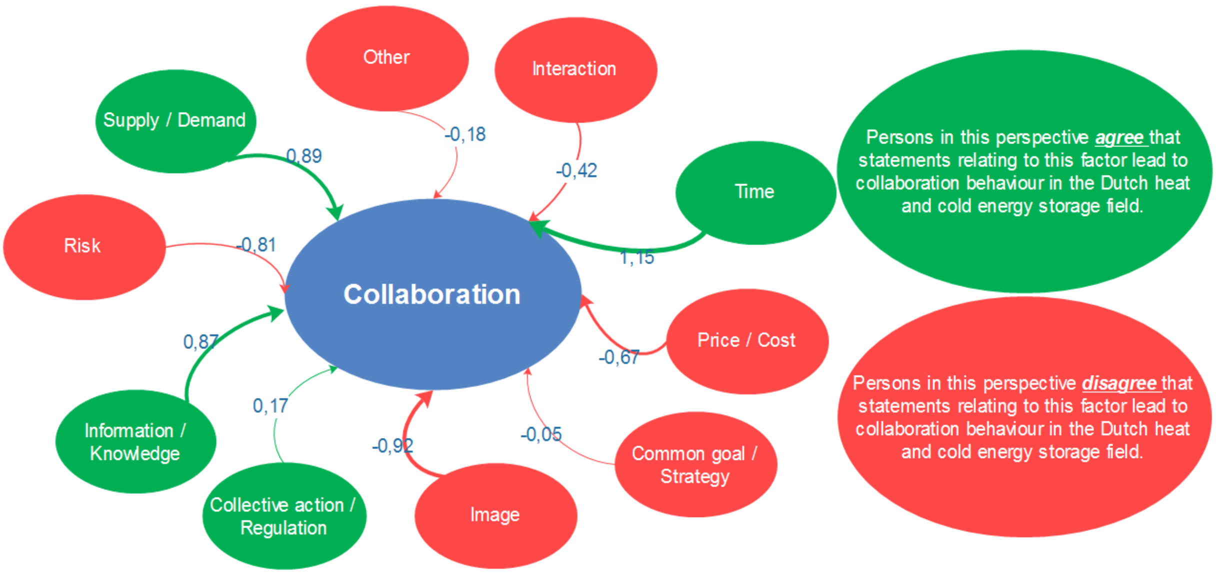

Figure 14 Relation diagram Policy Sceptics perspective

If one looks at the Policy Sceptics perspective, see Figure 14, there are multiple negative relations that can be incorporated in a policy, the most negative relations are those of the categories Image, Price / Cost and Interaction. Here clearly a different approach is needed than if one focusses solely on the first perspective. Stimulation of the Price / Cost category here leads to less collaboration and therefore discouraging the Price / Cost category while promoting the

Time and Information / Knowledge categories (assumed: highst valued relations will be more effective to stimulate).

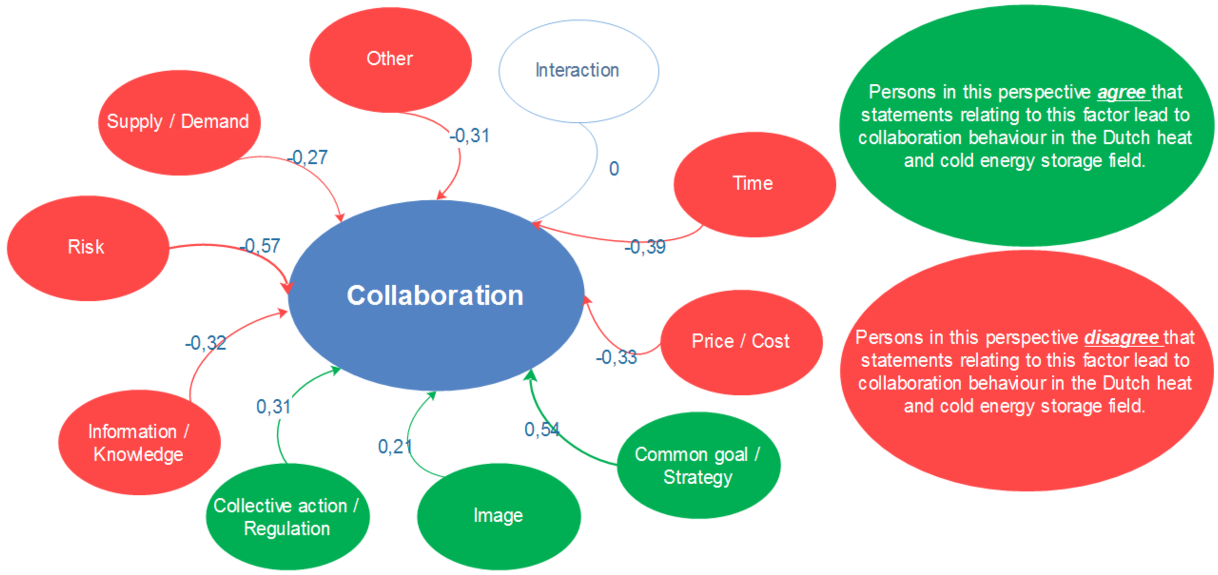

Figure 15 Relation diagram Quid pro quo perspective

Continuing the analysis towards the Quid pro quo perspective, see Figure 15, also here several negative relations are found in relation to collaboration: Time, Price / Cost, Information / Knowledge, Risk and Supply / Demand. What attracts the attention is that all these values are close to zero, meaning that the relation is rather weak. Therefore a milder strategy could be needed than with the other perspectives in the heat and cold energy storage field. Next to that the Interaction category attracts more attention since the average value of the combined Z-scores is zero. This does not imply that there is no relation at all however; the combined scores outweigh each other. Therefore an easy gain can be created in this perspective by stimulating the relation between Interaction and collaboration.

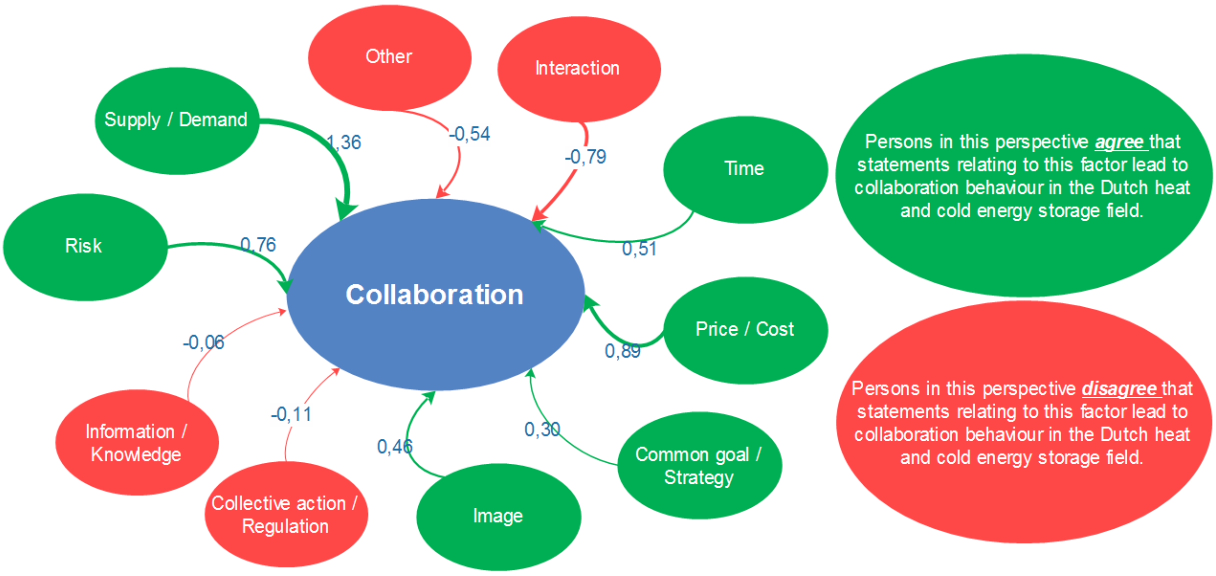

Figure 16 Relation diagram Second Movers perspective

The fourth perspective that of the Second Movers, see Figure 16, has similar to the first perspective less perspective less negative relations, however the negative relations are of less value than within the first the first perspective. Hence more collaboration could be expected. Combined with the information from information from the post sorting interviews, the data from

Table 13 shows clearly that the interactions in the field do not lead to collaboration and a strategy is needed to pull this group of participants into action. Furthermore promoting the categories Supply/ Demand and Price / Cost with a policy can be most effective since these are the strongest relations with collaboration within this perspective.

Forming a general conclusion, to the extend in which this is possible given the disclaimer on generalizability, it would formulated as to create a policy to change the red negative values into green positive values, starting with the lower valued negative relations in the most perspectives: Interaction and Information / Knowledge. Combined with the stimulation of the higher valued positive relations in the most perspectives: Price / Cost, Supply / Demand, Image and Risk. Finally, it would be advisable to steer with policy on the Policy Sceptics perspective (for Common goal / Strategy and Image) and on the Quid pro quo perspective (for Time, Information / Knowledge and Supply / Demand) since they have a negative relation with collaboration when the category has three positive relations the other perspectives.

This comparison shows that despite creativity in policy design, the impact on collaboration will be different for participants in each of the four perspectives in this Q-research.

EXPERT VALIDATION

6 Expert validation

The researcher has some power to steer the research in this thesis, this has been provided by the bandwidth of the methodology used in this thesis. It could be possible that the research is coloured or that the researcher has performed its duties with a tinted view. Therefore this chapter serves as a last step validation of the framework and its drivers by an expert He is asked to give his opinion about this research and specifically on the conclusions drawn related to the framework as well as on the recommendations that have been made.

This chapter shows the value of the framework as it has been developed. The added value of thesis lies in the combination of both topics into a single set of perspectives which are able to capture the heat and cold energy storage field in the Netherlands.

6.1 Testing options

Is it possible to test the validity of this specified framework the researcher of this report asked himself? The answer to this question is provided in the resoning that only an expert in the heat and cold energy storage field in the Netherlands can check for the applicability of the perspectives. This does not check whether or not the collaboration perspectives have been well performed in the set. It does do that in a slight way if an expert is found who has also shown signs of collaboration behaviour in the heat and cold energy storage field in the Netherlands. It could be also possible to reach out to a researcher specialised in collaboration, in order to check the exact drivers from literature. A third option would be to ask an expert, not in the P-set, to validate for the perspectives and to see whether or not the statements fit within the characteristics of the field. If one than chooses an expert with previous knowledge in the field, he or she should be able to have knowledge about collaborating from his or her perspective and this could solve our problems, if knowledge is built up over a long period of time.

6.2 Validation by field expert with long experience

For the purpose of this report the third option is chosen. The process to find an expert without the P-set proved to be relatively difficult. Many experts were already contacted. However, the chairman of the heat networks trust had not been able to join the set, but came highly recommended in the Q-sorts by other participants. Given the fact that Gijs de Man is currently in a role which requires to see the field from a higher perspective, he seemed to be the perfect expert to be able to relate to multiple sides of the heat and cold field. Next to that he represents many (40+) companies from different backgrounds in the Dutch heat and cold energy storage field. Next to his role as chairman of the heat networks trust Gijs de Man is also director of the heat-company in the Dutch city of Purmerend. This company operates as its own identity, however the municipality of Purmerend owns most of the shares and is therefore effectively in control.

Again it is important to note that the validation is now still heavily able to be influenced by the researcher, who can determine upon the correct people to invite. The questioning used during the validation research has therefore to be relatively scoped in order not to let too much freedom for the interviewer. To overcome framing more than already performed in the construction of the frameworks, the researcher used the following questioning format:

- Do you recognize this perspective in the heat and cold energy storage field in the Netherlands?
- To which extend do you relate yourself to this topic?
- If you look at the distinguishing statements from this framework, does it match with the description of the perspective?
- Do you relate to this perspective in any other way?

The interview was rounded off with the common questions related to work level, education level and current occupations.

6.3 Validation transcript

The next paragraph shows the results of the validation interview, given its importance the full text is included here. Because of the language of the researcher and the expert, the transcript is in the Dutch language as it also relates to Dutch statements in the Q-set. In case a translation is required this is at the disposal of the researcher of this thesis. At first the summary from each perspective was provided to the interviewee. After reading through all the perspectives, the questions were asked per perspective. Some general remarks have also been made during the interview, they have been noted in chronological order.

The Early Adopters perspective

Many participants load on this perspective. This results in a less sharp agreement on the reasons for collaboration. Important for them is the sharing of both profits and losses as a starting point for collaboration "this enables bigger projects with in itself more collaboration (P-17)". Next to that a believe is that government ambitions could slightly help to start the first collaboration behaviour, but a strong notion in the comments leads to the perception that in the end, the companies will to? it themselves. There is an important disagreement that the number of interactions is too low in the heat and cold field; they say there are more than enough interactions which lead to collaboration. Next to that they are hands-on related to infrastructure and backbones. "If it's not there we will make it (P-14)".

- *Do you recognise this perspective in the heat and cold energy storage field in the Netherlands?*

"This touches on the essence why a company is active in the heat and cold field. Some of them from a perspective of business. In that case SW is vital and than you certainly need all parties in the chain. That is recognizable, because someone is obliged to do the case. This person is really taking the initiative. This in sharp contrast to a warm cold field, where people often take the initiative from an economic perspective. Money is, therefore, an important driver. That's why it is difficult in the starting cooperation; other parties quickly see that they cooperate with a company who wants to gain money on them. This is the main reason why parties, by nature, are not on the same level and disagree on some main points."

- *To which extend do you related yourself to this topic?*

"I recognize stimulating by the government as a step in the process. This from the idea that you want to execute an economic activity, the context makes whether the solution warm cold fits. This context is heavily determined by the government; think about the aims of CO_2-reduction, making subsidies available, determing a consumption norm for buildings or the set up of a stimulant. You often sea that this stimulant is rather half-hearted: in the BEA first edition, heat did not participate. The reason behind it, which I heard from the durability umbrella-organisations and Economic Affairs, was that it was the complexity of the field. Economic Affairs and the umbrella-organisations told that the complex negotiating table was no guarantee for success projects of heat and it was difficult to negotiate there."

Why was that? "Heat and cold (storage) is more delicate and smaller with more stakeholders; more specific work is necessary in comparison with other kinds of durability/transition solutions for the Dutch energysystem. The result is that now an "Action list other energy values" is added as addendum to the energy agreement with the message that heat can play a role in transition to get it started."

- *If you look at the distinguishing statements from this framework, does it match with the description of the perspective?*

"There has to be a durabilitygoal: if a party says I will do it, that party needs so many other stakeholders; local councils for licences, also a lot of other parties are needed, because not all parties have the same urgencies at the same moment. E.g. the collabortion of housing cooperations 5 years ago to bring back the energy label form E to B was becoming a great success, but, because of the changing of the Rental Act in connection with the inhabitants contribution, the necessity disappeared. Maybe it returns with this warmtebrief."

- *Do you relate to this perspective in any other way?*

"No not specific, but for the incentive related to infrastructure: Urgency is first of all necessary to get from gas usage to heat usage. This process is a bigger supported Dutch transition like it has happend in the past when the Netherlands shifted from coal to gas. Or there should be an improvement for the end-customer, but at the moment it is not there."

The Policy Sceptics perspective

These participants are known for their scepticism in relation to changing policy related to energy and the heat and cold energy storage market. In their opinion it burdens development and growth and does not stimulate collaboration behaviour at all "It would be nice if they would be a bit consistent for 10 years or so (P-8)". These participants do not cooperate to put innovations into the market which suits their profile: banker (risk averse) and a close related end-user (does not have the position to do that). Neither is climate change an important driver for collaboration "there are many other ways to handle that (P-12).

- Do you recognise this perspective in the heat and cold energy storage field in the Netherlands?

"I really recognize this vision. What is heat? Why are you doing it, the infrastructure activity → the result of that investment is low, but hopefully it is worthwile on the long term. SDE + to SDE and MEP are also good, but many changes took place in the past years. It is also ambiguous when the aims are not explicit as the means. In the vision around heat it is postponed for 1.5 year → That is why a separate executing agenda heat is produced next October."

- *To which extend do you related yourself to this topic?*

"This changing policy often returns last period. The heat-price should with the NMDA take effect (stay equal) on January 1, 2014. What does gas cost: investments, maintenance, result, gas-price etc. So, there are many price parameters in that formula. One expected that it would stay equal and - apart from the gas-price (fluctuates internationally) - not be adapted. However, the minister has executed an update over all parameters, while he had promised about a year ago that only the gas-price would change. In stead of that he turned the result the other way. That is why the sector is afraid indeed that each year the price will change. See also the minister's decision regarding the Heat Law (for inspection after June 20 and published in December, 2013)."

- *If you look at the distinguishing statements from this framework, does it match with the description of the perspective?*

"This also depends on the perspective of investment in infrastructures. Pension funds and banks act accordingly. They assume that the policy does not change for a longer period."

"Climatic aim is a higher target, appointed by the government. As an individual you do not have a relation herewith. The significance depends on (1) to realize this target at lowest possible costs → is plan SDE (+) and (2) how can it be realized as easy as possible (far away Windmills at sea). Construction is the problem; other infrastructures can act with fewer stakeholders."

- *Do you relate to this perspective in any other way?*

"Existing heat client uses 35 GJ average on heat demand. This is dived into 27 GJ for space-heating and 8 for tapwater. For new houses the average demand is only 16 GJ. This diminishes especially at the expense of space-heating. The 7 GJ for tapwater increased last years and nowadays 90/70 degrees Celcuius water is flowing through the pipes (because of legionella).The intention is now to have the temperature at 60/40 degrees for space-heating. To use more of the residual heat is only possible at certain conditions."

The "Quid pro quo" perspective

As well as other perspectives, the participants in this perspective put trust on the most agree position as a condition before collaboration can start. Distinguishable for this perspective is the importance they put in a collective agreement or expectation in collaboration or a project. Despite the complexity in the field they do not agree (most disagree) that the complexity puts a burden on collaboration, "especially for that reason I collaborate (P-5)". Next to that they do relate a lot of value to the repeating character of the collaboration "If you already know the other parties, you can save an enormous amount of time (P-2)". They are also sceptical with relation to the inter comparability of heat and cold via different tax regimes within the Netherlands and put that on +4 in the ranking. In similar agreement they expect that more sustainability ambitions by the local government create more collaboration.

- *Do you recognise this perspective in the heat and cold energy storage field in the Netherlands?*

"We do need each other, otherwise it will not be realized. That is rather recognizable, awaiting behaviour. It is not a solar panel, which is easy to sell from door to door. Heat is difficult, much more difficult to sell. Therefore, cooperation is necessary. You are working on it for a long period. It is long-lasting, mutual and returning. This really makes it different. We indeed have to do it, but it feels difficult to start with the first cooperating-steps. As said before, it helps a lot when having a repeating cooperation. Than, there will exist much more trust in the outcome; e.g. local communities who like this, but in the beginning meet loss in trust in the outcome because of the long schedules. →The community of Maastricht has 3 residential areas with heat power supplies. There also happens a lot during re-building + will there be built a tunnel in main road A2 →At first there was a tought to add a tube, but because of the complexity the élan of the cooperation got lost. You must not give up and carry on. The community of Groningen also should want to do more with heat and, therefore, there has been set up a joint venture heat-city Groningen with the heat-company and the local community. This because market does not start it."

- *To which extend do you relate yourself to this topic?*

"Especially in the long term: the result of the cooperation is a long relation to renting people and voters in the communities. As a result public private cooperation constructions are established because of relation after developing and building, holding each other takes care of (1) support. For instance, Purmerend Public, a lot of important cooperation overhere. And (2) that is how to avoid that housing corporations threaten that they will not buy heat of your power source and take gas. By acting as a public authority in an economic and organizational way it is easier to make a the step towards each other."

- *If you look at the distinguishing statements from this framework, does it match with the description of the perspective?* –

  Do you relate to this perspective in any other way? I think that PPS forms are really needed and also produce more in the long term, this partly because of market failure.

The Second Movers perspective

"This perspective is known for a second-mover perspective this cannot be generalized to risk aversive, but they do not take the first action in the market for collaboration and economic growth. It looks like as they wait until goals are set by amongst others the government or they do not wait, but they do see it as a task of the government to set goals and ambitions related to heat and cold. The distinguishing statements 15 (*Long-lasting (local) government-ambitions result in heat and cold initiatives. =+5*) and 3 (*Collaboration is developing because governments initiate projects. = +3*) confirm that. Next to that the collaboration is to ensure the recipients of heat. They do also have sustainability as a high aspect to collaborate. But more important is that they tend to wait to collaborate until the moment that infrastructure is provided by other parties."

- Do you recognise this perspective in the heat and cold energy storage field in the Netherlands? "This waiting process for infrastructure is related to three things:

1) Success rate higher (new source or new customers) and faster from idea towards realisation.
2) Risks are clearer. Related to risks it is really tensive process, making something for 1000 or 4000 connections is a big deal, since you might expect new customers in the future (expanding options for the grid).

If I look at statement four, many municipalities have their sustainability goals somewhere in 2035-2040 (ambition (15)) and everyone is already proud of that at the moment. However, there is no policy instrument for these goals; there is nothing to actually realise the goals. Statement (3) is really necessary to be able to grow more if they (municipalities resp.) would really spend time / organizational skills/ permits granting/ thinking with the companies, than bigger steps forward can be made.
Maybe also to take a further step and actually investing money in there (e.g. scaling down the natural gas production in Groningen is a real next step)"

- To which extend do you related yourself to this topic?

"(Image is not that positive). We are already doing things like that, so for us the step is relative smaller and if something is in the ground it is much easier to connect new things to it, also because of political success."

- If you look at the distinguishing statements from this framework, does it match with the description of the perspective? -
- Do you relate to this perspective in any other way? -

6.4 Validation reflected and concluded

Despite the validation it should be mentioned that the researcher has a very powerfull framing option while deducing the perspectives. This makes the researched somewhat less valuable, however this is common for Q-methodology, a reflection on that topic would be to dicuss the perspectives with a research group rather than alone (Van der Voort et al., 2009).

From an institutional perspective two more steps could have been taken. "One step digs deeper and inquires into the drivers that affect the structure of the situation" (Ostrom, 2011). The second step could be to explore "how an action situation changes over time in light of how the outcomes at an earlier time affect perceptions and strategies over time" (Ostrom, 2011). The first step is relevant because the assumption that collaboration is lacking behind was found to be correct, it does however not exclude other reasons for the lack of development in the field. The second step is not covered because the results are more a snapshot these steps were not in the scope of this thesis, but over time the results could change if policy has been developed for all four perspectives. The decision to change several aspects of the heat law adds as argument for market failure, however the result seemed unwanted(Tweede Kamer der Staten Generaal, 2013).

With relation to the scope of the results, a clear boundary was set on the Netherlands as geographical boundary to the research. This action was taken to make this thesis very applicable in the Dutch field. As a consequence the results are relative focussed and therefore the possibility to generalise the results is limited. The validation has shown that the perspectives are indeed very applicable in the Dutch setting.

According to Gijs de Man these four perspectives are seen common in the market. This results in a positive recommendation for the validity of both Q-methodology as a method and the interpretation of the researcher of the Q-sorts and the Principal Component Analysis. No other common perspectives were suggested in the interview.

REFLECTION, DISCUSSION & IMPLICATIONS

7 Reflection and Discussion

This chapter provides an important part of this research related to the scientific steps as well as the assumptions taken to come to the results. A critical reflection is performed in the first part of this chapter; furthermore a discussion mostly related to the results and the implications for the field is shown in the second paragraph, finally a small section is used to present some implications for the field.

7.1 Reflection

In this section the main goal is to put the outcomes and results of the research into perspective by means of a critical reflection. Firstly a reflection on the scope and used system analysis is performed; afterwards the focus is mainly on the analysis of the results performed with the Q-methodology technique. Furthermore the results are critically studied, both the scientific and practical relevance are covered in the last part.

Because of the lack of development in the heat and cold energy storage field, the main goal of this thesis was to find the reason for this situation in order to overcome the gap in the development. Hereto a systems analysis has shown that institutionally the interactions do not lead to collaboration, hence drivers for collaboration behaviour in the heat and cold energy storage field in the Netherlands were studied. In principle, it is believed that the research design that was chosen is successful, since the research generated four valuable perspectives and specific categories for policy recommendations on collaboration behaviour. They form an answer to the main research question of this thesis and thus the research is in that way valuable for the field. Secondly this thesis is valuable because the Q-methodology is used to structure a complex socio-technical system with a negative image. Via this structure the problem areas have been objectively defined and discussed, something that was not possible beforehand and which is repeatable in time as well as in other sectors. This is a very important addition to the scientific literature on the structuring of discussions in multi actor contexts and in complex socio-technical systems.

Reflecting on the choice for the three T, E & I pillars and not using the method via a TIP design in the systems analysis, it seems clear that this approach has opened the view of the researcher more to create a clear and untangled systems perspective in comparison than the TIP perspective as used in the run-up of the thesis project. Possibly this was initiated because the system analysis part of the research was mainly performed at the ING bank (more focus on financials). However the information on process design is limited due to this choice, it did provide the option to use the IAD framework in the institutional analysis.

One of the aims of this thesis was to find applicable drivers for the Q-methodology. In relation to finding drivers for collaboration behaviour, both the literature and field experts were consulted. To ensure even more applicability in the field extra interviews could have been performed than two, also more different types of actors could have been consulted for these interviews. The validation has shown that the Q-methodology has delivered what was expected: perspectives and the drivers therein are recognised in the field hence the methodology performed as expected.

Specifically related to the drivers and the interviews, I believe that the drivers related to cold, drivers related to the cost of arriving at agreements (transaction costs) and drivers for economic subjects in general, are not as well represented as could be in the statements as well as in the perspectives. This was done on purpose and many arguments for this choice were found in the economic systems analysis furthermore the costs were represented and the statements 11 (I collaborate to save money for all parties involved) imply costs. The cold is off course represented in all of the statements because of the main question "Which drivers determine collaboration in the heat and ***cold*** energy storage field in the Netherlands?" Despite that representation I had the feeling it was less obvious for some competitors in the P-set. The assumption that collaboration is indeed a problem in the field was acknowledged by experts. As mentioned this does not include transaction costs and it could be that the perspectives change if the economic value is clearer throughout the research. However the interviews as well as some statements revealed that all participants understand that economics are important, so the expected change if it would be incorporated is small.

Practical reflection:

As mentioned the researcher has a strong influence in steering his research. This steering was especially visible in the Q methodological steps; therefore heuristics from literature were used to ensure an objective research. This literature (Cuppen et al., 2010; Exel, 2005; Watts & Stenner, 2012) acknowledges to some extent the limitations of the Q methodology, but as researcher I argue that it is not very disturbing in the total results in this thesis. As researcher I have noticed that on three points I was able to steer a lot in the research.

1. Firstly while choosing the literature and the experts to incorporate drivers around collaboration behaviour to create statements. This was done by categorising the similar results, but stays subjective.
2. Furthermore to determine the participants in the P-set the value of the research increases if a fruitful set is created. By doing an actor analysis as part of the IAD framework, I have incorporated as many types of actors as are currently recognised in the field. However if actors are not yet very active, they might have slipped the view of this thesis. This has been tried to solve via experts who could look at the statements and an iterative process of in- and excluding of participants. However this is not a solid approach from a scientific point of view.
3. Thirdly there is a possibility to frame your sentences and the research as such in the interview by formulating your questions sharper or in a specific (expected) reaction. However by recording and listening to the first three interview after day one, there was a clear line visible on how the framing was done, this was relative consistent during the rest of the interviews. Also the expert validation the framework of perspectives has an influence on that topic.

The amount of freedom is however widely accepted in the field, this is not a proper fact, but it puts this reflection into perspective of the Q-research field (Cuppen et al., 2010; Watts & Stenner, 2012). Choises for other research methodologies as mentioned in the paragraph 3.2 would probably not have resulted in such an open discussion about intrinsic behaviour of experts in the field and neither would this have provided the option to find different perspectives.

Specifically related to the drivers and the interviews, I believe that the drivers related to cold or cooling specifically, drivers related to the cost of arriving at agreements (transaction costs) and economic subjects in general are not as well represented as could be in the statements as well as in the perspectives. This was done on purpose and many arguments for this choice were found in the economic systems analysis furthermore the costs were represented and the statements 11 (I collaborate to save money for all parties involved) imply costs. The cold is off course represented in all of the statements because of the main question "Which drivers determine collaboration in the heat and ***cold*** energy storage field in the Netherlands?" Despite that representation I had the feeling it was less obvious for some competitors in the P-set. The assumption that collaboration is indeed a problem in the field was acknowledged by experts. As mentioned this does not include transaction costs and it could be that the perspectives change if the economic value is clearer throughout the research. However the interviews as well as some statements revealed that all participants understand that economics are important, so the expected change if it would be incorporated is small.

The most important results of this research are obviously the four perspectives that have been found in the factor analysis and the specific important drivers per aspect. This is a clear result for the thesis and the difference between these results, implicates the usability for future policy based on different angles combined in one policy to influence the heat and cold energy storage field in the Netherlands. The spectrum of drivers for collaboration behaviour is quite broad. This confirms the discussion in the running up of this thesis. Despite the broad bandwidth two perspectives clearly form the middle, while the Early Adopters perspective is at one extreme of the spectrum and the other extreme is covered by the Second Movers perspective. This is a fruitful situation because differences between perspectives increase the intelligibility of each perspective. Given the choice of Q-methodology, the type of participants in the P-set, the expertise of the interviewed experts and the number of interviews this is the wanted outcome of this thesis. It could be that with a longer time span to analysis the field instead of the shorter period used now, more perspectives follow from the same set of statements because of system changes (policy, substitute products etc.) that influence choices of the participants over time. However due to the long term investment and life cycle of the infrastructure often needed in this field, this expectation is low. Nevertheless the Q-methodological research is replicable over time to ensure the same effects. With research by different researchers and in the case the same statements are used while checking the repeatability of the research, it is assumed similar results are created. However if the statements would be adapted by other researches, the results will most likely be differentiating from the found perspectives in this research due to the nature of the Q-methodology which than tests different n-cases than in this design.

Once more reflecting from a scientific point of view the scientific literature shows also that collaboration aspects are shown in these perspectives, but they are enlarged with field specific reasons for collaboration. This was not possible beforehand since one could never tell from literature alone which of the collaboration drivers are specifically applicable for a case, field or problem.

The societal relevance in this thesis is served by two important parts. Firstly the Q-methodology provides a method to structure the discussion about the development of the field and sub parts of the field. This structure is shown by combining the discussion topics on collaboration in four perspectives rather than a big overview. An even higher societal impact was created by finding applicable drivers and that make this thesis more applicable to the heat and cold energy storage field. The resulting drivers per perspective create the possibility to develop an effective policy agenda since the effects of a general policy, if split up in drivers, can be "tested" for impact on each perspective. Rather than concluding based on drivers from literature and theory about collaboration. The research has been validated to be very applicable and also used in a recent discussion structuring by the Port of Rotterdam.

As has mentioned before, Q-methodology does what is should do, however a disclaimer should be provided with the results as mentioned in paragraph 5.5. Despite the well designed set of participants in the P-set, the data is not generalizable to the entire population because of the small size of the set (twenty). Furthermore the data here is not 'hard'; to get this 'hard' data a survey would be more suitable. A survey on the relations between the found drivers in paragraph and collaboration under more participants could be used to create a generalizable dataset and (in theory) significant causal relations. Since it would not be able to identify perspectives this has specifically not been the purpose of this research.

Concluding I believe that the steps taken to overcome softer points in this research have effectively tackled these hurdles in a scientific way. As a researcher I have enjoyed the steps taken to do this, although they are sometimes very time-consuming.

7.2 Discussion

This paragraph is constructed in order to create a discussion that originates from the results of the research. It also serves as input for the implications of the results for the heat and cold energy storage field in the Netherlands.

Firstly a discussion is formed for the four perspectives to see which insights they deliver into the field; also a comparison for formal and informal embedding in the Dutch institutional setting is presented. Further on in this paragraph several general non distinguishable but important statements are discussed that were not specific for a perspective but characteristic for the field. Next to that several models are discussed that could elaborate on the effects on policy design and the analogy with foreign countries is drawn. A final discussion is shown to see which policy implications are indeed visible in the field.

Early Adopters perspective

Many producers load on this perspective that is characterised by the first movers or creators in the current heat and cold energy storage field. There are however not only building, producing or supplying actor-types in the field, hence it is also logical that not all participants load significantly related to collaboration on this perspective. What is also interesting to notice is that despite the name of this group, not as much heat and cold energy storage is actually build despite similar opinions on collaboration, this puts the position of this perspective into context. Interesting to notice is that currently the institutional setting is based on the group of first movers. This can be derived from the Warmtewet with the NMDA principle which is specifically designed to protect the ordinary citizen against opportunistic behaviour from the producers and suppliers of heat. If this is translated into the policy field, more policy to create a clearer need and urgency for heat might serve well to cope with this perspective (source Warmtebrief 1 April).

Policy Sceptics perspective

The participants from the Policy Sceptics perspective load more negative specific on statements that argue institutional driven collaboration is key for development for the field. Possibly this stems from the last decade in which indeed energy and heat regulation (since there was no specific heat regulation for a long while) has changed significantly. Projects and subsidies that were granted have however always been granted, so the scepticism related to the subsidies might be slightly ungrounded. Long term planning, with a lower risk profile for investments as a consequence, was probably relative more difficult due to changes in policy, the exact reason however falls out of the scope of this research. Since recently (<2 years) the specific Warmtewet has been developed, in this regulation despite promises of the minister several important changes have been made to principle calculation methods and comparisons with energy carriers for heat production has varied (Tweede Kamer der Staten Generaal, 2013). Linking these topic changes to the situation abroad the Netherlands, an important implication can be devised from Germany and Denmark within comparable Western-European markets, that long term strict policy (>10) year might prove useful.

Quid pro quo perspective

Participants loading on this perspective do certainly understand the complexity of the Dutch heat and cold energy storage field. They provide examples such as the case for greenhouse farmers with a CHP plant and a gas line, a heat pump and a small heat buffer. All are viable and potential options in the Dutch system, but many different regulations apply; the Gaswet, Warmtewet, Electriciteitswet, Splitsingswet and also several environmental regulations apply (Rijksoverheid, 2013). Given this fact, collaboration is seen as key to eventually overcome this. However collaboration is time consuming, expensive and sometimes inefficient of it is not recurrent. Hence they seem not to take big steps to develop the field. A potential solution area to overcome this setting forward a clear locally applicable strategy or goal with a group if stakeholders or by local and regional government.

Second Movers perspective

Second Movers participants are not unwilling to collaborate in the field; they do however need a little push before they go into action. This type of behaviour is probably most in common with the literature and theoretical frameworks that exist. In practise most collaboration papers (Ligtvoet, 2013; Ostrom, 1997)do mention Second Movers behaviour. The specific interesting notion for this field is that most loaders find problems related to investments in infrastructure. Even a producer loads on this perspective. The main reasoning behind this is that they wait for a big infrastructure to be financed, comparable with the Dutch gas grid, before they take a step into the field. One important notion is that it is unclear how big this infrastructure should be in order to push the loaders over the edge in order to collaborate. An important implication for policy relates to the possibility to create a state owned infrastructure or the process of 'socializing the heat infrastructure' so that automatically more development comes forward.

General common statements

In the results mostly the four perspectives have come forward, this is a typical situation in Q-methodology, however there are several statements in the Q-sets of the participants that seem very important, but are not distinguishable for one perspective. The most recurring driver in that sense is trust, followed by reciprocity of the collaboration and the common goal + culture underlying/ within projects. Important is here to notice that all these general important but not specific statements stem from the literature resources to form statements. Apparently current literature is not adequately specific enough to cope with the distinguishing statements in the perspectives.

Models to solve

For this decision making, a model of the entire heat and cold energy storage field in the Netherlands can be very useful. This is the case because in that way policies can be tested or executed in a controlled virtual environment, without disruptive behaviour in the field. A short overview is provided from several existing models in the heat and cold energy storage field. A very special point of all these models that are available in Dutch heat and cold energy storage field is that none of them is extensively used by policy makers. This implies that a complete model (potentially based on earlier models is a step that requires more attention in the field next to the Warmtebrief of the 1st of April. In the Netherlands alone 3 specific models are already in the field active on different levels:

- Frauenhofer ISE (full energy systems) (Henning, 2015);
- Quintel (Energytransitionmodel.nl, 2015);
- PBL (Vesta model);
- Models from single heat providers such as Eneco and Vattenfall (Nuon)(Van de Burg, 2014);
- TU Delft (Linny-R);
- ING /BNG (MAIS model, under construction).

That models are not the ideal policy to create real life solutions is clarified by the case of the Vesta model (Folkert & Wijngaart van den, 2012) which is the most poignant. TNO uses this model but as single client, but only if a specific request for a location presents itself. PBL, the Dutch environmental planning agency is the owner, but does not use the model (Van Swaaij, 2015).

Institutional solution space

Provided the discussion above it is clear that the perspectives do show different aspects of collaboration behaviour in the opinion of Dutch experts. This means that different options are possible to enable the development of the field. Informal institutions are harder to change but provide a long term effect. Formal regulations take time to get accepted, but are strict for the entire field. Ideally an institutional design is created that incorporates aspects of all four perspectives. With the mentioned MAIS model under construction, options to steer this process into a desired shape is relatively easy. Therefore the 'ideal' team for the construction should exist from at least the actor types as represented in the perspective, as well as the decision makers from earlier analysis: producers, grid owners, suppliers, (large) consumers, financers, installers/contractors, ministry of Home Affairs and Economics, provinces and municipalities (n.b. Ministry of Finance was a non-loader and is not taken into account for this purpose).

The assumption of twenty participants in the sample size has proven to be sufficient enough to create data overview. Despite that only two significant resulting participants have loaded on the Policy Sceptics perspective and also the Quid pro quo perspective has shown only three loaders. Both these results have had significant loaders (>0.40).

Since the assumption was made that the sample size suits the purpose of the research appropriately a reflection suits this choice. The sample size has shown significant results with nineteen of twenty participants, since there was one non-loading participant in the final rotated factor matrix. Despite that a ratio of 1 participant towards (42/19) = 2.2 statements satisfies the average 1:2 criteria of Watts & Stenner (2012) while also having a minimum of 13 participants.

The system analysis showed that the location of the performance issue stems from an institutional problem situation, a snapshot of the current system was taken for this purpose. This short time period for the assessment was chosen deliberately due to time constraints. For a more deliberated overview of the system all three systems-perspectives could be more detailed. For instance an extension of the actor analysis could have resulted in more actors types and into more participants in the P-set, which could enrich the knowledge of the field. Furthermore a limited generalizability of energy storage techniques towards other countries is possible due to the scope of the systems analysis.

The IAD framework for the institutional analyses was not used in its full potential as was specified in chapter 2.4; it served much more as the structure for the institutional analysis. This was very useful because there were many informal and formal institutions that blurred the overview that is needed from a systems analysis. For that reason, it is not possible to say something on institutional design in chapter two. This makes sense because information on the specific collaboration behaviour was not available at that time; however in the next paragraph some basic institutional design steps are discussed.

Concluding the discussion one can see that regulation does apparently not take all the current perspectives into account. This is an important implication for the field. They might need to change their natural role if collaboration is the wanted outcome. Another option as stated in the introduction policy makers should not only take policy towards regulation into account.

7.3 Implications for the heat and cold energy storage field in the Netherlands

The perspectives that have been found are at itself a valid reason to finish the scientific part of this research, however as mentioned in the introduction and discussion also an applicable paragmatic research is desired to cover its socieatal relevance.

This research has shown that not all the perspectives are captured in (in-)formal institutions. A special need for formalization of new institutions was created on the 1st of April 2015, provided by the Minister of Economic Affairs who wrote a letter to the parlement mentioning the need for change in the heat and cold energy storage field in the Netherlands (Kamp, 2015). Focus was put on a common understanding in the field, amongst others via a calculation MAIS model (Multi Actor Impact Simulation). Deduced from this policy letter can be that collaboration behaviour is desired to create common understanding with such a model, hence making use of the different perspectives for collaboration could policy makers in general.

Within the market are four perspectives for collaboration, the Early Adopters perspective has most participants loading on the perspective, hence more development is expected, since they "build". This is not the case, the most important institutional artefact, the heatlaw, is designed to protect end-customers, which are not well represented in this perspective (Rijksoverheid, 2013).

Regulation does not take all the current perspectives into account. This is an important implication for the field. They (the field respectivley) might need to change their natural role if collaboration is the wanted outcome. Another option as stated in the introduction, collaboration should not be seen as the only desired outcome of the system, however this is not recommended by the author. Moreover this is an important notion to policy makers, if insitutions are in place not only focus on the interactions, *"so-called "collaboration" gatherings with mainly well served coffee and tea (P-17)"* but also focus on the drivers for collaboration in the field, this should lead to the development of the heat and cold energy storage field in the Netherlands, therewith creating the desired outcome of collaboration from patterns of interaction (solving the lack as identified with the IAD framework in paragraph 2.3.1).

At least, the field should put effort in four points according to this research, each taking some of the perspectives into account:

1. Creating more need for heat and cold energy storage, hereto creating the incentive for the loaders in the Early Adopters perspective to start investing more in the field;
2. Setting out a clear and above strict policy around heat and cold energy storage with a focus on the long term usage;
3. Developing more hands-on and concrete sustainability goals on both a national and also important local level. To align with participants from the quid pro quo perspective, since they understand the need for collaboration in this field, but do not see (potential) options at this moment.
4. Taking the first step in a market which is currently known by market failure (see paragraph 1.3 and 2.5) in relation to the infrastructure for heat and cold energy storage. Hence by taking the first step in (socialising) infrastructure the Second Movers come in action

An institution comparible to the Dutch Gasunie (owner of gas grids respectively) would be an example which captures all above point for the gas sector.

Combined these implications for the field should be taken into account by the local and national regulators, producers, financers, and suppliers especially because they load the strongest on the perspectives. Nevertheless for a full development of the heat and cold energy storage field in the Netherlands all stakeholders with decision making power should gather. For instance by gathering knowledge in a model with common viewpoints such as the MAIS model.

CONCLUSION & RECOMMENDATIONS

8 Conclusion & Recommendations

The conclusion is presented in this chapter. The chapter is structured into two parts. The first part summarizes the steps taken to come to the conclusions with the use of Q-methodology to find common perspectives and drivers for the heat and cold energy storage field in the Netherlands. The second part contains the recommendations for policy improvements and further research.

8.1 Conclusion on Q-methodology

In the Netherlands growth is expected in the heat and cold energy storage field. However interactions do not lead to collaboration. For the Dutch heat and cold energy storage field, this research has found four different perspectives for collaboration stemming from Q-methodology based interviews. The most important implication for the field as shown in this research is that not all these four perspectives are shown in (in-)formal institutions, which do not lead to the expected growth.

At the beginning of this research it has become clear that this expectation of growth stems from three main reasons. Firstly due to the downscaling of natural gas usage, which is to be replaced by different sources of water. Secondly via the European directive on heat mapping and finally because of the unbalance in demand and supply for heat as well as for energy. This results in installed overcapacity and dumping of energy to balance the supply with demand ánd the grid. Heat and cold energy storage could overcome these problems.

A system analysis was therefore performed to see why the heat and cold energy storage field in the Netherlands is not developing. The analysis from a technological perspective revealed that heat and cold energy storage technologies are mature, but only locally implemented. The economic analysis shows that heat and cold energy storage has many options for electrical energy storage functions to complete a business case in the value chain. Therefore, the economy is not burdening the development of the heat and cold energy storage in the Netherlands. In addition, a big part of the economic design can be argued to relate much to the institutional design because of the environmental tax regulations. The institutional systems analysis by use of the IAD framework shows that despite of interactions, no desired outcomes are found in the Dutch heat and cold energy storage field. This desired outcome should be collaboration to develop the field further. The institutions are thus not well suited to the social and physical conditions of the field (both technical and economic). Furthermore, the institutions are not yet able to create the right incentives for the market in order create collaboration behaviour to grow the fields' development. Without stating the obvious, the drivers of the community of users put a big impact on the effect of any process design for institutional artefacts (Auer, 2006). Hence, further research was performed to see which drivers are distinguishable for collaboration behaviour in the heat and cold energy storage field in the Netherlands. This led to the following research question:

"Which are the most important drivers for collaboration behaviour in the Dutch heat and cold energy storage field?"

SQ1: Which are the drivers for collaboration behaviour stemming from literature?

SQ2: Which are the drivers for collaboration behaviour stemming from the experts in the field?

The both theoretical and practical literature review resulted in a total of seventy-three drivers which provide the answer to Sub Question 1 (SQ1); the full overview is shown in Table 19 Q-set on page 131.

The answer to the second research question is provided by the outcomes of the two field expert interviews. This resulted in eleven categories of drivers from the field: Price & Cost, Time, Collective action & Regulation, Interaction, Image, Information, Risk, Supply & Demand, Common goal & Strategy and Others. As mentioned before cateories have been derived from literature to reduce to time spent in the Q-srts for but the researcher and the participants in the P-set, a common action in Q-mothodological research (Barry & Proops, 1991; Cuppen, 2013; Dyer, 2002; Ligtvoet, 2013). For a full overview of the drivers and corresponding statements per category see Table 3 Final Q-set on page 38.

In the quantitative analysis with twenty experts in the Dutch heat and cold energy storage field and the post interview qualitative information, four perspectives were found on collaboration behaviour in the Dutch heat and cold energy storage field. These perspectives explain a significant amount of variance, 61% and the perspectives were also validated by an expert in the field.

The Early Adopters perspective *is distinguished by the group of participants all ensuring their own infrastructure. These participants do not wait for the creation of infrastructure with collaboration. Withal they feel the number of interactions is not burdening the development of the field. Moreover sharing profits and losses are an important driver in their opinion to collaborate.* Amongst others producers score high on this perspective.

The Policy Sceptics perspective *participants are known for their sceptics against changing government policy. Likewise they have in common to collaborate to save time in the project or collaboration compared to a situation where they would have to do the project by their selves. Nevertheless the scepticism burdens their driver to collaborate.*

The "Quid pro quo" perspective *is marked by participants who are intrinsically aware of the need for collaboration. They, however, do not wish to invest unless a common or similar expectation in a project or collaboration can be expected and they do not feel collaboration saves them time or costs. Next to that they find it difficult to compare heat according to taxes and that burdens their incentive to collaborate. Here, initiative is better for other competitors to start collaborating in the market before participants in this perspective collaborate.*

The Second Movers perspective *relates to the idea that collaboration only starts after action from another party, mainly after the government invested in infrastructural backbones. However, they also agree upon the fact that there is not such a situation in which the solution is too complex to collaborate, resulting from a more hands on and can do attitude.* This perspective is the only perspective in which not all participants have education from a higher level.

From a scientific point of view, these perspectives structure the discussion in a replicable way; why the heat and cold energy storage field is not developed into a sector. This could be applied in other sectors. Secondly scientific literature on collaboration has many different drivers, but this research has shown that they are represented in four perspectives specifically in the heat and cold energy storage field in the Netherlands. Thirdly this research has enlarged the literature drivers with field specific drivers for collaboration, whereas this was not possible before.

From the perspectives, groups of drivers are clearly visible and specific policies can be targeted to the perspectives. Current regulations do not take all the perspectives into account. This has an important implication to the field. Moreover, this is an important notion to policy makers, if institutions are in place not only focus on the interactions, *"so-called 'collaboration' gatherings with mainly well served coffee and tea (P-17)",* but also focus on the drivers for collaboration in the field; this should lead to the development of the heat and cold energy storage field in the Netherlands, therewith solving the lack as identified with the IAD framework in paragraph 2.3.1.

In order to provide an uncluttered overview of the drivers per specific perspective easier, four relation diagrams were developed. Insights from these diagrams have led to the conclusion that there is no driver for the heat and cold energy storage field which always has a positive or negative relation with collaboration in each of the perspectives (except for the Other-category which is always negative).

The drivers Interaction and Information / Knowledge have mostly small negative relations and could be stimulated effectively with policy. On the other hand a stimulating policy could be effective if it focusses on positive drivers in the most perspectives: Price / Cost, Supply / Demand, Image and Risk.

Finally, it would be advisable to steer with policy on the Policy Sceptics perspective (for Common goal / Strategy and Image) and on the Quid pro quo perspective (for Time, Information / Knowledge and Supply / Demand), since they have a negative relation with collaboration when the category has three positive relations with the other perspectives.

A last remark that followed from the discussions is that the general drivers: trust at first before collaboration, reciprocity of the collaboration and the common goal + culture underlying/ within projects, are all general important but not in specific statements. Unremarkable they stem from the literature resources, apparently current scientific literature is not adequately specific enough to cope with the distinguishing statements in the perspectives.

Herewith the answer to the research question can be concluded. The most important drivers for collaboration behaviour in the heat and cold energy storage field in the Netherlands are represented in four perspectives: the Early Adopters, Policy Sceptics, Quid pro quo and the Second Movers. With therein the categories of drivers: Interaction, Information / Knowledge, Price / Cost, Supply / Demand, Image and Risk, which have the strongest positive relations towards collaboration behaviour in the Dutch heat and cold energy storage field.

8.2 Recommendations

Within this paragraph all knowledge gained in the research during the thesis project is combined and translated into three main recommendations.

This report started with a problem statement resulting in an institutional knowledge gap. This gap has been clearly identified, however, the assumption was made that collaboration behaviour is the most important reason for further development of the heat and cold energy storage field in the Netherlands. Combined with the assumption of market failure it is necessary to know which other forms of desired outcomes lead to a development of the field. Hence, "one step digs deeper and inquires into the drivers that affect the structure of the situation" (Ostrom, 2011). A systematic research into market models for the heat and cold energy storage field in the Netherlands could enable this other view on the drivers for the structure of the field.

Further research into embedding collaboration perspectives in future policy is needed. As it has already been sketched in paragraph 8.3, especially the type of policy instruments applicable in the Dutch context could be very well assessed. Doing this in the execution policy agenda for the heat vision in October 2015 provides an excellent podium for this purpose. This is needed for two reasons, firstly because if all perspectives need to be taken into account a detailed design is needed for both informal as formal regulation. Secondly collaboration might have different drivers in different stages of a project, Ligtvoet (2013) mentioned this already after conducting interviews on the Delft thermal grid project in his Phd research project.

Finally, a recommendation is provided to create more structure in the entire field. This thesis solved to structure the discussion why the development is lacking behind despite the needs in the field, especially at this moment in the Netherlands. Nevertheless, if a solution for this problem is still to be implemented and given the high cost in a complex socio-technical system, a model study of the desired improvement(s) could create the required overview. Naturally many models do exist currently (see for instance: (Troffolo (2009), (Christofides, 1975) & (Valdimarsson, 1997), however, the need for a calculation-based model is very clear from the Warmtebrief as written by the minister of Economic Affairs. One of these models could be the MAIS (Multi Actor Impact Simulation) model which is currently being developed in the Dutch heat energy storage field (not cold). It is highly recommended to incorporate the identified perspectives into this model.

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APPENDICES

A. APPENDIX A: Types of energy storage

This appendix provides a description according to the Frauenhofer Institute of different types of electrical energy storage. Five types are distinguished also in other literature (Gil, et al., 2010)(Chen et al., 2009; DTI, 2004; IEC, 2011; International Energy Agency, 2014). See also

Figure 3 Types of Electrical energy storage systems (IEC, 2011) for a geographical overview of the below mentioned types of electrical energy storage.

A.1. Energy storage definition

In the first chapter of this thesis energy storage needs to be defined, this is needed so that the scope of this research is clear. As the field is quite broad energy storage is defined in a broad way so that also geothermal and heat grids are taken into account.

A common definition therefore is: "Energy storage is the storing of some form of energy that can be drawn upon at a later time to perform some useful operation" (Gil et al., 2010). Alternative definitions for energy storage exist; more technical or for instance specified to a type of storage. For this report it is also important to see which definitions of thermal (heat and cold) storage are used. Hasnain (1998) acknowledges two types of thermal storage: latent and sensible heat storage (Hasnain, 1998). Latent storage of heat is defined by Abhat (1983) as the "heat of fusion in suitable substances that undergo melting and freezing at a desired temperature level". This definition does not contain the liquid-to-vapour phase transition. Therefore Abhat defines latent heat storage to contain at least 3 of the following elements: "(a) a heat storage substance that undergoes a solid-to-liquid phase transition in the required operating temperature range and where the bulk of the heat added is stored as the latent heat of fusion, (b) a container for holding the storage substance and (c) a heat exchanging surface for transferring heat from the heat source to the phase changing material and from the latter to the heat sink" (Abhat, 1983).

The earlier mentioned type sensible heat storage can be defined as "storage in which the temperature of the storage material varies with the amount of energy stored"(Hasnain, 1998). The latter is at this moment in an advanced developed technology compared to latent heat storage (Hasnain, 1998). However multiple other definitions also exist, a more fundamental definition is created by Dinçer and Rosen (2002). They argue that since the second law of thermodynamics argue that energy cannot be created nor destroyed and that energy storage can consist of kinetic, potential, chemical and internal energy (Dinçer & Rosen, 2002). Distilled from above definitions the following definition is used in this thesis to consider energy storage: "Energy storage is the storing of some form of energy that can be drawn upon at a later time to perform some useful operation" (Gil et al., 2010).

A.2. Mechanical energy storage

Mechanical energy storage is energy stored in its kinetic form

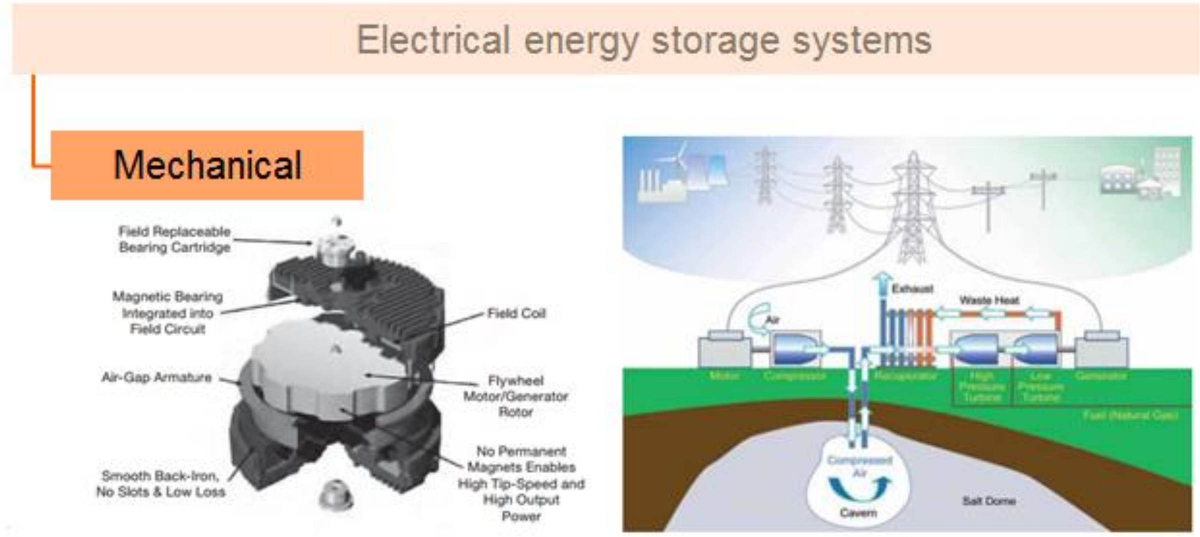


Figure 17 Mechanical energy storage systems (IEC, 2011 page 18-20)

Common forms are storage in flywheels and storage in CAES (Compressed Air Energy Storage).

A.3. Electrochemical energy storage

Electrochemical energy storage is energy stored in electrons in a chemical compound. This form of energy storage is often implied by people if we just say energy storage.

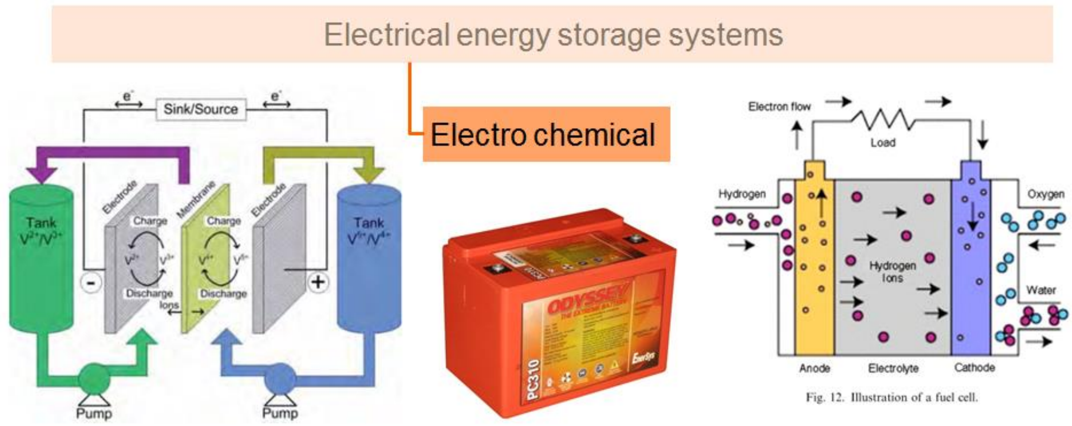


Figure 18 Electrochemical energy storage (IEC, 2011 page 20-25) (Autostarts, 2015)

Common forms are storage in batteries such as Li-ion, NaCd, $BiCL_2$, metal air, lead acid batteries. Also in this type belong the flow battery (Redox) and the fuel cells.

A.4. Chemical energy storage

Chemical energy storage is energy stored in a chemical energy carrier. This form of energy storage is often forgotten by people if we talk about energy storage. Also complicated is that there are many different definitions of this type of storage available. Common is that energy storage is only reported in literature if it is connected to the grid directly. Storing chemical energy is not always needed in connection with the grid, hence in many reports there is little or no data available.

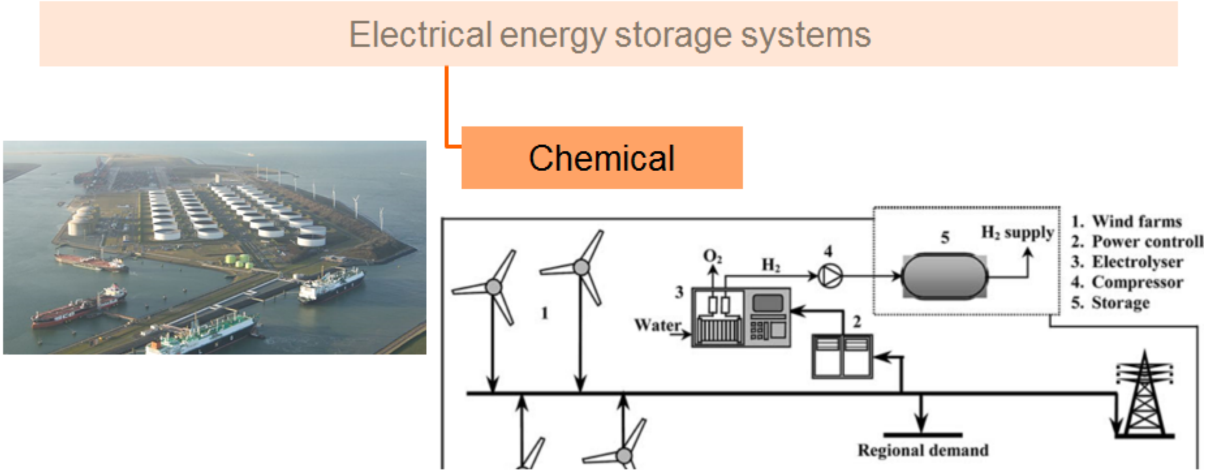


Figure 19 Chemical energy storage (IEC, 2011 page 25-27)

A.5. Electrical energy storage

Often if energy storage is discussed, this electrical form is mistaken with the type electrochemical storage; these two look similar but are different. This is best seen in the capacity of the systems and the charge and discharge times.

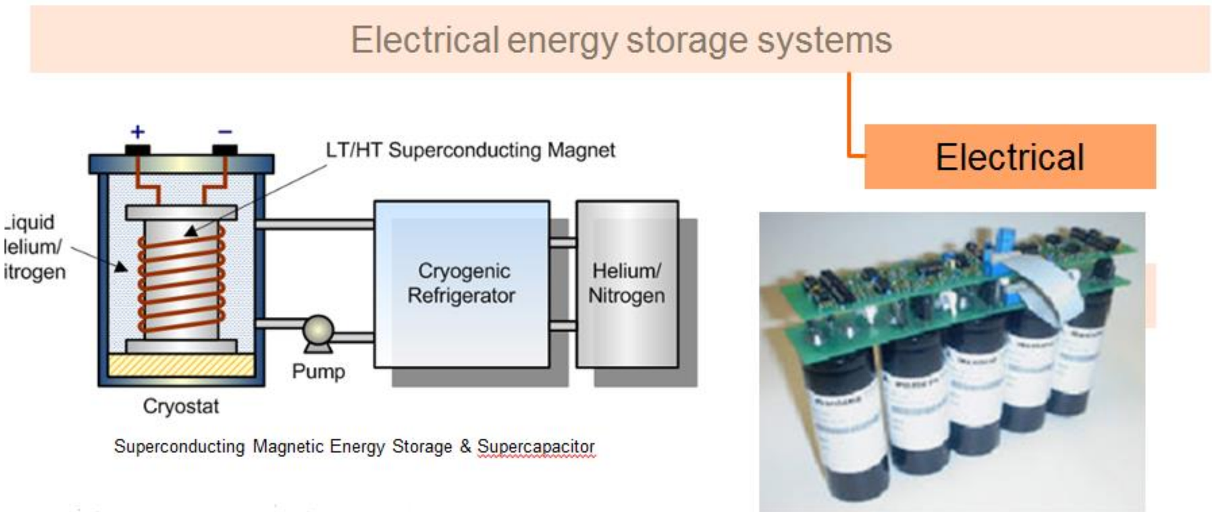


Figure 20 Electrical energy storage (Ibrahim, Ilinca, & Perron, 2008; IEC, 2011 page 27- 28)

Common forms are storage in super capacitors or DLC (Dual Layer Capacitors) and also SMES belongs to this type of storage (Superconducting Magnetic Energy Storage). In an SMES energy is stored in the magnetic field of the flow in direct current in a superconducting coil which has been cooled to a temperature below its superconducting critical temperature (IEC, 2011 page 27- 28).

A.6. Thermal energy storage

"Thermal (energy) storage systems store available heat by different means in an insulated repository for later use in different industrial and residential applications, such as space heating or cooling, hot water production or electricity generation. Thermal storage systems are deployed to overcome the mismatch between demand and supply of thermal energy and thus they are important for the integration of renewable energy sources (IEC, 2011 page 29)". With this description many different techniques of heat and cold energy storage are included.

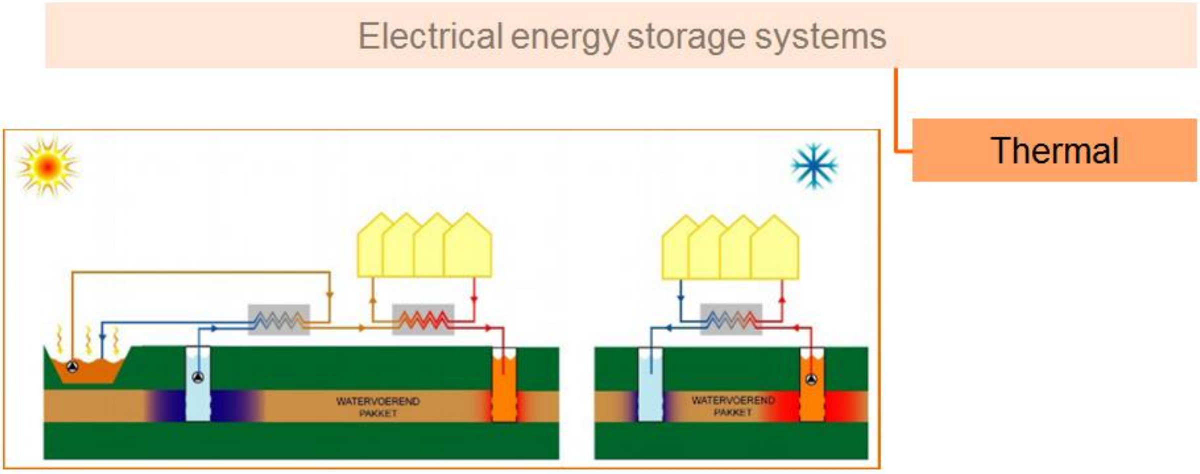


Figure 21 Thermal energy storage (IEC, 2011 page 29-31)

Common forms are geothermal storage, general heat and cold storage (WKO) and given the definition of Gil et al (2011) (district) heating grids. A more uncommon form for instance is heating up large oil tanks with excess energy.

B. APPENDIX B: Systems analysis

This appendix provides an extensive overview of several characteristic values of the energy storage technologies from a desk study. More details for the choice of averages and data difficulties in compiling this set can be read in paragraph 2.2.2 Characteristics and maturity of the energy technologies on page 10.

B.1. Values of characteristics for all EES

For a complete overview it is best to use a computer with a spread sheet program such as Microsoft Office Excel 2010 or newer. A permanent link with the averages is available at this link. An overview has been tried to create in Table 14 and 13 on pages 96 and 97.

Name	Avg Ramp Up Speed (W/min)	Avg Ramp Down Speed (W/min)	Avg Energy Degradation (%/day)	Avg Energy Conversion Efficiency (%)	Avg Lifetime (cycles)	Avg Lifetime (years)	Min Discharge Time (hours)	Max Discharge Time (hours)
MS - Flywheel	35000000	35000000	0	70	0	50	1	100
MS - Pumped Hydro Storage	55000000	55000000	0	72	0	32,5	3	40
MS - Compressed Air Energy Storage	0	0	0,2	82,5	51100	6,5	0,5	10
ES - Lead Acid Batteries	0	0	0,1	92,5	52250	10	0,5	15
ES - Lithium Ion Battery	0	0	0,2	72,5	10000	15	4	10
ES - Vanadium Redox Flow Battery	#N/A	#N/A	0,4	65	2750	15	#N/A	#N/A
Ni Cd	#N/A	#N/A	20	80	2500	12,5	1	10
NaS	#N/A	#N/A	15	87,5	2500	12	#N/A	#N/A
NaNiCl ZEBRA	#N/A	#N/A	5	68	2000	7,5	#N/A	#N/A
ZnBr	#N/A	#N/A	0,1	#N/A	1000	10	#N/A	#N/A
Fuel Cell	0	0	21	79	50005000	20	0,0002	1
ES - Supercapacitors	0	0	12,5	92,5	100000	25	0,001	0,1
MagnS SMES	1000500	1000500	#N/A	70	0	20	0,5	90
TS - Sensible Heat - Hot Water	1000500	1000500	#N/A	70	0	20	0,5	90
TS - Sensible Heat - Underground Storage	2985000	7950000	#N/A	66,5	0	0	15	15
TS - Sensible Heat - Molten Salts	100500	100500	#N/A	82,5	0	0	2	72
TS - Latent Heat (Phase Change Materials)	2505000	2505000	1,5	75	42,5	16	240	480
Gas S - Hydrogen Electrolysis	2505000	2505000	1,5	37,5	56,5	16	240	480
Synthetic Methane Storage - Methanation (Use of H_2 via electrolysis with met CO_2)	27083333	4175833	0	0	0	15	240	480
Gas S - Salt Caverns	41493056	18229167	0	0	0	20	1920	3600
Gas S -Aquifers & Depleted gas/oil field	6,16E+08	28125000	0	0	0	20	288	2400

Table 14 Characteristics of EES (part 1)

Name	Avg Discharge Power (W)	Avg Charge Power (W)	Avg Energy storage capacity (Wh)	Avg Energy Density (Wh/m3)	Avg RespTime Discharge (min)	Avg RespTim Charge (min)	Discharg e Time (hours)	Avg Operatio nal Time (min)
S - Flywheel	1002500	1050000	12750	0	0,001	0,001	0,125625	7,541667
MS - Pumped Hydro Storage	25,02E+8	2,5E+09	6,06E+10	1000	7,583	8	50,5	3030
MS - Compressed Air Energy Storage	18,5E+07	1,15E+08	1610000000	12000	10	10	21,5	1290
ES - Lead Acid Batteries	25000500	25000500	25000500	60000	0,0167	0,0167	5,25	315
ES - Lithium Ion Battery	2500500	2500500	50000250	350000	0,0167	0,0167	7,75	465
ES - Vanadium Redox Flow Battery	5002500	5002500	4250000	25000	2,68E-06	2,68E-06	7	420
NI cd	3515000	3515000	#N/A	130000	0,0167	0,0167	#N/A	180,0083
naS	4025000	4025000	120200000	195000	0,0167	#N/A	5,5	180,0083
NaNiCl ZEBRA	150000	150000	#N/A	165000	#N/A	#N/A	#N/A	180,0083
ZnBr	1025000	1025000	2050000	45000	0,0010	0,0010	#N/A	900,0083
Fuel Cell	25000000	25000000	#N/A	400000	#N/A	#N/A	#N/A	1080,008
ES - Supercapacitors	505000	505000	500001	7,55	0,0167	0,0167	0,5001	30,005
MagnS SMES	5005000	5005000	500005	1350	0,00167	0,00167	0,0505	2,541667
TS - Sensible Heat - Hot Water	5005000	5005000	450002500	50000	7,5	7,5	45,25	2220
TS - Sensible Heat - Underground Storage	5005000	5005000	450002500	50000	7,5	7,5	45,25	2220
TS - Sensible Heat - Molten Salts	19900000	53000000	30000000	312500	7,5	7,5	15	900
TS - Latent Heat (Phase Change Materials)	505000	505000	0	86500	7,5	7,5	37	2220
Gas S - Hydrogen Electrolysis	25050000	25050000	9,0006E+11	1555555	10	10	360	0
Synthetic Methane Storage - Methanation (gebruik van hydrogen via electrolyse met CO_2)	25050000	25050000	1,1006E+11	2590555	10	10	360	0
Gas S - Salt Caverns	16,3E+08	2,51E+08	5,415E+11	15400	60	60	360	22200
Gas S - Aquifers & Depleted Gas/Oil Fields	1,08 E+10	5,25E+09	3,303E+13	15400	810	810	2760	165600
Gas S- Liquified Natural Gas (LNG)	39,3E+08	1,88E+08	5,415E+11	15400	12,5	12,5	1344	3360

Table 15 Characteristics of EES (part 2) (Beaudin et al., 2010; Black & Vetch, 2012; British Geological Survey, 2008; Chen et al., 2009; DTI, 2004; Ecofys, 2014; EPRI, 2003, 2010; European Commission Directorate-general for energy, 2013; IEC, 2011; International Renewable Energy Agency, 2012; Koolwijk et al., 2010; López-Maldonado, Ponce-Ortega, & Segovia-Hernández, 2011; Pierie, Someren, & Noppen, 2015)

B.2. Example overview of characteristics visualised for a small set of EES

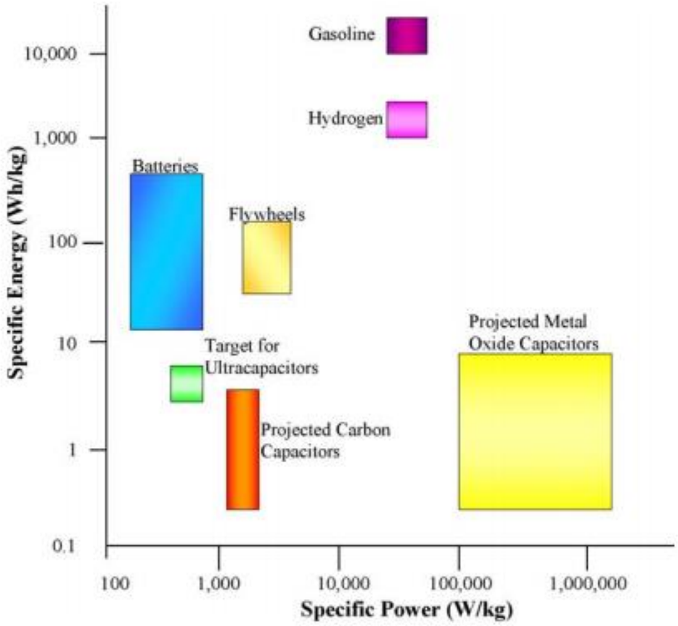


Figure 22 Overview of storage techniques with capacity and power. Adapted from (Hadjipaschalis, et al., 2009)

See Figure 22 for an impression of some common techniques. It is important to understand that many techniques are promising but are in different stages of the value chain of energy. This difference stems from the principle and assumption that the price of energy in the end should stay the same from a consumer perspective.

B.3. Motivation for function positions in the value chain

This paragraph provides a motivation in table form for the postion of each function of energy storage in the value chain. As can be seen multiple positions in the value chain can be applicable for each type of storage. The decisions are made mostly on three criteria (see also Table 2 Criteria to sort the EES functions in the value chain): The discharge period (min), the response time (s) and the power rating (W). The discharge period is mainly the key indicator in combination with the power rating for the size of the EES. A bigger/smaller size simply means a different the position in the value chain, for instance due to system requirements or because stakeholder consensus is not plausible on a place in the value chain at this moment. Furthermore the markets for electricity determine the response time required, hence apposition in the technical value chain is determined by an economical point of view and implemented via an institutional artefact (electricity law).

Application	Where
Seasonal storage	ES: keep a long big part stored.
Arbitrage	ES: store a source, not electricity Generation: store after production on site Load: buy when price is cheap, use for own use later or sell to neighbours later.
Frequency regulation	G; because save a fine for unbalanced output T: because short term full area/ interconnections D because short term, local area
Load following	T: because short term full area/ interconnections D because short term, local area
Voltage support	T: because short term full area/ interconnections D because short term, local area
Black start	Load: Very useful especially off-grid
Transmission and Distribution (T&D) congestion relief	T D
T&D infrastructure investment deferral	T D
Demand shifting and peak reduction	Load: to save on bill (peak price or unexpected demand bill) ES: save in carrier to use on later time if you have peak for H_2 demand at facility or peak for CH_4 demand at a facility.
Off-grid	Load: Clever
Variable supply resource integration	T: at converter stations to equal input D: at converter stations to equal input L: to balance einput in specific area
Waste heat utilisation	G: because there is the heat L: so that no big own supply is needed or big cooling facilities ES: to prepare an energy source for processing
Combined heat and power	G: because there is the supply
Spinning reserve	G: to steer output T: to steer in and output of voltage, frequency etc D: to steer in and output of voltage, frequency etc L: Uninterupted power supply systems
Non-spinning reserve	Any place in the value chain in case of blackouts or if no grid connection is available

Table 16 Position of EES in the Dutch value chain

In Table 16 the value chain elements are represented by the following letters: ES= Energy Source, G= Generation, T= Transmission network, D= Distribution networks, L= Load/ Metering.

B.4. Distribution of EES functions in the value chain

This section provides an overview of all the possible positions energy storage can take in the value chain. This is done based on the three criteria from Table 2 on page 15: Discharge period (hours), Response time (hours) and Power rating (Watt). Not all the functions from the previous paragraph are mentioned in this figure, sicne that would decrease the readability too much. The interested reader could easily couple the data from the previous paragraph into this figure.

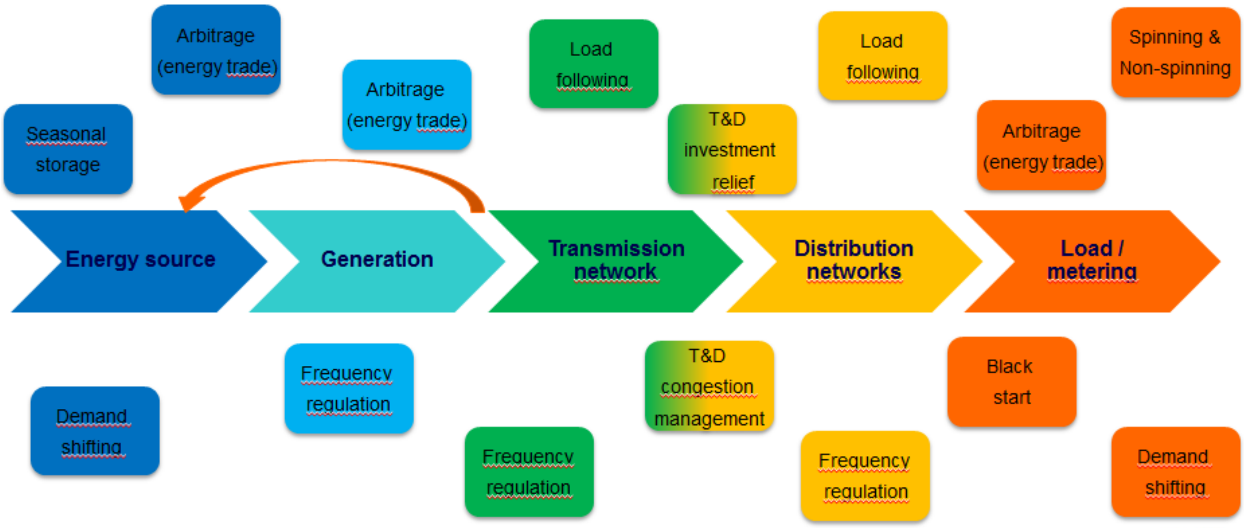


Figure 23 Functions of EES in the value chain

The value chain in Figure 23serves as a (partial, most common) representation of the functions of energy storage in the value chain. This serves as illustration for the assumption that energy storage is viable from an economical perspective if functions and benefits are stacked.

B.5. Energy markets

This appendix shows the possible markets to sell electricity stemming from a device for energy storage. In this case the only focus is on electrical energy output and not on thermal energy output. It is therefore a shortcoming in this research that this has not been investigated more extensively. However provided the scope and the assumption of this research that heat and cold energy storage is economically possible, this does not influence the results of the research.

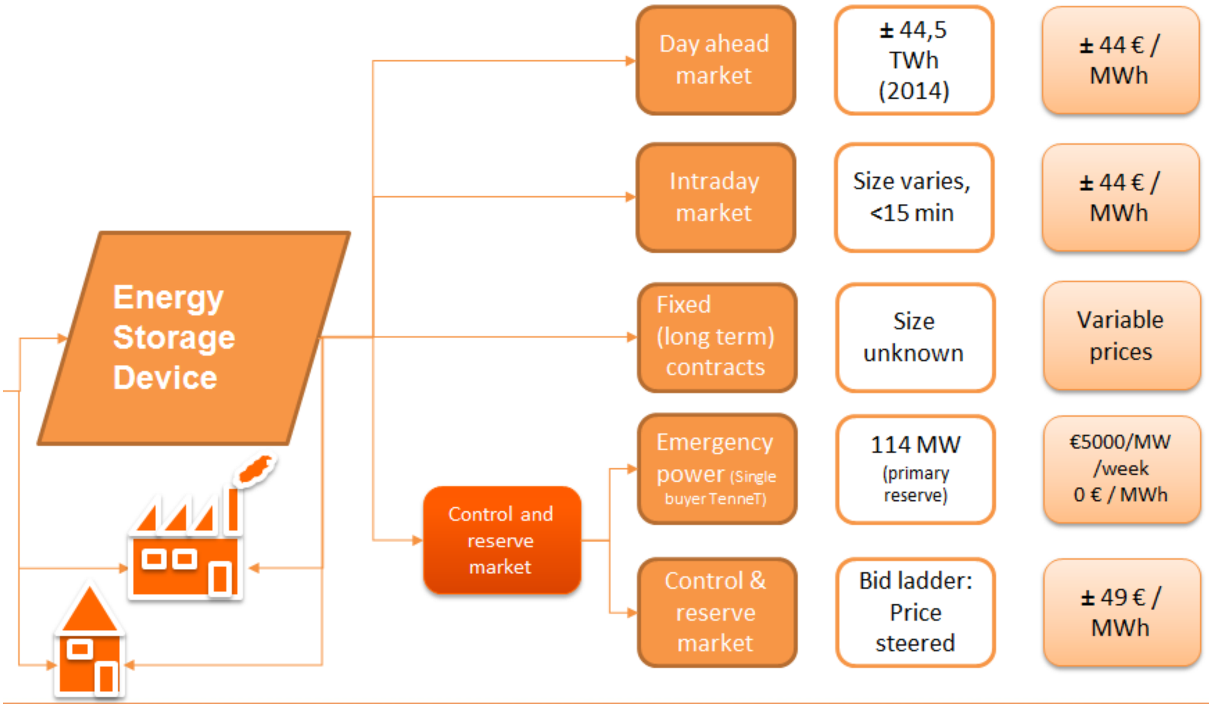


Figure 24 Energy storage markets in the Netherlands (2014/2015)

In the data from fugure 18, four markets can be derived that are potentially interesting for the Dutch market of (heat and cold) energy storage. There are five markets, but the consumer market is at this moment not interesting, because the price differences are to small, so the end cost are to high to create a business case. In the other markets it is important to note that the prices represent an average. This average is differentiating between each PTU (Programme Time Unit =15 min) for which the market is regulated, also the duration of the demand for load is somewhat different (day ahead per 1 hr, intraday per 15 min, emergency power, 15 min, control and reserve market is from < 15 min to > 1hr).

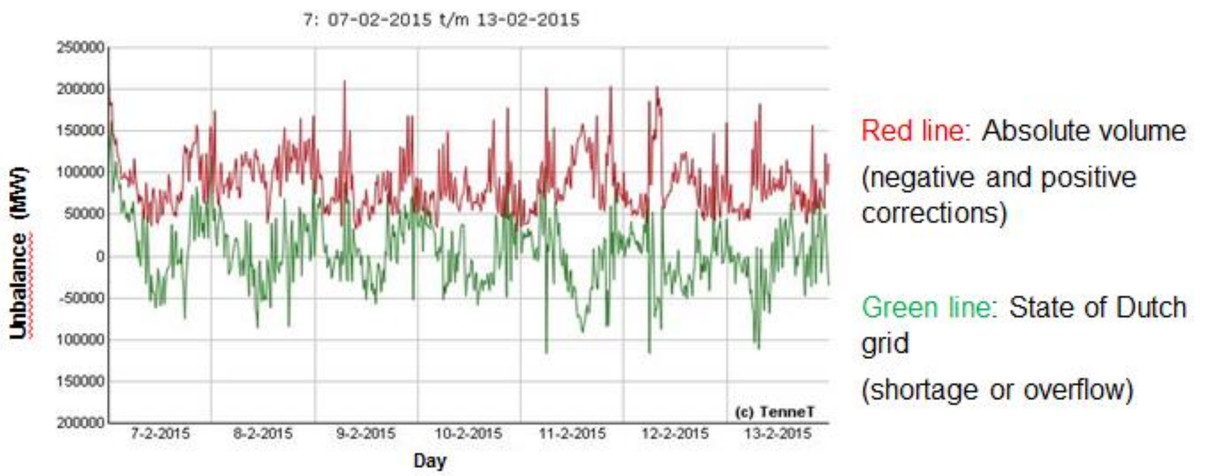


Figure 25 Volume control- & reserve market from 7-2-2015 until 13-2-2015 (TenneT, 2015).

As an example in figure 19 the market condition of one week is presented, here one can see that the corrections needed are substantial. Another example in ths case for the contracted power for the same market is shown. Here can be derived that on a daily base 800MW is netto contracted, 400 MW up and 400 MW down.

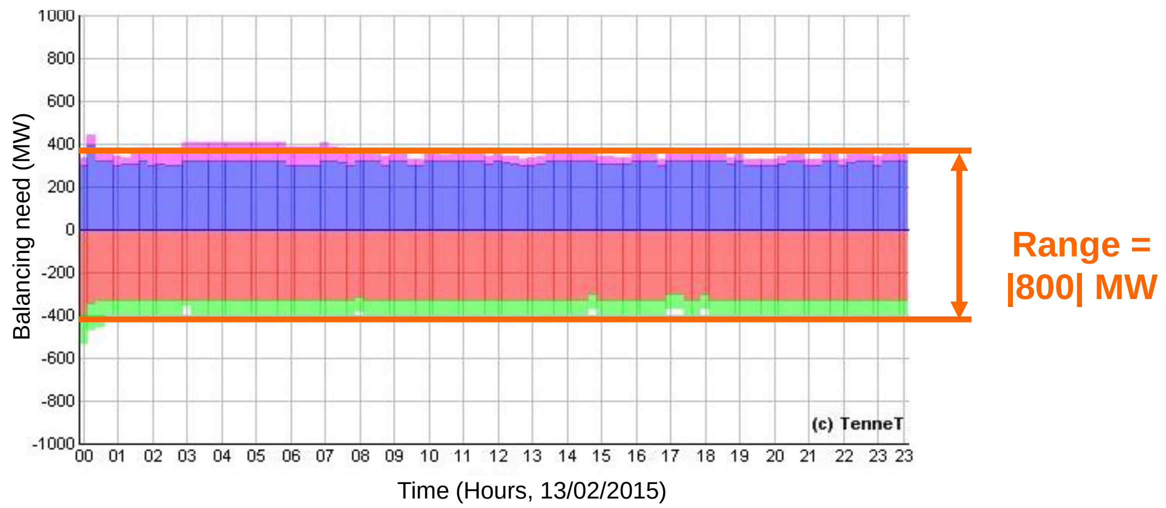


Figure 26 Demand- and supply gap in MW per day: volume control- and reservemarket (TenneT, 2015)

B.6. Formal map

In this sub-appendix the formal map of the Dutch heat and cold energy storage field is presented in a graphical way. In order to assess all the characteristics of the actors I have used the book of (Enserink et al., 2010) to perform the formal map analysis in combination with the IAD framework's context analysis of the institutional arrangements (rules in use) and the attributes of the community (Ostrom, 2007).

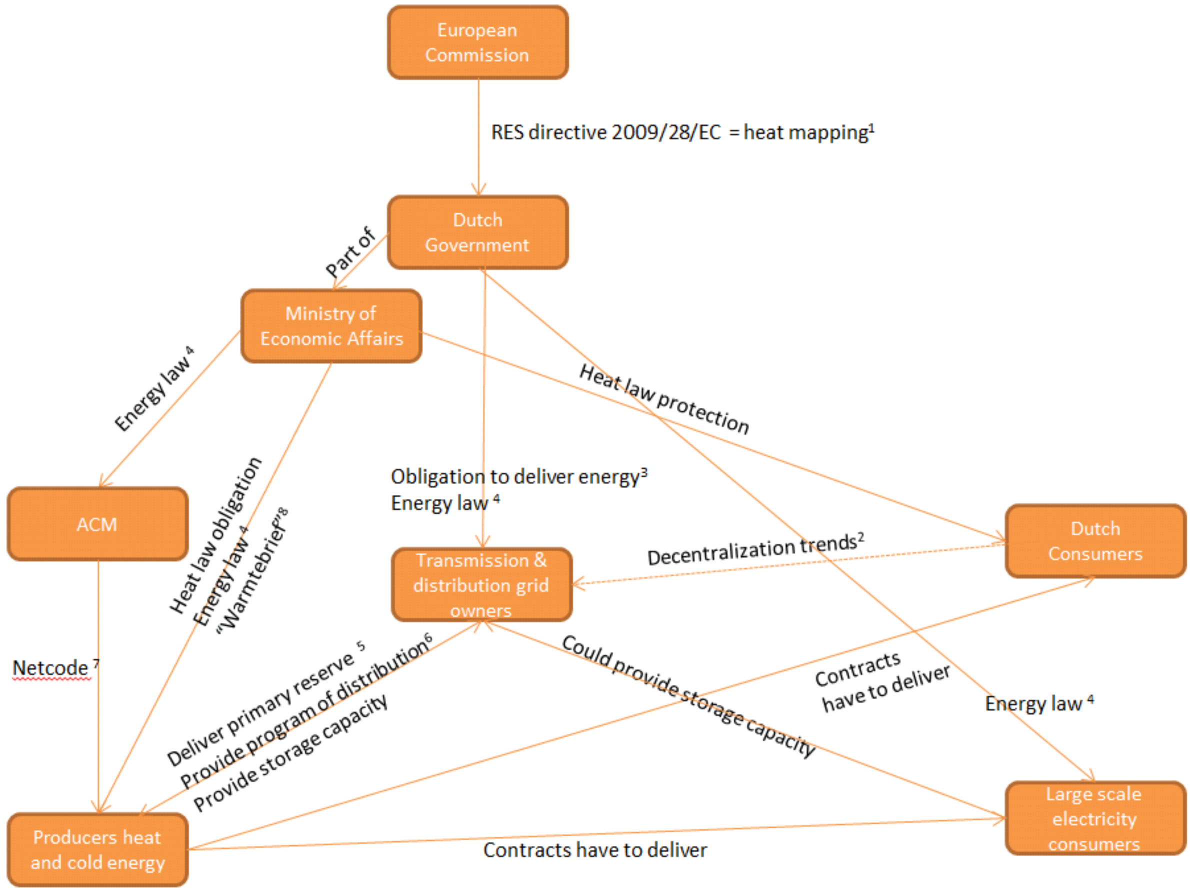


Figure 27 (Part of) formal map of the heat and cold energy storage field in the Netherlands

The picture above shows the regulatory framework, or the formal map (Enserink et al., 2010). This analysis was performed as part of the institutional systems analysis within the IAD framework. This step is not common within the framework but has many overlaps, hence the knowledge of the researcher was used to extend the framework somewhat on this part.

B.7. Actor analysis

Typically for the IAD framework (Baldwin, 2013), and a system in a networked hierarchy (Chisholm, 1989)the actor analysis is from a networked perspective in the type such as for instance described in (Enserink et al., 2010). In order to not only dive in the network but to keep a slightly more systems perspective (with the processes design in the back of mind), also some components for a more resource and interdependency driven actor/stakeholder analysis is added (Enserink et al., 2010).

To determine which actors are most important for the heat and cold energy storage field. The actors that can be of influence are listed here in table form. Secondly the actors will have the driving forces and influence listed, as well as their positions the heat and cold energy storage field. Also their means will be listed and the possibility of investing in the growth of the field. At last the actors who have the means and possible interests will be analysed.

Actor group	Status	Influence/means	Interests
Producers / Heat grid owers **(Nuon, Eneco, ENNatuurlijk, Eon, AEB, HVC, Purmerend, Warmtebedrijf Roterdam etc.)**	Active	Monetary resources, grid, knowledge, capacity	Producing and building
Installation / project managers **(Balance, A. Hak, Cofely, Wolter en dros, Dura Vermeer, etc.)**	Active	Monetary resources, knowledge	Producing and building
National (e) grid operator **(ECN, 2014; Koolwijk et al., 2010; van der Slot, Althoff, & van den Berg, 2010)**	In-active	Grid, Monetary resources	Balancing
Distribution grid operators **(Stedin, Enexis etc.)**	In-active	Grid, Monetary resources	Balancing
National gas grid operator **(Gasunie, 2015)**	In-active	Grid, Monetary resources	No residual heat usage)
Governments **Ministry of Finance, Ministry of Economic Affairs, Ministry of Spatial development, Ministry of Internal Affairs, TKI Energo Etc.)**	Active In-active	Regulation, financing, Permits (geo), subsidies, aera control	Receive tax incomes, Destimulate gas usage, stimulate heat usage etc.
Financers **(pension funds, BNG, ING, Rabo, ASN etc.)**	Active	Monetary resources	Find low risk investments
Research	In-active	words	-

(TU Delft /Twente /Utrect. ECN, PLB, Ecofys, CE Delft,TNO etc)			
Dutch competition authority	In-active	law	Control heat and electricity market
Local Authorities **(Municipalities, Provinces)**	Active	Regulation, financing, Permits (geo), subsidies, aera control	Sustainability goals
Direct related end-customers **(Reeshof Warmte, Nautilus Amsterdam , housing Coop- etc.)**	Active/ In-active		Cheap heating

Table 17 Actor analysis heat and cold energy storage field in the Netherlands

In Table 17 the total overview is provided as result from the actor analysis. For a full interpretation a detailed study of the sources mentioned is recommended, with special attention for active actors. However concluding one can state that some actors have monetary resources (financers) but lack of (technical) knowledge to perform complex projects on its own, which is available at producers/ grid owners. Special attention was already for the grid owners who are not allowed to feed thermal or electrical energy in on the net as producers (because of the Splitsingswet) (Rijksoverheid, 2013). Clients seem to be an important resource if we look at the websites of producers and local thermal grid owners (NUON, 2015; EnNatuurlijk, 2015). Many actors do seem to have the resources that the researcher assumes are needed; money, time, knowledge, willingness.

C. APPENDIX C: Q-Methodogy applied

This appendix contains the most important data that have been analysed in the process of forming the framework in chapter 4. Therefore firstly a short description is provided in paragraph 13.1.1 until 13.1.6 of the steps in Q-methodology.

C.1. Steps in Q-methodology

C.1.1. Defining the concourse

The definition of concourse is normally performed by a literature research. This thesis does however search for specific applicable drivers in a relative narrow field. First a literature study is performed by means of a desk study while looking at different internet search-engines for drivers that can elaborate (parts of) collaboration behaviour. Specifically is looked at collaboration behaviour since that implies that firstly the collaboration does not have to be successful, but attempts also count. Secondly it implies that the TPM students' Process design has connections with this part of the research (Bots & Daalen, 2012). Herewith the first research sub question can be answered.

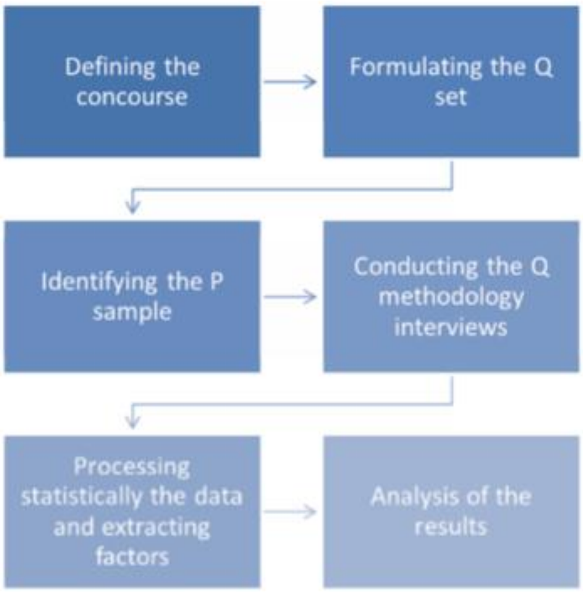


Figure 28 The six basic standard steps of Q-methodological research (Brown, 1980; Konstantelos, 2014)

C.1.2. Define the Q-set

The Q-set is defined by using the drivers from literature and developing them into statements. Next to the literature study a structures interview is planned with experts from the heat and cold energy storage field in the Netherlands to get more variables and answers sub research question two. This results in a list of testable statements for the Q-sort. Overlap between sets will be removed firstly by deduction, with categorization and with the help of the before mentioned experts. The interview with the experts will be structured upfront to ask specific questions to the same person.

C.1.3. Create the P-set (set of participants);

The creating of the P-set is the process of finding the correct participants. For this process first a pool of participants is combined based on participants from the 5 types of actors in the IAD analysis in paragraph 2.4.1.2 on page 17. The P-set is explicitly not a generalizable group of the population, since the statements combined with the P-set form later on the variables for factor rotations (n-cases in normal statics research). The view from the stakeholders is very important in the creation of this set as different viewpoints are expected from participants with a varying background.

C.1.4. Q-sort

In this step the Q-set (which will be formed in the next paragraph) is ranked by the participants from the P-set. The rank proceeds as normal: The participants are asked to rank the set of statement according to a semi-normalized distribution between -5 and +5.

C.1.5. Analysis

This step in the research is formed by the extraction of factors from the Q-sorts which can explain the variance in the distribution and hence in drivers for collaboration behaviour in the heat and cold energy storage field in the Netherlands.

C.1.6. Interpretation of the results

This will be done in chapter six separately. Expected is that not a single participant will relate closely to one perspective, but it is a representation of the ideal way of collaboration for a specific participant (actor).

C.1.7. Development of the concourse and Q-set

C.1.8. Extra method to find aspects related to heat and cold in the Dutch energy field.

The following interview structure has been developed for two reasons: Firstly more collaboration behaviour factors ought to be gained from experts in the field. Secondly more detailed information than is deduceable from literature reviewis gained on the applicability of factors from literature in the heat and cold energy storage field in the Netherlands.

INTERVIEW (TELEPHONE)

Interviewee	Name	
	Company	
	Function	
	Notes:	
Interviewer	TU DELFT STUDENT	Jorick Weijers

START OF THE CALL:

- Explain my situation as a student;
- Tell about ING and Balance;

- I will write a short report to summarize our conversation and will e-mail this to the interviewee;
- Is it allowed to record this conversation?

WHAT WOULD I WANT TO REACH WITH THIS CONVERSATION.

Create more insight into the drivers for collaboration in the heat and cold field;

Update knowledge in the field;

Examples of good collaboration from the field, but preferably out of own experience (to tell about in Q-sort);

Examples of bad collaboration from the field, but preferably out of own experience (to tell about in Q-sort);

….. more details here if needed depending on how far I am with the list of statements. Else, show the list.

Add or remove aspects to the created list (SEND BY E-mail);

SPECIFIC QUESTIONS:

Which of the aspects is most important according to you?

Which the least?

Which parties should be included in most projects around heat and cold?

Which should be excluded?

ROUND OF INTERVIEW

Thank interviewee for the interview, the final product will be sent to you.

Conclude with the procedure that I will send some transcript as promised.

I will create a deadline within 3 days, in order to let the interviewee withdraw his/her statements.

The full interviews are added in Appendix C.2 on page 120.

With the results from this interview one can partly answer the second sub research question because it is now clear that several of the drivers are indeed recognised in the field. However it is not clear if all of them are recognised. This can only be analysed by looking at the acceptance of the Q-set during the Q-sort. As mentioned before this does serve as a test for the drivers stemming directly from and their applicability into, the heat and cold energy storage field in the Netherlands because the interview tests for adjustments, applicability, ambiguity or the level of questions as well as for double statements. See for the full results of the resulted drivers paragraph 3.3.1.2.

C.1.9. Second round of revising

In the last and second round of revising the adjustments and suggestions from the interviews are taken into account and check that overlap from drivers that are double or extra is removed. This is also shown in the last column of Table 16. A good example is the split of the statement: "There is no level playing field" into 5 sub statements because of the ambiguity of the statement. Another example of removal of an overlapping statement is the combination of "Ik werk samen omdat dit het aanzien van mij en mijn samenwerkingspartner(s) verbetert." And "Ik werk samen omdat dit het imago van mij en mijn samenwerkingspartner(s) verbetert." Into "Ik werk samen om mijn imago te verbeteren" this was because and there was overlap between status and image. Next to this change, also the singularity was added to the statement, to test the intrinsic motivation of the participant.

A final criteria used in the revising process of the statements towards the Q-set was the expected time needed to perform the Q-sorting. Van Exel & De Graaf (2005) provide a heuristic, but no exact measurement is provided. The final design consists of forthy-two statements which are expected to be sorted in 45-60 minutes including the introduction, see also page 120.

Clearly the procedure of forming the Q-set and the concourse had overlap due to the iteration brought in the design to test the applicability in the market. The researcher would like to urge here that there is no such thing as a correct way to generate a Q-set, as emphasized by (Watts & Stenner, 2012, p. 57) "A Q-set must be tailored to the requirements of the investigation and to the demands of the research question it is seeking to answer." Hence, I as the author of this thesis had power and freedom to decide upon an appropriate procedure for creating the Q-set and this forms a weakness of the method.

Table 18 shows the process that has been gone through to formulate the concourse and the translation to a set of statements; the Q-set. The first column shows the category of literature (interview respectively) that has been studies for the drivers or category of drivers in the second column. The drivers were developed into statements and during that process overlap was partially removed as can be seen in the third column. The fourth column shows statements on which the interviewees suggested additions, removals, splitting, reframing or adjustments in general. These suggestion have been analysed and processed in the second iteration, that resulted in a reducing of the total statements to fourthy-two; the final Q-set.
The final Q-set is also shown in a more comprehensive overview in Table 19 Q-set on page 131. A full overview is available online here.

Sources	Factors	Action / iteration 1: Categorising	ENGLISH: Making of statements	Action / iteration 2 change statements and factors	DUTCH: Total set of statements 20/3/2015 (before interview with experts)	Interview Wim Voogd & DirkJan van Swaaij	Action / iteration 3	Stellingen die overblijven na iteratieslag 2	Definitie voor onduidelijkheid bij stelling
R. wagner-dobler and Transaction cost economics)	Collaboration on your own	Price	-	deleted, no collaboration out of scope thesis --> trans action cost assummed not to be of influence					
Donald Chisholm - Coordination without hierarchy (complex systems) (Chisholm, 1989)	Interdependencies so have to collaborate (sunk cost)	-	(failure to reduce interdependencies so I collaborate)	Resources combined with capacity					
Donald Chisholm - Coordination without hierarchy (complex systems) (Chisholm, 1989)	No coordination needed, so no collaboration needed	-	-	-	Samenwerking binnen het warmte koude veld in Nederland is in mijn geval niet nodig.		add ondanks de complexiteit	Ondanks de complexiteit is samenwerking binnen het warmte koude veld in Nederland in mijn geval niet nodig.	
Interaction theory + IAD	Interaction: behaviour occurs if motivation,	Interaction	-	-	Er zijn weinig gelegenheden voor samenwerking in het Nederlandse warmte / koude veld.		Delete: overlap met: te geringe interacties		
	opportunity,	Interaction	-	-	Ik beschik niet over de juiste capaciteiten om samen te werken.			Ik beschik nu niet over de juiste capaciteiten om samen te werken.	Defenitie voor interactie is nodig: motivatie, gelegenheid, capaciteiten. Denk aan specifieke kennis of assets, gebrek aan personeel.
	capability	Interaction	-	-					

Sources	Factors	Action / iteration 1: Categorising	ENGLISH: Making of statements	Action / iteration 2 change statements and factors	DUTCH: Total set of statements 20/3/2015 (before interview with experts)	Interview Wim Voogd & DirkJan van Swaaij	Action / iteration 3	Stellingen die overblijven na iteratieslag 2	Definitie voor onduidelijkheid bij stelling
	. Rules to allow for interaction.	Interaction	-	-					
	Resources.	Interaction	-						
Healy power defined as: Collective planning in perspective	(Collaboration because of) collective planning	Collective action / regulation		Not applicable,no coordination in field according to interviews		Not applicable, no coordination in field according to interviews	deleted		
Donald Chisholm - Coordination without hierarchy) (Chisholm, 1989)	Steering in the market concept "Two types of governments: Stimulate collaboration facilitating, stimulate collaboration by inititating projects (performing tasks).	Collective action / regulation		~~by: exploring possibilities for cooperation by government .~~	Samenwerking ontstaat doordat overheden projecten initiëren.	Splitted in two		Samenwerking ontstaat doordat overheden projecten initiëren.	
					Samenwerking ontstaat doordat overheden samenwerking(-sbijeenkomsten) faciliteren.			Samenwerking ontstaat doordat overheden samenwerking(-sbijeenkomsten) faciliteren.	
(Ostrom, 1997)	Trust	Trust			Voor samenwerking is eerst vertrouwen nodig.			Voor samenwerking is eerst vertrouwen nodig.	
(ostrom, 1997& Ligtvoet 2013)	inzicht in informatie (ligtvoet en trust ostrom)	Trust	I don't collaborate to ensure others in the value chain don't get my information	Positive formulation in line with other statements	Ik werk samen om informatie van derden in de waarde keten te achterhalen			Ik werk samen om informatie van derden in de waarde keten te achterhalen	
(Ostrom, 1997)	Image	Combined to image	reputatie / image		Ik werk samen omdat dit het aanzien van mij en mijn samenwerkingspartner(s) verbetert.	Respect is not good, changed to image	alleen imago van eigen overgelaten		
(Ostrom, 1997)	Respect / reputation				Ik werk samen omdat dit het imago van mij en mijn samenwerkingspartner(s) verbetert.			Ik werk samen om mijn imago te verbeteren	Reputatie: beeld dat feitelijke relaties van je hebben. VS imago = beeld dat algemene epubliek bij je heeft

Sources	Factors	Action / iteration 1: Categorising	ENGLISH: Making of statements	Action / iteration 2 change statements and factors	DUTCH: Total set of statements 20/3/2015 (before interview with experts)	Interview Wim Voogd & DirkJan van Swaaij	Action / iteration 3	Stellingen die overblijven na iteratieslag 2	Definitie voor onduidelijkheid bij stelling
(Ostrom, 1997)	reputation (ostrom)	Image	I collaborate to improve my reputation		Ik werk samen om mijn reputatie te verbeteren		alleen imago van eigen overgelaten		
(Ostrom, 1997),	Reciprocity	-			Ik werk samen vanuit het principe van wederkerigheid.			Ik werk samen vanuit het principe van wederkerigheid.	Wisselwerking.
(Ostrom, 1997) , Groenewegen, 2013)	incentives	-	repetitiveness of the collaboration	zie thesis groenewege	Ik werk samen vanwege het repeterend karakter van de samenwerking.			Ik werk samen vanwege het repeterend karakter van de samenwerking.	Komt elkaar vaker tegen
(Ostrom, 1997)	Efficiency --> what is efficiency	Time			Ik werk samen omdat dit de efficiëntie van projecten verbetert.			Ik werk samen omdat dit de efficiëntie van projecten verbetert.	
(Ostrom, 1997)	Increase income / save costs à economic drivers	Price / Cost	Ik werk samen met anderen om geld te besparen voor alle partijen	GELD VERDIENEN????	Ik werk samen met anderen om geld te besparen voor alle partijen.			Ik werk samen met anderen om geld te besparen voor alle partijen.	Geld besparen voor iedereen binnen de samenwerking. / goedkoper dan gas, airco's, koelwater of koeltorens of elektriciteit of andere vormen
(Ostrom, 1997)	Economies of scale	Price / Cost	I create economies of scale by collaborating	Door samen te werken kan ik schaalvoordelen benutten.	Door samen te werken kan ik schaalvoordelen benutten.			Door samen te werken kan ik schaalvoordelen benutten.	
(Ostrom, 1997)	Time;	Time	Ik werk samen omdat ik tijd bespaar in het project ten opzichte van de situatie waarin ik het project alleen doe.		Ik werk samen omdat ik tijd bespaar in het project ten opzichte van de situatie waarin ik het project alleen doe.			Ik werk samen omdat ik tijd bespaar in het project ten opzichte van de situatie waarin ik het project alleen doe.	

Sources	Factors	Action / iteration 1: Categorising	ENGLISH: Making of statements	Action / iteration 2 change statements and factors	DUTCH: Total set of statements 20/3/2015 (before interview with experts)	Interview Wim Voogd & DirkJan van Swaaij	Action / iteration 3	Stellingen die overblijven na iteratieslag 2	Definitie voor onduidelijkheid bij stelling
Own input		Time	Ik werk niet samen met anderen om tijd te besparen want die zijn minder capabel.	Overlap met samenwerking in tijd besparen, alleen uitwerken					
		Information / knowledge	Ik werk samen met anderen want /omdat zij meer capabel zijn.	Ik werk niet samen met anderen want die zijn minder capabel	Ik werk niet samen met anderen want die zijn minder capabel.				
	Capability of others:	Information / knowledge	Ik werk samen omdat anderen kennis hebben.		Ik werk samen met anderen omdat zij over meer kennis beschikken.			Ik werk samen met anderen omdat zij over meer kennis beschikken.	
Own input	Driver overheid	Collective action / regulation	Overheid stimuleert warmte	Overlap with governement initiate/ facilitate					
Own input		Collective action / regulation	Overheid stimuleert gas						
		Collective action / regulation			Duurzame (lokale) overheidsambities zorgen voor warmte en koude initiatieven.	WIM en Dirkjan van Swaaij duurzame overheidsambities zorgen voor warmte(netten)		Duurzame (lokale) overheidsambities zorgen voor warmte en koude initiatieven.	
own input	Level playing field ontbreekt	-		Dit meer Smart maken. Opsplitsen / EEN Lelel playing field maakt samenwerking overbodig / HET ONTBREKEN VAN EEN LEVEL PLAYING FIELD VEREIST SAMENWERKING	Er is geen level playing field voor de verschillende oplossingen. 1-5 subs	Er is geen level playing field voor de verschillende oplossingen. --> opslitsen!			

Sources	Factors	Action / iteration 1: Categorising	ENGLISH: Making of statements	Action / iteration 2 change statements and factors	DUTCH: Total set of statements 20/3/2015 (before interview with experts)	Interview Wim Voogd & DirkJan van Swaaij	Action / iteration 3	Stellingen die overblijven na iteratieslag 2	Definitie voor onduidelijkheid bij stelling
		Collective action / regulation		1	Verschillende vormen van warmte en koude kunnen niet belastingtechnisch vergeleken worden.			Verschillende vormen van warmte en koude kunnen niet belastingtechnisch vergeleken worden.	
		Collective action / regulation		2	CO_2	Uit interview met Dirk Jan		Levering warmte/ koude kan niet worden vergeleken via CO_2-rechten.	
		-		3	ruimtelijke ordening	Uit interview met Dirk Jan + WIM		Levering van warmte /koude schaadt andere warmte/koude alternatieven in de ruimtelijke orde	
	Financiën	Price / Cost		Financiën worden gecoverd door stelling met cost besparing		Deze twee categoriën komen uit het interview met WIM			
	, publiek privatesamenwerking.	-		PPS an sich is niet beschouwd als facotr voor samenwerking omdat het slechts 1 keer als main driver is genoemd en niet in de literatuur voorkomt.					
(Groenewegen, 2013)	Risk	Risk	Ik werk samen omdat ik risico's verdeel in het project ten opzichte van de situatie waarin ik het project alleen doe.		Ik werk samen omdat ik risico's verdeel in het project ten opzichte van de situatie waarin ik het project alleen doe.			Ik werk samen omdat ik risico's verdeel in het project ten opzichte van de situatie waarin ik het project alleen doe.	Vanwege te hoog individueel risico

Sources	Factors	Action / iteration 1: Categorising	ENGLISH: Making of statements	Action / iteration 2 change statements and factors	DUTCH: Total set of statements 20/3/2015 (before interview with experts)	Interview Wim Voogd & DirkJan van Swaaij	Action / iteration 3	Stellingen die overblijven na iteratieslag 2	Definitie voor onduidelijkheid bij stelling
(Groenewegen, 2013)		Risk	Risk of getting locked in (thesis maarten, bron nog opzoeken						
(Ligtvoet, 2013)		Risk	Risk of information sharing (thesis maarten bonr nog opzoeken / ik wil geen riscolopen dat anderen mijn informatie zien	DELETE Koppelen met trust van ostrom en geothermie project van ligtvoet in den haag					
(Groenewegen, 2013)		Risk	risk of dependency						
(Ligtvoet, 2013)		Price / Cost	Gain and pain sharing	Ik werk samen om zowel de winsten als verliezen te delen				Ik werk samen om zowel de winsten als verliezen te delen.	
own		collective action / regulation			Regelgeving is te individueel gericht voor samenwerking.			Regelgeving is te individueel gericht voor samenwerking.	
own		Common goal / strategy			Ik werk samen om synergie tussen bedrijven te bevorderen.			Ik werk samen om synergie tussen bedrijven te bevorderen.	
		-			Levering warmte wordt nog niet gewaardeerd in toekenning CO_2-rechten.	WIM	overlap met level playing field, nu opgesplitst		
own		Collective action / regulation			Collectieve oplossingen zijn te complex.			Collectieve oplossingen zijn te complex.	
		-			Er is in Nederland geen basis voor een structurele duurzame energiemarkt.	WIM			wetgeving niet adequaat
OWN		Price / Cost			Kosten en baten kunnen nu niet eerlijk verdeeld worden.				

Sources	Factors	Action / iteration 1: Categorising	ENGLISH: Making of statements	Action / iteration 2 change statements and factors	DUTCH: Total set of statements 20/3/2015 (before interview with experts)	Interview Wim Voogd & DirkJan van Swaaij	Action / iteration 3	Stellingen die overblijven na iteratieslag 2	Definitie voor onduidelijkheid bij stelling
own	Policy	collective action / regulation	whimsical policy does not lead to collaboration / Periodic investments not possible because of whimsical plicy	Wisselend beleid van de Nederlandse overheid maakt samenwerking op langere periodieke basis onmogelijk	Wisselend beleid van de Nederlandse overheid maakt samenwerking op langere periodieke basis onmogelijk			Wisselend beleid van de Nederlandse overheid maakt samenwerking op langere periodieke basis onmogelijk	wisselend beleid
Own input	ADD: technische desgin	-		split in 2 kanten, technische design en project management	het design van projecten is niet future proof	Uit interview met Dirk Jan	tech	Het technische design van warmte / koude projecten is niet future proof.	
Own input	ADD: Project management	-					proj manag	Het projectmanagement van warmte / koude projecten is niet future proof.	
		-			Energiebelasting maakt de competitie met gas niet mogelijk.	Dirkjan	samen met niet belastingtechnische vergelijken		
IAD framework negative formed	Interactions not there	Interaction	The # of interact-io ns in heat and cold projects is ~~too~~ low for collaboration	combined with interactions from (Chisholm, 1989)	Het aantal interacties in het warmte koude veld is te gering voor samenwerking.			Het aantal interacties in het warmte koude veld is te gering voor samenwerking.	
		supply demand			Levering in de toekomst van warmte / koude is onzeker.	Dirkjan	overlap met : Ik werk samen om de zekerheid van de levering te garanderen.		
own		supply demand			Blijvende afname van warmte koude is in de toekomst onzeker.		overlap met : Ik werk samen om de zekerheid van		

Sources	Factors	Action / iteration 1: Categorising	ENGLISH: Making of statements	Action / iteration 2 change statements and factors	DUTCH: Total set of statements 20/3/2015 (before interview with experts)	Interview Wim Voogd & DirkJan van Swaaij	Action / iteration 3	Stellingen die overblijven na iteratieslag 2	Definitie voor onduidelijkheid bij stelling
							afname te garanderen.		
own		interactions			Initiatieven voor samenwerking zijn versnipperd.			Initiatieven voor samenwerking zijn versnipperd.	Onderwerp
own		interactions			Initiatieven voor samenwerking zijn verdeeld over heel Nederland.			Initiatieven voor samenwerking zijn verdeeld over heel Nederland.	Afstand
own		-	Hydrological system not capable of large scale implementation.		Het (grond) watersysteem is niet geschikt voor grootschalige implementatie van warmte/koude projecten.			Het (grond) watersysteem is niet geschikt voor grootschalige implementatie van warmte/koude projecten.	
field		-	Competition is too fierce to combine forces.		De concurrentie is te groot om te kunnen samenwerken.			De concurrentie is te groot om te kunnen samenwerken.	
field		supply demand	I collaborate to create security of supply.		Ik werk samen om de zekerheid van de levering te garanderen.			Ik werk samen om de zekerheid van de levering te garanderen.	Security of supply
field		supply demand	I collaborate to create security of demand.		Ik werk samen om de zekerheid van afname te garanderen.			Ik werk samen om de zekerheid van afname te garanderen.	Security of demand
field		collective action / regulation			Ik werk samen in het warmte warmte koude veld als er infrastructuur is.			Ik werk samen in het warmte kou-de veld als er infrastructuur is.	

Sources	Factors	Action / iteration 1: Categorising	ENGLISH: Making of statements	Action / iteration 2 change statements and factors	DUTCH: Total set of statements 20/3/2015 (before interview with experts)	Interview Wim Voogd & DirkJan van Swaaij	Action / iteration 3	Stellingen die overblijven na iteratieslag 2	Definitie voor onduidelijkheid bij stelling
field		collective action / regulation			Ik werk samen in het warmte warmte koude veld omdat ik/wij de benodigde infrastructuur faciliteer.			Ik werk samen in het warmte kou-de veld omdat ik/wij de benodig-de infra-structuur faciliteer.	
	regelgeving periodiek niet betrouwbaar	collective action / regulation	DELETE						
????	innovaties gebrek	risk	Collaborate to share risk of new innovations. ~~To share the risk of new innovations in the Dutch heat and cold field i try to collaborate~~	To share the risk of new innovations in the Dutch heat and cold field i try to collaborate --> risk eruit, wordt al getest	Ik probeer samen te werken om innovaties in de markt te zetten			Ik werk samen om innovaties in de markt te zetten.	
(Ligtvoet, 2013)	Environmental	image	Ligtvoet	I collaborate in the Dutch heat and cold field to reduce the environmental change.	Ik werk samen in het Nederlandse warmte /koude veld om klimaatverandering te verminderen.			Ik werk samen in het Nederlandse warmte /koude veld om klimaatveranderin g te verminderen.	
Bronder and Pritzl (1992, p. 415) 5	Bronder and Pritzl (1992, p. 415) 5	time	~~I colaborate to create faster development (time advantages~~	Delete Overlap met samenwerken om tijd te besparen					
Bronder and Pritzl (1992, p. 415) 5	1	Price / Cost	I collaborate to improve access to markets	Ik werk samen om toe te treden op nieuwe markten	Ik werk samen om toe te treden op nieuwe markten		added inkomsten	Ik werk samen om toe te treden op nieuwe markten zodat ik mijn inkomsten kan verhogen	
Bronder and Pritzl (1992, p.	2	Price / Cost	i collaborate to create costs	Overlap met geld besparen					

Sources	Factors	Action / iteration 1: Categorising	ENGLISH: Making of statements	Action / iteration 2 change statements and factors	DUTCH: Total set of statements 20/3/2015 (before interview with experts)	Interview Wim Voogd & DirkJan van Swaaij	Action / iteration 3	Stellingen die overblijven na iteratieslag 2	Definitie voor onduidelijkheid bij stelling
415) 5			advatages						
Bronder and Pritzl (1992, p. 415) 5	3	competition	System competence						
Bronder and Pritzl (1992, p. 415) 5	4	Risk	Risk sharing						
Bronder and Pritzl (1992, p. 415) 5		Image	~~i collaborate only if the others have a good reputation~~	You cannot say good, re-frame is to subjective					
	Personal networks	-	personal networks are essential for collaboration	DELETE					
(ligtvoet, 2013)	policy goals	Collective action / regulation action / regulation	I collaborate to reach policy goals (ligtvoet = geothermie den haag)	To general, splitted up in different such as; costs, innovation etc					
(Huisman 2010 & Ostrom 1994)	operations	Common goal / strategy			Ik werk samen om een gezamenlijke of gelijkwaardige activiteit te bewerkstelligen			Ik werk samen om een gezamenlijke of gelijkwaardige activiteit te bewerkstelligen	
(Huisman 2010 & Ostrom 1994)	strategy	Common goal / strategy			Ik werk samen om een gezamenlijke of gelijkwaardige strategy na te streven			Ik werk samen om een gezamenlijke of gelijkwaardige strategy na te streven	
(Huisman 2010 & Ostrom 1994)	expectations	Common goal / strategy			Ik werk samen vanwege een gezamenlijke of gelijkwaardige verwachting in een project/samenwerking			Ik werk samen vanwege een gezamenlijke of gelijkwaardige verwachting in een	doel

Sources	Factors	Action / iteration 1: Categorising	ENGLISH: Making of statements	Action / iteration 2 change statements and factors	DUTCH: Total set of statements 20/3/2015 (before interview with experts)	Interview Wim Voogd & DirkJan van Swaaij	Action / iteration 3	Stellingen die overblijven na iteratieslag 2	Definitie voor onduidelijkheid bij stelling
								project/samenwerking	
(Huisman 2010 & Ostrom 1994)	cultures	Common goal / strategy			Ik werk samen vanwege een gezamenlijke of gelijkwaardige cultuur in een project / samenwerking			Ik werk samen vanwege een gezamenlijke of gelijkwaardige cultuur in een project / samenwerking	
(Huisman 2010 & Ostrom 1994)	cheap	Price / Cost			Ik werk samen in het warmte/koude veld in Nederland om een goedkopere bron dan gebruikte alternatieven of afzetmarkt te vinden voor mijn warmte /koude vraag of aanbod.		DELETEte veel overlap me tbesparen en nieuwe markten voor inkomen		

Table 18 Drivers (73) and iteration from literature and interview

Table 18 provides in this form a somewhat unclear overview of the iteration process in the steps taken. It is very common to use categorization as a tool to downsize the amount of drivers in any typical research set. This step is performed due to time constraints of mostly the interviewees, if all drivers would have to be taken into consideration in a Q-methodology type of interview; this would take too much time (even if the overlapping drivers are excluded). After the first resizing step of the drivers (the categorisation), the statements were translated into Dutch because in that way the knowledge of the participant English' was taken out of the scope of this research, more controlled. A second iteration led to the Dutch set of statements and drivers which were presented to the field experts. After this iteration the field experts provided many insights so a final iteration was constructed to form the total Q-sort. This last step has been fairly difficult and did include som subjective opinions from the researcher, however two guidelines where used in every choice for in or exclusion of a statement. 1) Is it applicable on the field of heat and cold energy storage. And 2) is it still overlapping or double with other statements in the set so far.

C.2. Interviews for the Q-set

Two interviews have been performed. The initial plan was to do telephone interviews; in the end a face-to face setting was chosen. The two respondents are in order of interviewing:

Dirk Jan van Swaay (Director Energy transition and PPP at ING Bank N.V.)

Wim Voogd (senior business consultant at Balance (project management and interim)

(Also shortly conducted was Herman Exalto (Director at Eneco heat and cold B.V.), but not in a full interview setting. Some of his notions and opinios were however used to form the research opinion and have been indirectly influencial in the process of making statements)

The interview structure has been shown in paragraph C.1.8, hence the interviews are now shown below, the first and second interviewer also performed a test of the Q-sort and provided feedback on the statements made. The information form the outcome is kept undisclosed, but has been very helpful and was used to create more statements.

C.2.1. First interview to find aspects related to the field.

INTERVIEW (TELEPHONE)

Interviewee	Name	Dirk Jan van Swaaij
	Company	ING Bank
	Function	Director Energy Transition and Public Private Partnerships
	Notes:	-
Interviewer	TU DELFT STUDENT	Jorick Weijers

START OF THE CALL:

- Explain my situation as a student;
- Can I e-mail you the aspects that are currently being investigated?
- I will write a short report to summarize our conversation and will e-mail this to the interviewee;
- Is it allowed to record this conversation?

WHAT WOULD I WANT TO REACH WITH THIS CONVERSATION.

Create more insight into the drivers for collaboration in the heat and cold field;

Update knowledge in the field;

Examples of good collaboration from field but preferably out of own experience (to tell about in Q-sort) ; *Welk, wanneer waarom* →

- Warmte keten is vooral netten in de private handen. Warmte netten in handen graag van gemeenten. Niet meer bij private partijen.

Examples of bad collaboration from field but preferably out of own experience (to tell about in Q-sort);

Welk, wanneer waarom →

- If the CO_2 price is involved in the business case project tend to be trickier.

….. more details here if needed depending on how far I am wth the list. Else, show the list.

Add or remove aspects to the created list, (SEND BY E-mail);

SPECIFIC QUESTIONS:

Which of the aspects is most important according to you?

- Clear decision making in the entire field. That should be added to a statement.

Which the least?

The field is not to complex.

Which parties should be included in most projects around heat and cold?

- Financiers, overheden, project managers, Local governments are very important for the ambitions of regions and projects.

Which should be excluded?

No one or maybe customers, they delay the project., but you should change the level playing field, this is ambigious.

If you want a real fast decisoin makin process don't invite anybode exept for the only needed, but than you have a communistic approach and it will be hard to"polder that in" the Netherlands.

To add: Financiën, publiek privatesamenwerking. Also spatial planning is missing. The design of project is not future proof.

Energy taxes make it hard to compare competition or to compete with gas.

The supply of gas is insecure in the fure, demand is much more secure, despite the higher isolation etc etc.

ROUND OF INTERVIEW

Thank for the interview, the final product will be sent to you.

Conclude with the procedure that I will send some transcript as promised.

I will create a deadline within 3 days, in order to let the interviewee withdraw it statements.

C.2.2. Second interview to find aspects related to the field.

INTERVIEW (TELEPHONE)

Interviewee	Name	Wim Voogd
	Company	Balance

	Function	Project advisor
	Notes:	Temporariliy based in Hoogezand-Sappemeer and purmerend at heat and cold projects.
Interviewer	TU DELFT STUDENT	Jorick Weijers

START OF THE CALL:

- Explain my situation as a student;
- Can I E-mail you the aspects that are currently being investigated?
- I will write a short report to summarize our conversation and will e-mail this to the interviewee;
- Is it allowed to record this conversation?

WHAT WOULD I WANT TO REACH WITH THIS CONVERSATION.

Create more insight into the drivers for collaboration in the heat and cold field; and update the interviewers' knowledge in the field;

Please give two examples of good collaboration from field but preferably out of own experience (to tell about in Q-sort) ;

Locatie: Hogezand Sappemeer.
Deelnemers zijn het waterbedrijf & Groningen duurzaam, de energy valley, Esca graphic board (heeft restwartme over) de gemeente Hogezand Saper meer en de provincie Groningen.

Dit ziet er operationeel ongeveer zo uit = Het waterbedrijf, esca en de gemeente en de woningbouw cooperaties werken samen het meeste samen.
Waarom?
De restwarmte die is al beschikbaar, deze willen de individuen al graag inzetten voor verwarmen van gebouwen.
UNIEK: gemeente heft 2 majeure projecten = dit zijn echt de launching customers voor het warmtenet. Hiervoor is het zwembad en sportcentrum + het huis van cultuur en bestuur.
Huis heeft behoefte aan warmte en het zwem en sportcentrum moet verwarmd worden.

Waarom wordt er dan nu opens samengewertk? Het uitfaseren van projecten stond al op de rol, zodoende was men er al langzaam mee bezig. Dit warmtenet geldt als opstap voor uitbreiding op een mogelijk groter net.
Er wordt dus duidelijk nu eerst klein geïnvesteerd met de hoop later een groter net te kunnen kopppelen?
Ja, dit is echt een goede opstap maar geldt ook als opstap voor risico spreading. En zorgt voor grotere uitrol mogelijk. Later.

- **Locatie: Metropool regio Amsterdam**
  Samenwerking is hier gestart op twee 2 manieren.
  1) Public private samenwerking voor de afvalenergie-bedrijf, de gemeente Amsterdam en Nuon. Dit is de noemer Westpoort warmte, deze levert nu al warmte via Nuon in Almere.
  2) POLITIEK = wensen om te kijken of er samenwerking mogelijk in breder verband (Zaandam). In die regio zijn enekel industriële bedrijven die een overschot aan warmte hebben. Denk aan industrie van Lassie met warmte en Tata uit Velsen Noord / IJmuiden

ook nog erbij. Hierbij zijn verder betrokken zowel Nuon en Alliander en enkele lokale gemeentes. Grootschaligheid. Kennis. Ambitie van bestuurlijk en politiek.

- **Locatie: KAM in de regio K?, Arnhem en Nijmegen.**
  Hier hebben de gemeenten duidelijk erg duurzame ambities uitgesproken en hiervoor deels hebben opgesteld. Daarnaast is Nuon als bedrijf daar aanwezig en Nuon wil koppelen van netten. Zowel duurzaam als bestaand.

Welk, wanneer waarom→ Warmte keten is vooral netten in de private handen. Waermte netten in handen graag van gemeenten.

Can you give examples of bad collaboration from field but preferably out of own experience (to tell about in Q-sort); Which, whenn and why?

Could you look at my set of aspects i have created? [give more details here if needed depending on how far I am with the list. Else, show the list.]

Add or remove aspects to the created list, (SEND BY E-mail); *I showed the list on cards sorted out.*

Idee voor stelling: Warmte koude in NL wordt gedreven hier door duurzame ambitie van overheden.

SPECIFIC QUESTIONS:

Which of the aspects is most important according to you?

1) Er is geen level playing field voor de verschillende oplossingen → Er is nu geen beleid en geen regel, subsidie, belasting, vergunningverlening, wetten/ juridische kaders, ruimtelijke ordening. Oplossingen: bedoelen ze met andere energy carriers. Denkt Wim op die manier te interpreteren.
HET ONTBREKEN VAN EEN LEVEL PLAYING FIELD VEREIST SAMENWERKING. EEN LEVEL PLAYING FIELD MAAKT SAMENWERKING OVERBODIG

2) Ik werk samen in het warmte koude veld als er een infrastructure is → Komt moeilijk van de grond er is geen eerlijke start

Which the least?

1) Schaalvoordelen, kosten besparing, verhogen winsten, deen kennis, niet om aanzien.
   INFORMATIEVOORZIEINING IS ZO SLECHT> publieke opinie verstrooid.

Mensen gepiepeld vanwege verstrooid. Meer om imago. Communicatie over wamte koude is goed/ slecht. Communicatie over wamte koude is goed/ slecht.

2) schaalvoordelen, kosten besparing, verhogen winsten, deen kennis, niet om aanzien
   INFORMATIEVOORZIEINING IS ZO SLECHT> publieke opinie verstrooid. Mensen gepiepeld vanwege verstrooid. Meer om imago.

Which parties should be included in most projects around heat and cold.

PPS

Which should be excluded?

No one.
Ik zou graag wat stellingen toevoegen rondom: **Financiën , publiek privatesamenwerking.**
ROUND OF INTERVIEW

Thank for the interview, the final product will be sent to you.

Conclude with the procedure that I will send some transcript as promised.

I will create a deadline within 3 days, in order to let the interviewee withdraw it statements.

C.3. Procedure Q

This paragraph shows the set-up that was chosen for the interview. A major guideline herein was Annex A from (Watts & Stenner, 2012, pp. 22–24) .

Procedure Q:

This study is about the Dutch heat and cold energy storage field. This interview method is to find drivers which in your opinion enable collaboration behaviour in the Dutch heat and cold energy storage field. Be aware that this also includes collaboration without clear end-product, but set up with the goal of a clear end-product. So the successfulness of the collaboration is not important. This is tested by providing you a set of questions related to several aspects of collaboration: you can agree most or disagree most with all of the statements. The goal is to rank these aspects in a normalised distribution. It is not possible to make mistakes; your opinion and motivation for this opinion are leading.

The results of this interview will be used solely for this interview and are anonymised in the report.

Pre- sorting:

1. Please state your name, role, function (expertise) and the organisation you belong to?
2. Please elaborate on what kind of business your organization performs?
3. (If applicable) Does or did your company perform a type of collaboration in the Dutch heat and cold field? What was the nature of these collaboration(s)?

Disagree Most Agree Most

-5	-4	-3	-2	-1	0	1	2	3	4	5

Step 1
Take the set of cards. The numbers on these cards are just randomly and their only purpose is to analyse the place you put them in the sorting. Read all of the cards carefully, if you have any questions please ask them.

Sort the cards into a pile you tend to agree with, one pile with statements you neither agree nor disagree with or which you find not relevant and create a pile of cards you disagree with. Again no wrong or right answers are possible since the interest of this research is into you opinions.

Step 2
Take the cards from the agree pile and read them all again. Sort the two you agree most with on the position of the agree most position. Fill in the rest of the cards on the deck as you agree with them accordingly. TIP: The distribution is relative, do not spend 10 min to choose the most extreme statements, the research is looking for the general picture. The position of the statement under the same column does not play any role in the ranking order.

Repeat the step above for the pile of cards you disagree with initially and the pile of cards you neither agree nor disagree with or did not find relevant in step 1.

Step 3
Review your sort and shift cards according to your opinion. It is possible to agree with all of the statements; however it is important that you make a choice between them.

Step 4
Can you elaborate on the statements that you sorted on the extreme agree? What do they mean to you? Why you feel so strongly about them? Why do you agree most with the statements on the right?

Step 5
Can you elaborate on the statements that you sorted on the extreme disagree? What do they mean to you? Why do you disagree most with the statements on the left? Why do you feel so strongly about them?

Step 6
Do you have any specific comments on the cards in the middle? Or did you struggle with any specific card? Items which you did not fully understand?

Step 7
Why did you shift card # from position X to position Y?

Step 8
Write the numbers of the cards on the place you have located them (computer or analogue).

Rounding up questions: (5 -10 min)

Did you miss any topic in this interview?

Where would this topic fit the distribution?

What is your own experience with projects in the heat and cold chain?

Can you mention a successful project with relation to collaboration: Examples of good collaboration from preferably out of own experience, but they could come from the field or competition.

Can you mention an unsuccessful project with relation to collaboration: Examples of not so good collaboration from preferably out of own experience, but they could come from the field or competition.

What is your educational background (last highest education)?

Which persons or parties do you suggest I should speak in the Dutch heat and cold field?

Do you have any other comments or suggestions to add?

Final (1 min)

Thank you for the interview, the final product (thesis) will be sent to you. To remind you, the results are anonymized in the total set. Only a general description of the field of your job will be used (so I can differentiate between the sets of people when doing analysis). A transcript of the final meeting will be sent to you, before I will use this data you will be provided with a response time of 3 days, after which I assume your permission for using your data is best for mankind and can be used in my thesis.

With the procedure for the Q methodological interview (the Q-sort) prepared the next step has to be designed: Analyzing the results. The anaylsis will be performed with a statistical tool specifically designed for this purpose, the PCQMethod from Schmolk (2014). An explanation of the usage will be provided in chapter 5.1.

C.4. Post sorting

The questions asked in the steps 4-7 of the process are so called post-sorting questions (Cuppen et al., 2010; Watts & Stenner, 2012). They enable the researcher to extract more qualitative information from the participant of the Q-sort. Next to that they are 'needed' to capture the reasoning and the logic behind some of the choices to place specific statements at specific slots of the distribution. The openness of the questions lets the participants free to give a comment about more than the questioned items (when time allows).

From all the interviews with the participants step 8 will be performed by the researcher and he also ensures transcription of the questions for format see appendix C.6. The original transcripts are in the disposal of the author of this thesis and can be accessed upon request in anonymized form.

C.5. Final Q-set

The table below is the final representation of the Q-set as it wazs used in the interviews to collect data from the field experts. The statements 43, 44 and 45 have been obtained by the field experts in the Q-set, not to be mistaken with the field experts who's input has been used to create this final Q-set.

#	Q-set expanded with field input	Definition in case of ambiguity	English translation	Source	Category
1	Ondanks de complexiteit is samenwerking binnen het warmte koude veld in Nederland in mijn geval niet nodig.		Despite the complexity, collaboration in the heat and cold energy storage field in the Netherlands is, in my case, not necessary.	(Chisholm, 1989)	Other
2	Ik beschik nu niet over de juiste capaciteiten om samen te werken.	Definitie voor interactie is nodig: motivatie, gelegenheid, capaciteiten. Denk aan specifieke kennis of assets, gebrek aan personeel.	At this moment, I do not dispose of the right capacities to collaborate.	(Ostrom, 2007)	Interaction
3	Samenwerking ontstaat doordat overheden samenwerking (-sbijeenkomsten) faciliteren.	"Bijeenkomsten" georganiseerd door een centraal orgaan met als doel samenwerking te faciliteren en stimuleren	Collaboration is developing because governments facilitate collaboration (-meetings).	(Chisholm, 1989)	Collective action / Regulation
4	Samenwerking ontstaat doordat overheden projecten initiëren.		Collaboration is developing because governments initiate projects.	(Chisholm, 1989)	Collective action / Regulation
5	Voor samenwerking is eerst vertrouwen nodig.	In kunde	For collaboration you need, at first, trust.	(Ostrom, 1997)	Other
6	Ik werk samen om informatie van derden in de waarde keten te achterhalen.		I collaborate to gain information of third parties in the value chain.	(Ligtvoet, 2013; Ostrom, 1997)	Information / Knowledge

7	Ik werk samen om mijn imago te verbeteren.	Reputatie: beeld dat feitelijke relaties van je hebben. VS imago = beeld dat algemene publiek bij je heeft	I collaborate to improve my image.	(Ostrom, 1997)	Image
8	Ik werk samen vanuit het principe van wederkerigheid.	Wisselwerking. Reciprocity	I collaborate to the principle of reciprocity.	(Ostrom, 1997)	Other
9	Ik werk samen vanwege het repeterend karakter van de samenwerking.		I collaborate because of the repeating character of the collaboration.	(Baldwin, 2013; Groenewegen, 2013)	Other
10	Ik werk samen omdat dit de efficiëntie van projecten verbetert.		I collaborate because it improves the efficiency of projects.	(Ostrom, 1997)	Time
11	Ik werk samen met anderen om geld te besparen voor alle partijen.	Geld besparen voor iedereen binnen de samenwerking. / goedkoper dan gas, airco's, koelwater of koeltorens of elektriciteit of andere vormen	I collaborate with other parties to save money for all parties concerned.	(Ostrom, 1997)	Price / Cost
12	Door samen te werken kan ik schaalvoordelen benutten.		By collaborating I can make use of economies of scale.	(Ostrom, 1997)	Price / Cost
13	Ik werk samen omdat ik tijd bespaar in het project ten opzichte van de situatie waarin ik het project alleen doe.		I collaborate to save time during the project in relation to doing the project on my own.	(Ostrom, 1997)	Time
14	Ik werk samen met anderen omdat zij over meer kennis beschikken.		I collaborate with other persons, because they possess more knowledge	(Groenewegen, 2013)	Information / Knowledge
15	Duurzame (lokale) overheidsambities zorgen voor warmte en koude-initiatieven.		Long-lasting (local) government-ambitions result in heat and cold initiatives.	Wim Voogd, Dirkjan van Swaaij	Field (Collective action / Regulation)
16	Verschillende vormen van warmte en koude kunnen niet belastingtechnisch vergeleken worden.		You cannot compare different types of heat and cold via the tax system.	Dirk Jan van Swaaij	Field (Collective action /

					Regulation)
17	Levering warmte/ koude kan niet worden vergeleken via CO_2-rechten.	EU ETS	Delivering heat/cold cannot be compared by CO_2-emission rights.	Dirk Jan van Swaaij	Field (Other)
18	Levering van warmte /koude schaadt andere warmte/koude alternatieven in de ruimtelijke orde.		The supply of heat/cold can harm other heat/cold alternatives in the spatial environment.	Wim Voogd, Dirk Jan van Swaaij	Field (Collective action / Regulation)
19	Ik werk samen omdat ik risico's verdeel in het project ten opzichte van de situatie waarin ik het project alleen doe.	Vanwege te hoog individueel risico	I collaborate to divide the risks of the project in comparison to the situation of doing the project on my own.	(Groeneweg en, 2013)	Risk
20	Ik werk samen om zowel de winsten als verliezen te delen.		I collaborate to share both profit and loss.	(Ligtvoet, 2013)	Price / Cost
21	Regelgeving is te individueel gericht voor samenwerking.		The regulatory regime is too individual focussed in relation to collaboration.	Own input	Collective action / Regulation
22	Ik werk samen om synergie tussen bedrijven te bevorderen.		I collaborate to promote the synergy between companies.	Own input	Common goal / Strategy
23	Collectieve oplossingen zijn te complex.		Collective solutions are too complex.	Own input	Collective action / Regulation
24	Wisselend beleid van de Nederlandse overheid maakt samenwerking op langere periodieke basis onmogelijk.	Wisselend beleid SDE+, sde	Because of varying policy of the Dutch government, it is impossible to collaborate on a longer periodical basis.	Own input	Collective action / Regulation
25	Het technische design van warmte / koude projecten is niet future proof.		The technical design of heat/cold projects is not future proof.	Dirk Jan van Swaaij	Field (Other)
26	Het projectmanagement van warmte / koude projecten is niet future proof.		The project management of heat/cold projects is not future proof.	Dirk Jan van Swaaij, Wim Voogd	Field (Other)

27	Het aantal interacties in het warmte koude veld is te gering voor samenwerking.		The number of interactions in the heat/cold field is too small.	IAD	Interaction
28	Initiatieven voor samenwerking zijn versnipperd.	Onderwerp	Initiatives for collaboration are split up.	Own input	Interaction
29	Initiatieven voor samenwerking zijn verdeeld over heel Nederland.	Afstand	Initiatives for collaboration are divided throughout the Netherlands.	Own input	Interaction
30	Het (grond)watersysteem is niet geschikt voor grootschalige implementatie van warmte/koude projecten.		The (ground) water-system is not suited for large-scale implementation of heat/cold projects.	Own input	Other
31	De concurrentie is te groot om te kunnen samenwerken.	Binnen warmte / koude veld, niet met andere alternatieven voor warmte / koude.	There is too much competition to be able to collaborate.	Own input, Dirk Jan van Swaaij, Wim Voogd	Field (Interactions)
32	Ik werk samen om de zekerheid van de levering te garanderen.	Security of supply	I collaborate to guarantee that supply will be certain.	Dirkjan van Swaaij	Field (supply /demand)
33	Ik werk samen om de zekerheid van afname te garanderen.	Security of demand	I collaborate to guarantee that demand will be certain.	Dirkjan van Swaaij	Field (Supply / Demand)
34	Ik werk samen in het warmte koude veld als er infrastructuur is.		I collaborate in the heat/cold field when infrastructure is available.	Own input, Dirk Jan van Swaaij, Wim Voogd	Field (Collective action / Regulation)
35	Ik werk samen in het warmte koude veld omdat ik/wij de benodigde infrastructuur facilite(e)r(en).		I collaborate in the heat/cold field, because I/we facilitate the necessary infrastructure.	Own input, Dirk Jan van Swaaij, Wim Voogd	Field (Collective action / Regulation)
36	Ik werk samen om innovaties in de markt te zetten.		I collaborate to put innovations in the market.		Risk

37	Ik werk samen in het Nederlandse warmte /koude veld om klimaatverandering te verminderen.		I collaborate in the Dutch heat/cold field to reduce climate changes.	(Ligtvoet, 2013)	Image
38	Ik werk samen om toe te treden op nieuwe markten zodat ik mijn inkomsten kan verhogen.		I collaborate to join new markets, in order to increase my profits.	(Bronder & Pritzl, 1992)	Price / Cost
39	Ik werk samen om een gezamenlijke of gelijkwaardige activiteit te bewerkstelligen.		I collaborate to realize a common or equal activity.	(Huisman, 2010; Ostrom et al., 1994)	Common goal / Strategy
40	Ik werk samen om een gezamenlijke of gelijkwaardige strategie na te streven.		I collaborate to aim for a common or equal strategy.	(Huisman, 2010; Ostrom et al., 1994)	Common goal / Strategy
41	Ik werk samen vanwege een gezamenlijke of gelijkwaardige verwachting in een project/samenwerking.	Doel	I collaborate because of common or equal expectations in a project/collaboration.	(Huisman, 2010; Ostrom et al., 1994)	Common goal / Strategy
42	Ik werk samen vanwege een gezamenlijke of gelijkwaardige cultuur in een project / samenwerking.	Spreekt zelfde taal	I collaborate because of a common or equal culture in a project/collaboration.	(Huisman, 2010; Ostrom et al., 1994)	Common goal / Strategy
43	*Purity of role*				Statements from the post sortinginterviews
44	*Profiling*				
45	*Concretize the energy taxes to improve collaboration behaviour*				

Table 19 Q-set with Categories and elaborated statements

C.6. Transcriptions of the interviews

As can be seen in the overview in Figure 29, for obvious readability reasons, and the lack of necessity, the original transcripts are in disposal of the researcher and can be requested upon by the researcher via jorickweijers@PLEASE DONOTSPAM gmail.com. The specific set is anonymized.

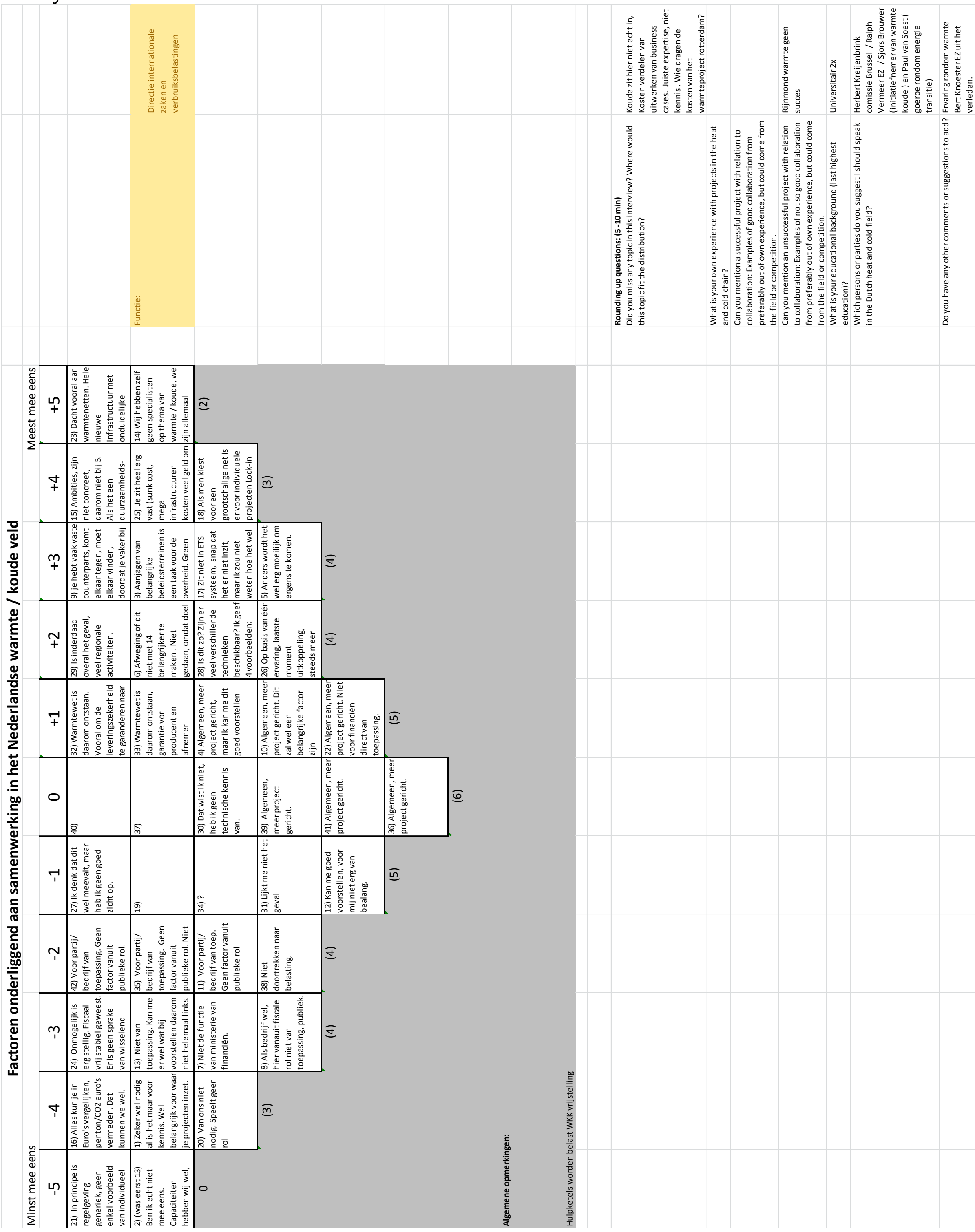


Figure 29 Transcript Q-interview

D. APPENDIX D: Results of the Principal Componant Analysis

This appendix shows the results from the Q-analysis. Different tables are produced as outcome from the PQMethod tool.
The correlation matrix is shown below; it shows the correlation between participants. A value of - 100 corresponds with a complete opposite Q-sort and if the value is 100 the Q-sorts are identical.

D.1. Correlation and communalities matrix

	SORTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	MinFin	**100**	-2	6	0	32	22	18	-3	22	26	11	17	1	15	8	-10	3	2	22	11
2	TUDelft	-2	**100**	1	3	28	40	7	14	11	21	23	17	33	9	21	36	5	22	5	0
3	Branche	6	1	**100**	51	44	51	55	11	28	49	35	6	35	52	48	39	49	39	35	49
4	Instal	0	3	51	**100**	54	34	57	12	33	54	49	12	45	59	51	22	57	35	44	56
5	MinBZ	32	28	44	54	**100**	41	42	-5	30	41	48	12	36	39	40	34	35	39	56	48
6	Bank1	22	40	51	34	41	**100**	56	17	37	70	46	38	55	55	40	42	51	46	45	41
7	NetOwn	18	7	55	57	42	56	**100**	18	38	71	41	21	63	70	40	24	59	36	37	51
8	Bank2	-3	14	11	12	-5	17	18	**100**	7	20	22	17	17	37	25	-5	11	45	-6	18
9	Close1	22	11	28	33	30	37	38	7	**100**	39	17	13	29	35	14	27	22	13	20	16
10	ProvNB	26	21	49	54	41	70	71	20	39	**100**	52	43	54	67	63	18	76	54	48	57
11	Produ1	11	23	35	49	48	46	41	22	17	52	**100**	44	42	47	44	16	56	55	45	49
12	Close2	17	17	6	12	12	38	21	17	13	43	44	**100**	37	32	46	23	19	26	19	38
13	HCoorp	1	33	35	45	36	55	63	17	29	54	42	37	**100**	59	43	25	42	37	26	54
14	Geoth	15	9	52	59	39	55	70	37	35	67	47	32	59	**100**	39	18	66	52	35	59
15	Produ2	8	21	48	51	40	40	40	25	14	63	44	46	43	39	**100**	27	47	44	42	65
16	TKI	-10	36	39	22	34	42	24	-5	27	18	16	23	25	18	27	**100**	10	25	26	30
17	Produ3	3	5	49	57	35	51	59	11	22	76	56	19	42	66	47	10	**100**	46	34	53
18	MinEZ	2	22	39	35	39	46	36	45	13	54	55	26	37	52	44	25	46	**100**	39	63
19	Munici	22	5	35	44	56	45	37	-6	20	48	45	19	26	35	42	26	34	39	**100**	48
20	PBwkZH	11	0	49	56	48	41	51	18	16	57	49	38	54	59	65	30	53	63	48	**100**

Table 20 Correlation matrix

As has been shown in paragraph 5.1 in Table 6 on page 48 the PCA analysis has resulted in eight (unrotated) factors, they were identified automatically with the PQMethod software for PCA. As explained 5 resulting factors with an eigenvalue of 1 or higher and minimal two significant factor-loadings were taken into account for further analysis.

This has resulted in a Varimax rotation on the factors. That Varimax rotation has the goal to rotate the axes is such a way that most variation can be explained.

	Cumulative Communalities Matrix								
	SORTS	1	2	3	4	5	6	7	8
1	MinFin	0.0394	0.1747	0.1810	0.7962	0.8049	0.8437	0.8648	0.8682
2	TUDelft	0.0699	0.1629	0.6965	0.6982	0.7128	0.7448	0.8830	0.8835
3	Branche	0.4406	0.4978	0.5079	0.6092	0.6207	0.6251	0.6974	0.7804
4	Instal	0.5055	0.5535	0.6157	0.6841	0.6842	0.6844	0.6924	0.8163
5	MinBZ	0.4114	0.5669	0.6250	0.6261	0.6917	0.7824	0.7979	0.8506
6	Bank1	0.5651	0.5653	0.6603	0.6750	0.7172	0.7173	0.7208	0.8527
7	NetOwn	0.5883	0.6107	0.6413	0.6421	0.7577	0.7666	0.7688	0.7688
8	Bank2	0.0752	0.5254	0.5640	0.5747	0.6067	0.8218	0.8946	0.9047
9	Close1	0.1795	0.2782	0.3136	0.3447	0.5981	0.6044	0.6657	0.7455
10	ProvNB	0.7313	0.7315	0.7402	0.7862	0.7956	0.8121	0.8210	0.8643
11	Produ1	0.4871	0.5128	0.5128	0.5194	0.6009	0.6077	0.6892	0.6948
12	Close2	0.2027	0.3514	0.4026	0.5516	0.5956	0.8421	0.8811	0.8900
13	HCoorp	0.4808	0.5059	0.5160	0.5167	0.5782	0.6359	0.6692	0.7481
14	Geoth	0.6317	0.6371	0.7030	0.7065	0.7773	0.7792	0.7792	0.7809
15	Produ2	0.4921	0.5204	0.5204	0.5234	0.6192	0.6560	0.6902	0.6932
16	TKI	0.1608	0.1674	0.5442	0.7280	0.7294	0.7364	0.8562	0.8642
17	Produ3	0.5423	0.5427	0.6610	0.6643	0.6697	0.6816	0.7745	0.8346
18	MinEZ	0.4530	0.5783	0.5813	0.5893	0.6293	0.7711	0.7764	0.7923
19	Munici	0.3566	0.4750	0.4811	0.4822	0.6672	0.6771	0.6773	0.6812
20	PBwkZH	0.5949	0.5982	0.6265	0.6403	0.7260	0.7349	0.7797	0.7921
Cum % expl.Var.		**40**	**48**	**55**	**62**	**68**	**73**	**77**	**81**

Table 21 Cumulative Communalities Matrix

According to statistical equation from (Brown, 1980), a load is significant if it has a higher factor-loading than the value that follows from the formula: Significant factor-loading = Standard deviation * (1 /(√n statements)). Translated to forty-two statements and the standard deviation of 2.58 that results in a value of approximately ± 0.4 in our case.

$2.58\times(1/\sqrt{42}) = .3981 \approx \pm 0{,}4.$

D.2. Z-scores

In the following paragraph the calculations of the Z-scores are provided for each statement within the Q-set specified per factor. Naturally only the factors 1, 2, 3 and 4 are taken into account. As mentioned in the main text in paragraph 6.2 the calculation of the Z-scores provides for the ranking of the statements within a factors distribution. Next to that also cross comparison between the perspectves is made possible via Z-scores. Needed for this stap is the ideal distribution of the statements over each perspective. Combined these results are shown in each seperate table.

With both above options the statistical comparison options of Q-methodology are strengthened. However the information from the post sorting interviews might be useful to interpret the perspectives.

No.	Statement	No.	1	2	3	4
1	Ondanks de complexiteit is samenwerking binnen het warmte ko	1	-5	-5	-3	-5
2	Ik beschik nu niet over de juiste capaciteiten om samen te w	2	-4	-3	-1	-4
3	Samenwerking ontstaat doordat overheden samenwerking(-sbijee	3	-1	-1	-5	3
4	Samenwerking ontstaat doordat overheden projecten initiëren.	4	-1	-3	1	2
5	Voor samenwerking is eerst vertrouwen nodig.	5	5	5	5	4
6	Ik werk samen om informatie van derden in de waarde keten te	6	0	2	-1	1
7	Ik werk samen om mijn imago te verbeteren.	7	0	-1	-2	-1
8	Ik werk samen vanuit het principe van wederkerigheid.	8	0	2	4	0
9	Ik werk samen vanwege het repeterend karakter van de samenwe	9	0	-2	3	0
10	Ik werk samen omdat dit de efficiëntie van projecten verbete	10	4	3	2	3
11	Ik werk samen met anderen om geld te besparen voor alle part	11	4	-2	3	1
12	Door samen te werken kan ik schaalvoordelen benutten.	12	1	2	1	4
13	Ik werk samen omdat ik tijd bespaar in het project ten opzic	13	1	4	-4	0
14	Ik werk samen met anderen omdat zij over meer kennis beschik	14	5	3	-1	-1
15	Duurzame (lokale) overheidsambities zorgen voor warmte en ko	15	1	0	4	5
16	Verschillende vormen van warmte en koude kunnen niet belasti	16	-1	1	4	-2
17	Levering warmte/koude kan niet worden vergeleken via CO_2-rec	17	-2	-3	-3	-3
18	Levering van warmte/koude schaadt andere warmte/koude altern	18	-3	0	-3	-4
19	Ik werk samen omdat ik risico's verdeel in het project ten o	19	3	4	-2	2
20	Ik werk samen om zowel de winsten als verliezen te delen.	20	2	-4	-4	0
21	Regelgeving is te individueel gericht voor samenwerking.	21	-3	0	2	-3
22	Ik werk samen om synergie tussen bedrijven te bevorderen.	22	2	1	0	-1
23	Collectieve oplossingen zijn te complex.	23	-3	-3	1	-5
24	Wisselend beleid van de Nederlandse overheid maakt samenwerk	24	-2	5	0	0
25	Het technische design van warmte/koude projecten is niet fut	25	-2	-2	-5	-2
26	Het projectmanagement van warmte/koude projecten is niet fut	26	-1	0	-2	-2
27	Het aantal interacties in het warmte koude veld is te gering	27	-4	3	1	-2
28	Initiatieven voor samenwerking zijn versnipperd.	28	0	-1	0	-3
29	Initiatieven voor samenwerking zijn verdeeld over heel Neder	29	-1	-1	2	2
30	Het (grond)watersysteem is niet geschikt voor grootschalige	30	-3	-1	-4	-3
31	De concurrentie is te groot om te kunnen samenwerken.	31	-5	-4	-3	-4
32	Ik werk samen om de zekerheid van de levering te garanderen.	32	3	2	0	3
33	Ik werk samen om de zekerheid van afname te garanderen.	33	0	4	-2	5
34	Ik werk samen in het warmte koude veld als er infrastructuur	34	-4	1	3	-1
35	Ik werk samen in het warmte koude veld omdat ik/wij de infra	35	-2	3	0	1
36	Ik werk samen om innovaties in de markt te zetten.	36	1	-5	-1	2
37	Ik werk samen in het Nederlandse warmte /koude veld om klima	37	3	-4	3	4
38	Ik werk samen om toe te treden op nieuwe markten zodat ik mi	38	1	0	-1	-1
39	Ik werk samen om een gezamenlijke of gelijkw activiteit te	39	4	-1	2	1
40	Ik werk samen om een gezamenlijke of gelijkw strategie na te	40	2	1	0	3
41	Ik werk samen vanwege een gezamenlijke of gelijkw verwachtin	41	3	-2	5	1
42	Ik werk samen vanwege een gezamenlijke of gelijkw cultuur	42	2	0	1	0

Table 22 Factor arrays from the four perspectives: Variance = 7.381 & St. Dev. = 2.717.

Perspective 1		
No.	Statement	Z-SCORES
5	Voor samenwerking is eerst vertrouwen nodig.	2.019
14	Ik werk samen met anderen omdat zij over meer kennis beschik	1.576
11	Ik werk samen met anderen om geld te besparen voor alle part	1.410
39	Ik werk samen om een gezamenlijke of gelijkw activiteit te	1.138
10	Ik werk samen omdat dit de efficiëntie van projecten verbete	1.125
19	Ik werk samen omdat ik risico's verdeel in het project ten o	1.031
32	Ik werk samen om de zekerheid van de levering te garanderen.	0.988
37	Ik werk samen in het Nederlandse warmte /koude veld om klima	0.906
41	Ik werk samen vanwege een gezamenlijke of gelijkw verwachtin	0.829
40	Ik werk samen om een gezamenlijke of gelijkw strategie na te	0.801
20	Ik werk samen om zowel de winsten als verliezen te delen.	0.725
42	Ik werk samen vanwege een gezamenlijke of gelijkw cultuur	0.712
22	Ik werk samen om synergie tussen bedrijven te bevorderen.	0.699
15	Duurzame (lokale) overheidsambities zorgen voor warmte en ko	0.683
12	Door samen te werken kan ik schaalvoordelen benutten.	0.665
38	Ik werk samen om toe te treden op nieuwe markten zodat ik mi	0.615
13	Ik werk samen omdat ik tijd bespaar in het project ten opzic	0.590
36	Ik werk samen om innovaties in de markt te zetten.	0.535
33	Ik werk samen om de zekerheid van afname te garanderen.	0.398
8	Ik werk samen vanuit het principe van wederkerigheid.	0.285
6	Ik werk samen om informatie van derden in de waarde keten te	0.179
9	Ik werk samen vanwege het repeterend karakter van de samenwe	0.114
7	Ik werk samen om mijn imago te verbeteren.	-0.049
28	Initiatieven voor samenwerking zijn versnipperd.	-0.127
16	Verschillende vormen van warmte en koude kunnen niet belasti	-0.207
29	Initiatieven voor samenwerking zijn verdeeld over heel Neder	-0.347
26	Het projectmanagement van warmte/koude projecten is niet fut	-0.512
3	Samenwerking ontstaat doordat overheden samenwerking(-sbijee	-0.520
4	Samenwerking ontstaat doordat overheden projecten initiëren.	-0.554
25	Het technische design van warmte/koude projecten is niet fut	-0.612
17	Levering warmte/koude kan niet worden vergeleken via CO_2-rec	-0.685
35	Ik werk samen in het warmte koude veld omdat ik/wij de infra	-0.823
24	Wisselend beleid van de Nederlandse overheid maakt samenwerk	-0.870
30	Het (grond)watersysteem is niet geschikt voor grootschalige	-1.048
21	Regelgeving is te individueel gericht voor samenwerking.	-1.048
18	Levering van warmte/koude schaadt andere warmte/koude altern	-1.194
23	Collectieve oplossingen zijn te complex.	-1.282
34	Ik werk samen in het warmte koude veld als er infrastructuur	-1.406
27	Het aantal interacties in het warmte koude veld is te gering	-1.519
2	Ik beschik nu niet over de juiste capaciteiten om samen te w	-1.582
31	De concurrentie is te groot om te kunnen samenwerken.	-1.738
1	Ondanks de complexiteit is samenwerking binnen het warmte ko	-1.898

Table 23 Z-scores perspective 1

Perspective 2		
No.	Statement	Z-SCORES
5	Voor samenwerking is eerst vertrouwen nodig.	2.201
24	Wisselend beleid van de Nederlandse overheid maakt samenwerk	1.974
13	Ik werk samen omdat ik tijd bespaar in het project ten opzic	1.420
19	Ik werk samen omdat ik risico's verdeel in het project ten o	1.207
33	Ik werk samen om de zekerheid van afname te garanderen.	1.107
35	Ik werk samen in het warmte koude veld omdat ik/wij de infra	1.080
14	Ik werk samen met anderen omdat zij over meer kennis beschik	0.980
27	Het aantal interacties in het warmte koude veld is te gering	0.966
10	Ik werk samen omdat dit de efficiëntie van projecten verbete	0.880
12	Door samen te werken kan ik schaalvoordelen benutten.	0.867
8	Ik werk samen vanuit het principe van wederkerigheid.	0.780
6	Ik werk samen om informatie van derden in de waarde keten te	0.767
32	Ik werk samen om de zekerheid van de levering te garanderen.	0.667
34	Ik werk samen in het warmte koude veld als er infrastructuur	0.640
22	Ik werk samen om synergie tussen bedrijven te bevorderen.	0.554
16	Verschillende vormen van warmte en koude kunnen niet belasti	0.200
40	Ik werk samen om een gezamenlijke of gelijkw strategie na te	0.100
18	Levering van warmte/koude schaadt andere warmte/koude altern	0.014
21	Regelgeving is te individueel gericht voor samenwerking.	0.014
26	Het projectmanagement van warmte/koude projecten is niet fut	0.000
42	Ik werk samen vanwege een gezamenlijke of gelijkw cultuur	0.000
38	Ik werk samen om toe te treden op nieuwe markten zodat ik mi	-0.014
15	Duurzame (lokale) overheidsambities zorgen voor warmte en ko	-0.086
30	Het (grond)watersysteem is niet geschikt voor grootschalige	-0.113
39	Ik werk samen om een gezamenlijke of gelijkw activiteit te	-0.113
29	Initiatieven voor samenwerking zijn verdeeld over heel Neder	-0.200
3	Samenwerking ontstaat doordat overheden samenwerking(-sbijee	-0.213
7	Ik werk samen om mijn imago te verbeteren.	-0.213
28	Initiatieven voor samenwerking zijn versnipperd.	-0.227
9	Ik werk samen vanwege het repeterend karakter van de samenwe	-0.540
25	Het technische design van warmte/koude projecten is niet fut	-0.567
11	Ik werk samen met anderen om geld te besparen voor alle part	-0.667
41	Ik werk samen vanwege een gezamenlijke of gelijkw verwachtin	-0.767
23	Collectieve oplossingen zijn te complex.	-0.980
4	Samenwerking ontstaat doordat overheden projecten initiëren.	-0.980
2	Ik beschik nu niet over de juiste capaciteiten om samen te w	-1.080
17	Levering warmte/koude kan niet worden vergeleken via CO_2-rec	-1.434
20	Ik werk samen om zowel de winsten als verliezen te delen.	-1.534
31	De concurrentie is te groot om te kunnen samenwerken.	-1.547
37	Ik werk samen in het Nederlandse warmte /koude veld om klima	-1.633
36	Ik werk samen om innovaties in de markt te zetten.	-1.747
1	Ondanks de complexiteit is samenwerking binnen het warmte ko	-1.760

Table 24 Z-scores perspective 2

Perspective 3		
No.	Statement	Z-SCORES
5	Voor samenwerking is eerst vertrouwen nodig.	1.733
41	Ik werk samen vanwege een gezamenlijke of gelijkw verwachtin	1.615
8	Ik werk samen vanuit het principe van wederkerigheid.	1.603
16	Verschillende vormen van warmte en koude kunnen niet belasti	1.399
15	Duurzame (lokale) overheidsambities zorgen voor warmte en ko	1.345
37	Ik werk samen in het Nederlandse warmte /koude veld om klima	1.277
34	Ik werk samen in het warmte koude veld als er infrastructuur	1.169
9	Ik werk samen vanwege het repeterend karakter van de samenwe	1.004
11	Ik werk samen met anderen om geld te besparen voor alle part	0.975
21	Regelgeving is te individueel gericht voor samenwerking.	0.764
29	Initiatieven voor samenwerking zijn verdeeld over heel Neder	0.764
39	Ik werk samen om een gezamenlijke of gelijkw activiteit te	0.758
10	Ik werk samen omdat dit de efficiëntie van projecten verbete	0.672
4	Samenwerking ontstaat doordat overheden projecten initiëren.	0.567
23	Collectieve oplossingen zijn te complex.	0.529
27	Het aantal interacties in het warmte koude veld is te gering	0.496
12	Door samen te werken kan ik schaalvoordelen benutten.	0.260
42	Ik werk samen vanwege een gezamenlijke of gelijkw cultuur	0.240
35	Ik werk samen in het warmte koude veld omdat ik/wij de infra	0.186
22	Ik werk samen om synergie tussen bedrijven te bevorderen.	0.100
28	Initiatieven voor samenwerking zijn versnipperd.	0.100
32	Ik werk samen om de zekerheid van de levering te garanderen.	0.068
40	Ik werk samen om een gezamenlijke of gelijkw strategie na te	0.000
24	Wisselend beleid van de Nederlandse overheid maakt samenwerk	-0.222
2	Ik beschik nu niet over de juiste capaciteiten om samen te w	-0.248
36	Ik werk samen om innovaties in de markt te zetten.	-0.253
14	Ik werk samen met anderen omdat zij over meer kennis beschik	-0.306
6	Ik werk samen om informatie van derden in de waarde keten te	-0.340
38	Ik werk samen om toe te treden op nieuwe markten zodat ik mi	-0.524
33	Ik werk samen om de zekerheid van afname te garanderen.	-0.610
7	Ik werk samen om mijn imago te verbeteren.	-0.850
19	Ik werk samen omdat ik risico's verdeel in het project ten o	-0.880
26	Het projectmanagement van warmte/koude projecten is niet fut	-1.061
31	De concurrentie is te groot om te kunnen samenwerken.	-1.104
18	Levering van warmte/koude schaadt andere warmte/koude altern	-1.153
17	Levering warmte/koude kan niet worden vergeleken via CO_2-rec	-1.245
1	Ondanks de complexiteit is samenwerking binnen het warmte ko	-1.271
20	Ik werk samen om zowel de winsten als verliezen te delen.	-1.374
13	Ik werk samen omdat ik tijd bespaar in het project ten opzic	-1.449
30	Het (grond)watersysteem is niet geschikt voor grootschalige	-1.479
3	Samenwerking ontstaat doordat overheden samenwerking(-sbijee	-1.491
25	Het technische design van warmte/koude projecten is niet fut	-1.763

Table 25 Z-Scores perspective 3

Perspective 4		
No.	Statement	Z-SCORES
15	Duurzame (lokale) overheidsambities zorgen voor warmte en ko	2.093
33	Ik werk samen om de zekerheid van afname te garanderen.	1.607
12	Door samen te werken kan ik schaalvoordelen benutten.	1.414
37	Ik werk samen in het Nederlandse warmte /koude veld om klima	1.359
5	Voor samenwerking is eerst vertrouwen nodig.	1.350
3	Samenwerking ontstaat doordat overheden samenwerking(-sbijee	1.216
10	Ik werk samen omdat dit de efficiëntie van projecten verbete	1.113
32	Ik werk samen om de zekerheid van de levering te garanderen.	1.109
40	Ik werk samen om een gezamenlijke of gelijkw strategie na te	0.814
36	Ik werk samen om innovaties in de markt te zetten.	0.772
19	Ik werk samen omdat ik risico's verdeel in het project ten o	0.752
29	Initiatieven voor samenwerking zijn verdeeld over heel Neder	0.668
4	Samenwerking ontstaat doordat overheden projecten initiëren.	0.553
41	Ik werk samen vanwege een gezamenlijke of gelijkw verwachtin	0.481
39	Ik werk samen om een gezamenlijke of gelijkw activiteit te	0.428
11	Ik werk samen met anderen om geld te besparen voor alle part	0.412
35	Ik werk samen in het warmte koude veld omdat ik/wij de infra	0.301
6	Ik werk samen om informatie van derden in de waarde keten te	0.163
20	Ik werk samen om zowel de winsten als verliezen te delen.	0.088
42	Ik werk samen vanwege een gezamenlijke of gelijkw cultuur	0.049
8	Ik werk samen vanuit het principe van wederkerigheid.	0.014
9	Ik werk samen vanwege het repeterend karakter van de samenwe	-0.073
13	Ik werk samen omdat ik tijd bespaar in het project ten opzic	-0.095
24	Wisselend beleid van de Nederlandse overheid maakt samenwerk	-0.131
38	Ik werk samen om toe te treden op nieuwe markten zodat ik mi	-0.134
34	Ik werk samen in het warmte koude veld als er infrastructuur	-0.215
22	Ik werk samen om synergie tussen bedrijven te bevorderen.	-0.275
14	Ik werk samen met anderen omdat zij over meer kennis beschik	-0.275
7	Ik werk samen om mijn imago te verbeteren.	-0.441
25	Het technische design van warmte/koude projecten is niet fut	-0.527
16	Verschillende vormen van warmte en koude kunnen niet belasti	-0.603
27	Het aantal interacties in het warmte koude veld is te gering	-0.731
26	Het projectmanagement van warmte/koude projecten is niet fut	-0.771
28	Initiatieven voor samenwerking zijn versnipperd.	-0.824
21	Regelgeving is te individueel gericht voor samenwerking.	-0.921
17	Levering warmte/koude kan niet worden vergeleken via CO_2-rec	-0.965
30	Het (grond)watersysteem is niet geschikt voor grootschalige	-1.271
18	Levering van warmte/koude schaadt andere warmte/koude altern	-1.368
2	Ik beschik nu niet over de juiste capaciteiten om samen te w	-1.482
31	De concurrentie is te groot om te kunnen samenwerken.	-1.604
23	Collectieve oplossingen zijn te complex.	-1.984
1	Ondanks de complexiteit is samenwerking binnen het warmte ko	-2.066

Table 26 Z-scores perspective 4

D.3. Z-scores and distinguishing statements

This paragraph shows four tables with the most common statements for the four perspectives. They are used in the description and are the most important guideline to couple the qualitative statemens to the quantitative distribution of the statements.

Distinguishing Statements for Perspective 1									
(P < .05 ; Asterisk (*) Indicates Significance at P < .01) Both the Factor Q-Sort Value (Q-SV) and the Z-Score (Z-SCR) are Shown.									
		1		2		3		4	
No	Statement	Q	Z	Q	Z	Q	Z	Q	Z
20	Ik werk samen om zowel de winsten als verliezen te delen.	2	0.73	-4	-1.53	-4	-1.37	0	0.09
15	Duurzame (lokale) overheidsambities zorgen voor warmte en ko	1	0.68	0	-0.09	4	1.34	5	2.09
13	Ik werk samen omdat ik tijd bespaar in het project ten opzic..	1	0.59	4	1.42	-4	-1.45	0	-0.10
35	Ik werk samen in het warmte koude veld omdat ik/wij de infra	-2	-0.82*	3	1.08	0	0.19	1	0.30
24	Wisselend beleid van de Nederlandse overheid maakt samenwerk	-2	-0.87	5	1.97	0	-0.22	0	-0.13
34	Ik werk samen in het warmte koude veld als er infrastructuur	-4	-1.41*	1	0.64	3	1.17	-1	-0.21
27	Het aantal interacties in het warmte koude veld is te gering	-4	-1.52*	3	0.97	1	0.50	-2	-0.73

Table 27 Distinguishing Statements for perspective 1

Distinguishing Statements for Perspective 2									
(P < .05 ; Asterisk (*) Indicates Significance at P < .01) Both the Factor Q-Sort Value (Q-SV) and the Z-Score (Z-SCR) are shown.									
		1		2		3		4	
No	Statement	Q	Z	Q	Z	Q	Z	Q	Z
24	Wisselend beleid van de Nederlandse overheid maakt samenwerk	-2	-0.87	5	1.97*	0	-0.22	0	-0.13
13	Ik werk samen omdat ik tijd bespaar in het project ten opzic	1	0.59	4	1.42	-4	-1.45	0	-0.10
35	Ik werk samen in het warmte koude veld omdat ik/wij de infra	-2	-0.82	3	1.08	0	0.19	1	0.30
18	Levering van warmte/koude schaadt andere warmte/koude altern	-3	-1.19	0	0.01*	-3	-1.15	-4	-1.37
15	Duurzame (lokale) overheidsambities zorgen voor warmte en ko	1	0.68	0	-0.09	4	1.34	5	2.09
30	Het (grond)watersysteem is niet geschikt voor grootschalige	-3	-1.05	-1	-0.11	-4	-1.48	-3	-1.27
11	Ik werk samen met anderen om geld te besparen voor alle part	4	1.41	-2	-0.67*	3	0.97	1	0.41
41	Ik werk samen vanwege een gezamenlijke of gelijkw verwachtin	3	0.83	-2	-0.77*	5	1.61	1	0.48
37	Ik werk samen in het Nederlandse warmte /koude veld om klima	3	0.91	-4	-1.63*	3	1.28	4	1.36
36	Ik werk samen om innovaties in de markt te zetten.	1	0.53	-5	-1.75*	-1	-0.25	2	0.77

Table 28 Distinguishing Statements for perspective 2

Distinguishing Statements for Perspective 3									
(P < .05 ; Asterisk (*) Indicates Significance at P < .01)									
Both the Factor Q-Sort Value (Q) and the Z-Score (Z) are Shown.									
		1		2		3		4	
No	Statement	Q	Z	Q	Z	Q	Z	Q	Z
41	Ik werk samen vanwege een gezamenlijke of gelijkw verwachtin	3	0.83	-2	-0.77	5	1.61	1	0.48
16	Verschillende vormen van warmte en koude kunnen niet belasti	-1	-0.21	1	0.20	4	1.40*	-2	-0.60
15	Duurzame (lokale) overheidsambities zorgen voor warmte en ko	1	0.68	0	-0.09	4	1.34	5	2.09
9	Ik werk samen vanwege het repeterend karakter van de samenwe	0	0.11	-2	-0.54	3	1.00*	0	-0.07
23	Collectieve oplossingen zijn te complex.	-3	-1.28	-3	-0.98	1	0.53*	-5	-1.98
36	Ik werk samen om innovaties in de markt te zetten.	1	0.53	-5	-1.75	-1	-0.25	2	0.77
33	Ik werk samen om de zekerheid van afname te garanderen.	0	0.40	4	1.11	-2	-0.61*	5	1.61
19	Ik werk samen omdat ik risico's verdeel in het project ten o	3	1.03	4	1.21	-2	-0.88*	2	0.75
13	Ik werk samen omdat ik tijd bespaar in het project ten opzic	1	0.59	4	1.42	-4	-1.45*	0	-0.10
3	Samenwerking ontstaat doordat overheden samenwerking(-sbijee	-1	-0.52	-1	-0.21	-5	-1.49*	3	1.22
25	Het technische design van warmte/koude projecten is niet fut	-2	-0.61	-2	-0.57	-5	-1.76*	-2	-0.53

Table 29 Distinguishing Statements for perspective 3

Distinguishing Statements for Perspective 4									
(P < .05 ; Asterisk (*) Indicates Significance at P < .01)									
Both the Factor Q-Sort Value (Q-SV) and the Z-Score (Z-SCR) are Shown.									
		1		2		3		4	
No	Statement	Q	Z	Q	Z	Q	Z	Q	Z
15	Duurzame (lokale) overheidsambities zorgen voor warmte en ko	1	0.68	0	-0.09	4	1.34	5	2.09
3	Samenwerking ontstaat doordat overheden samenwerking(-sbijee	-1	-0.52	-1	-0.21	-5	-1.49	3	1.22*
20	Ik werk samen om zowel de winsten als verliezen te delen.	2	0.73	-4	-1.53	-4	-1.37	0	0.09
13	Ik werk samen omdat ik tijd bespaar in het project ten opzic	1	0.59	4	1.42	-4	-1.45	0	-0.10*
34	Ik werk samen in het warmte koude veld als er infrastructuur	-4	-1.41	1	0.64	3	1.17	-1	-0.21
27	Het aantal interacties in het warmte koude veld is te gering	-4	-1.52	3	0.97	1	0.50	-2	-0.73*
23	Collectieve oplossingen zijn te complex.	-3	-1.28	-3	-0.98	1	0.53	-5	-1.98*

Table 30 Distinguishing Statements for perspective 4.

D.4. Categories in relation to collaboration

This paragraph contains the calculations that were used to create the relationship diagrams between the categories (as drivers) and collaboration behaviour in the heat and cold energy storage field. The results are graphically shown in paragraph 5.5 on page 55, here merely the numerical data of the relation and the size of the relation is determined. Secondly this paragraph provides an analysis per category over all the perspectives to show that the effects of a policy can be different in the Dutch heat and cold energy storage field.

In order to be able to compare the strength of the relationships between the perspectives, the Z-scores of each statement in the Q-set for the four perspectives are needed. These scores have been represented in the paragraphs D.2 and D.3. In the table below the calculations of the number of categories per perspective is shown. To calculate the average influence per category of statements the sum of all the Z-scores is taken and divided by the number of statements per category. The outcome of this calculation is shown in Table 31.

Relationship values between drivers and collaboration					
Categories:	Statements per category	Early Adopters	Policy Sceptics	Quid pro quo	Second Movers
Other	8	-0.29	-0.18	-0.31	-0.54
Interaction	5	-1.06	-0.42	0.00	-0.79
Time	2	0.86	1.15	-0.39	0.51
Price / Cost	2	1.71	-0.67	-0.33	0.89
Common goal / Strategy	5	0.84	-0.05	0.54	0.30
Image	2	0.43	-0.92	0.21	0.46
Collective action / Regulation	10	-0.72	0.17	0.31	-0.11
Information / Knowledge	2	0.88	0.87	-0.32	-0.06
Risk	2	0.78	-0.27	-0.57	0.76
Supply / Demand	2	0.69	0.89	-0.27	1.36

Table 31 Average Z-score values of the relation between categories and collaboration per perspective

As can be seen from Table 31 not all the categories are always positive or negative. A disclaimer should be provided with these data. They are not generalizable to the entire population because of the small (20) set of participants in the P-set. Furthermore the data here is not 'hard'; to get this 'hard' data a survey would be more suitable. To see a clear overview of all the statements in a category see Table 19 on page 131.

Conclusions on this data show that to improve collaboration behaviour in the heat and cold energy storage field, steering mechanisms per alternative differ a lot. To start with, the category "Other" has a negative relation with collaboration behaviour in the heat and cold energy storage field in all of the four perspectives. A reasonable explanation therefore is hard to provide, firstly all the statements are different in the driver they represent from literature and this makes a hard distinction difficult. However in the Second Movers' perspective a more negative relation is shown in comparison with the other perspectives, therefore a deeper analysis is recommended. As one zooms in on the “Interaction” category the most upfront notion is that in the Quid pro quo perspective is loaded with a zero. This implies no effect, or at least on average on collaboration. Interesting here is the confirmation of the institutional analysis result: that interaction currently does not lead to collaboration (from the institutional analyses with IAD framework), which forms a part of the basis for this thesis. With relation to the “Time category”, these data also confirms the viewpoint of the participants in the Quid pro quo perspective; collaboration is not necessarily time-saving. However in the other three perspectives time has a more positive relation with collaboration.

Going through the table with the category “Price / Cost” it is interesting to realize that both the Early Adopters’ and the Second Movers’ participants see that as an high driver for collaboration, however the other two perspectives load negative on this aspect. This implies that for future policy a price-steered mechanism might not have effect on the entire heat and cold energy storage field. The “Common goal / Strategy” category shows clearly that most perspectives have a positive relation with collaboration, however the Policy Sceptics do not take that viewpoint, be it only slightly negative. An important distinction can be made with the “Image” category which has a negative regulation for only the Policy Sceptics. They say for instance”My primairy driver is making money, image is hip but I am not making money with this” (P-08) and “If you’re a monopolist image is not important” (P-12). This is implying that the rest of the interviewed field could be steered towards collaboration if the steering mechanism results in a more positive image.

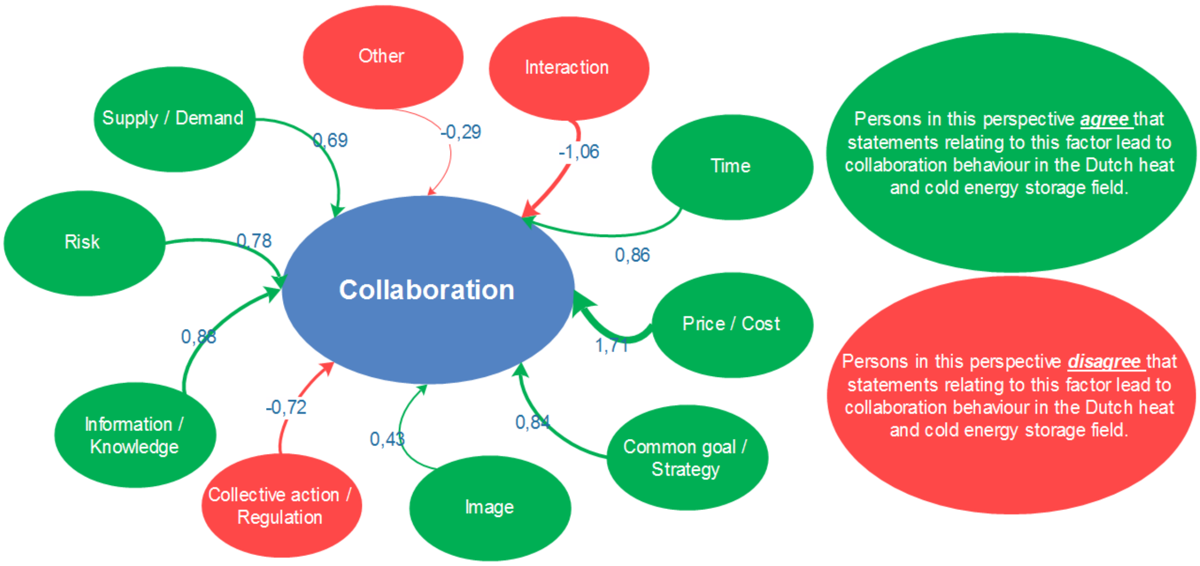
Zooming in on the last three categories “Information / Knowledge” as category is differently rated amongst the perspectives, however on average it is an important driver for collaboration in the energy field, with only a minor negative relation in the third and fourth perspective. The category “Risk” however, brings more differentiation over the field is than most of the other perspectives, it is possible that the participants in the first and fourth perspective are more risk averse than the other participants in the second and third perspective and therefore seek more collaboration to share these risks. Hence increasing risks has a positive relation for them with collaboration. The loaders on the second and third perspective have that relation in a negative direction. The last category “Supply / Demand” has a positive relation for the most perspective, implying that supply and demand (and the securing thereof) are reasons for collaboration. This implies that creating more security of supply and demand would stimulate the growth of the heat and cold energy storage field in the Netherlands. In the Quid pro quo perspective however, the supply and demand categories have a negative relation with collaboration, thus this stimulation would have a negative impact for the participants loading on this perspective.

For the easy consult of the perspectives, these final pages present the overview of the four perspectives in the field. The highly readable relation diagrams are provided here as well.

Early Adopters perspective

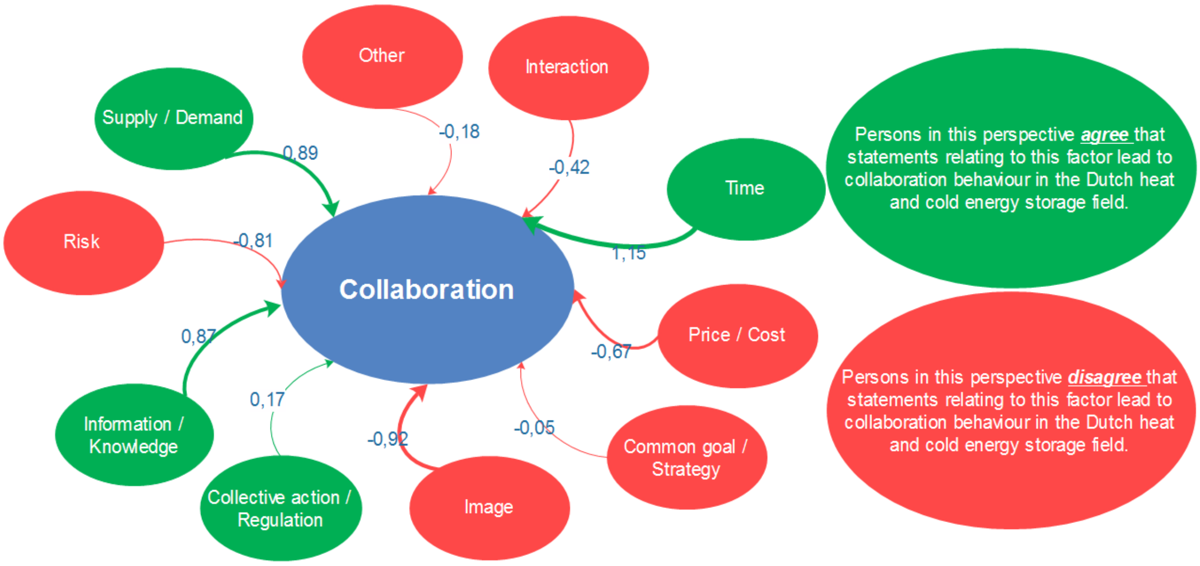
Many participants load on this perspective. This results in a less sharp agreement on the reasons for collaboration. Important for them is the sharing of both profits and losses as a starting point for collaboration "this enables bigger projects with in itself more collaboration" (P-17). Next to that a believe is that government ambitions could slightly help to start the first collaboration behaviour but a strong notion in the comments leads to the interviewers interpretation that in the end, the companies will do it themselves. There is an important disagreement that the number of interactions is too low in the heat and cold field, they say there are more than enough interactions which lead to collaboration. Next to that they are hands-on related to infrastructure and backbones. "If it is not there we will make it there" (P-14).

Many loaders are one of the early movers in the field and already own a grid, or produce and supply heat to a heat grid or other interested parties. The most interesting loader might be the Province of North Brabant, given that the local governments are not always are first movers. Apparently this is the case in the Dutch heat and cold field. One of the participants, who is owner of a heat grid, said: "Collaboration is always needed, for a collaboration agreement I do however put more effort than in the relation between supplier and customer".



Policy Sceptics perspective

These participants are known for their scepticism in relation to changing policy related to energy and the heat and cold energy storage market. In their opinion it burdens development and growth and does not stimulate collaboration behaviour at all "It would be nice if they would be a bit consistent for 10 years or so (P-8, Energy financer at a bank)". These participants do not collaborate to put innovations into the market which suits their profile: banker (risk averse) and a close related end-user (does not have the position to do that). Neither is climate change an important driver for collaboration "there are many other ways to handle that (P-12, a direct related heat customer)". Furthermore these participants are not per se sceptical towards collaboration, but they see hurdles on the road towards the collaboration: "So you must assume that in the future heat will not flow in the nets anymore" and "the costs should go down first before more collaboration will start driven by end-users" (End-customer heat).

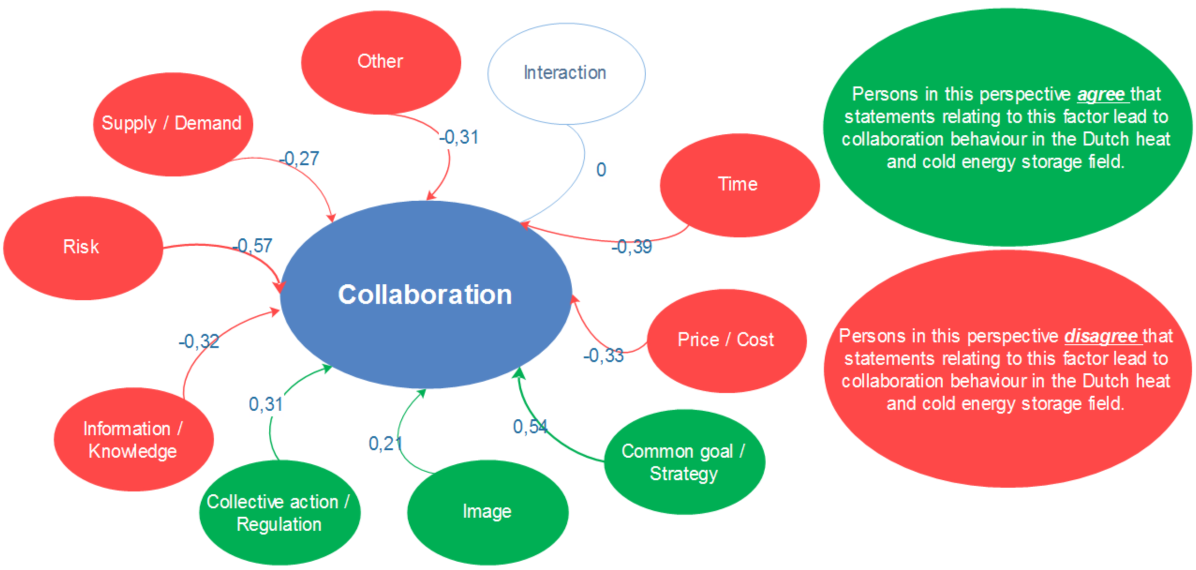


Quid pro quo perspective

Just like in other perspectives, the participants in this perspective put trust on the most agreed position as a condition before collaboration can start. Distinguishable for this perspective

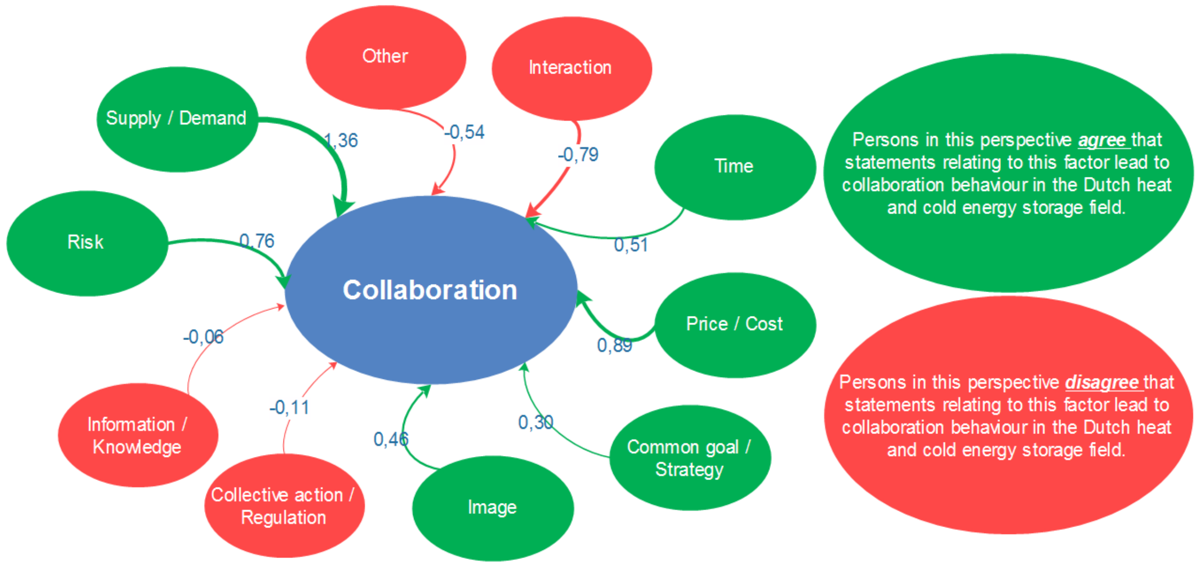
is the importance they put in a collective agreement or expectation in collaboration or a project. The expectation or gain from a perspective seems important "It is per se about getting the entire field towards sustainable heat, from my perspective also the parties should gain in order to get them moving (P-15)", also participant 2 commented "collaboration is time consuming, the negotiations etc., it might be much better for individuals to get a heat pump up and running, this would probably not develop the fields faster though" Despite the complexity in the field they do not agree (most disagree) that the complexity puts a burden on collaboration, "especially for that reason I would collaborate (P-5)". Next to that they do relate a lot of value to the repeating character of the collaboration "If you already know the other parties, you can save an enormous amount of time (P-2)".

They are also sceptical with relation to the inter comparability of heat and cold via different tax regimes within the Netherlands and put that on +4 in the ranking. In similar agreement they expect that more sustainability ambitions by the local government could create more collaboration. One of the participants commented that "heat should be the choice; however gas can still be lying next to it in the ground" (TKI). Herewith referring to the complexity of the market, but this can be bridged with collaboration.



Second Movers perspective

This perspective is known for a second-mover perspective, this cannot be generalized to risk aversive, but they do not take the first action in the market for collaboration and economic growth. It looks like they wait until goals are set by amongst others the government or they do not wait, but do see it as a task of the government to set goals and ambitions related to heat and cold. The distinguishing statements fifteen (Sustainable (local) government ambitions enable heat and cold initiatives *(+5*) and three (Collaboration exists because governments organise collaboration (-meetings) (*+3*) confirm that. Next to that the collaboration serves to ensure the recipients of heat. They do also have sustainability as a high aspect to collaborate. But most important is that they tend to wait to collaborate until the moment that infrastructure is provided by other parties.



Master of Science Thesis

Systems Engineering, Policy Analysis and Management

Jorick Weijers

TU Delft

Balance
Advies + Projecten + Interim

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