Analyzing the organizational complexity and related risks that influence the successful development in the front-end phase of innovative smart urban energy projects

- Using a Fuzzy Delphi Methodology and a Risk Diagnosis & Management methodology

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"Any darn fool can make something complex; it takes a genius to make something simple." (Pete Seeger)

Preface

This research concludes my graduation project for my master 'Construction Management and Engineering' at Eindhoven University of Technology. During my master it became clear that cities need to reduce the impact of urbanization through increasing urban energy efficiency and by switching to clean, low carbon resources. There is a need for smarter, integrated and sustainable solutions in the urban area to enhance this transition. But, realizing such successful smart and innovative projects appears to be difficult. Everything is changing so fast and projects have become more complex and dynamic in today's globally connected, competitive and fast changing world.
Based on these 2 challenges, I was determined to do research to a relatively unknown area for me to expand my knowledge on the subject's innovation, smart cities and project management. In order to have a contribution, this research focused on identifying the organizational complexity in innovative smart urban energy projects and by developing a risk diagnosis model to assess and diagnose the organizational complexity related risks.

The here presented master thesis represents the steps undertaken and the found research results. My appreciations and thanks go out to several people. I am grateful for their contribution, useful feedback, guidance, time and help. This master thesis had never been realized without them.

First of all, I would like to thank Ms. den Ouden, my first supervisor from Eindhoven University of Technology, for her process guidance, advice and vast expertise and support during my whole research. You introduced me to various theoretical concepts that I applied in my research. I greatly appreciate the guidance and time you spend on my research whenever I needed it. Additionally, I would like to thank Ms. Han, my second supervisor of the Eindhoven University of Technology, for her guidance during my graduation research and her advice and knowledge especially concerning the methodology. Your expertise of the Fuzzy Delphi Method and your guidance helped me to create valuable and practical outcomes which sharpened and structured my research.

Secondly, this graduation research would not have been possible without the help of all the enthusiastic experts. I am grateful for the experts who welcomed me and shared their interesting experience and knowledge during the interviews and case study. Therefore, I would like to thank all the experts who participated in this study.

Last but not least, I want to thank my family for their continuous support, motivation and friendly words during my entire study and my friends for their advice and moments of distraction.

I hope you will enjoy reading this graduation thesis and hopefully it will inspire you. Enjoy reading!

Stijn Kusters
Eindhoven
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Management summary

Smart Urban Energy (SUE) initiatives gets emergent attention due to the climate change, rapid growth of the urban population and the energy challenge. It is critical to develop our cities into intelligent and sustainable environments to counter those developments and It is clear that those developments are necessary for governments and municipalities to achieve and meet their objectives before 2030. Efficient design and engineering of innovative SUE projects is challenging and complex. Innovative SUE developments is not only the use of innovative technologies. Technology is most of the time not the problem but the organizational and management part is the key challenge for project success. It is about integral collaboration and co-creation where several partners from different sectors are working together with their own incentives, objectives but also with their own organizational cultures. Moreover, it is challenging because of the complex city, all the systems that are dependent and interrelated with each other as well as the many different stakeholders. It requires a different way of working from the organizations and people. The cooperation between multiple parties in innovative SUE projects results in organizational complexities and complex processes. Recognizing the Organizational Complexity (OC) is a great challenge and of importance in the management of today's projects and to enhance the development of Innovative SUE projects. The increasing complexity in projects and the underestimation of it is one of the main reasons for project failure. Therefore it is necessary to have insights in the OC and related risks that could arise in innovative SUE projects and to predict and deal with it in advance during the early phases of a project to avoid that it jeopardizes the project success.

The main aim of this study is to characterize and examine the sources of organizational complexity (OC) and to assess associated risks in innovative SUE projects. Analyzing the sources of OC in innovative SUE developments is necessary in order to facilitate and accelerate the successful development of SUE projects. Since the complexity changes during the project life cycle, this research focusses on the early project phases (front-end) where projects are considered more complex and uncertain.

The procedure of this research consists of both qualitative as quantitative elements. The study is structured along four main parts: (1) the theoretical part for characterizing innovative SUE projects and for conceptualizing the complexity concepts, (2) the development and quantification of the OC framework and its OC factors using the fuzzy Delphi method (FDM), (3) the development of an OC related risk diagnosis model (OCRDM) based on the FDM results and (4) a case study in which the OCRDM is applied on an innovative SUE project.

This study showed that addressing and analyzing the OC and associated risks create more certainty and awareness and makes SUE projects more manageable. The FDM findings showed insights in the OC that are relevant and arise in SUE projects. Top OC factors have been identified and the ambiguity, subjectivity and imprecision in complexity judgements have been reduced. 'Trust in and between the project team and stakeholders' and 'commitment and support of top management, users, partners' have been identified as factors contributing the most to the OC.
The developed OCRDM proved to be very useful in assessing and diagnosing the mechanisms OC related risks. The model enabled it to identify and focus on the weaknesses in the innovation process and it served as a decision-making tool for focusing on the risks that needs more attention. The OCRDM is useful for applying it in the SUE industry and it serves as a

decision-making tool on how complex on the organizational field a SUE project is and where this complexity and associated risks is situated. The results and the model allowed practitioners to pay attention to the OC factors and risks that are worth more attention. The model created awareness among the project team and it enabled to take a look at the risks in a holistic way but also on an individual way. It enabled to perform an analysis with multiple cross-sectoral people where they expressed their concerns in an equal unbiased way.

At this moment a transition has started towards more sustainable and smart urban areas. Still, innovative SUE projects often fail due to the organizational difficulties. The results of this research serve as an accelerator to the development of more successful SUE projects. However this research showed the importance of analyzing the OC and associated risks, it does not contain a blueprint for future innovative SUE developments. On the contrary, this study illustrates the importance of recognizing the main drivers of complexity and front-end analysis of complexity and risks in order to facilitate and accelerate the successful development and management of innovative SUE projects. It illustrates that such projects is real human work and that organizing SUE developments does not only requires insights in the process but also other skills. The developed framework and model should not be an end in itself, but a means to provide guidance between various partners in the decision making process about the organizational complexities and related risks.

Samenvatting

Slimme stedelijke energie (SUE) initiatieven krijgen opkomende aandacht vanwege de klimaatverandering, de snelle groei van de stedelijke bevolking en de energie uitdaging. Het is van cruciaal belang om onze steden te ontwikkelen tot intelligente en duurzame omgevingen om deze ontwikkelingen tegen te gaan en het is duidelijk dat slimme en duurzame oplossingen noodzakelijk zijn voor overheden en gemeenten om hun energie doelstellingen vóór 2030 te behalen. Echter, het blijkt dat efficiënt ontwerpen en engineeren van dergelijke innovatieve-projecten uitdagend en complex is. Innovatieve SUE ontwikkelingen gaat niet alleen over het gebruik van innovatieve technologieën. Opmerkelijk is dat technologie veelal niet het probleem is maar dat het organisatorische en managementgedeelte de grootste uitdaging vormt voor projectsucces. De uitdaging komt voort uit het integraal samenwerken en co-creatie waarbij verschillende partners uit verschillende sectoren samenwerken met hun eigen drijfveren, doelstellingen maar ook met hun eigen organisatieculturen. Bovendien is het een uitdaging vanwege de complexiteit van een stad, evenals de vele verschillende belanghebbenden en alle systemen die afhankelijk van elkaar zijn en onderling verband houden,. Het vereist een andere manier van werken van de organisaties en mensen. De samenwerking tussen meerdere partijen in innovatieve SUE-projecten resulteert in organisatorische complexiteit en complexe processen. Het erkennen van de organisatorische complexiteit (OC) is een grote uitdaging en van groot belang bij het managen van hedendaagse projecten die steeds complexer worden en om de ontwikkeling van innovatieve SUE-projecten te stimuleren en te verbeteren. De toenemende complexiteit in projecten en de onderschatting daarvan is een van de belangrijkste redenen voor het falen van projecten. Daarom is het noodzakelijk om inzicht te hebben in de OC en gerelateerde risico's die zouden kunnen ontstaan in innovatieve SUE projecten en om deze vooraf te voorspellen en te managen tijdens de eerste fasen van een project om te voorkomen dat dit het projectsucces in gevaar brengt.

Het hoofddoel van dit onderzoek is om de bronnen van organisatorische complexiteit (OC) te karakteriseren en te onderzoeken en om de bijbehorende risico's in innovatieve SUE-projecten te beoordelen. Het analyseren van de bronnen van OC in innovatieve SUE-projecten is noodzakelijk om de succesvolle ontwikkeling van SUE-projecten te faciliteren en te versnellen. Omdat de complexiteit tijdens de projectlevenscyclus verandert, richt dit onderzoek zich op de vroege projectfasen (front-end), waar projecten als complexer en onzekerder worden beschouwd.

De procedure van dit onderzoek bestaat uit zowel kwalitatieve als kwantitatieve elementen. Het onderzoek is gestructureerd langs vier hoofdonderdelen: (1) het theoretische deel karakteriseert innovatieve SUE-projecten en complexiteitsconcepten worden vastgesteld en geconceptualiseerd, (2) de ontwikkeling en kwantificering van het OC-raamwerk en de OC-factoren met behulp van de Fuzzy Delphi Method (FDM), (3) de ontwikkeling van een OC gerelateerd Risk Diagnosis Model (OCRDM) op basis van de FDM resultaten en (4) een case studie waarbij de OCRDM is toegepast op een innovatief SUE-project.

Dit onderzoek toont aan dat het adresseren en analyseren van de OC en de bijbehorende risico's meer zekerheid en bewustzijn creëert en dat het innovatieve SUE-projecten beter beheersbaar maakt. De FDM bevindingen toont inzichten in de OC en de bijbehorende risico's die relevant zijn en ontstaan in SUE projecten. Top OC-factoren zijn geïdentificeerd en de

ambiguïteit, subjectiviteit en onnauwkeurigheid in complexiteitsoordelen zijn verminderd. 'Vertrouwen in en tussen het projectteam en stakeholders' en 'betrokkenheid en ondersteuning van het topmanagement, gebruikers, partners' zijn geïdentificeerd als factoren die het meest bijdragen aan de OC.
Het ontwikkelde OCRDM bewijst functioneel te zijn bij het beoordelen en diagnosticeren van de mechanismen van OC-gerelateerde risico's. Het model stelt het in staat om structurele zwakheden in het innovatieproces te identificeren en het dient als een besluitvormingsinstrument voor het focussen op de OC gerelateerde risico's die meer aandacht behoeven. Het kan in de SUE-industrie worden gebruikt en toegepast en dient als een beslissingsinstrument voor hoe organisatorisch complex een SUE-project is en waar deze complexiteit en de bijbehorende risico's gesitueerd zijn. De resultaten en het model stellen vaklieden in staat om aandacht te besteden aan de OC-factoren en risico's die meer aandacht behoeven. Het model creëert bewustzijn bij het projectteam en maakt het mogelijk om de risico's op een holistische manier, maar ook op een individuele manier te bekijken. Het stelt het project team in staat om een analyse uit te voeren met meerdere intersectorale mensen waar zij hun bezorgdheid op een gelijkwaardige, onbevooroordeelde manier kunnen uiten.

Op dit moment is er een transitie gestart naar meer duurzame en slimme stedelijke gebieden. Toch falen innovatieve SUE-projecten vaak vanwege organisatorische moeilijkheden en uitdagingen. De resultaten geven inzicht in de OC en de geassocieerde risico's die zich voordoen in innovatieve SUE projecten waar integraal en cross-sectorale werken karakteristiek is. De resultaten dienen als een accelerator voor de ontwikkeling van meer succesvolle SUE-projecten. Dit onderzoek toont het belang van het analyseren van de OC en de bijbehorende risico's, echter het bevat geen blauwdruk voor toekomstige innovatieve SUE-ontwikkelingen. Integendeel, deze studie illustreert het belang van het herkennen van de belangrijkste drijfveren van complexiteit en front-end analyse van complexiteit en risico's om de succesvolle ontwikkeling en management van innovatieve SUE-projecten te vergemakkelijken en te versnellen. Het illustreert dat dergelijke projecten echt mensen werk is en dat het ontwikkelen van innovatieve SUE niet alleen inzichten in het proces vereist, maar ook andere vaardigheden. Het ontwikkelde raamwerk en model zouden geen doel op zich moeten zijn maar een middel om begeleiding te bieden tussen verschillende partners in het besluitvormingsproces over de organisatorische complexiteit en gerelateerde risico's die kunnen optreden.

Abstract

These days it is critical to develop our cities into intelligent and sustainable environments to counter developments as climate change, growth of the urban population and the energy challenge. Smart Urban Energy projects are necessary for governments and municipalities to achieve and meet their objectives before 2030. The mindset is present but why are those sustainable and innovative developments still not/slowly happening? Project results show that SUE developments are characterized as complex especially on the organization dimension. Technology is most of the time not the problem but the organizational and management part is the key challenge for project success. Therefore, recognizing the OC and associated risks is a great challenge and of importance in the management of innovative SUE projects and to enhance the development of such projects. Although literature and project results emphasizes that the organizational part is the key challenge, the underlying factors that influence this are not well understood and are poorly addressed. To increase the project success of SUE initiatives and to accelerate the development of our cities into intelligent and sustainable environments it is critical to identify the potential OC and associated risks in such projects as early as possible. Using the Fuzzy Delphi Method (FDM) the relevant OC factors are identified that could arise and influence the development of innovative SUE projects in the front-end phase. The results of the FDM are included in the OC related Risk Diagnosis Model (OCRDM) which has been applied on the Interflex case. This model enables it to assess and diagnose systematically potential OC related risks in innovative SUE projects that could jeopardize project success. The results show the importance of recognizing the main drivers of complexity and front-end analysis of complexity and risks in order to accelerate the successful of innovative SUE projects. It illustrates that such projects is real human work and that it does not only requires insights in the process but also other skills. The identified OC factors and developed OCRDM should not be an end in itself, but a means to provide guidance between various partners in the decision making process.

Key words: *Smart Urban Energy projects; Organizational Complexity; Organizational Complexity factors; Fuzzy Delphi Methodology; OC related Risk Diagnosis Model;*

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1. Introduction

Abstract: *This chapter introduces the research which include the following aspects. The research context will be discussed in section 1.1 followed by the problem definition in section 1.2. The research questions, objectives and limitations are introduced in section 1.3. Section 1.4 illustrates and explains the research design. The expected results are descried in section 1.5 and finally the research outline of this thesis report will be described in section 1.6.*

1.1. Research context

1.1.1. Background and motives

Over the last decades, it has become clear that the world cannot continue in the current way of energy production and consumption. The changes in climate and use of our resources has caused substantial impacts on human and natural systems in all continents and across all oceans (IPCC, 2014). The Earth is increasingly suffering from the environmental problems all over the world. These environmental problems occur due the growth of human welfare and the growth of human population. Moreover, the urbanization trend continues and cities will become even more dominant consumers of energy and other global resources.

In 2014, 54 per cent of the world population lived in urban areas. It is estimated that the world population will continue to grow to 9.2 billion people in 2050. It is predicted that 66 per cent of these 9.2 billion people will live in urban areas in 2050 (United Nations, 2015; World Energy Council & ARUP, 2016). During the twentieth century, there was a big expansion of the consumption of natural resources. The consumption of fossil fuels grew by a factor 12 (UNEP, 2011). The problem of these fossil fuels is that they are non-renewable and finite in their supply. Current energy sources run out and are clearly not sufficient for the future. Those energy sources cannot satisfy the even growing demand for energy in the next decades (Foidart, Oliver-Sola, Gasol, Gabarrell, & Rieradevall, 2010). It is predicted that there will be an increase of 48 per cent in the global energy consumption between 2012 and 2040 and fossil fuels will still account for more than three-quarters of global energy consumption through 2040 (EIA, 2016). Nowadays, cities are responsible for more than half of the global energy consumption and 40 per cent of all the greenhouse gas emissions (World Energy Council & ARUP, 2016). The biggest part of this energy consumption and emissions is due the built environment. A critical paradigm shift is required if problems like climate change, the energy crisis and exhaustion of resources needs to be effectively solved. It is critical for cities to switch to clean low carbon resources (renewable energy sources) and to increase urban energy efficiency to tackle abovementioned trends and problems.

Nations and cities finally acknowledge the problem based on the Paris agreement. The European Union (EU) has set itself binding energy targets for 2020 which are (EU, n.d.):

- Consuming 20 per cent less energy;
- Increasing the share of renewable energy to 20 per cent;
- Reducing greenhouse gas emissions by 20 per cent.

As a response to the agreements governments and cities translated the energy targets in their own ambitions. When it comes to this, cities are much more ambitious than their national governments. Municipalities translate the abovementioned objectives into more local oriented objectives and policies. For example, the municipality Eindhoven wants to become an energy neutral city during the period 2035 – 2045 (Gemeente Eindhoven, 2013) and the municipality Utrecht has the ambition to become energy neutral in 2030. As a result of these EU and municipal energy ambitions, smart and sustainable urban energy projects is subject to increased attention within cities and the EU. Developing our cities into intelligent and sustainable environments is one of the biggest challenges of our times. Enhancing sustainability and energy efficiency in urban areas is of high priority for sustainable development. Such projects aims at taking advantage from information and communication technologies to improve the quality of life of citizens and businesses, improve the use of resources and decrease the negative impacts on the environment (EC, 2015; Mosannenzadeh, Bisello, Diamantini, Stellin, & Vettorato, 2017; Washburn, et al., 2010). The EU acknowledged the emergency of such projects and it has become a major goal. Many Smart Urban Energy (SUE) projects were and are funded under the EU sixth and Seventh framework Program for research and technologic development (FP6 and FP7). Within this program 'smart cities and communities' is a subject of special attention. Even though most of the projects showed their technical success, these SUE development were also troubled with different barriers and uncertainties and were partly financed by the EU. Following the objectives of the national governments and municipalities, the mindset is present but why are those sustainable and innovative developments still not/slowly happening. It is clear that reducing the impact of urbanization through increasing urban energy efficiency and switching to clean, low carbon resources is evidently critical for cities to continue to thrive as engines of economic growth and to accomplish the set ambitions.

1.1.2. Problem definition

Besides the present mindset and awareness of smart and sustainable necessities in urban areas, the process of (re)development, responsibilities, business models and associated roles are changing. Everything is changing so fast and projects have become more complex and dynamic in today's globally connected, competitive and fast changing world where everyone has a wide access to resources and where there is the weight for cheaper, quicker and smarter solutions (Thamhain, 2013; Bakhshi, Ireland, & Gorod, 2016; Torok, Nordman, & Lin, 2011).

Addressing the complexity in projects is a great challenge in these times. The increasing complexity in projects and the underestimation of the project complexity is one of the main reasons for project failure (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011; Bakhshi, Ireland, & Gorod, 2016). This complexity could result in surprises throughout the whole lifecycle of a project which affects the project performance. Reason for this is for example due to increasing interconnections and interdependencies in our society and organizations. Moreover, there are structural changes in urban projects in the last two decennia according to Salet (2010). The dependency on the environment is increasing, the position of stakeholders is rapidly changing and the complexity and uncertainty of decision-making increased vastly (Salet, 2010). Also of big importance, research shows that organizational complexity factors and their significance are dominant (Bosch-Rekveldt, Mooi, Bakker, & Verbraeck, 2012; Vidal & Marle, 2008; Vidal, Marle, & Bocquet, 2011). Bosch-Rekveldt et al., (2012) concluded in their research that organizational complexity factors worried project managers the most in engineering projects. Some research even suggest that much of the root cause of project risks can be found to the organizational dynamics and multidisciplinary environment that characterizes today's business environment, especially for technology-based developments (Torok, Nordman, & Lin, 2011; Thamhain, 2013). This is due the many processes, people, technologies spread over different organizations, government agencies, customers etc. Therefore, complexity and especially organizational complexity is a great challenge for most projects nowadays and the literature recognizes the importance of it. Front-end analysis of this complexity becomes more and more important in the management of today's projects. To deal with this it is necessary to examine and understand the sources of complexity before the start of a project (Qazi, Quigley, Dickson, & Kirytopoulos, 2016; Thamhain, 2013; Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011).

Where project complexity and especially organizational complexity is mentioned of big importance, smart city projects are characterized as complex, uncertainty and dynamic, both in organizational as in the technical area (Weening, 2006). Those projects are becoming more complex due unexpected behavior and characteristics (Bakhshi, Ireland, & Gorod, 2016). Getting SUE projects of the ground is not only about applying technology. Those projects have to deal with the complex environment of cities, all their stakeholders, design approaches and rapid growth of new technologies (Zhao, Hwang, & Gao, 2016). Reports from the European Union and the city of Amsterdam shows that technology is not the problem. Such SUE projects requires new networking and management competencies due to the fact that those developments are often not implemented by one party (Winden, Oskam, Buuse, Schrama, & Dijck, 2016; EU, n.d.). Such initiatives take shape in networks with the involvement of different parties and citizens/end users (Winden, Oskam, Buuse, Schrama, & Dijck, 2016). Often a large number of actors are involved in decision making with their own (conflicting) perceptions, goals and interests. This results in an information deficit, lack of consensus and ambiguity in the decision making (Weening, 2006). Most important, the smart city subject has been poorly addressed in the literature from the managerial and organizational points of view (Moheno, Calzada, & Hernlandez, 2017). Winden, Oskam, Buuse, Schrama, & Dijck (2016) concludes in their research that technology is the easiest part. The most difficult part in smart city projects is the organizational and management issues. Although literature emphasizes that the organizational part is the key challenge, the underlying factors that influence this are not well understood. It is not clear what the organizational complexity in SUE projects is and what contributes to this. Understanding and examining the sources of the organizational complexity and associated risks in SUE projects is necessary to make it manageable and to improve project performance and eventually increase the development of SUE projects.

1.2. Research aim and research questions

The main aim of this thesis is understand and examine the sources of organizational complexity (OC) in SUE projects and to develop a hierarchical framework consisting of quantified organizational complexity (OC) components and parameters that can be used to evaluate the organizational complexity (OC) related risks in innovative SUE projects. Since the complexity changes during the project life cycle, this research focusses on the early project phases (front-end) where projects are considered more complex and uncertain.

In order to reach the main aim, an approach is needed to guide the process for achieving the main aim:
This research firstly proposes (1) to develop a theoretical framework. This include defining SUE projects and their characterization and investigating the OC for SUE projects. Next to that, it should include an outline of the organizational complexity concept. OC factors should be

identified and categorized according to the literature which could influence the development of innovative SUE projects. This framework serve as basis for evaluating the front-end OC in innovative SUE cases. The second aim is (2) developing a methodology for the evaluation of the OC framework for SUE projects using the Fuzzy Delphi Methodology. This should result (3) in identifying the most important OC factors and categorization for innovative SUE projects. A hierarchical framework will be developed consisting of OC parameters which can be used for evaluating the OC in innovative SUE developments. This framework will be used (5) for assessing and understanding the OC related risks and mechanisms in a selected innovative SUE case using the risk diagnosis model .

Resulting from the problem definition and objectives, the main research question that will be answered in this thesis is:

What are the most important sources of organizational complexity linked to the front-end phase of innovative SUE developments and how do the organization complexity and related risks influence the successful development and performance of innovative SUE developments?

In order to answer the main research question, five sub-questions are formulated which are the base of this research. These five sub-questions are:

1. What are the characteristics of innovative SUE projects and what makes those innovative SUE projects complex related to the organizational domain?
2. What theory about the OC derived from the literature applies for innovative SUE projects and what are the characterizations of the core concepts which can be used for evaluating the OC for such projects?
3. What OC categorization and OC parameters are recognized to be part of the OC and are relevant for developing an OC framework for analyzing the OC in innovative SUE projects?
4. What are the driving OC parameters in the development of innovative SUE projects that influence project performance?
5. How are the OC factors and associated risks contributing and influencing the project performance in the selected SUE case experienced by the different project professionals?
   a. How do the OC factors and related risks influence the project performance according to different project professionals?
   b. Is there a difference in perception regarding the OC and their influence on project performance between the different involved professionals with different backgrounds in innovative SUE developments?

Understanding and examining the sources of OC in innovative SUE developments is necessary in order to facilitate and accelerate the successful development and management of innovative SUE projects. Addressing the OC and associated risks create more certainty and awareness and makes SUE projects more manageable. The ultimate goal is to manage and master project complexity and associated risks which should result in a decrease of project failures and an increase in project performance.

1.3. Research design

The research consists of both qualitative as quantitative elements and it is based on four parts: (1) literature review, (2) model design, (3) results and (4) finalization. Based on problem statement and research questions the research design is structured as depicted in Figure 1-1. The first part is the development of a theoretical framework (purple box). An in-depth literature study is conducted to establish the research gap and it will serve as a base for this research. The review explores the background information, input information and methodologies information. The theoretical framework consist of the characterization of SUE developments, OC and complexity theory related to innovative SUE projects and it will function to identify and collect possible OC factors and categorizations related to innovative SUE projects. Based on this analysis a first selection and framework of OC factors will be made together with its categorization. The second part (green box) consists of the development and carrying out the Fuzzy Delphi Methodology (FDM). Based on the FDM results a Risk Diagnosis Model has been developed and applied on an innovative SUE project for validation and insights. To provide a complete overview of the OC parameters and their associated categorization it is necessary to scrutinize the most important OC parameters from the literature. The assessment of OC factors for SUE projects by experts is subjective of nature and results from the opinion of an expert. The Fuzzy Delphi Methodology (FDM) is the most suitable method for identifying the most important OC factors from the literature and to develop a hierarchical OC framework for SUE projects. Experts from the field with practical knowledge will be approached with a questionnaire. The theoretical framework together with the expert knowledge resulting from the FDM results in a hierarchical set of OC factors related to innovative SUE projects. These results has been used as input for the Risk Diagnosis Model to assess the mechanisms of the OC related risks and their impact on project performance. In Step 8, the Risk Diagnosis Model has been developed and applied on an innovative SUE case for validation and for assessment of the OC related risks on project performance. Experts related to the concerning case has been approached for applying the model by using a questionnaire and for reflecting on the results and model by using semi-structured interviews. It results in more theory building, increased understanding of the mechanisms of the OC factors and related risks and it provides insights in OC and related risks in SUE projects. Part three (yellow box) consist at analyzing the data and generating knowledge. This step will be supported by the input data from part one, two and three The last part, part 4 (blue box), is writing out conclusions and recommendations and consist of finalizing the whole research.

1.4. Expected results

The expected result and true value of the research is to have a framework and model which is specifically generated for innovative SUE projects that can be used as a basis to examine the OC and related risks for SUE projects. It provides a footprint of where the OC can be expected. Eventually, it will result in more theory building, increased understanding of the mechanisms of the OC factors and associated risks and it provide insights in the factors that could jeopardize the successful realization of the project objectives in the front-end phase of an innovative SUE projects.

The framework and model can be applied as guidance for practitioners in the SUE industry and can serve as a decision-making tool on how complex a SUE project is and where this complexity and associated risks will be situated. It results in a clear understanding of the critical OC factors and related risks and it allows them to pay attention to the OC factors and

risks that are worth more attention and to manage and master this. Understanding and examining the sources of OC and related risks in innovative SUE developments is necessary in order to facilitate and accelerate the successful development and management of SUE projects. It should finally result in valuable guidance for the management of the OC and related risks for professionals focusing on the development and implementation of SUE projects. It should support professionals in various management and strategic decisions to anticipate on potential difficulties and scarce resources will be allocated efficiently.
The framework aims at transforming linguistic complexity terms into a more systematic quantitative-based analysis. The strength of numbers is that it explains more than words. Top OC factors will be identified and discussed for SUE projects. Ambiguity, subjectivity and imprecision in complexity and risk judgements will be reduced. The judgement of assessing the complexity and risk is mainly linked to the subjectivity of the observer. This differ among parties and an objective complexity measurement is needed. By applying the outcomes on a real life case results in-depth understanding of the mechanisms of those OC factors and related risks.

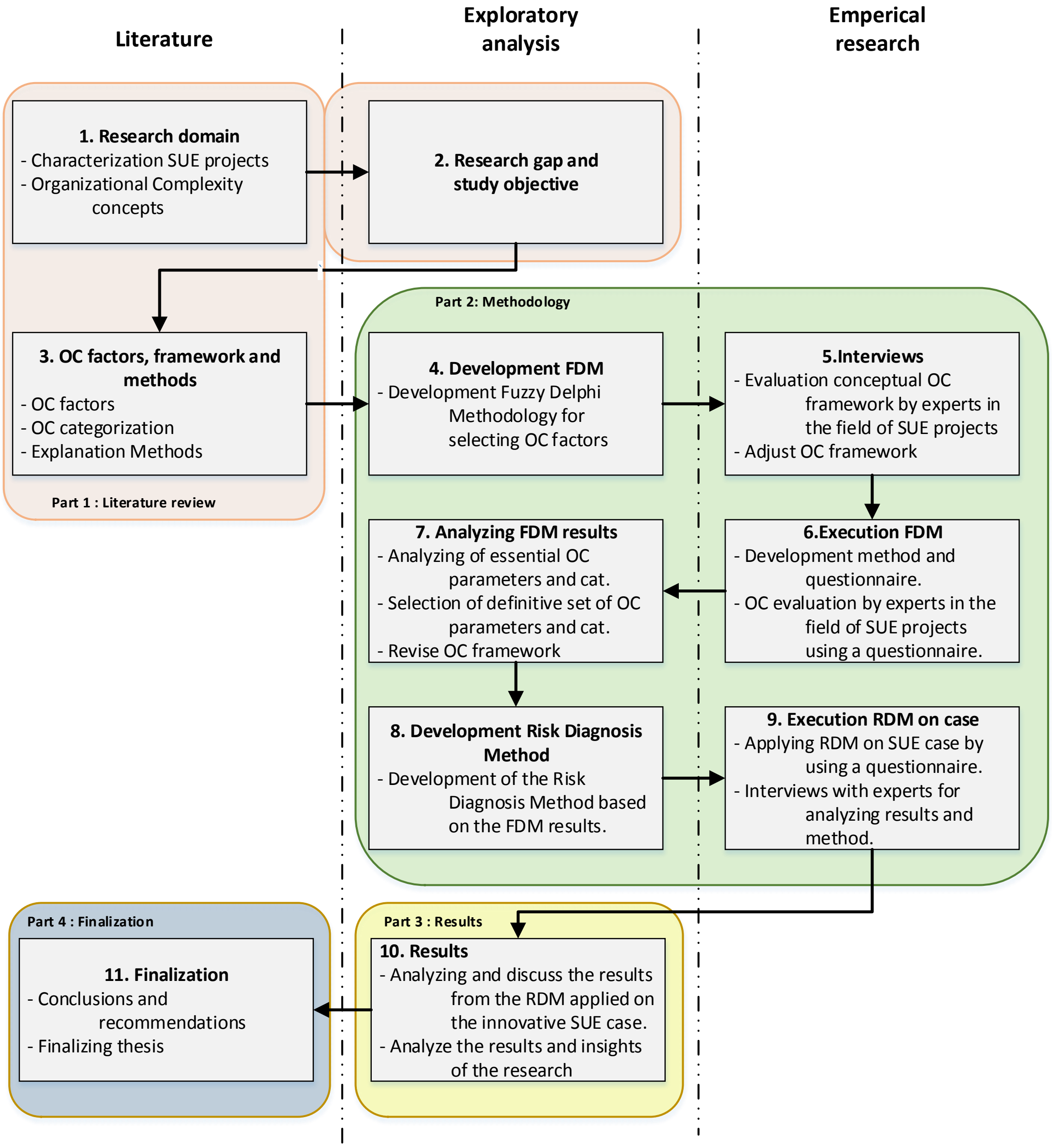

Figure 1-1: Research design.

1.5. Research outline

This research focuses on identifying the relevant OC factors and on the development of an OC related Risk Diagnosis Model especially developed for innovative SUE projects. This research mainly consists of four parts. The first part, chapter two and three, will introduce the relevant literature to the subject. Chapter two mentions the broad perspective and characteristics of the innovative SUE project concept and the organizational challenges. Chapter three presents a review of the state-of-the art literature concerning the (organizational) complexity theory that could apply for SUE developments. This literature review serves as basis for understanding the OC and for the development of an OC framework for analyzing the OC in SUE projects .

The second part of this research is focused on the development of an OC framework based on the literature review and it outlines the applied methodologies. Based on the outcomes, this part deals with the questions how the OC results can be combined in a conceptual framework, how this framework can be further analyzed by using the Fuzzy Delphi methodology and how these results can be used to further analyze and assess the mechanisms of the identified critical OC factors and related risks in innovative SUE projects. It outlines the development of the OC framework and the methodologies. The aim is to identify and assess the most important OC factors from the literature that influence the project performance the most in innovative SUE projects. The Fuzzy Delphi experiment will be set up in this part and the results will be discussed. Based on the FDM results all factors will be quantified and the most important OC factors will be identified that is used in the third part of this research.

The third part aims at getting more insights into the mechanisms of the OC related risks and to detect the factors that could jeopardize the successful realization of the project objectives in the front-end phase of an innovative SUE projects. It provides a practical application of the FDM results. The OC based Risk Diagnosis Model is constructed and applied on an ongoing innovative SUE case. The results and important insights will be discussed in this part.

Finally, the last part of this report, the conclusion, will discuss the findings that emerge from the different parts of this study and recommendations for future research are given.

2. The context and characterization of SUE projects

Abstract: *SUE initiatives gets emergent attention due to the climate change, rapid growth of the urban population and the energy challenge. It is critical to develop our cities into intelligent and sustainable environments to counter those developments. Efficient design and engineering of SUE projects is challenging and complex. But, it is clear that those developments are necessary for governments and municipalities to achieve and meet their objectives before 2030. It is necessary to understand SUE initiatives for further research. A literature study is conducted to understand the context and characteristics of such initiatives which enables it to link the OC concept with such projects. The literature shows an interrelationship between the sustainable city, smart city and smart energy city where SUE developments contributes to a smart energy city. In this chapter, the 5W + 1H model is used to characterize SUE projects. The holistic objective of such initiatives is to aim for economic, environmental, social and institutional sustainable growth of the city. Those innovative projects requires new networking and management competences due to the fact that those developments are not implemented by one party. Such initiatives take shape in networks with the involvement of different partners. Literature shows that the technical part of SUE projects is not the problem in SUE projects but the organizational and management part is.*

Keywords: *Smart city; Smart energy city; Characteristics; 5W + 1H model; Smart urban energy projects; Organizational issues; Organizational complexities.*

2.1. Introduction

It is necessary to characterize SUE projects for evaluation, further investigation and to examine the OC in the early project phases (front-end) where projects are considered more complex and uncertain. The characterization of SUE projects is needed to apply the OC theory on such projects. Different levels have to be addressed for answering the first research question. This chapter reviews the state-of-the art literature in the field of the research domain and how it contributes to this research. The literature review is completed according to a systematic review of the existing literature applying the search strategy in Appendix A. The literature on SUE developments is reviewed and synthesized. The research domain is explored alongside the following guiding research question:

1. *What are the characteristics of innovative SUE projects and what makes those innovative SUE projects complex related to the organizational domain?*

Section 2.2. describes the interrelationship between the sustainable city, smart city and the smart energy city and the role of SUE projects within these concepts. Section 2.3. analysis the definitions used in the literature and its key elements. Section 2.4. explores the key characteristics of SUE developments. As a result of the literature review on the topic, a model is presented with the identified characteristics. Section 2.5 shows issues and challenges in organizing SUE projects and section 2.6. discusses the local innovation ecosystem which is of importance in such developments. Based on this exploration, a discussion is presented in section 2.7.

2.2. Interrelationship sustainable city, smart city, smart energy city and SUE

SUE initiatives gets more and more attention during the past decade and it is an emerging concept in the urban development as response to the climate change, rapid growth of the population in urban areas and the energy challenges. These developments has strong consequences for people in urban areas especially on their livability and manageability (Chourabi, et al., 2012). To understand innovative SUE projects it is important to understand in what context such projects are developed and how these projects can be defined and characterized. The word 'smart' can be interpreted in many different ways which makes it a real container concept. Take the very popular term 'smart city'. Although the term 'smart city' is used very often, it seems that there does not exist one universally, widespread, unambiguous definition of a 'smart city' project (Vanolo, 2014; Mosannenzadeh, Di Nucci, & Vettorato, 2017; Albino, Berardi, & Dangelico, 2015; Bibri & Krogstie, 2017; Chourabi, et al., 2012). Present studies (Albino, Berardi, & Dangelico, 2015; Chourabi, et al., 2012; Bibri & Krogstie, 2017) attempts to analyze, based on an extensive literature review, the main definitions of a 'smart city'. They all concluded that definitions and interpretations regarding the term 'smart cities' is still unclear and inconsistent. It demonstrates that the 'smart city' concept is used in different contexts and meanings by differ privy. Different authors, institutions, companies, etc. define the concept in its own way which benefits themselves.

Where the term smart city is inconsistent, the literature do presumes an interrelationship between smart city, sustainable city and smart energy city. A smart city consists of domains. Cities have turned into a complex system of different systems/domains. Efficient design and engineering of those systems are challenging and complex because of those systems that are dependent and interrelated with each other as well as the different stakeholders from those different domains. Energy or smart energy city is presumed as one of the smart city domains/systems (Schleicher, et al., 2016; Nam & Pardo, 2011; Lazaroiu & Roscia, 2012; Mosannenzadeh & Vettorato, 2014; Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014; Albino, Berardi, & Dangelico, 2015; Centre of Regional Science Vienna UT, 2007). Neirotti et al., (2014) classified the smart city domains relevant to the urban development topic into hard and soft domains. According to the publication (Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014), hard domains refer mainly to office and residential buildings, energy grids, natural resources, energy and water management, waste management, environment, transport, mobility and logistics. Soft domains refer to areas as education, culture, policies, social inclusion, innovation and communication. Energy is part of the hard domain of a city but it interacts with the other hard and soft domains. Based on previous research, the conclusion can be made that smart energy city is a domain of the smart city. The energy domain interacts and overlaps with the other smart city domains. Researchers even think that the main aim of the smart (energy) city is to manage the urban energy footprint or to provide sustainable energy systems for urban areas (Mosannenzadeh, et al., 2017). SUE developments are part and contributes to the smart city and the smart energy city and their objectives. SUE projects are projects in the smart energy city domain which take place in urban areas that contributes to the development of a smart energy city.

The smart city objective consists of more than only the energy objectives. It aims at improving the sustainability, efficiency and quality of life through many urban domains (Mosannenzadeh & Vettorato, 2014; Nielsen, Ben Amer, & Halsnæs, 2013). Besides the relationship between the smart city and the energy domain, the literature also suggest an interaction between the smart city and the sustainable city. Sustainable city developments tries to improve and balance economic, environmental and social values and goals (Bibri & Krogstie, 2017). According to Shmelev & Shmeleva, (2009) the institutional aspects should be included as well.

The common objective of smart cities is to improve sustainability in cities with the help of new technologies. In smart cities there is a stronger focus on innovative technologies and ''smartness'' compared with sustainable cities (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017). According to Ahvennniemi et al., (2017) a city that is not sustainable cannot be classified as smart. Sustainable development in smart (energy) city initiatives cannot be neglected and aims at improving economic, social and environmental sustainability (Bibri & Krogstie, 2017). Knowing this, it can be concluded that the sustainable city and smart city are also related to each other and that the smart energy city, smart city and sustainable city are interrelated with each other. Figure 2-1 illustrates the interrelationship between the sustainable city, smart city and the smart energy city concept. The figure was compiled based on literature review and an expert focus group which consisted of six experts from different research fields and countries. The research (Mosannenzadeh, et al., 2017) shows that the sustainable city incorporates integration of social, economic, environmental and institutional facets. The smart city try to improve the sustainability of cities by applying information and communication technology (ICT), through collaboration of key stakeholders and by integrating the smart (energy) city domains. Innovative SUE projects are part of the smart energy city. Those projects contribute to the development of a smart energy city. It has the same features but SUE projects are developed in urban areas and could be developed within different smart energy city domains.

The characteristics of SUE developments are further explained in section 2.3. and 2.4. As mentioned before, the energy domain is part of the smart city. As illustrated in Figure 2-1, a distinction is made between real and labeled smart city and smart energy city developments. The developments are defined real when it is meeting sustainability requirements. So, if SUE project do not contribute to sustainability they are 'labeled' and are not classified as SUE developments (Mosannenzadeh, et al., 2017).

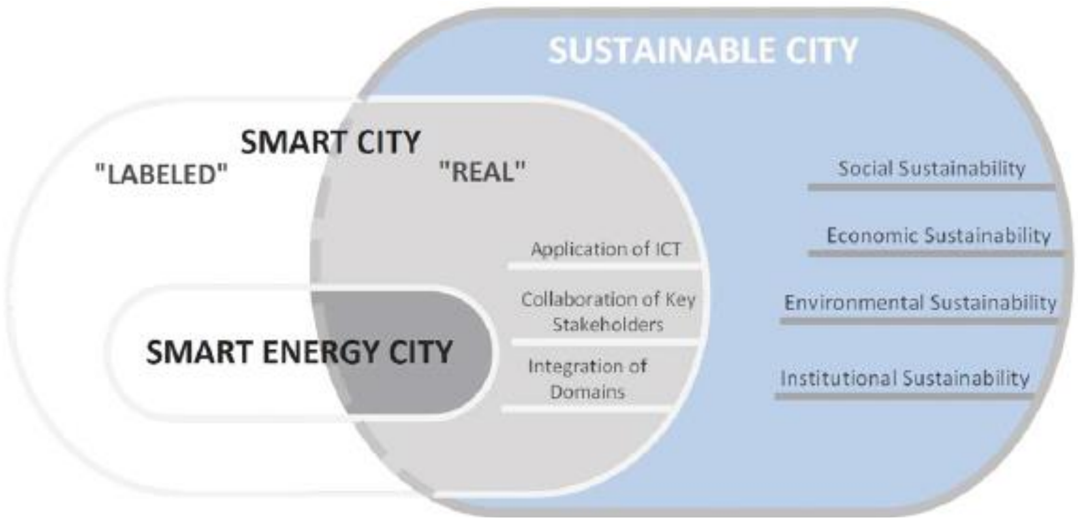

Figure 2-1: Relationship between sustainable city, smart city and smart energy city *(Mosannenzadeh, et al., 2017)*.

2.3. Definition SUE developments

It is important to have a working definition on the subject. Reviewing and analyzing the different definitions and used terms enables it to capture the core aspects. In the literature, many definitions are used for defining a smart energy city and for the term smart city. The urban part is most of the time not used in the literature. There is one definition from an urban planner's perspective (Mosannenzadeh, et al., 2017). Many search terms related to the SUE theory are used when reviewing the literature. Search terms related to SUE projects are for example: smart energy city/urban area, smart energy, sustainable city, smart and sustainable city. What has been noticed with the working definitions of 'smart cities' also applies for defining SUE developments. There is no overall consensus on one definition (Nielsen, Ben Amer, & Halsnæs, 2013). Table 1 provide an overview of a number of definitions derived from the literature based upon different perspectives.

Table 1: definitions smart (urban) energy cities/network/system.

Definition	Point of view	Source
*"The Smart Energy City (SEC) is highly **energy and resource efficient** and is increasingly **powered by renewable energy sources**; it relies on **integrated and resilient resource systems**, as well as insight-driven and innovative approaches to strategic planning. The application of **information, communication and technology** are commonly a means to meet these objectives. The Smart Energy City, as a core to the concept of the Smart City, provides its users with a **livable, affordable, climate-friendly and engaging environment** that **supports the needs and interests of its users and is based on a sustainable economy."***	Transformation of cities - objectives perspective	(Nielsen, Ben Amer, & Halsnæs, 2013)
*'A Smart Energy Network is a functional energy network system **consisting of grid, natural gas and district heating pipelines,** which improves **reliability, security, and efficiency** of the entire energy systems by enabling an **optimum integration of renewables, energy storages, and effective natural gas energy** applications with bulk energy generations and through implementing the **information and communication technologies** for achieving online monitoring and real-time simulation''.*	Technical – network perspective	(Chai, Wen, Nathwani, & Rowlands, 2011)
*''Smart Energy Systems are defined as an approach in which **smart electricity, thermal and gas grids are combined and coordinated** to identify **synergies** between them to **achieve an optimal solution** for each individual sector as well as for the overall energy system''.*	Technical – system perspective	(Lund, 2014)
"Smart energy networks use **advanced information and communication technology** to monitor and manage the transport of energy **from multiple fuel sources to meet the varying energy service demands of end users.** Four characteristics distinguish smart energy networks from other energy configurations: i) multiple fuels; ii) information and communication technologies; iii) energy service provision; and iv) integration''.	Technical – network perspective	(Belanger & Rowlands, 2013)
*''Smart energy city development is a component of smart city development aiming at a site-specific continuous transition towards **sustainability, self-sufficiency, and resilience of energy systems**, while ensuring **accessibility, affordability, and adequacy** of energy services, through optimized integration of **energy conservation, energy efficiency, and local renewable energy sources**. It is characterized by a combination of **technologies** with **information and communication technologies** that enables **integration of multiple domains** and enforces **collaboration of multiple stakeholders**, while **ensuring sustainability** of its measures''.*	Urban planner perspective	(Mosannenzadeh, et al., 2017)

The first thing to notice from the definitions in table 1 is that not one definition is specifically intended for SUE projects. Moreover, one concrete and unambiguous definition is missing. It really depends on the perspective of the party who is defining the concept. The definitions can be divided into definitions which are very technical and look at the network perspective (e.g. Chai et al., 2011) or at a system perspective (e.g. Lund, 2014; Belanger & Rowlands, 2013) or definitions which have a more holistic perspective which address it from a perspective of transformation (Nielsen, Ben Amer, & Halsnæs, 2013) and from an urban planner perspective

(Mosannenzadeh, et al., 2017). This does not mean that there are no similarities in the definitions or meanings that come back. Key components based on Table 1 which apply for SUE projects are:

- The first key element in all the definitions is the **system integration of the different resources and interoperability** of those resources. The systems in a SUE development cannot be seen as an isolated system. For example, energy is a combination of sources like gas, electricity, heating etc. Waste is also linked to energy and resources. Those different resources should be integrated and should work interoperable in the energy system;
- A second key element is the **accessibility** of **affordable, and climate-friendly** energy services. There should be access to an energy system which aims at environmental, social and economic sustainability.
- **Resilience** is the third element. This is a key factor because of the expected changes in the climate. A SUE development should aim for **resilience, sustainability and preferably self-sufficiency**;
- Another key element is **energy and resource efficiency** in a SUE project. This is essential because of the growing scarcity of energy sources and due the climate problem;
- The use of **renewable energy** is an essential element. It will prevent further climate changes and the system will be more resilient and efficient. But, a city cannot (yet) only function on renewable energy. This should be integrated in combination with other sources like gas;
- **Collaboration of different stakeholders** is an element which comes back in three definitions. If stakeholders are not actively involved and do not take their responsibilities then the system will not result in the expected outcomes (Nielsen, Ben Amer, & Halsnæs, 2013). Mosannenzadeh et al. (2017) conclude in their definition that **the integration with the other (smart city) domains** is also necessary;
- The combinations of **technologies with information and communication technologies** is an element which is stated in every definition. However, the use of these technologies are a means to achieve the objectives of a SUE project. It is not an objective on its own to apply those technologies but it is obvious that (new) technologies is an enabler to improve urban functions and to involve stakeholders;
- At last, everything should have the aim to **ensure sustainability**. It should influence the social, economic, environmental and institutional domain in the urban area. In the end, the quality of life should be improved which makes the city more livable.

Usage of the working definition of a SUE development:
Drawing on the review above, the definitions of Nielsen et al. (2013) and Mosannenzadeh et al. (2017) are most suitable for this research because those definitions are more holistic and comprehensive and both definitions are from an urban perspective. The working definition that will be used for this research will be the definition of Mosannenzadeh et al. (2017). This is due the following motivations:

- The definition is objective orientated but also includes important aspects of the smart city concept and the SUE concept while the definition of Nielsen et all., (2013) is mainly objective oriented. The remaining definitions are technical oriented and does not include a holistic view of the concept;
- The definition elaborates on the definition of Pezzutto et al. (2015) and Pezzutto et al. (2015) elaborated on the definition of Nielsen et al. (2013);

- It includes organizational components in the definitions like integration of (smart city) domains, system integration and stakeholder participation.

Figure 2-2 visualizes the definition using different aspects. Section 2.4. provide an in-depth literature review concerning those different aspects.

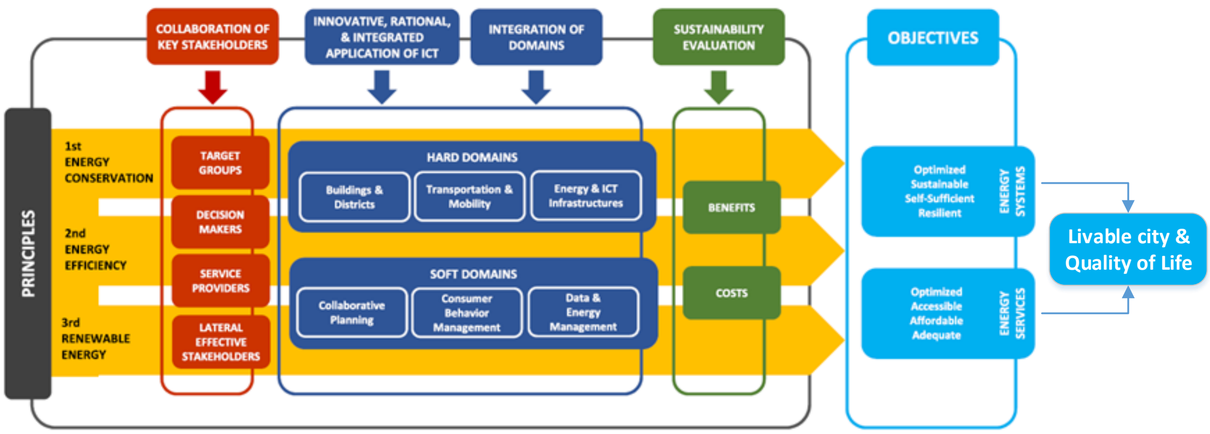

Figure 2-2: Visualization of the working definition of a SSUE development. Retrieved and adjusted from: (Mosannenzadeh, et al., 2017).

2.4. Characterization SUE development concept

Section 2.3. provide numerous definitions derived from the literature from different perspectives and the key elements regarding a SUE development. This section provide an in-depth conceptualization of SUE developments. The model 5W + 1H (why, what, where, who, when, how) is applied to guide the characterization of SUE developments systematically.

2.4.1. Objectives (why)

Many challenges and opportunities aroused in cities due the rapid global population growth, resource scarcity and the climate concerns. These developments are the main driver of smart city initiatives and innovative SUE developments. According to the literature (Nielsen, Ben Amer, & Halsnæs, 2013; Mosannenzadeh, Bisello, Diamantini, Stellin, & Vettorato, 2017; Mosannenzadeh, et al., 2017; Chai, Wen, Nathwani, & Rowlands, 2011) led these developments to specific SUE project objectives which could be:

- **Energy conversation:** the objective is the decline in energy demand;
- **Energy and resource efficiency:** fewer energy consumption for the similar level of services;
- **Renewable energy:** increasing the use of renewable energy sources;
- **Accessibility:** meeting the energy demand of the people by making the system more accessible;
- **Affordability**: improving the affordability of the energy system;
- **Resilience:** improving the resilience of the energy systems to for example climate change. The system should be more sustainable and self-sufficient for the future.

These specific energy objectives should contribute to more holistic objectives. Mosannenzadeh & Vettorato (2014) studied the main goals and drivers of smart city initiatives based on a keywords analysis in the literature. Governments aims mainly at improving the cities sustainability on economic, environmental, institutional and social domains. Examples are improving the quality of life, increase economic growth of the city or improving cities competitiveness. Industries are more concerned with pursuing economic growth, efficiency

and also competitive advantage. Academics are aiming for improving governance, communities and/or improving the environment.
In conclusion, SUE objectives contributes to more holistic objectives which are improving the economic, environmental, social and/or institutional sustainability of a city while every individual organization can aim for individual objectives within the project.

2.4.2. Domains of intervention (what)

Smart cities domains are identified as hard and soft domains which are the key fields for stakeholders to bring in their attention and investment (Mosannenzadeh & Vettorato, 2014). Smart cities should optimize the use and exploitation of tangible and intangible assets (Neirotti et al., 2014). Literature concerning SUE developments reveals that the domains of intervention are, according to Mosannenzadeh et al., (2017), also identified as hard and soft domains. SUE developments are new or existing developments in one domain or within both domains.
The SUE hard domains are identified as (EC , 2013; Mosannenzadeh, et al., 2017; Mosannenzadeh, Bisello, Diamantini, Stellin, & Vettorato, 2017):

- **Buildings and districts**: a distinction is made between existing and new developments.
- **Transportation and mobility:** this domain include the shift to new alternative vehicle technologies and renewable energy sources, multi- & intermodality solutions that improve the use of public transport nodes and improve the connection between nodes and transport modes and services. Additionally, it includes transport infrastructure solutions.
- **Energy and ICT infrastructure:** this is divided into electricity, thermal and data infrastructure. The transition to smart energy infrastructures contains a complex range of solutions. This include organizational, regulatory, technically and market design issues that are part of the soft domains (Mosannenzadeh, et al., 2017).

Mosannenzadeh et al., (2017) even add one more domain to it which is the **cross-cutting domain**. It is described as the solution that integrate all domains and their communication.
The SUE soft domains are identified as (Mosannenzadeh, et al., 2017; EC , 2013):

- **Collaborative planning:** these are tools that support coordination and communication of knowledge, data and stakeholder ideas. Furthermore, it enable collaborative decision making.
- **Consumer (prosumer, see section 2.4.3.) Behavior Management:** This domain is increasing the information and awareness amid stakeholders related to their options to reduce energy, about their energy consumption and the application of energy solutions. Additional, it includes demand management through changing consumer behavior.
- **Data & Energy Management:** This domain are activities that tries to optimize the energy system. This is both from the energy supply as the demand side. These solutions are for example forecasting, monitoring through collection, storage and transforming data.

Also in the soft intervention domains, Mosannenzadeh et al., (2017) adds the **cross-cutting domain** that bond the soft domains.
Hard and soft domains of intervention have a transversal link to each other. All the soft domains can be implemented within the hard domains (Mosannenzadeh, et al., 2017).

2.4.3. Stakeholders (Who)

Mosannenzadeh et al., (2017) divided the SUE stakeholders into four categories. These four categorizations included:

- **Decision makers**: influential people and organization at diverse administrative levels. Those have the obligation and ability to adopt and implement measures;
- **Service providers**: offer energy services to other stakeholders for charges;
- **Target groups**: the stakeholders who are intended to influence or are influenced with a SUE development;
- **Lateral effective stakeholders**: not directly involved but who can influence the behavior of other stakeholders in a positive of a negative way;

Another research (Perboli et al., 2014) tried to make a classification of smart city projects based on 28 European projects. The results show that energy is the most crucial sector to invest in (Perboli et al., 2014). Projects with multiple goals are the most important projects. Of these projects with multiple goals, energy was included 75% of the time. The other sectors, besides energy, were transportation, buildings, CO2 emissions, water, security, E-governance and social innovation (Perboli et al., 2014). Furthermore, Perboli et al. (2014) identified 5 key stakeholders in smart city projects. These are:

- **City**: cities or a part are always an active stakeholder;
- **Government**: public sector is involved in the analysis of the problem and they promote the implementation of possible solutions;
- **Small and medium sized enterprises**: enterprises are involved in smart city projects;
- **Universities**: researchers develop and create innovations and ideas;
- **Consumers/Citizens (prosumer[1])**: can be involved directly (test procedures or decisions) or indirectly (as end user).

Another practical research (Winden et al., 2016) about organizing smart city projects in Amsterdam, identified six different partners in every projects partnership. These are:

- **Public organizations;**
- **Private companies;**
- **Utilities;**
- **Non-governmental organizations (NGOs);**
- **Knowledge institutions;**
- **Citizens.**

Mosannenzadeh, Bisello, Diamantini, Stellin, & Vettorato (2017) used a case-based learning methodology to predict barriers for SUE project based on previous projects. One step of their research was characterizing the CONCERTO SUE cases. They characterize the project partners in 16 categories. These categories are (Friuli Venezia Giulia Region, 2013; EU, n.d.) mayors/politicians, city administration, utilities/energy service companies/networks operators, developers, architects/planners/engineers, housing/construction companies, renewable energy industry, other industries, component manufacturers, information and communication technology (ICT) companies, financial institutions, research and development (R&D) institutes/universities, inhabitants (owners, tenants, etc.) innovation/technology consultants, energy consultants, and transportation consultants. According to (Friuli Venezia Giulia Region, 2013) the main stakeholders that needs to be involved are local authorities,

[1] Not mentioned in the specific reference (Perboli et al., 2014) but added because of the importance due new insights in other literature (World Energy Council & ARUP, 2016; Olkkonen, Korjonen-Kuusipuro, & Grönberg, 2016; European Union , 2016).

energy producers, energy distribution and transmission operators, storage systems manufacturers, telecommunication providers, electric mobility authorities and householders. What can be concluded is that those 16 categories can be placed into the classification from Perboli et al (2014) and Mosannenzadeh et al., (2017) but that the classification of Winden et al (2016) is even more suitable due their separation of private organizations and utilities and knowledge institutions instead of universities. Which is remarkable in the literature regarding the stakeholders is that they only talk of consumers/citizens/owners/tenants. No attention is made regarding the term 'prosumers' which gets emergent attention in the energy field. Traditional consumers become energy prosumers. 'Prosumers' acts on both sides of the market where they consume and produce energy (World Energy Council & ARUP, 2016; Olkkonen, Korjonen-Kuusipuro, & Grönberg, 2016). Their role changes from passive to active where they can produce energy by local generation (decentralized energy system) (Arup; Siemens;, n.d.). The energy excess which they produce will be sold back the grid. In the future the energy will be traded within communities or between residents. Examples of prosumers are residential prosumers, community/cooperative energy, commercial prosumer and public prosumer (European Union , 2016). This is an important stakeholder which in many SUE projects should be incorporated.

The three different classifications all look like the Quadruple Helix Model. In this model, government, companies/industry, academia and civil participants/people, are working together and are interconnected to develop innovation solutions with the focus on the user (Leydesdorff, 2012; Arnkil, Järvensivu, Koski, , & Piirainen, 2010; Carayannis,, Barth, & Campbell, 2012). The classification of Winden et al (2016) is the most clear and concrete one. Furthermore, it is remarkable that in the reviewed literature nothing is said about prosumers. Prosumers is an emergent topic in research and especially in the transition SUE developments like decentralized energy systems/communities and smart grids. Prosumers should be included within the group of civil participants/people.

2.4.4. Initiator SUE projects

There are many stakeholders involved in an SUE development which are interrelated with each other and who collaborate during the whole development. Maier (2016) made a separation of smart city initiatives from an organizational perspective. The research classified smart cities in top-down smart cities, which are mostly initiated by city institutions, ICT and/or research facilities, or bottom-up smart cities which are mostly initiated by local citizens. Despite which perspective, the planning and implementation of SUE projects involves many stakeholders. Perboli et al., (2014) divided project initiators of smart city project into the private sector, public sector and mixed. Public sector like government entities aiming at enhancing the city sustainability and security while the private sector want to improve their efficiency and to get a competitive advantage. Based on the identified projects they concluded that 46% of the projects was initiated by the private sector, 36% was a mix of private and public parties and 18% was initiated by public parties. An important note is that these are smart city projects and those are not specially focused on SUE projects. SUE developed projects which are called the CONCERTO initiative, which is a European Commission program funded under EU Sixth and Seventh framework program (FP6 and FP7), shows public or public owned organizations as well as private organizations were the driving force behind the projects. But, local and regional departments have tended to be leading in those initiatives. In the majority of the initiatives, public authorities were coordinating the whole planning process. Even if the public authorities were not the initiator they were often cooperating as a key-stakeholder (CONCERTO, 2010). This is not a surprise because energy efficiency, less dependence on fossil fuels and sustainable planning is of big interest for public authorities.

2.4.5. Spatial (where)

Research (Mosannenzadeh, Bisello, Diamantini, Stellin, & Vettorato, 2017) characterized the already executed SUE projects on their spatial scale. The spatial scale of the projects were on the scale of building, district or city-wide. SUE projects include different scales in urban areas. Additionally, each different city and urban area has a unique environment related to the economic, environmental, social and institutional aspects. This results in different needs, capacities and priorities across the different cities. This makes a SUE development different for every city (Kitchin, 2014). The potential for SUE developments differs. SUE developments are not a priority in every city (or districts). It could be that there are other priorities like affordable houses or technically better houses. Neirotti et al., (2014) explains a variety of factors which can influence the development of smart initiatives. These are (Neirotti, et al., 2014):

- The size and demographic density of the city can matter. Bigger cities attract more human capital and rely most of the time on greater implementation of infra resources. However, smaller cities can be more suitable for pilot projects due their shorter installation time;
- Cities with a good economic situation and with a high GDP growth rate tend to get easier financial resources for smart city investments. Moreover, economic developed cities are more attractive for smart city initiatives because the people want to increase their quality of life;
- Technically developed cities intend to develop and adopt smart city initiatives earlier and easier. Additional, high R&D investments in both public as private sector results in cities that are more likely to develop smart city initiatives;
- Institutional factors can also influence smart city initiatives. For example, the level of corruption or political risks can influence the implementation of those initiatives especially from enterprises due the unstable political situation and uncertainties.

Furthermore, the potential is higher in cities with a flexible and accepting society and where the people who manage and operate the energy project are trained and experienced. Another factor is that the potential is higher in cities where regulations are updated especially in favor of new technologies. SUE developments in all countries can learn and benefit from each other but the SUE specific developments are always based on the local characters and context (Mosannenzadeh, et al., 2017).

2.4.6. How

How a SUE initiative will be developed is important but also difficult to answer. The projects executed within the CONCERTO initiative already shows that those different projects include already 63 different technologies (Mosannenzadeh, Bisello, Diamantini, Stellin, & Vettorato, 2017). As mentioned before each city has a unique environment related to the economic, environmental, social and institutional aspects. This also means that there is not one-size fits all solution for every city. However, there are some principles that apply for every SUE developments to meet their objectives.

- The first principle is the use of **innovative technologies and in particular ICT** (Chai, Wen, Nathwani, & Rowlands, 2011; Nam & Pardo, 2011; Mosannenzadeh, et al., 2017). It is an element which is stated in every definition shown in section 2.2.2. However, the use of these technologies are a means to achieve the objectives of a SUE project. It is not an objective on its own to apply those technologies but it is obvious that (new) technologies are an enabler to improve urban functions and to involve stakeholders. In SUE developments is the use of **renewable energy** an essential element. But, a city cannot (yet) only function on renewable energy. This should be integrated in combination with other sources like gas and technologies.

- The second principle is the **integration with other domains** (Chai, Wen, Nathwani, & Rowlands, 2011; Nielsen, Ben Amer, & Halsnæs, 2013; Mosannenzadeh, et al., 2017). These new innovative technologies should be **integrated** with the other energy system components which should lead to an improved interoperability of the SUE components.
- The third principle is **stakeholders active collaboration** (Chai, Wen, Nathwani, & Rowlands, 2011; Nielsen, Ben Amer, & Halsnæs, 2013; Mosannenzadeh & Vettorato., 2014; Nam & Pardo, 2011; Chourabi, et al., 2012). It ensures improved collaborative relationships between stakeholders. It also enables joint decisions and it leads to more effective implementation of the energy initiatives. Prosumers in different forms are important concerning this third principle as mentioned in section 2.4.4.

2.4.7. Temporal (When)

SUE developments should be a constant improvement of the urban energy domain (Mosannenzadeh & Vettorato., 2014). When looking at project specific then there are no real implications related to how long SUE developments should take. It is only important to finish the project to the agreed project time because of risks and financial consequences.

When looking at time in general then there are some commitments made between parties which means that there are some obligations regarding time. These are for example:

- Covenant of mayors for climate & energy: this is a commitment of several local and regional authorities who voluntarily committed to implement EU climate and energy objectives on their territory. One commitment is that municipalities who signed this covenant are obliged to reduce CO_2 emissions in their municipality by at least 40% before 2030. Another commitment is to increase the resilience by adapting to the impact of climate change. More than 7000 local and regional authorities across 57 countries signed the covenant. At least 27 municipalities in the Netherlands signed this covenant (European Commission , n.d.).
- The European Union has set itself binding energy targets for 2020 (EU, n.d.). These are consuming 20% less energy, increasing the share of renewable energy to 20% and reducing greenhouse gas emissions by 20%.
- Many Dutch cities translated those targets into their own targets which are even more ambitious. For example, the municipality Eindhoven wants to become an energy neutral city during the period 2035 - 2045. The ambition is to become an energy neutral city, exclusive mobility, before 2035 and to become it, inclusive mobility, before 2045 (Gemeente Eindhoven, 2013). Other examples are the municipality Utrecht who wants to become energy neutral before 2030 and the municipality Groningen before 2035.

There are time limits for developing SUE projects due to the made commitments by the European Union, governments and municipalities. To achieve those targets it is necessary to develop numerous SUE projects.

2.5. Issues and challenges in organizing SUE projects

There is literature about challenges which concerns smart city initiatives and grey literature about organizing smart city initiatives. Chourabi et al., (2012) proposed a set of factors (Figure 2-3) that are important for understanding smart city initiatives/projects. This framework, developed and based on an extensive literature review. This smart city initiative framework, shown in Figure 2-3, explains the relationships and influences between the factors and smart city initiatives. Each of the factors is important in examining smart city initiatives according to Chourabi et al., (2012). Each factor has a two way impact in smart city initiatives where the outer factors are influenced more than the inner factors (technology, organization and policy). The inner factors are the key factors which have a direct impact on the smart city and the outer factors have an overall impact on the smart city (Solano, Casado, & Ureba, 2017). As the framework shows the organization factor is part of the inner factors. The organizational factor is the most important one for influencing the OC but the other factors also include factors related to the organizational complexity.

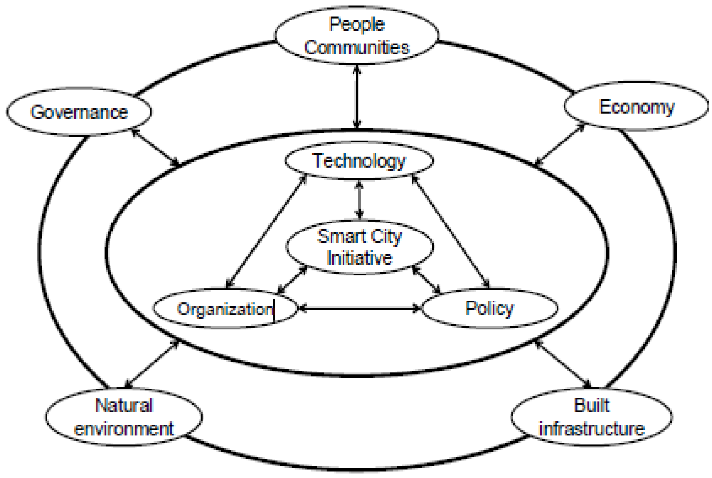

Figure 2-3: Smart city initiatives framework (Chourabi, et al., 2012).

Organizational and managerial challenges in such initiatives are (Chourabi, et al., 2012; Gil-Garcia & Pardo, 2005): the project size and the diversity of the users and organizations involved. Another challenge is the lack of alignment of organizational goals and project multiple or conflicting goals. Furthermore, individual interests, manager's attitudes and behavior leads to resistance to change, turf issues and conflicts. This is based on e-government initiatives but there is much in common with SUE projects which are also often driven by governments/municipalities and are also part of a smart city. Ebrahim and Irani (2005) investigated technological challenges related to the organizational categorization. These challenges are cross-sectoral cooperation, inter-departmental coordination, unclear vision and management strategy, politics and political impact, cultural issues and resistance to change.

Cities felt a need for better governance to manage smart city initiatives and projects because such initiatives involves multiple stakeholders (Chourabi, et al., 2012). According to Scholl et al. (2009) stakeholders relations is one of the critical factors that determine if a project will be successful or not. This stakeholder's relation refers to the ability to cooperate amid stakeholders, structure of alliances, support of leadership and working under diverse jurisdictions. Another factor that is important for good governance of such initiatives is the presence of leadership (Chourabi, et al., 2012). Good governance is stated as an significant characteristic of a smart city which his based on citizen participation and public private partnerships (Chourabi, et al., 2012).

One part that is important are the people and communities in cities and their involvement in smart city initiatives. SUE initiatives have an impact on citizens quality of life and it often aims at participatory citizens. They could be key stakeholders which can influence the success of an initiative. They should not only be seen as individuals but also as groups and communities with wants and needs. Furthermore, people and communities is a factor which is sensitive in SUE projects. Such projects should balance the needs of various communities (Chourabi, et al., 2012). A challenge is the digital divide which reproduces other forms of inequalities in societies (Scholl, Barzilai-Nahon, Ann, Popova, & Re, 2009) and how people and communities should participate in such projects/initiatives.

Developing smart city and SUE solutions and getting it off the ground is not only about applying the technology as mentioned before. It is also about new management and networking competencies. Such initiatives take shape in networks with the involvement of citizens/end users (Winden, Oskam, Buuse, Schrama, & Dijck, 2016). The Smart City subject has been poorly addressed from the managerial and organizational points of view (Moheno, Calzada, & Hernlandez, 2017). Winden, Oskam, Buuse, Schrama, & Dijck (2016) analyzed a number of smart city projects in Amsterdam on their managerial angle. They analyzed 12 smart city projects in Amsterdam in three key themes in urban sustainability (energy, mobility and circular economy). They excluded projects which were just started and the projects should be complex in terms of partners/stakeholders. Therefore, simple projects were excluded. Available documents and reports were used and also in-depth semi-structured interviews were held. The study (Winden, Oskam, Buuse, Schrama, & Dijck, 2016) provided some key insights regarding the initiation, development and execution of smart city projects. These are (Winden, Oskam, Buuse, Schrama, & Dijck, 2016):

- The partnership should fit the project scope and must be open to new input;
- The project scope and focus should be clear and shared by all partners involved. This is especially vital when projects have multiple partners. Each party should be transparent about its intended ambitions, objectives and expectations;
- Projects benefit from clear ownership and committed project leadership. Involved partners have to agree that the project is valuable and they must commit resources to it. All partners must have clear incentives in joining the project, especially citizens or end users;
- User involvement is a multi-layered and ongoing process and different users should be approached in a different way. The level of user involvement depends on the goal and type of the project. New roles and relations arise;
- Engagement of users and community building is a complex process requiring more time and effort than was usually envisioned at the start of a project;
- Value of the project needs careful consideration and evaluation;
- Creating a viable and clear business model is key to continuation and upscaling of the project. Translating sustainable and social value into a continuous revenue stream is important to increase the possibility of successful upscaling;
- Technology itself is not the problem. It is the way technology is used and integrated. Many projects fail because of the project underestimate the reluctance of people and organizations to change their behavior and routines;
- Upscaling is a multi-layered process and cannot prosper without sharing knowledge.

Besides those key insights there are also some issues (European Innovation Partnership on Smart Cities & Communities, 2017):

- Partnership and communication with citizens is very important especially when there are many partners involved. Communication is vital with the citizens;
- Project leadership and ownership after the subsidy ends. Many projects failed on this part and the project stops when the subsidy ends;

- A transparent system for sharing risks & returns is desired. Be explicit and clear from the beginning and throughout the process. Be clear about the risks and returns and how to divide them;
- Commitment at the top level of the participants is key;
- Technology is the easiest part. The more difficult parts are the legal issues, organizational issues, management issues, the business model and so on.

2.6. The role of a local innovation ecosystem in SUE projects and their OC

An important aspect in SUE developments is the stakeholders active collaboration. It ensures improved collaborative relationships between stakeholders. It also enables joint decisions and it leads to more effective implementation of the energy initiatives. Developing innovation, such as in SUE developments, is a complex process and is ever more dependent on inter-organizational activities that complement each other and that go well beyond internal capabilities and normal exchange relationships (Iansiti & Levien, 2004; Adner, 2006; Winden, Braun, Otgaar, & Witte, 2014). Previous sections provide factors like interdependence between stakeholders and sharing resources/people in SUE projects. Such networks where organizations combine their offering with the aim of creating and providing an overarching value proposition is frequently discussed as an innovation ecosystem (Adner, 2006). A report of the European Union (Edelstam, 2016) is saying that smart cities has a strong focus on the interaction between regional and local level in the innovation ecosystem. This includes stakeholders from all sectors and exchange of international experiences. The report also concludes that a key area to understand is the dynamics of the innovation ecosystem and how to govern it to support the transformation of cities (Edelstam, 2016). The objective of the report (Edelstam, 2016) is to increase understanding how a local innovation ecosystem around smart cities can add value to this transformation. Those ecosystems contribute to new innovations, new forms of collaboration and participation and new business and investment models. The basic assumption is that local innovation ecosystems are strategic assets in city transformation (Edelstam, 2016). The concept of the innovation ecosystems can be linked to SUE developments and their organizational complexity. SUE projects are often part of an local innovation ecosystem where multiple stakeholders are actively collaborating in a network. According to Galen (2015), an ecosystem is typically characterized by a complex network composed of:

1) Highly interdependent and differentiated stakeholders that depends on each other for their effectiveness, performance and survival;
2) Stakeholders are brought together by their vision of value creation and to pursuit a common set of goals and objectives;
3) Stakeholders complement each other by their assets and capabilities in order to produce an integrated solution for the end user/customer.

SUE project are characterized as projects where stakeholders are actively collaborate together which is necessary to achieve the intended objectives. So, a SUE development as a whole is dependent on its stakeholders. This is also the case in an innovation ecosystem where the system as a whole is dependent on its distinct stakeholders and vice versa. This implies that failure of a (key) stakeholder negatively influences other organizations in the system (Iansiti & Levien, 2004; Adner, 2006; Moore, 1993; Adner & Kapoor, 2010; Williamson & De Meyer, 2012). A serious challenge is to align goals and objectives of the different stakeholders. Stakeholders try to influence the ecosystem structure to align it with their own interests (Galen, 2015; Williamson & De Meyer, 2012; Wilkinson & Young, 2002). This makes it a complex factor also due the multitude of stakeholders with their own roles, assets and capabilities. The multiple stakeholders typically chase a diversity of goals, intentions and strategies based on prior vested interests (Moore, 1993; Williamson & De Meyer, 2012; Kapoor & Lee, 2013). This diversity (background , cultures) could result in decisions and actions among stakeholders that follow misaligned and diverse paths (Adner, 2006; Williamson & De Meyer, 2012). Galen (2015) concluded in his research that factors which influence how stakeholders reach alignment were:

- Misalignment between similar organizations (intra-organizational): this misalignment results due differences in interests, visions, expectations and strategies. Furthermore, in general organizations act from self-interest and intra-organizational relationships are superficial and hardly transparent.
- Misalignment between different organizations (inter-organizational): every organization have different drivers and role in a project. This results in misaligned interests and/or strategies which then results in a challenging collaboration setting.
- Existence of contrasting organizational characteristics: this causes difficulties during the collaboration which can be attributed to a high level of misunderstanding, mistrust and incomprehension.

Local and regional innovation ecosystems is an important part of smart city developments and therefore also for SUE developments. This collaboration with different stakeholders should be incorporated in the OC.

2.7. Discussion

Considering the literature analysis, this chapter is established to answer the first sub-question: *What are the characteristics of innovative SUE projects and what makes those innovative SUE projects complex related to the organizational domain?*

It is important to notice that for answering this first sub-question the state of the art literature is mainly focused on the smart city concept and not specifically for SUE projects. However, this does not mean that the findings does not apply for SUE projects. As explained, it is even clear that the SUE concept is linked and part of the smart city concept.

The literature presumes an interrelationship between the sustainable city, smart city and smart energy city concepts. The sustainable city incorporates integration of the economic, environmental, social and institutional aspects of a city and tries to improve the sustainability of it. The smart city concept is related to the sustainable city which means that a smart city development should always aim at improving the sustainability of the city otherwise it cannot be classified as smart. The smart city concept aims at improving the sustainability, efficiency and quality of life through many urban domains with the application of ICT and new technologies, by collaborating with the key stakeholders and by integrating the smart urban domains. Energy is presumed as one of the smart city domains. Those findings indicates that SUE projects are projects that contribute to the development of the smart energy city domain and moreover the smart city as a whole. For this reason, based on the existing literature, SUE projects can be classified as part of the smart city concept which means that characteristics of the smart city and its projects could also apply to a certain extent in SUE projects.

Zooming in on the literature about SUE developments it becomes clear that it is strongly related to smart city projects. The objectives of a smart city are reflected in SUE objectives. They improve the sustainability by declining energy conversation, energy and resource efficiency, use of renewable energy, improve accessibility of energy, improve affordability and improving the resilience of the energy systems. Those objectives contribute to more holistic objectives of smart cities and the sustainable city which are improving the economic, environmental, social and/or institutional sustainability of a city such as improve quality of life and improve the livability of city. A SUE development has also the ultimate goal to improve quality of life and the livability of a city. Although the existing literature is mainly focused on smart cities and smart city projects, it is clear that SUE projects are strongly related to it.

Analyzing the different literature about the definitions and the key elements enabled to capture the core aspects of a SUE projects and to identify what makes it complex and challenging in an organizational way. The hard and soft energy domains in which the interventions take place have to deal with the complex environment of cities, all their stakeholders and dynamic environment. The application of smart city projects and in this case SUE projects is not only about applying technology. Even more interesting is that the technology is most of the time not the problem but the organizational and management part is the key challenge. Those innovative SUE projects requires new networking and management competences due the fact that those developments are not implemented by one party. Such initiatives take shape in networks with the involvement of various partners. As the literature shows, collaboration with different stakeholders is needed otherwise the intended results will not be achieved. The cross-sectoral cooperation is a challenge in such projects where stakeholders from different sectors are working together. Often a large number of actors are involved in decision making with their own perceptions, goals and interests. Furthermore, SUE projects are challenging and complex because of the complex city, all the systems that are dependent and interrelated with each other as well as the many different stakeholders.
Regarding the organizational complexity aspect, there is little data available about this aspect associated with SUE projects. A Shortcoming in the literature is that the smart city/SUE subject has been poorly addressed in the literature from the managerial and organizational points of view. It is not clear what complexity contributes to this in SUE projects and how it affects the project performance. Some key insights and challenges are provided in initiating a smart city initiative but those are mentioned in a general and superficial way. More important, no research is done with a scientific basis concerning the OC in smart city initiatives and in this case SUE developments. This chapter discuss the core aspects of SUE developments but a deeper understanding is needed to the complexity theory, how to analyze and understand the complexity and associated risks in such innovative SUE projects and how this is related to the project performance. The next chapter provide scientific research about the OC which is used to investigate the OC topic in SUE developments.

3. Organizational complexity

Abstract: *In recent years, several complexity frameworks have been proposed to be used as aid to determine the complexity in several different projects. Many of those frameworks were developed for specific type of projects and not for SUE projects. To increase the project success of SUE initiatives and to accelerate the development of our cities into intelligent and sustainable environments it is critical to identify the potential OC in such projects as early as possible. This chapter presents a review of the state-of-the art literature on organizational complexity that could apply for SUE developments. It serves as basis for understanding the OC and for the development of an OC framework for analyzing the OC in SUE projects further on in the research. Several complexity concepts have been studied and discussed. Eventually, 70 possible OC factors and 4 classifications were identified from the literature which could apply and be used to examine and evaluate the OC for SUE projects. This literature study enabled it to develop a conceptual OC framework to examine and evaluate the OC in SUE projects and it provided fundamental knowledge for further research towards the OC in SUE projects..*

Keywords: *Organizational complexity; Complexity theory; Project complexity; Organizational complexity factors; Complexity and risks;*

3.1. Introduction

Chapter 2 mentioned the broad perspective and characteristics of the concept of SUE developments and their interrelationship with smart (energy) cities and sustainable cities. Chapter 2 also shows that SUE developments are complex due they are characterized with multiple stakeholders, networks of stakeholders, sectors, technologies and fields of research that should collaborate. Different issues and challenges occurs especially in the organizational field. This chapter presents a review of the state-of-the art literature concerning the OC that could apply for SUE developments. This literature review serves as basis for understanding the OC and for the development of an OC framework for analyzing the OC in SUE projects further on in the research. The literature review is also done according to a systematic review of the existing literature applying the search strategy in appendix A. The literature on OC are reviewed and synthesized on different quality and content criteria (appendix A). The research domain will be explored alongside the following guiding research questions:

2. *What theory about the OC derived from the literature applies for innovative SUE projects and what are the characterizations of the core concepts which can be used for evaluating the OC for such projects?*

Section 3.2. describes the (organization) complexity in general and in SUE projects and the relevance of investigating it. Section 3.3. analysis the organizational complexity from the viewpoint of the complexity theory. Section 3.4. views the organizational complexity from a project complexity perspective. Furthermore, section 3.5. explains the process of identifying the OC categorizations and OC factors. It also provide reasoning why those factors should be further investigated. Section 3.6. details important issues in an innovation ecosystem which SUE initiatives are often part of. Section 3.7. explains the linkage between complexity, uncertainty and risks. This is important because it provides more context to this research. Based on this exploration, a discussion is presented in section 3.8.

3.2. Relevance of the organizational complexity in SUE projects

Literature provide a limited articles about complexity and the relevance of OC in smart city projects which can be related to SUE projects. As mentioned before, getting SUE developments of the ground is not only about applying technology but that it requires new networking and management competencies due the fact that those developments are not implemented by one party (Winden, Oskam, Buuse, Schrama, & Dijck, 2016). Smart city projects are characterized as complex, both on organizational as on technical content. The complexity in such projects arise from the many involved stakeholders who are dependent of each other, but also the technical system and physical network that will be developed is complex because of all the components which are interconnected (Weening, 2006). Weening (2006) perceives smart city projects as complex systems that are characterized as incomprehensible and in which unexpected interactions occur which confuse coordinating actors. Dynamic reinforces this confusion even more. Smart city projects are also subject to unpredictable changes e.g. changing actor groups. According to Weening (2006), the organizational complexity consists of dynamic, nonlinear processes and unpredictable outcomes. These nonlinear processes and unpredictable outcomes arise from the variety of components and (inter)relationships in and around the organizational system which someone is trying to manage. This makes initiating and developing a SUE project real complex.

Addressing complexity is a great challenge in these times. The increasing complexity in projects and/or the underestimation of the project complexity is one of the reasons for project failure (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011; Bakhshi, Ireland, & Gorod, 2016). Reason for this are for example due the increasing interconnections and interdependencies in our society and organizations. Moreover, there are structural changes in urban projects in the last two decennia according to Salet (2010). The dependency on the environment is increasing, the position of stakeholders is rapidly changing and the complexity and uncertainty of decision-making has increased enormously (Salet, 2010). OC covers a wide area of complexity in projects and research shows that organizational complexity factors and their significance are dominant in project complexity (Bosch-Rekveldt et al., 2012; Vidal & Marle, 2008). But when analyzing the term complexity then not one universal definition is available for what it exactly is. The business dictionary defines complexity related to the organizational dimensions as follows:

‘’Condition of having many diverse and autonomous but interrelated and interdependent components or parts linked through many (dense) interconnections. In the context of an organization, complexity is associated with (1) interrelationships of the individuals, (2) their effect on the organization, and (3) the organization's interrelationships with its external environment. How these interrelationships arise and how they enable the organization to evolve, is not well understood’’.

When reviewing the literature two dominant thoughts within the construct of organizational complexity are identified. The first perspective is the complexity theory (part of system theory) and then especially applied in organizational sciences. The second perspective is the project complexity theory. These two perspectives are discussed in the next sections to better understand the theories concerning the OC aspects that could apply for SUE initiatives and to provide a basis for analyzing the OC for SUE projects.

3.3. Concept of complexity theory

3.3.1. Explaining the complexity theory

Complexity theories is a term that serves as an umbrella for numerous developed theories and research by different scientific disciplines (Burnes, 2005; Parwani, 2002). Burnes (2005) argued that *'complexity theories are concerned with the emergence of order in dynamic non-linear systems operating at the edge of chaos'*. Which means that systems are continuously changing and where cause and effect seems not to apply. Those systems emerge in various fields like chemistry, biology, physics. People who apply complexity theories to organizations argue that organizations (systems) are complex, dynamic, non-linear self-organizing systems in which the results of their actions are unpredictable (Burnes, 2005; Stacey, 2007; Burnes, 2004), but which are governed by a set of simple order-generating rules (Burnes, 2005). Hatch & Cunliffe (2012) argues that complexity refers to the number and diversity of the elements in an environment that are interacting and which change and evolve constantly. Hatch & Cuncliffe (2012) also mentioned the rate of change which refers to how rapidly these elements change. The higher the complexity and the higher the rate of change the higher the uncertainty within an organization/environment. Small change in non-linear systems can drastically change the behavior of the whole system or even large change can have little or even zero effect. This is called chaos (Anderson , 1999).

3.3.2. OC within the complexity theory

Organizations must be complex adaptive systems encompassing the many interacting agents who are behaving in nonlinear ways (Hatch & Cunliffe, 2012). Organizational complexity emerge from the variability of components and the (inter)relationships between those components that make up a system (Meulman, 2017; Boisot & Child, 1999). Meulman (2017) argued that the components in the organizational system are not all tangible of nature but numerous of these components are intangibles (e.g. experience, expectations, perceptions, etc.). Garud, Gehman, & Kumaraswamy (2011) argued that sustaining innovation is a complex process because it involves interactions between networks of technologies and people from multiple levels of organizations and through macro and micro levels of an organization. They also argued that the innovation process is nonlinear, with many up's and downs and dead-ends which can results in a variety of outcomes (Garud, Gehman, & Kumaraswamy, 2011). Backlund (2002) defines complexity in organizations as complex when the behavior, inner structure and processes are complex. The structure of an organization is complex when (Backlund, 2002):

- The organization consists of many components or subsystems;
- And/or there are many relations and/or interactions between the components;
- And/or these relations are not symmetric;
- And/or when the arrangement of the components and/or subsystems is not symmetric.

The processes of an organization are complex when (Backlund, 2002):

- Many parts of the organization are involved in the process;
- And/or there are many phases in the process and the matter-energy or information reaches many states or is transformed many times;
- And/or there are many different kinds of matter-energy and/or information involved in the process.

According to Garud, Gehman, & Kumaraswamy (2011) complexity involves four types of complexity that are inherent in innovation processes. These four types of complexity are (Garud, Gehman, & Kumaraswamy, 2011):

- **Regulative complexity:** This complexity refers to the collection and use of routines or rules that form a 'grammar' that governs how elements can be combined or used. This 'grammar' could be understood as being more or less complex. This is especially in terms of its variety;
- **Manifest complexity:** complexity that arises through the spreading of diverse artefacts in the organization. These artefacts could be tangible and intangible (e.g. services, people, products, departments, committees). The higher the variety in these artefacts, the harder it gets for people to understand and make sense of this variety;
- **Relational complexity:** complexity that emerge due the combinations or interactions between heterogeneous actors. The actors are heterogeneous in terms of objectives, visions or stakes;
- **Temporal complexity:** complexity that arise from non-linear dynamics of processes. This complexity is driven by differences in rhythms and time delays.

Meulman (2017) states that **emergent behavior** is the common dominator of those four types of complexity. Meulman (2017) also argued that each type of complexity is driven by a mixture of factors from different categories. For example, Manifest complexity emerge from the variety in departments, committees and types of products.

3.3.3. Relevance and usage of the complexity theory for SUE projects

Complexity theories are a way of understanding and changing organizations (Burnes, 2005) and for understanding and explaining the (un)intended effects of control (Meulman, 2017). These theories are mainly focused on single organizations and their change through the time. Please note, a SUE project is in fact temporal organization which involve a variety of organizations and stakeholders who work together to achieve a goal. Temporary organizations are characterized as ex- ante limited duration, high degree of novelty, uncertainty and risk, missing routines, ambiguous hierarchy, heterogeneity and diverse project team and a more informal coordination (Hanisch & Wald, 2014). As a result, cross-sectoral collaboration is needed resulting in a variety of interconnected and interdependent parties.

Usage of the complexity theory

The characteristics in this section reflects the OC in a general way and for (permanent) organizations. It is not focusing on specific OC for temporary projects like SUE initiatives. This does not mean that there are not elements and complexity factors that does apply for SUE developments. What can be concluded is that the OC contains according to the complexity theory of **dynamic, nonlinear processes and unpredictable outcomes.** Simple **cause-and-effect** relationships between parts do not apply. These nonlinear processes and unpredictable outcomes arise from the **variety of components, uncertainty and (inter)relationships/interdependencies** in and around an organization. These are the general components of the complexity theory which also apply for SUE developments. The four types of complexities described by Garud, Gehman, & Kumaraswamy (2011) also applies for the organizational complexity in SUE projects. All four types of complexity includes OC factors. But these types of complexity still make it a bit vague without real concrete examples. It can be concluded that this section describes complexity in general for organizations. It lacks aspect like user involvement and concrete OC factors.

3.4. Concepts of project complexity

Project complexity is next to the complexity theory an important subject of attention in the literature to explain organizational complexity. It is especially relevant for this research because SUE developments consists of a temporarily project organization consisting of a variety of organizations and stakeholders. This section will provide an in-depth review of organizational complexity factors in project complexity. This will result in a more concrete practical understanding of the organizational complexity.

3.4.1. Explaining project complexity theory

Baccarini (1996) defined complexity in projects as '*consisting of many varied interrelated parts'* in which it can be operationalized into terms of differentiation and interdependence. This is in line with the system theory where it is commonly defined in terms of differentiation and connectivity (Klir G. , 1985). Bakhshi, Ireland, & Gorod (2016) defined project complexity based on an extensive literature review (420 articles) with the following key words: interdependence of the elements (tasks, teams, etc.), cause-and-effect relationships between parts does not exist, predictability and control is reduced, unclear scope and boundaries, decentralized project governance and autonomous teams, self-organized and adaptable, low transparency (objectives, process, methods) and diversity of resources is heterogeneous. Baccarini (1996) divided the project complexity into technical and organizational complexity. Another research (Qureshi & Kang, 2015) argued that project complexity consists in various forms like social, technological, environmental and organizational complexity. But most importantly, research shows that organizational complexity factors and their significance are dominant. Bosch-Rekveldt et al., (2012) concluded in their research that organizational complexity factors worried project managers the most in engineering projects. Additional, Vidal & Marle (2008) contended that roughly 70% of project complexity factors are organizational. OC covers a wide area of complexity in projects which makes it relevant to analyze and understand it. However, understanding the complexity does not automatically assume controllability and reducing this complexity but it is suggested that it support project management (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011). This section attempts to provide insight into the perceptions of the OC from a managerial angle for innovative SUE projects. Research in project complexity especially in the construction sector primarily focuses on the following areas (Luo, He, Jaselskis, & Xie, 2017):

- (1) Influencing factors contributing to project complexity;
- (2) Impact of project complexity;
- (3) Complexity measurement methods;
- (4) Managing project complexity.

This research aims to explore the research domain concerning the organizational complexity. The research area which is about the (1) influencing OC factors and (2) impact of these factors are most important to investigate for this research. However, the remaining two focus areas could be interesting when it is focusing on the OC. This research focuses on the OC and not on the project complexity as a whole. Some researches about project complexity will be discussed because of the importance in de development of project complexity through time and because a major part is about the OC. An overview is given of the used studies in appendix C.

3.4.2. Comparison of previous research

As mentioned, Baccarini (1996) published a review about the concept of project complexity. Williams (1999) continued on the concept of Baccarini where the concept was distinguished into two complexities: structural complexity and uncertainty. Williams (1999) argued that structural complexity (a project's underlying structure) included multi-objectivity and multiplicity of stakeholders. It was also argued that uncertainty (a project's uncertain or changing nature) is a categorization of complexity because it added to the complexity of a project. The above mentioned studies focused on the structural complexity and uncertainty. Research shows also softer aspects and influences from the environment that influence the complexity of projects (Geraldi & Adlbrecht, 2007; Bruijn, Jong, Korsen, & Zanten, 1996; Jaafari, 2003). Bruijn, Jong, Korsen, & Zanten (1996) breaks down the project complexity in technical, social and organizational complexity. The OC increases when (Bruijn, Jong, Korsen, & Zanten, 1996):

- Project becomes more ambitious: involved people increases and more groups arise;
- Increasing in scale: the same applies for this as for the more ambitious;
- Processing time becomes longer: new political and technical insights may arise, project goals may change and parts should be done again;
- Inadequate project organization: responsibilities and decision making powers are unclear;
- Time pressure is greater: could lead to undisputed specifications.

Furthermore, they (Bruijn, Jong, Korsen, & Zanten, 1996) assumed OC to be related to the project team, actors involved, organization structure, interests and the projects risks and consequences related to its environment.

Geraldi & Adlbrecht (2007) looked at causes and impact of other characteristics of complexity like uncertainty, multi-culturally, etc. They distinguished it in the complexity of fact, faith and interaction.

- Complexity of fact: refers to complexity due the amount of interdependent information;
- Complexity of faith: refers to complexity which is involved in creating something unique (uncertainty, dynamism and flexibility);
- Complexity of interaction: refers to the complexity of interaction which take place between people and organizations. It includes factors like empathy, politics, ambiguity.

The research (Geraldi & Adlbrecht, 2007) concluded that complexity of interaction was most intense and where people, internationality, multidisciplinary, and clients were the most important factors of complexity.

Complexity frameworks

Based on the previous research several researches developed complexity models and frameworks. Vidal & Marle (2008) developed a project complexity framework that can assist the understanding and management of project complexity. This model was developed for project managers. The research argued (Vidal & Marle, 2008), based on an extensive literature review on project management and project complexity, that project complexity can be characterized as technical or organization complexity factors. Those numerous factors are divided within four classifications which are the drivers of complexity. Vidal & Marle (2008) argued that those classification are: project size, project interdependence, project variety and elements of context. The research shows 48 organizational complexity factors and 21 technological complexity factors all divided within the four classifications.

Subsequently, Vidal, Marle, & Bocquet (2011) tried to define a measure of project complexity. The research identified multiple characteristics of project complexity. They reduced the characteristics to 18 complexity drivers using a Delphi study (38 respondents). 16 off these 18 complexity drivers were characterized as organizational and only 2 as technical. Most of the drivers were related to the project interdependencies (61.1%).

Bosch-Rekveldt et al., (2011) believes that project complexity is uncertain and should include structural, dynamic and interaction elements. This is in line with section 3.3. Bosch-Rekveldt et al., (2011) developed, based on existing work and 18 semi-structured interviews in 6 projects in the process engineering industry, a (TOE) framework for characterizing project complexity in large engineer projects. It includes fifty elements which are divided into the categories: technical (T), organizational (O) and environmental (E). Those categories are further divided into sub-orderings (T: goals, scope, tasks, experience, and risk; O: size, resources, project team, trust, and risk; E: stakeholders, location, market conditions and risk). The organizational category exists of 21 complexity elements. Some sub-orderings within the category technical and environment should be categorized within OC in this research. For example, aspects like goals and the variety and dependencies of stakeholders is part of the OC. This conclusion is partly confirmed by Bosch-Rekveldt, Mooi, Bakker, & Verbraeck (2012). They continued the research of Bosch-Rekveldt et al., (2011). A survey study (67 responses) was performed within the Dutch process engineering industry to evaluate the complexity framework of Bosch-Rekveldt et al., (2011). Results from this research (Bosch-Rekveldt, Mooi, Bakker, & Verbraeck, 2012) showed significant correlations between several factors of the framework and the perceptions of the respondents on technical, environmental and OC. As other research also argued (Vidal & Marle, 2008), the OC attributed the most to the project complexity. Results also showed that technical complexity factors, which was assumed that they contribute to the project complexity, have merely organizational implications according to the respondents. E.g. goal alignment, clarity of goals, conflicting norms and standards and uncertainties in scope had a correlation with the organizational complexity. The same applies for the environmental factors.
Bosch-Rekveldt (2013) changed for another research the TOE-model specifically to analyze the complexity of construction projects. Factors that were added were:

- Organizational factors: cultural differences, number of clients, quality of the contract, availability of resources, discontinuity in staffing and accessibility and logistics;
- Environmental factors: instability of project environment, experience of environmental partners, media influence, social impact, conflicting law and regulation and planologically/legal procedures.

Based on previous theoretical frameworks (Vidal & Marle, 2008; Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011) Qureshi & Kang, (2015) aims with their study at identifying and modelling the OC factors and their interrelationship. The structural equational modelling method was used in this research. Qureshi & Kang (2015) also used the division of size, variety, elements of context and interdependencies (Appendix D). The valid responses were 150 questionnaires from project management professionals working in four different geographical locations. Results showed that project variety and interdependences contribute the most to the organizational project complexity.

The research of Bakhshi, Ireland, & Gorod (2016) explores the development of project complexity through time. This article is about all the project complexity factors. The research examined more than 420 published research papers to show the present understanding of commonalities and differences in the literature. They concluded that there are three primary dominant schools of thoughts regarding complexity in projects. These are the Project Management Institute view, the System of Systems view and the view complexity theories view. Accoring to Bakhshi, Ireland, & Gorod (2016) *'each project consist of autonomous and interdependent parts and different structures that belong to the same project and are connected to other parts and systems in the project. Furthermore, the collection of actors, tasks and systems in the project are diverse and can generate unexpected emergent properties'.* Based on the examination of these three schools and perspectives the paper proposes seven dominant elements in project complexity. All project complexity factors can be divided under these seven project complexity drivers: These drivers are (Bakhshi, Ireland, & Gorod, 2016): context, autonomy, belonging, connectivity, diversity, emergence and size. What should be said is that this subdivision include all three perspectives but is mainly based on the system of systems theory. The study identified more than 125 complexity factors in their literature review. Finally, it resulted in an integrative systemic framework (Figure 3-1). Figure 3-1 shows the most important project complexity factors according to the number of citations in the literature review of the research. When comparing this framework with other studies (Qureshi & Kang, 2015; Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011; Vidal & Marle, 2008) many of the factors in the figure are organizational in nature.

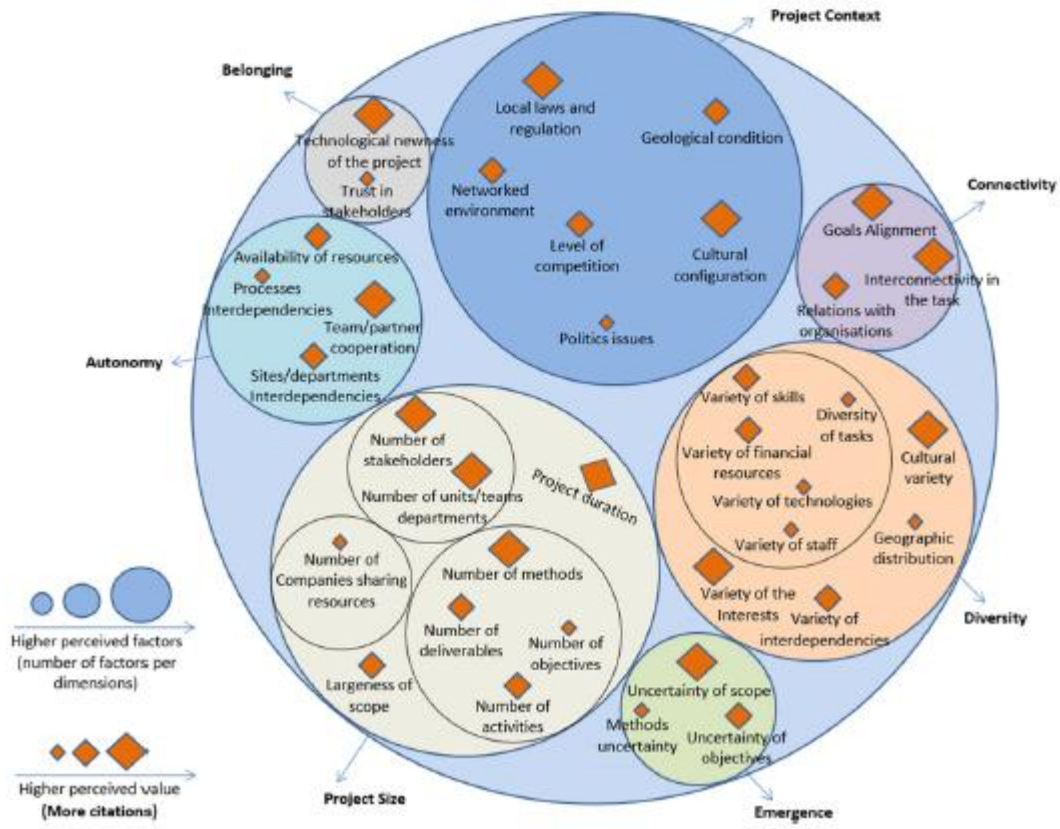

Figure 3-1: Project complexity factors according to the number of citations (Bakhshi, Ireland, & Gorod, 2016).

Finally, another paper (Rebentisch, et al., 2016) developed a framework to measure organizational complexity. The aim was to make this complexity visible and more easy to control for project managers. Four categorizations of organization complexity were identified in their broad literature analysis as shown in Figure 3-2. These categorizations are (Rebentisch, et al., 2016):

- **Diversity**: plurality of elements of organizations and their environment. It encompasses multiplicity and variety of elements;
- **Interdependence:** link or influence of different sorts between entities. It is often linked with interactions and influences between entities;
- **Ambiguity:** uncertainty of meaning. Multiple interpretations are possible. It can be defined as too much information with less clarity. It covers richness accuracy and availability of information. Increased ambiguity is encouraged by a declining predictableness within an organization but also outside the organization. When looking at the external perspective of an organization then it can be described as unpredictable change of the business environment and market conditions;

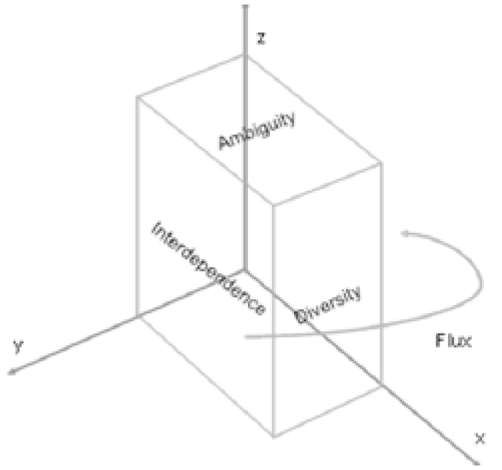

Figure 3-2: Four categorizations of organizational complexity (Rebentisch, et al., 2016).

- **Flux:** this categorization surround the other three categorizations. It highlights the constant change and adaption to changing conditions. This flux could be inside or outside the organization.

Furthermore, 44 factors were identified in the literature (Stracke, 2016) which contribute for the emergence of OC. These were clustered in 8 different clusters of OC (Rebentisch, et al., 2016; Stracke, 2016). According to Rebentisch, et al (2016) and Stracke (2016) these clusters have no influence on each other which makes them independent. Those 8 clusters were: inter-dependence, objective (incentive) alignment, operating standard procedures, information systems, management hierarchy, location, culture and personality. The research also present a ninth cluster (context of complexity). This cluster represents factors which appear in the context of complexity. It surrounds the eight clusters constantly. It exhibits that there is a constant flux and ambiguity around the eight clusters.
So each factor is subdivided in one of the four subdivisions and in one of the eight clusters. Only the complexity criteria are used which can be assigned to one of the four categorizations and only internal OC factors are used (Stracke, 2016). Complexity factors outside the organizational boundaries were not used.

Usage of the project complexity theory
The literature in this section reflects the OC from the perspective of projects and project managers. It compares previous research about project complexity. The complexity theory describes complexity more in a general way. Project complexity makes it more concrete and clear. This research is focusing on specific OC factors for projects which could be applicable for SUE initiatives. Several (organizational) complexity frameworks are identified in the literature. Those frameworks are developed for project managers in the engineering industry and/or for product development projects. Those frameworks with different categorizations and OC factors can be used to evaluate the O for SUE developments. It provides concrete OC factors which makes it much more clear for SUE projects. Furthermore, the studies are executed mostly in the large engineering sector, construction sector or product development sector. These are mostly temporary projects such as SUE developments. This makes it relevant and applicable for SUE developments.

3.5. Identification OC categorizations and factors influencing the OC

The conducted literature review specifically function as method to identify and collect possible OC factors for SUE projects. The literature under investigation had to fulfill some basic requirements for the identification of OC factors and categorizations. Only scientifically recognized literature will be considered in this thesis and the results should scientifically be proven. Furthermore, the literature have to align with the complexity research area. By setting those restrictions, a reliable result can be established. Based on the comparison of the previous literature and a content analysis, a set of OC factors and categorization is identified and selected from previous research. The content analysis is appropriate as a method to select OC factors and their categorization (Hwang, Zhao, & Gay, 2013; Osei-Kyei & Chan, 2015). It analysis the number of times that a factor occurred in previous relevant and comparable studies. Based on this analysis a first selection of OC factors and categorizations has been made. An example of the content analysis is provided in Table 2. It provide an overview of the possible OC categorizations.

Further, a total of 70 OC factors are obtained by using the content analysis on previous research. Two OC factors were added to this list because those were explicitly mentioned as important and complex in the grey literature in section 2.5. These two added factors are project leadership and user/community involvement. An overview of all OC factors and categorizations from the literature review is provided in appendix D. It details the number of times a factor is mentioned in the previous research related to the OC. For further research these 70 factors should be filtered and scrutinized to get a more clear and concrete framework for SUE projects. This reduction of OC factors is due a threefold reasoning. First, OC factors that are mentioned more often in previous studies can be considered as more likely to influence the OC. Second, there is a chance for overlapping factors due the different frameworks in the literature. Factor could have (almost) the same meaning and purpose and it is not desirable to have overlapping factors in the framework. Third, by reducing the magnitude of the OC framework, a more clear and concrete OC framework will be developed which proven to be influencing on SUE projects. Another benefit is the length of the questionnaire wherein the OC factors are examined. By reducing the factors, the lengths of the questionnaire decreases which will lead to more convenient responses. The obtained possible OC factors and categorization will only be used as input, and will be reevaluated and revalidated by experts in the next methodology section. Re-evaluating and revalidating these possible OC factors will contribute to the reliability of this research. The overview of all OC factors and categorizations from the literature review is given in appendix D

Table 2: Content analysis of the categorizations regarding the organizational complexity

Source	Interdependency	Size	Elements of context	Variety	Diversity	Ambiguity	Flux	Resources	Project team	Trust	Risk	Belonging	Emergency	Autonomy	Research area	Perspective of complexity	Reasoning dimensions
Stracke (2016)*	x				x	x	x								Product development projects	Organizational complexity	Literature review; *Cluster analysis;
Vidal & Marle (2008)	x	x	x	x											Project management	Project complexity	Literature review;
Vidal, Marle & Bocquet (2011)	x	x	x	x											Project management	Project complexity	Based on Vidal & Marle (2008)
Bosch-Rekveldt et al., (2011)		x						x	x	x	x				Large engineering projects	Project complexity	Literature review; Case studies;
Qureshi & Kang (2015)	x	x	x	x											Project Management; Construction; Textile; IT; Automobile; R&D.	Organizational complexity	Literature review;
Bakhshi, Ireland & Gorod (2016)	x	x	x		x							x	x	x	Project management; System of system; Complexity theories	Project complexity	Literature view;
Total:	**5**	**5**	**4**	**3**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**			

* Extra sub-division of dimensions

3.6. Link between (organizational) complexity, uncertainty and risks

Complexity and uncertainty are a big challenge for most projects nowadays. This results in the presence of risks which could create surprises throughout the whole lifecycle of a project which affects the project performance. It is even suggested that much of the project related risks is due the organizational dynamics and due to today's multidisciplinary business environment (Thamhain, 2013). Literature shows that the concepts of risk, uncertainty and complexity are linked to each other. There is often confusion regarding those terms. Explaining the concepts, differences and linkage of complexity, uncertainty and risk is important to understand the dynamics between the concepts and for SUE projects.

3.6.1. Uncertainty and risks

Each project has a certain degree of uncertainty (Mohan, 2011). Perminova, Gustafsson, & Wikstrom (2008) explained the link between uncertainties and risk management. Perminova, Gustafsson, & Wikstrom (2008) assumes risks as one of the implications of uncertainty. Risk is traditionally explained as an uncertain event that will have a positive or negative effect on at least one project objective (Perminova, Gustafsson, & Wikstrom, 2008; Project Management Institute, 2013). Literature describes the difference between a risk and uncertainty as follows: uncertainties are entire sets of events for which it is impossible for an individual to know something about it or to estimate a potential opportunity out of it (Saunders, Gale, & Sherry, 2015; Mohan, 2011). The measurement of uncertainties are not objective and does not assume perfect knowledge (Daniel & Daniel, 2017). Risks are events for which it is possible to attach a probability to it. The latter is also called a measurable uncertainty or quantitative measurement of an outcome (Mohan, 2011; Kardes, Ozturk , Cavusgil, & Cavusgil, 2013; Daniel & Daniel, 2017). Risks are composed of a complex group of variables, parameters and conditions which have the potential to impact a project (Thamhain, 2013).
In conclusion, risk is derived from uncertainty. It is an notable uncertainty that matters and which is measurable and predictable. Uncertainty is a lack of knowledge about upcoming events which makes it difficult to attach a probability to it.

3.6.2. Link Complexity with uncertainty and risks

Understanding the link between (organizational) complexity with uncertainty and risks is important. Especially in this research where the OC will be assessed and their consequences. As this section shows, a cause of OC is uncertainty which results in unpredictable outcomes. Bosch-Rekveldt, et al (2011) and Domingues, Baptista, & Diogo (2017) also mentioned this in their article. Daniel & Daniel (2017) made a distinction between complexity and uncertainty. Complexity defines the structure and dynamics of a project as a system and uncertainty defines the decision-making conditions of the system of management (Daniel & Daniel, 2017). Uncertainty is often seen as an element and driver of (organizational) complexity. On the contrary, uncertainty is also considered as a result of complexity and dynamics in which complexity and dynamics are sources of uncertainty (Weening, 2006). Complexity and uncertainty are linked to each other in a two way direction. Uncertainty is on the one hand a driver and an element of complexity and on the other hand complexity results in project uncertainty.

Risk management becomes more important in increasingly complex projects. There is no total consensus in the literature if risk is part of complexity or that those two concepts are distinctive. Literature shows a two way direction linkage between risk and complexity. Risk and uncertainty that are important contributors to (project) complexity (Bosch-Rekveldt, et al., 2011). On the contrary, Vidal & Marle (2008) consider complexity as a source of risk. Increased complexity appears to be one of the main reasons of the unpredictability of projects which cause problems and failures. Vidal & marle (2008) also discuss that perception appears to be an important issue for complexity. Every individual perceive the reality on their own. This depends on their mental model and representations (Jaafari, 2003). This results in dealing with complexity through a filter. This means that there is no consensus on what is complex and that it differs for every team member and every project. No project manager should aim for complexity reduction. The key is to manage complexity in a project to avoid the negative aspects of it. Understanding the complexity factors of a project before the start is of big importance (Qazi, Quigley, Dickson, & Kirytopoulos, 2016; Thamhain, 2013; Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011). Qazi, Quigley, Dickson, & Kirytopoulos (2016) tried to link complexity elements to different associated risks which affects the project objectives. Their research shows that complexity in a project in the construction industry is mostly narrowed to the technical aspects and where other complexity aspects (e.g. organizational, environmental) are ignored. Their research also showed that certain risks were influenced by a number of complexity factors which means that there is an interrelationship between those concepts. Another research (Thamhain, 2013) also suggests that there are at least three interrelated sets of variables that affect the ability of dealing with risks. These three variables are (Thamhain, 2013):

- Degree of uncertainty;
- Project complexity;
- Impact.

Understanding those three variables is significant according to Thamhain (2013) for selecting the right method for risk management and for involving the right people and organizations to deal with certain risk situation. Furthermore, the research showed that the risk management process in the construction industry relies in general on the project managers intuition and experience and that they do not consider the interaction of complexity and risks (Qazi, Quigley, Dickson, & Kirytopoulos, 2016). This is in line with the findings from Jaafari (2003).

The literature recognizes an increased complexity in projects and the intra-connectedness of projects. Managers realize that collective thinking and collaboration of all stakeholders is needed to identify and handle the complexity and associated risks. Thamhain (2013) mentioned that due the increased complexity of projects and processes, the effectiveness of analytical methods for risks management is limited and seems not sophisticated enough to represent the dynamics and complexities of all risk scenarios.
It is important to acknowledge that difficult project objectives, may actually cause a project team to choose methods that are more complex to achieve aggressive project goals. At this point complexity and risk are observed to diverge. The project team can purposely increase the complexity of a project with little to no impact to the overall project risk profile. In fact, some risks can be mitigated as a result of the more complex approach. It could also occur that a certain management strategy to mitigate a certain high complexity/risk to increase the project success could lead to increased complexity in other factors.

Usage of the relation between complexity, uncertainty and risks

To summarize, the view of this research on the concepts of uncertainty, risk and complexity in the context of projects is:

- There is a two way link between uncertainty and complexity. Uncertainty is seen as an element and driver of (organizational) complexity. It is also considered as a result of complexity. Uncertainty reduces throughout the lifecycle of a project.
- Risk is derived from uncertainty and complexity. It is an notable uncertainty that matters and which is measurable and predictable. Complexity is recognized within project risks. Risk management and identifying risks should not be a goal but as a means to manage a project and its complexity and uncertainties.
- Complexity appears to be a source of risk. It is important to provide insights regarding the complexity of a project to identify the possible risks for the risk management of a project.

Front-end analysis of complexity and risks are becoming more and more important in the management of today’s projects. It is not only important to understand and evaluate project complexity but also to visualize the complex interaction between project complexity and complexity induced risks in order to priorities critical risks and select optimal risk mitigation strategies (Qazi, Quigley, Dickson, & Kirytopoulos, 2016). Underestimating project complexity is one of the major causes of project failure (Lu et al., 2015). Recognizing the main drivers of complexity is the start of a successful project. This recognition is subjective and dynamic (TU Delft, n.d.).

3.7. Discussion

Using the literature analysis, this chapter is established to answer the second sub-question: *What theory about the OC derived from the literature applies for innovative SUE projects and what are the characterizations of the core concepts which can be used for evaluating the OC for such projects?*

There are four important things to discuss following the literature in this chapter. Firstly, the complexity theory does not contain a way to examine or evaluate the complexity in SUE projects .The scientific literature about the complexity theory is used to understand the OC in a general way with its characteristics. The OC contains according to the complexity theory of dynamic, nonlinear processes and unpredictable outcomes. Simple cause-and-effect relationships between parts do not apply. These nonlinear processes and unpredictable outcomes arise from the variety of components, uncertainty and (inter)relationships/interdependencies in and around an organization. It provides a deeper understanding about complexity but the literature is not meant for examining and evaluating the sources of OC complexity in SUE projects.

Secondly, the project complexity literature is more concrete and clear and provide frameworks which can be used to examine and evaluate the OC for SUE projects. The literature and its frameworks are executed mostly in the large engineering sector, construction sector or product development sector. These are mostly temporary projects such as SUE developments. This literature and its frameworks could be applicable for SUE developments but it should be further investigated. It cannot be concluded that it is one on one applicable for SUE projects because those research is not specifically done for smart city projects or SUE projects.

Thirdly, many OC factors are identified in the literature. But it is not sure that all possible factors potentially contribute to the OC and should be included in this research. Those factors need to be scrutinized based on a twofold reasoning. First of all, only the factors should be selected that are important in SUE developments and that contributing to the OC in such projects. Secondly, only a limited number of factors could be taken into account during the evaluation of the OC. To many factors is not wanted desired to make the research clear and concrete.

Lastly, recognition complexity is subjective and dynamic. The perception of experts appears to be an important issue for complexity. Every individual expert perceive a certain reality on their own which depends on their mental model and representations. This results in dealing with complexity through a filter. This means that there is no consensus on what is complex and that it differs for every team member. These characteristics need to be dealt with further on in this research.

4. Conceptual framework and Research Methodology

Abstract: *Literature shows the importance of providing insights regarding the OC of a project for project success and for identifying possible risks. Managers realize that collective thinking and collaboration of all stakeholders is needed to identify and handle the complexity and associated risks. Therefore, this chapter developed a first OC framework for SUE initiatives based on the literature review. The framework has been further analyzed by conducting expert interviews to make sure that the whole scope was included. This resulted in 56 possible OC factors for SUE projects. Next, the Fuzzy Delphi methodology has been used to quantify, assess and identify the relevant OC factors for SUE projects. In total, 25 out of 56 OC factors were accepted that contribute the most to the organizational complexity in the frond-end phase and that could influence the project success of SUE projects the most. The Fuzzy Delphi Method assured that all effective OC factors are identified for the identification and assessment of the OC related risks with the help of the Risk Diagnosis Methodology.*

Keywords: *Conceptual OC framework; Fuzzy Delphi Method; Risk Diagnosis Model; Definitive OC framework;*

4.1. Introduction

Chapter 2 and 3 presents a review of the state-of-the art literature on SUE developments and the OC that could apply for SUE developments. The literature study is reviewed and synthesized on different quality and content criteria (appendix A). Based on the outcomes of the literature review, this chapter deals with the questions how this can be combined in a conceptual framework, how this framework can be further analyzed by using the Fuzzy Delphi methodology, how these results can be used to further analyze and assess the mechanisms of the identified critical OC factors and related risks in innovative SUE projects. This chapter aims at answering the following guiding research questions:

3. *What OC categorization and OC parameters are recognized to be part of the OC and are relevant for developing an OC framework for analyzing the OC in innovative SUE projects?*
4. *What are the driving OC parameters in the development of innovative SUE projects that influence project performance?*

Section 4.2. presents the development of the conceptual framework that will be used for further analysis. Section 4.3. explains the Fuzzy Delphi Method and how it is developed for this research. The results from the Fuzzy Delphi Method will be mainly used to develop a risk diagnosis model (RDM) where the mechanisms of these OC factors and related risks can be assessed and evaluated. In section 4.4., the RDM will be explained in general and the design and application of the method will be discussed. Subsequently, section 4.5. provide the FDM results and analysis. This chapter concludes with a discussion in section 4.6.

4.2. Development conceptual OC framework

The conceptual OC framework to be used will be developed based on the findings from chapter 2 and 3. Based on the literature review of previous researches, a list of possible influencing OC factors in SUE projects is developed together with potential categorizations (appendix D). Those categorizations and OC factors are further analyzed in this chapter. A first conceptual OC framework is developed as a result of the literature review which is used in this study for further research and for evaluating the OC in SUE projects. This section provides an overview of the process to scrutinize the relevant OC factors which results in a more clear and relevant OC framework. Furthermore, it shows an overview of the OC factor selection process including their categorization. In the end it resulted in a definitive OC framework for SUE projects.

4.2.1. OC factors and categorization identification and selection

The conducted literature review specifically function as method to identify and collect possible OC factors for SUE projects. The literature under investigation had to fulfill some basic requirements for the identification of OC factors and categorizations. Only scientifically recognized literature will be considered in this thesis and the results should scientifically be proven. Furthermore, the literature have to align with the complexity research area. By setting those restrictions, a reliable result can be established. The content analysis is used in the literature review to obtain the possible OC factors and categorizations. A set of OC factors and categorizations is identified and selected from previous research. The content analysis is appropriate as a method to select (OC) factors and their categorization (Hwang, Zhao, & Gay, 2013; Osei-Kyei & Chan, 2015). It analysis the number of times that a factor occurred in previous relevant and comparable studies. Based on this analysis a first selection of OC factors and categorizations is made which are provided in appendix D. An example of the content analysis is provided in Table 3. It details an overview of the possible OC categorizations. In general the number of times that a certain OC factor is mentioned as an influencing factor for the OC in previous research, makes an OC factor considered as a possibly significant and influencing OC factor.

Table 3: Content analysis of the categorizations regarding the organizational complexity

Source	Interdependency	Size	Elements of context	Variety	Diversity	Ambiguity	Flux	Resources	Project team	Trust	Risk	Belonging	Emergency	Autonomy	Research area	Perspective of complexity	Reasoning dimensions
Stracke (2016)*	x				x	x	x								Product development projects	Organizational complexity	Literature review; *Cluster analysis;
Vidal & Marle (2008)	x	x	x	x											Project management	Project complexity	Literature review;
Vidal, Marle & Bocquet (2011)	x	x	x	x											Project management	Project complexity	Based on Vidal & Marle (2008)
Bosch-Rekveldt et al., (2011)		x						x	x	x	x				Large engineering projects	Project complexity	Literature review; Case studies;
Qureshi & Kang (2015)	x	x	x	x											Project Management; Construction; Textile; IT; Automobile; R&D.	Organizational complexity	Literature review;
Bakhshi, Ireland & Gorod (2016)	x	x	x		x							x	x	x	Project management; System of system; Complexity theories	Project complexity	Literature view;
Total:	5	5	4	3	2	1	1	1	1	1	1	1	1	1			

* Extra sub-division of dimensions

4.2.2. Procedure identification and selection

Numerous important OC factors are considered when selecting the OC factors and developing the OC framework. The procedure of the first selection of OC factors is presented in Figure 4-1. This procedure is used to filter the OC factors and to come up with a clear and concrete OC framework that could apply for SUE projects. In order to have significant contribution to this research, the OC factors have to fulfil some basic requirements. As mentioned, only scientifically recognized literature will be considered and the results should be proven scientifically. This first requirement is shown in figure 4.1 as 'literature requirement'.

Secondly, the literature have to align with the complexity research area (complexity requirement in figure 4.1). Lastly, the OC factors should comply with several aspects. Vidal, Marle, & Bocquet (2011) mentioned in their research that measuring the complexity consist of various complexity factors which makes it a multiple criteria characteristic (multi factor requirements in figure 4.1). As a result, complexity factors should meet some important aspects. Those aspects are (Vidal, Marle, & Bocquet, 2011; Baker, et al., 2002):

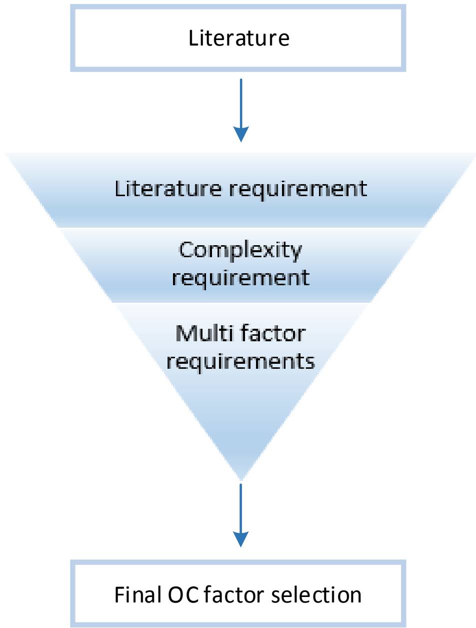

Figure 4-1: Procedure identifying and selecting OC factors.

- Able to discriminate between complexity levels and to support the comparison of complexity of alternatives (SUE projects);
- Complete to include all goals: A broad literature analysis is necessary to include all categorizations and factors related to the OC;
- Operational and meaningful: the OC factors have to contribute to the OC, should be applicable for SUE projects and they should be meaningful and applicable to decision makers and experts;
- Non-redundant: the avoidance of double counting. Each OC factor should be only captured by one factor and not multiple ones;
- Few in number: this secures the feasibility and manageability of the OC factor. This aspects will be applied if possible to reduce the magnitude of the framework.

4.2.3. Selection of OC factors

Based on the reviewed literature, a total of 70 OC factors are obtained which can be classified as possible factors that could contribute to the OC in SUE projects and influence the performance (appendix D). Most popular sources of factor identification are OC frameworks, project complexity frameworks, organization research and general complexity research.
Please note, some OC factors could be excluded for further research. The 70 identified factors are filtered and scrutinized based on the content analysis and the procedure shown in Figure 4-1. The reduction is relevant due a threefold reasoning. First, OC factors which are mentioned more often in previous studies can be considered as more likely to influence the OC. Second, there is a chance that there occur overlapping factors due the different frameworks in the literature. Factors could have (almost) the same meaning and purpose. Third, by reducing the magnitude of the OC framework, a more clear and concrete OC framework will be developed which proven to be influencing on SUE projects. Another benefit is the length of the questionnaire wherein the OC factors will be examined. By reducing the factors, the lengths of the questionnaire decreases which will lead to more convenient responses. The reduction of the OC factors is based on the following steps:

- Content analysis: when an OC factor is mentioned 4 times or more in the literature (appendix D) then it considered to be relevant and it is added in the OC framework;
- The remaining factors are processed according to Figure 4-1. 16 OC factors are initially excluded because they were not operational and meaningful for the front-end phase of SUE projects, and/or they were redundant/few in number and/or they were not frequently mentioned in the literature.

- Two OC factors are added due to their importance in the SUE literature and grey literature and due the analysis of section 2 and 3. These two factors are 'project leadership' and 'user, people and community involvement'. These two factors appears to be important in SUE projects and could potentially contribute to the OC.

This procedure resulted in first selection of 52 possible OC factors which are used for further research. Appendix D provide the reason per factor for excluding it from the conceptual OC framework. In order to consolidate these 52 OC factors, the subsequent task is to group these OC factors into logic categorizations.

4.2.3. Selection of OC categorizations

All the relevant restrictions are set in the previous sections. Many literature sources are studied from the period around 1996 till now. It is evident that most researches continues and built on previous research. The literature which is relevant and most useful for the identification of OC factors and categorizations is literature related to project complexity frameworks, OC frameworks and general research related to (project) complexity.
Six different researches were identified in which the OC or the project complexity is divided into several OC categorizations (table 3). Almost all developed frameworks are from a project management perspective where it includes several frameworks for measuring the project complexity. There is no consensus on the categorizations of the OC as detailed in Table 3. It is evident that that the categorizations 'interdependency and size' are both mentioned 5 out of 6 times. Moreover, the categorizations 'variety and diversity' can be perceived as an synonym for each other which means that this categorization is also mentioned 5 out of 6 times. The categorization 'elements of context' is mentioned 4 times. The other categorizations are mentioned only 1 time.
Further, 4 of the 6 researches are from a project complexity perspective and not only from an OC perspective. The two frameworks which are only from an OC perspective have two distinctive divisions of categorizations. Three researches used the same four categorizations (Vidal & Marle, 2008; Vidal, Marle, & Bocquet, 2011; Qureshi & Kang, 2015). Please note, those researches are based on each other and two of them have partly the same authors.
Two frameworks are from a project complexity perspective and both technical part as organizational part is divided into the same four categorizations (Vidal & Marle, 2008; Vidal, Marle, & Bocquet, 2011). One research (Bakhshi, Ireland, & Gorod, 2016) is focused on all project complexity factors in the literature. The used categorizations is only mentioned in their research and they are focusing on project complexity as a whole. There is not a scientific basis for this categorization in their research. This makes it not suitable for this research. One research (Stracke, 2016) is only focusing on the OC in product development projects. This research divide the OC into four categorizations and 8 clusters. The categorizations are derived from a broad literature review regarding the OC. Subsequently, the research identified multiple OC factors from the literature and grouped those factors that more similar to each other by using clustering. The commonalities were investigated between the factors in each cluster and the cluster were named based on these commonalities. Figure 4-2 shows those sub-division of the categorizations mentioned by

*Sub-division
1. Complexity context;
2. Culture;
3. Information systems;
4. Interdependence;
5. Location;
6. Management hierarchy;
7. Objective (incentive) alignment;
8. Operating standard procedure;
9. Personality.

Figure 4-2: categorization OC categorizations (Stracke, 2016)

Stracke (2016). The used categorizations enables it to understand the framework more and it reflects the categorizations in a clear and non-redundant way. But, the framework is not complete and other OC factors should be added according to the literature. This makes it difficult because those remaining OC factors are difficult to classify within one of these sub-categorizations.

Based on the literature, the categorizations size, interdependence, variety and elements of context will be used in this research. This is due the following reasons and also based on the requirements in Figure 4-1.

- Based on the content analysis, the categorizations size, interdependence, variety and elements of context are mentioned most often and multiple times in different scientific literature;
- All OC factors can be subdivided within those categorizations which makes is clear and concrete;
- The categorization of Stracke (2016) is also clear but not all factors can be divided into the classifications.

First conceptual OC framework
When reviewing and analyzing the OC concept, factors and categorizations, a first conceptual framework was derived. This first conceptual framework includes the elements of analysis that were defined from the literature review. It includes the OC categorizations, the related OC factors and corresponding abbreviation. This first conceptual framework will be further analyzed by experts from SUE projects by using the Fuzzy Delphi Method. This will be explained in the next sections.

4.3. Fuzzy Delphi Methodology (FDM)

Before diving into the reasons for selecting the methodology and the design and application of the Fuzzy Delphi Method (FDM), the FDM will be firstly explained in general to gain a better understanding of this research methodology.

4.3.1. FDM in general

The FDM, proposed by Ishikawa, et al (1993), is an analyzing technique based on two different methodologies. These two methods are the traditional Delphi methodology and fuzzy set theory (Glumac, Han, Smeets, & Schaefer, 2011; Hsu, Lee, & Kreng, 2010; Damigos & Anyfantis , 2011).
The Delphi method is a systematic method of collecting data to get a reliable consensus based on the opinions of a group of experts by using a questionnaire (Damigos & Anyfantis , 2011). Three important features of the Delphi method are anonymous and independent response by the experts, iteration and controlled feedback (Hsu, Lee, & Kreng, 2010). As statet by Damigos & Anyfantis (2011), the Delphi method is used in numerous fields of research like market analysis, health care, real estate, world events. The method is very useful in which agreed knowledge is lacking or considerable uncertainty is identified (Sourani & Sohail, 2015). It is a valid method for forecasting and it supports collective decision-making. However, there are also some downsides. The traditional Delphi method survey have tendency that both the questions and the answers are unclear. The base of the methodology is the opinion and expertise of experts. Differences in meanings and interpretations of the experts opinion could

occur. In addition, there is a notable issue to solve the fuzziness of the expert consensus within the group decision making (Glumac, Han, Smeets, & Schaefer, 2011).
To solve the downsides of the traditional Delphi method the concept of combining the fuzzy set theory and the Delphi method was proposed. The fuzzy theory is suitable to tackle the uncertainties in the problems which are studied (Damigos & Anyfantis , 2011). The uncertainties in the Delphi method are mainly because of the human element. This will be avoided in an improved way by embracing this fuzziness (Glumac, Han, Smeets, & Schaefer, 2011). The fuzziness of results is due to the inconsistency of the experts answers within a group whcih lead to a lack of consensus in answering. This will be avoided by taken the fuzziness into account (Glumac, Han, Smeets, & Schaefer, 2011). By integrating the traditional Delphi Method and the fuzzy set theory the vagueness and ambiguity of Delphi Method will be improved. The main difference in applying the fuzzy set theory in the Delphi method is the use of fuzzy numbers. Using these fuzzy numbers ensures that the fuzziness of the experts answers will be taken into account. By applying those two methodologies, the quality of questioning and the questionnaire will improve and this results in more efficiency and a more reliable study (Ishikawa, et al., 1993; Glumac, Han, Smeets, & Schaefer, 2011).

The FDM is applicable when diversity in answering could occur by different questioned experts. Applying the FDM to group-decision could resolve the fuzziness of mutual understanding of expert opinions (Hsu, Lee, & Kreng, 2010). Benefits using the FDM are saving time and diminish the amount of surveys. But most important, it takes the fuzziness into account that confronts ever survey process (Glumac, Han, Smeets, & Schaefer, 2011).

The application of the FDM includes the following steps which will be explained in more detail in section 4.3.3. (Hsu, Lee, & Kreng, 2010; Glumac, Han, Smeets, & Schaefer, 2011):

1. *Validate predefined list of the factors;*
2. *Collect opinions of expert groups;*
3. *Set up overall triangular fuzzy number;*
4. *Defuzzification;*
5. *Screen evaluation indexes.*

4.3.2. Purpose and rationale for FDM

The literature covers a broad range of different OC factors. There is no overview of OC factors influencing SUE projects. The FDM will be applied in this research to identify, assess and scrutinize the most important OC factors from the literature which applies for SUE projects. The OC factors will be determined that influence SUE projects the most. The OC factors identified from the literature are proven in previous research to be part of and influence the OC. But, reanalyzing is necessary to improve the reliability of this research. Previous research about the OC factors has not been studied in the field of SUE projects. In addition, besides the different focus area, previous research where OC factors are identified and assessed could deviate due region, cultural aspects, focus, etc. Therefore, the suitability of the OC factors for SUE projects should be determined and assessed in this research to make it reliable. By applying the FDM, the final result will be a hierarchical framework of OC factors. Each OC factor will be processed with a single value determined by experts in SUE projects. The number of OC factors will be scrutinized and ranked based on the FDM results.

The FDM will be suitable for this research because agreed knowledge about OC factors is lacking especially for SUE projects. With the knowledge of this researcher, no research is done concerning those OC factors occurring in SUE projects or even smart city projects.
Additionally, It is expected that the perceptions of OC and corresponding factors differ among the different parties involved in SUE projects. Diversity in answering by the different experts is expected because the author distinguish different expert groups. According to Jaafari, et al (2008), this diversity and vagueness could occur due potential deviations in interpretation of the provided research problem knowledge and provided information. This also applies to the subject of this research. For example, there might be differences in the experts interpretation on what contributes to the OC and what is perceived as complex. This methodology enables it to process the fuzziness of the experts answers. This is the major advantage of the FDM. It takes the fuzziness into account of the different involved experts and experts groups in this research.
It will result in a more reliable and improved quality of the survey and questioning in a more efficient way (Glumac, Han, Smeets, & Schaefer, 2011; Ishikawa, et al., 1993). The FDM is also a very suitable methodology due to the limited time frame for this research. An advantage is the practical matter such as saving survey time and the limited number of questionnaires which is needed (Glumac, Han, Smeets, & Schaefer, 2011).
Finally, the method is often used with the same purpose as in this research. Hsu, Lee, & Kreng, (2010) used the FDM to obtain the critical factors for selection of regenerative technologies. Another research (Glumac, Han, Smeets, & Schaefer, 2011) applied the FDM for structuring and rating the most relevant features that indicate the (re)development potential of brownfields. Lin & Chuang, (2012) used the Fuzzy Delphi Method to filter and collect their most important appeal candidate factors.

4.3.3. Fuzzy Delphi Methodology design and application

The FDM is able to solve the fuzziness in the mutual understanding of experts opinions. There are several membership functions and formulas used in previous research to take the fuzzy numbers into account. The most frequently used function in previous research is the triangular membership function (Glumac, Han, Smeets, & Schaefer, 2011), but other used functions which contain more information are trapezoid, quadratic, and Gaussian function (Hsu, Lee, & Kreng, 2010). To collect as much relevant data as possible and to keep the survey easy to understand, this research applies the triangular membership function as calculation method. Additionally, the triangular membership function contains simple mathematical operations and computational efficiency. To calculate the common expert group understanding for each specific identified OC factor and their importance the geometric mean model is used (Klir & Yuan, 1995; Glumac, Han, Smeets, & Schaefer, 2011)

The following steps explain in detail how the application of the FDM was conducted:

1. *Validate predefined list of the factors;*

Step one explains the process of obtaining and selecting the input data for the FDM. In this research it is about selecting OC factors in the OC framework which will be assessed for SUE projects. The literature review is used to identify possible OC factors and categorizations. Those OC factors must comply with several requirements to be part of the OC framework as discussed. Based on this literature review and requirements a first conceptual OC framework is developed. This literature review provides a good initial overview of the OC factors that could apply for SUE projects. For the relevance of this research, additional interviews with experts are required. This is due that the complexity factors identified in the literature are based on different types of projects and not specifically for SUE projects. Complexity factors could be missing or factors should be adjusted concerning the topic of this research. Preliminary interviews were conducted with experts to validate and if necessary adjust and/or add factors to the predefined framework. The selected OC factors and the first developed conceptual OC framework from the literature are examined and discussed with experts on the topic of the field. Those experts were asked whether the list of OC factors is complete or that factors should be added or adjusted. Their opinions provided insights in the OC factors in SUE projects. The experts enabled it to identify the relevant and missing OC factors and modified those gathered from the literature review. A total of four experts were part of this step.

- *Roger Boersma*: VolkerWessels iCity, project Manager and coordinator of smart city projects;
- *Annelies van der Stoep:* Amsterdam Smart City, Project Coordinator energy transition;
- *Alwin Beernink:* Park Strijp Beheer, Director Park Strijp Beheer and program manager Strijp-S.
- *Laetitia Ouillet,* TU/e, Director Strategic Area (SA) Energy and formerly Director Corporate Strategy at ENECO.

The first three experts are all involved in the entire process of developing SUE projects. Those experts know how partnerships are established and what the complexity is during the process and in the front-end phase of such projects. Those experts were suitable for this step due to the fact that they were involved in numerous projects and not only one or two. They have the experience with the subject to validate and adjust the first conceptual framework. The fourth expert got broad experience in the energy sector and related innovative projects and is now director of the strategic area energy at the TU/e which involves smart urban energy projects. Based on the results of the related expert interviews the conceptual OC framework was adjusted. Those experts were chosen because they have the needed overview and experience with the subject to validate and to construct a complete framework of OC factors for SUE projects.

The OC framework is adjusted based on the conducted expert interviews and their feedback. Eight OC factors are revised in their formulation, five OC factors are added to the framework and one OC factor has been removed from the list. Table 4 presents all factors that are revised, added or deleted with reasoning based on the expert interviews.

Table 4: Revised OC factors based on the expert interviews.

Formerly	Revised	Reasoning
Number of information systems	Number of information/data systems	Important to add data systems in the factor. This is an important element in smart city/ SUE projects.
Number of stakeholders	Number and hierarchy of stakeholders	The hierarchy is important in partnerships where people are co-creating.
Staff quantity	Number of directly involved project participants/partners	To make it more clear and formulated in favor of SUE projects.
Variety of interests of the stakeholders	Variety of the interests of the stakeholders (collective/individual and long/short term)	To make it more explicit and clear for the experts.
Variety of information systems to be combined	Variety of information/data systems to be combined	Important to add data systems in the factor. This is an important element in smart city/ SUE projects.
Variety of staff (experience, social background or references)	Variety (Or lack of variety) of involved project participants / partners (experience, social background or references)	The lack of variety could also be a complexity which could occur.
Geographical location of the stakeholders (and their mutual disaffection)	Geographical location of the stakeholders	Removal of judgement. No judgements are occurring in other OC factors.
Interdependence of information systems	Interdependence of information/data systems	Important to add data systems in the factor.
Number , diversity and clarity of contract types	Added OC factor	Important factor according to the literature and confirmed by the expert
Dividing and sharing risks among partners/stakeholders	Added OC factor	Important factor according to the literature and confirmed by the expert
Hierarchy of project objectives	Added OC factor	Important factor according to some experts
Political situation and influence	Added OC factor	Important factor according to the literature and confirmed by the experts
Upscaling the project	Added OC factor	Important factor according to the literature and confirmed by the experts.
Number of standardized processes	Removed OC factor	To similar and dependent on degree of innovation

The literature study together with the OC factors identified and discussed during the interviews provide a comprehensive list of in total 56 OC factors and 4 different categories. This is called the OC framework. In appendix E, the overview of the OC framework can be consulted and a more detailed explanation of each OC factor of the OC framework has been given. This OC framework with OC factors will be assessed by experts in the second part of the FDM which will be explained in the following steps.

2. *Collect opinions of expert groups;*

After the conceptual framework with possible OC factors that influence SUE projects has been completed (literature review and experts interviews) the second part of the FDM is started. The second step is to find the evaluation score for each OC factor. This evaluation score will be given by each expert by using linguistic variables in questionnaires (Glumac, Han, Smeets, & Schaefer, 2011; Hsu, Lee, & Kreng, 2010). An online questionnaire is used to gather the experts evaluations. Each expert involved in SUE project should give an evaluation score for every factor by using a seven-point Likert scale. The seven-point Likert scale is preferred above the five-point Likert scale because it provides more variance and extended number of choices then the five-point Likert scale which result in more specific results. It gives respondents the possibility to provide more accurate answers and to differentiate between the answer possibilities. The seven-point Likert scale is also preferred above the nine-point Likert scale in this research. The nine-pint Likert scale will result in a too complicated task for the respondents. It becomes more difficult to distinguish the alternatives and factors due to the differentiation. Further, due to the already many OC factors and the more complicated task with a nine-point Likert scale, the risk is to big that respondents will not finish the questionnaire because it is much more time consuming and more complicated.

In this study, the Min Max method, where respondents are asked to give a range for each of the factors (Ishikawa, et al., 1993), has not been used due to the size of the survey and the corresponding risk that actors are not finishing the survey.

Figure 4-3 describes the used seven-point Likert scale including its triangular fuzzy numbers for each value. To ensure the scale is understandable the 7 different scores are supported by text.

Description	Not at all		Little		Substantial		Very much
Value questionnaire	1	2	3	4	5	6	7
Fuzzy spectrum (a, b, c)	(0, 0, 0.1)	(0, 0.1, 0.3)	(0.1, 0.3, 0.5)	(0.3, 0.5, 0.7)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.9, 1, 1)

Figure 4-3: 7 point Likert scale with the corresponding fuzzy numbers . Retrieved from: (Bouzon, Govindan, Rodriguez, & Campos, 2016)

Based on the questionnaire set up, a survey is presented to the respondents including the different OC factors. The experts that are invited to fill in the questionnaire can be divided into 5 different groups:

- Public organizations;
- Private companies;
- Utilities;
- Non-governmental organizations (NGOs);

- Knowledge institutions.

Those experts will validate each single OC factor, related to their influence on the OC in SUE projects.

3. *Set up overall triangular fuzzy number;*

The third step contains of the calculation of the evaluation value of triangular fuzzy number of each altered OC factor given by experts and to derive the significance triangular fuzzy number of the altered OC factor (Hsu, Lee, & Kreng, 2010). At first, the outcome of the survey in step two will result in a matrix that expresses to what extent each of the factors contribute to the OC:

$$\begin{array}{c} \\ C_1 \\ C_2 \\ \cdots \\ C_m \end{array} \begin{array}{c} \begin{array}{cccc} R_1 & R_2 & \cdots & R_n \end{array} \\ \begin{bmatrix} L_{11} & L_{12} & \cdots & L_{1n} \\ L_{21} & L_{22} & \cdots & L_{2n} \\ \cdots & \cdots & & \cdots \\ L_{m1} & L_{m2} & \cdots & L_{mn} \end{bmatrix} \end{array}$$

Where:

$R_i = The\ i^{th}\ respondent, i = 1, 2, \ldots.n$
$C_j = The\ j^{th}\ OC\ factor, j = 1, 2, \ldots.m$
$L_{ij} = The\ linguistic\ evaluation\ of\ OC\ factor\ j\ by\ respondent\ i$

Subsequently, the experts' evaluation should be combined and the fuzzy number for each OC factor j can be calculated. This research will use the general mean model proposed (Klir & Yuan, 1995; Glumac, Han, Smeets, & Schaefer, 2011) to discover the common understanding of group decision. At first, the evaluation value of a single OC factor by a single respondent is expressed as triangular fuzzy number (displayed in Figure 4-3). The computing formula is as follows:

$$\widetilde{w}_{ij} = (a_{ij}, b_{ij}, c_{ij})$$

Where element j OC factor given by element i respondent of n respondents where $i = 1,2, \ldots n, j = 1,2, \ldots.m$. Then the fuzzy weighting $\widetilde{w}_j$ of j is:

$$\widetilde{w}_j = (a_j + b_j + c_j), j = 1,2, \ldots m. \quad \text{And where:}$$

$$a_j = \underset{i}{Min}\{a_{ij}\}, \qquad b_j = \frac{1}{n}\sum_{i=1}^{n} b_{ij}, \qquad c_j = \underset{i}{Max}\{c_{ij}\}$$

4. *Defuzzification;*

The next step in the FDM process is converting the unique triangular fuzzy numbers into single real numbers. This step in the process is called defuzzification. For this research the simple center of gravity method (Klir & Yuan, 1995) will be used to defuzzify the fuzzy weight $\widetilde{w}_j$ of each single OC factor to definite value S_j. The formula is as follows:

$$S_j = \frac{(a_j + b_j + c_j)}{3}, where\ j = 1, 2, \ldots m$$

5. *Screen evaluation indexes.*

Final, a selection will be made of relevant OC factors which can be selected from the numerous OC factors by setting a threshold α. In this research, the OC factors that contribute the most to the complexity in the frond-end phase of a SUE project will be selected by setting the threshold α. The principle of screening is as follows:

if $sj \geq \alpha$, then No. j OC factor is very important and included in the OC framework.
if $sj < \alpha$, then No. j OC factor is less important and not included in the OC framework.

The literature does not provide one standard for setting a threshold. Hsu & Chen (1996) mentioned in their research that setting the threshold is based on the needs of the study. The typically used threshold in scientific research is 0,7 but it differs based on the researcher's judgement in different studies (Habibi, Jahantigh , & Sarafrazi, 2015). Another way to determine the threshold which is used commonly is to calculate the mean of the single derived numbers and examine the crisp numbers against this mean. The used threshold value is explained in section 5.5.3.

4.4. Constructing OC related risk diagnosing model (RDM method)

The results from the Fuzzy Delphi Method will mainly be used to develop a model where the mechanisms of these OC factors can be assessed and evaluated. Those OC factors will be translated into OC related risks and will be assessed by using the RDM method. Before going into the reasons for selecting the methodology and the design and application of the Risk diagnosing methodology (RDM), the RDM will be firstly explained in general to gain a better understanding of this research methodology and its suitability for this research.

4.4.1. RDM in general

The RDM method developed by Halman & Keizer (1994) aims at identifying and evaluating potential risks in different domains (e.g. technology, organization and business) in product innovation projects. According to Halman & Keizer (1994), the method is designed to be applied in several phases in the product creation process but the strongest contribution is at the end of the feasibility phase. The feasibility phase is part of the front-end phase. The RDM has been developed through case-study investigations within multinational companies. The method has been tested and improved on product-innovation projects (Halman & Keizer, 1994; Halman & Keizer, 1993). It detects those factors which could jeopardize the successful realization of the project objectives and it could provide strategies that will improve the chance of a project's success by identifying and managing its potential risks (Keizer, Halman, & Song, 2002). The whole model consists of three main steps in which every main step is divided into three sub-steps. Those three main steps are:

1. Risk identification;
2. Risk assessment;
3. Risk response development and control

The model generates pro-active, cross-functional solutions for managing specific project risks in an effective way. In this research, the specific risks that are included in the model are the OC related risks which will be based on the FDM results. Additionally, the outcomes can be used to search for structural weaknesses in the innovation process. This will yield the necessary data to improve learning, increase capabilities and with that increase the project success (Keizer, Halman, & Song, 2002). The model has five striking characteristics (Halman & Keizer, 1993):

- It is meant to identify (organizational, technological and commercial) risks;
- Identification and valuation takes place on an individual basis and cross-sectoral;
- Identification and valuation are systematically and coherently structured;
- The risks are mapped in a topography;
- It will enhance commitment for the project objectives and deliverables;

4.4.2. Purpose and rationale for RDM for this research

Understanding and examining the sources and mechanisms of OC in SUE developments is necessary and of big importance in order to facilitate and accelerate the successful development and management of SUE projects. The aim is to develop a model that could assess how the OC factors are contributing and influencing the project performance in the selected SUE case(s) experienced by the different project professionals and to evaluate if there are major differences between the participants. The model can be applied by practitioners in the SUE industry and can serve as a decision-making tool on how risky a SUE project is and where this OC based risks are situated. It results in a clear understanding of the critical OC based risks and it allows them to pay attention to the factors that are worth more attention and to manage and master this OC based risks. This should finally result in valuable guidance for the management of the OC and OC related risks and it should support professionals in various management and strategic decisions to anticipate on potential difficulties. Moreover, scarce resources can be allocated efficiently based on the results. Eventually it can contribute to the successful management of innovative SUE projects. The reason why the RDM will be useful for this research is fourfold.

First of all the method developed by Halman & Keizer (1994) allows it to diagnose thoroughly and systematically the OC related risks that a project faces and the mechanisms of those OC factors. Based on these results, it also enables to formulate and implement proper OC related risks management strategies.

Secondly, the method takes a cross-functional individual perspective. It includes different assessors from different involved sectors (cross-sectoral). The model presents the degree of perceived OC related risks by the majority of the assessors and the distribution of their opinions. Differences in perceptions can be identified in an easy way and it compels you to look beyond your own area of expertise due to the cross-sectoral perspective. This is of big importance in smart city projects and in this case SUE projects where cross-sectoral and integral perspectives and cooperation is of importance. Furthermore, it supports the chosen approach in the FDM where different experts from different backgrounds (cross-sectoral) responded on the questionnaire.

Additionally, the outcomes will not be biased because the OC related risks will be assessed on an individual basis. It allows the participants to express their genuine fears without being judged. Additionally to that is that the perception appears to be an important issue for complexity. Every individual perceive the reality and complexity on their own in a subjective way. This method allows to judge it on your own and combine it into a combined OC related risk topography. It results in a consensus on what is complex/risky and its effect.

Thirdly, research shows (Keizer, Halman, & Song, 2002) that it helps the project team to focus their minds and to communicate OC related risks in an effective holistic way and it will enhance the commitment for the project objectives and deliverables.

At lastly, the method is mainly suitable in cases of innovative, complex and/or significant projects (Keizer, Halman, & Song, 2002; Halman & Keizer, 1994). SUE projects and smart city projects are characterized as innovative, uncertain and complex.

4.4.3. Design and application

The RDM will be used and adjusted to the context of this OC research. As mentioned before, the outline of the whole RDM contains three main steps. This research does not focus on all three steps because of the limited time for this research and because this research aims at developing a model that could evaluate and assess how OC factors could influence the project performance in a SUE project experienced by the different project professionals. For that reasoning, this research only focusing on the first two steps: 1) OC identification and 2) OC related risks assessment. Those steps are explained and how they are applied in this research. This also explains the how the FDM will fit-in and how it is linked to the RDM process:

1. *Organizational Complexity identification with the Fuzzy Delphi Method.*

The objective of this step in the RDM is to identify and develop a comprehensive overview of all critical aspects, in this case the OC factors, in innovative SUE projects that could jeopardize the project performance. Keizer, Halman, & Song (2002) mention that this data could be gathered by interviewing the project participants in an individual way. This will be done in a different way as mentioned before in the previous chapter.
The FDM will be applied in this research to identify and scrutinize the most important drivers of OC factors from the literature that could affect the project performance in SUE projects. The FDM is suitable, as indicated previously, because agreed knowledge about OC factors is lacking and diversity in answering by the different experts is expected and due to the time frame of this research. Furthermore, agreed knowledge is lacking for this subject. The FDM will result in a general and comprehensive list of OC factors that could appear in every SUE project instead of one project specific. At last, the OC identification in the FDM will be performed by individual assessment by different experts in different sectors. The assessment of the OC for one project specific will also be done by different cross-sectoral experts which makes the results more reliable and consistent.
Once all relevant OC factors have been identified in the FDM, the focus of the OC diagnosis will change from identification to assessment of the OC for a specific SUE project. The OC factors will be translated into OC related risks. This will be explained in the next step.

2. *Organizational Complexity assessment using the RDM.*

The focus from identification in the previous step changes to assessment of the OC by making use of the RDM. This main step is subdivided into three sub-steps which are discussed below:

a) *Processing the identified OC factors and development of the OC questionnaire.*

The OC based risk questionnaire is developed in this step for the assessment and OC based risk diagnosis. The critical OC factors from the literature review, expert interviews and the FDM results will be analyzed and processed in the questionnaire. The critical OC factors from the analysis will be translated into positive OC based risk statements of ''objectives to be realized''. Negative statements are avoided because negative framing induces more positive perceptions than positive framing according to the prospect theory (Kahneman & Tversky, 2013; Keizer, Halman, & Song, 2002). In the case of OC identification and OC based risk assessment it is preferred that people do not accept complexity and OC based risks too easily.

When all potential OC factors are transformed into positive statements the questionnaire will be verified if every statement is clearly understood and formulated before going to the assessment of it.

b) Assessment of the OC based risk questionnaire by project participants.

Once the questionnaire is developed and approved in the previous step then the second step of the RDM method can be started in which the focus will change from identification to valuation on the impact of the OC related risks via the developed questionnaire. The goal is to develop a model that can assess the influence and impact of the OC based risks on the project performance experienced by the different project professionals.

Complexity appears to be a source of risk. It is important to provide insights regarding the complexity of a project to identify the possible risks for the risk management of a project. The questionnaire supports the assessment of the current OC based risk level of project by assessing the influence and impact on the project at a particular point in the project life cycle. It can be used for different phases of a project and supports the implementation of proper management strategies relevant to the identified complexity and risks. It helps organizations in reducing the likelihood that the associated OC based risk will cause poor performance. Normally risks are evaluated depending on is likelihood of occurring and the impact if it does occur. In the RDM, the assumption is made that the impact is not only depending on those two factors but also on the ability to influence the specific situation. Therefore, the respondents of the questionnaire are asked to judge the developed OC based risk statements on three five-point scales accordance with (Halman & Keizer, 1994; Keizer, Halman, & Song, 2002) :

- Level of certainty that the OC based risk statement will be true. As stated in the literature review, uncertainty is seen as an element and driver of complexity and risk;
- Ability to influence course of action within time and resource limits: ability of the team to reach an appropriate solution using the project's allotted time and resources;
- Relative importance of the statement for obtaining project success.

Respondents should answer the questionnaire as completely as possible. It could occur that a statement will not be relevant or that the respondent has no opinion about it then the respondents are asked to not respond.

c) Construction of the OC based risk profile and evaluation of results.

After the respondents completed the questionnaire, the OC based risk profile should be constructed based on their assessment scores. The responses are processed and accumulated in a OC based risk topography. Every statement is reported with its scoring for the three evaluation scales. It shows the degree of risk perceived by the majority of the respondents and the distribution of their assessment scores. The criterion for which a certain statement is supported by the majority can be chosen differently. Keizer, Halman, & Song (2002) chose a minimum support of 50% to reach a score.

For every statement, two more actions of scores will be fulfilled (Keizer, Halman, & Song, 2002):

1. Appointing every OC based risk statement along the 3 parameters into a risk group.

The RDM decision rules are used to determine the riskiness of every statement for the project. Firstly, every OC based risk statement will be summarized and classified along the three parameters into one of four risk groups. Every statement will be examined on the distribution of the participants assessment scores over the five-point scales and will be appointed into one of the four complexity/risk groups with the use of the decision rules shown in Table 5. This classification into risk groups has to do with the degree of complexity/riskiness of the specific statement. Please note, this classification has nothing to do with the categorization used in chapter 3 and 4. The classification is used in this method to determine the level of complexity/riskiness of a certain parameter/statement.

Table 5: Decision rules for classification into one of the risk groups. Reprinted from: Keizer, Halman, & Song (2002)

Score	Risk groups	Decision rule
''*''	High complexity / risk	At least 50% of the scores are 1 or 2 on the 5-point scale (1 being "very complex"), and there are no scores of 5 on the 5-point scale.
''0''	Low complexity / risk	At least 50% of the scores are 4 or 5 on the 5-point scale, and there are no scores of 1 on the 5-point scale.
''M''	Medium complexity / risk	At least 50% of the scores are 3 on the 5-point scale, and there are no scores of 1 or 5 on the 5-point scale.
''?''	Lack of consensus on complexity / risk	For all remaining cases. There exists a lack of consensus, visible in a wide distribution of opinions.

2. Combined scores of every OC based risk statement.

Subsequently, each statement can be appointed into a risk class. This appointing will be done by observing the combined scores on the three evaluation parameters in step 1. The RDM method (Keizer, Halman, & Song, 2002) uses five risk groups: Safe (S), Low (L), Medium (M), High (H) and Fatal (F). As an example: a combination of scores, based on Table 5, on the three evaluation parameters for a statement could be ''*, *, *''. This combination of scores would results in a fatal classification (risk class F). The combination ''0, 0, 0'' would results in a risk that is safe (risk class S). There are 64 possible combinations of risk scores. Those different combinations are presented in appendix G.

It often occurs that a statement will have distributed opinions among the respondents in the topography. Then, the risk score will be presented as a range between the lowest and highest risk class. An example score could be L-H. From here, a pessimistic and optimistic scenario could be established. The optimistic scenario could be calculated by supposing that all statements will eventually end up in the most favorable risk class (e.g. L-H becomes L, M-F becomes M). The opposite is assumed for the pessimistic scenario.

Additionally to the two preceding steps and results, the OC related risks can be quantified for the project as a whole. A weight can be determined to each of the risk classes. According to Keizer, Halman & Song (2002), the different risk classes can be valued in the following way: S=0, L=1, M=2, H=3 and F=4 where 3 assumptions are taken into account:

- The classes symbolize spots on a OC related risk dimension ranging from safe to fatal.
- The spots on this OC related risk dimension have equal distances from each other.
- Class S is assumed to be safe, and is given the weight of 0.

The total project OC related risk can be quantified on a 0-100 risk scale. This results from summing the same OC related risk classes and multiply this with the corresponding weight. The maximum OC related risk score of 100 will be reached if all the statements in the model are classified as fatal (F class, weight4). The minimum score of 0 will be reached if all the statements in the model are classified as safe (S class, weight 0).

As discussed before, statements could have distributed assessments scores (e.g. L-H, M-F) due to the different opinions of the respondents. In that case, a pessimistic and an optimistic scenario can be established. Figure 4-4 provide an example of such distribution. It shows a graphical representation of the project OC related risk on a 0-100 scale.

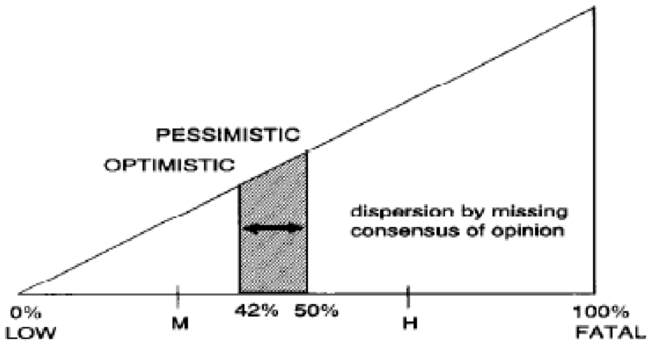

Figure 4-4:Graphical representation of OC related project risk on a 0-100 scale (Halman & Keizer, 1994).

4.5. FDM data collection and results

4.5.1. Questionnaire FDM

The purpose of this questionnaire is to identify, structure and rank the most important drivers of OC in the front-end phase (initiation - development) of innovative SUE projects that could affect the project performance. As described in the methodology steps, the survey consist of a web-based online questionnaire that is developed based on the literature review and expert interviews. One of the reasons for distributing an online version of the questionnaire is due to the needed time for answering the questionnaire. It makes is possible for every individual to answer the questionnaire at a moment they prefer. It is also easy to fill in and it makes it possible to develop the data analysis processing. A disadvantage is the expected response rate. This is due the possibility that respondents postpone the answering of the questionnaire and due to the non-personal contact method. To improve and obviate the response rate, experts were if possible approached by phone. Also the personal network of the TU/e and its professors was used concerning the topic. Furthermore, the questionnaire is kept as small as possible to contribute to a more clear understanding by the respondents. According to Denscombe (2014), a web-based online questionnaire involves three steps: 1) designing the questionnaire; 2) distribution of the questionnaire; and 3) data retrieval. Those steps are discussed below.

Questionnaire design

The questionnaire has been developed with the Berg enquete system of the Eindhoven University of Technology. The questionnaire consists of two main parts:

1. Introduction and general questions;
2. Questions about the factors contributing to the organizational complexity in SUE projects.

The whole overview of questionnaire can be found in appendix F. The questionnaire is developed and provided both in Dutch as in English because the consulted experts are both Dutch as international people due to the international collaborations and different nationalities in such projects. Respondents can chose which language they prefer which improves the readability and decrease the possibility for misunderstandings.

1. *Introduction and general questions*

The introduction provides a description and purpose of the research and what is expected from the respondent. People who enter the questionnaire but who are not eligible for the questionnaire will most likely stop at the introduction page due to the complete overview which includes the purpose and expectations of the respondents. This is especially necessary because the questionnaire will also be distributed on platforms. After the introduction the respondent continues with the general questions. This part is developed to make sure that only response from qualified people will be used for analysis. In doing so the quality of the respondents answers are monitored and unqualified respondents can be excluded.

2. *Questions about the OC factors*

The second part of the questionnaire contains the input for the FDM. The OC factors will be ranked by each respondent. Each expert in developing SUE project(s) will be asked to what extent each organizational factor could potentially contribute to the complexity in the front-end phase (initiation - development) of a smart city project with a special focus on smart urban energy projects. Respondents indicate every OC factor on a scale from 1 (not at all) to 7 (very much).

Distribution and retrieval of the questionnaire

The questionnaire is distributed in two different ways. The questionnaire is presented to people who are experts in the development (front-end phase) of SUE projects (see chapter 4.4.2.). The first and most effective way is sending out the questionnaire to individual experts by mail. When possible, the experts were firstly contacted by phone. The questionnaire was send to the experts as a link attached in the email. Experts were approached by using the personal network and the network of the TU/e and its professors. Respondents are asked to share the questionnaire to experts in the field within their company/network. Furthermore, there are several networks, databases and documentations available concerning SUE projects with contact details. Retrieved from online searches, the questionnaire is distributed to experts and also placed on several networks/platforms. The distribution on networks/platforms makes the general questions even more important to monitor the relevant response.
The data retrieval was simple and reliable by using the Berg enquete system of the Eindhoven University of Technology. Results are automatically saved on the network as respondents could automatically save the results by ending the questionnaire. Even if people finished a part of the questionnaire then still the filled in results are saved. It decreases the risk for a lower response. However, the commitment to cooperate by the approached experts is unpredictable also due to the fact that there is not a whole database to which the questionnaire can be distributed to.

4.5.2. Respondents and analysis

Type of respondents

The questionnaire is presented to experts in the development (front-end phase) of SUE projects. The general requirements that the experts should met are at least that they have experience with the development of smart city projects preferably within the energy domain/SUE projects. The reason to approach for experts in smart city projects is due to the uncertainty of not getting enough responses when only experts in the development of SUE

projects gets targeted. Chapter 2 shows that in all likelihood there are no big differences in the OC between smart city projects and SUE projects. If there are enough responses from experts in SUE projects then other experts in other domains with experience in other projects will not be included in the analysis.
The experts in the development of SUE project that are invited to fill in the questionnaire can be divided into 5 different groups as stated in the literature review. These are public organizations, private companies, utilities, non-governmental organizations (NGOs) and knowledge institutions. The variety of the relevant experts resulting from the literature review phase assures that all relevant features are collected. This is suggested by numerous authors that explore and use the Delphi method (Delbecq, Ven, & Gustafson, 1975; Schmidt, Lyytinen, Keil, & Cule, 2001). One single expert from one single background is not likely to have the knowledge of all development situations needed to yield a complete list of OC factors. Based on this starting point, the consulted experts with different backgrounds were asked about their willingness to participate in this research.

Field of experience (individual respondents)
The respondent itself should have a certain knowledge and experience within the field of smart city projects/SUE projects. Additionally, they should have experience with the front-end phase (initiation – development) of such projects. This is essential in order to be able to answer the questionnaire. The judgement about whether the respondent is qualified or not is firstly based on their own judgment. If it turns out that a respondent is not qualified based on the results and data then the respondent's data will be removed.

Response rate
The total amount of completed responses is 21. It is difficult to say anything about the total number of contacted experts as a whole. Reason for this is because the questionnaire is also distributed on networks/platforms with different ranges (e.g. smart Amsterdam network (+4700 members) H2020 smart cities and communities (+9700 members)). The distribution on platforms/networks did not result in many valid responses as hoped before (maximum 2 with the knowledge of the researcher). More importantly, the approach to personally contact experts was much more effective. The total number of personally contacted experts is 78. The total amount of respondents is 21. The overall response rate (if only the personal contacted experts are included) is 26,92% (21 out of 78). The number of responses and response rate was approximately expected beforehand. Despite the mitigation measures to increase the response rate, some reasons could have led to a possible reduction in responses.

- The length of the questionnaire. Many OC factors were present with a lot of jargon.
- The questionnaire is monotonous and unexciting. All OC factors need to be assessed in the same way over and over. Therefore, the chance that people stop with the questionnaire during the process increases. (14 people partly answered the questionnaire and stopped the questionnaire during the process).
- Specific experience and knowledge is necessary in order to properly answer the questionnaire. Many people could consider themselves not eligible to answer the questionnaire.

Response distribution and type of experience
The total number of responses is 22. One respondent did not have any experience in the development of such projects. The results of this respondent is excluded because the

respondent has no experience in the development of SUE projects which makes the answer not valid. Therefore the questionnaire resulted in 21 distinct expert opinions.
The distribution of how they were involved is as follows: public organization 38,1% (8)[2], private organization 28,6 (6)[2], utilities 14,3% (3)[2], NGOs 4,8% (1)[2], knowledge institute 0% (0) and other 14,3% (3). The respondents that answered 'other' specified their answers as follows:

- *Respondent 1:* Involved from a private organization and from a NGO.
- *Respondent 2:* Involved from a utility organization, from a public organization and from the EU.
- *Respondent 3:* Involved in a public private partnership.

All the three responses are valid and useful because they have experience within more than one former classified organization. The literature (Delbecq, Ven, & Gustafson, 1975; Schmidt, Lyytinen, Keil, & Cule, 2001) suggests that with a homogeneous group of ten to fifteen participants the outcome of an FDM questionnaire might be reliable. All these categorization groups are too small which means that it is not possible to draw conclusions out of these independent respondent categorizations. This means that to draw conclusions and to determine which OC factors will be most important for the next phase of this research all results of the 21 respondents will be used together. Additionally, the variance within the 21 respondents has been reviewed for every factor to determine if it is suitable to draw conclusions out of it. In general the variance lies between 0.02 and 0.06. Therefore, the answers of the respondents are relatively the same and can be considered as valid to procedure the results of all the respondents as one group.
Next to the needed experience, it is preferred that the respondents have at least experience within in the energy domain. Figure 4-5 details in which smart city domains each respondent have been involved. 19 out of 21 respondents have been involved in the energy and natural resources domain.

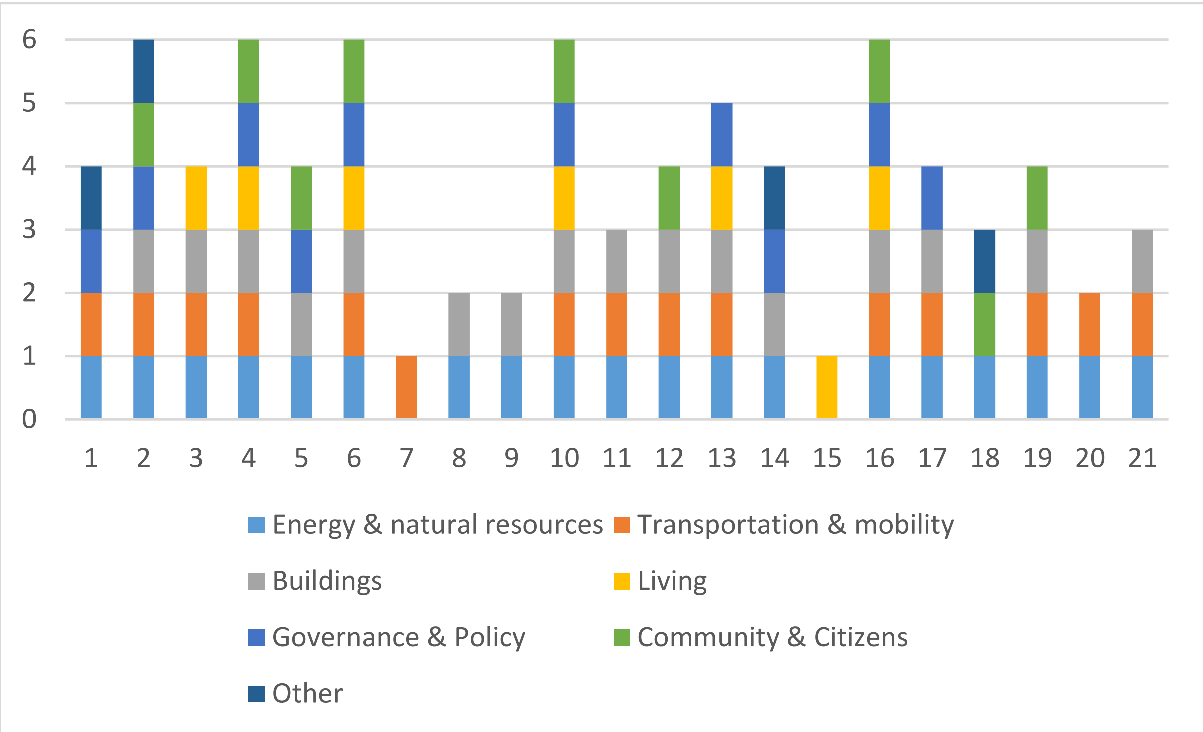

Figure 4-5: Project involvement in the smart city domain per respondent.

[2] If the thee respondents with the answer 'other' were processed within the first four categories then the distribution of this category changes with 1 or 2 (dependent on the answers).

Respondent 7 and 15 are/were only involved in respectively the transportation & mobility and living domain. They do not have the preferred experience and knowledge within the energy domain but it was not necessarily required to enter the questionnaire. Experience and knowledge in the development of smart city project was required. Their expertise lies in two other smart city domains. The respondents without experience in the energy domain are included due to the following threefold reasoning:

- Firstly, when it is intuitively argued then, there should not be a major difference in the OC between different smart city projects in the different domains as the literature shows. Both respondents have experience with the development of smart city projects in the living and mobility domain. The transportation and mobility domain is strongly related to the energy domain. When it is intuitively argued and according to the literature then respondent 7 and 15 are qualified and experienced and therefore reliable for this research.
- Secondly, there is no big difference in the results when respondent 7 and 15 are excluded from the results compared with when they are included. A FDM scenario is calculated in which those two respondents are included and excluded in the results. The results clearly shows no major differences between the two scenario's and results.
- Lastly, the variance and standard deviation is calculated for all OC factors. The answers of respondent 7 and 15 for the critical OC factors that are located nearby the set threshold are reviewed and compared with the standard deviation and variance. The answers are reviewed and compared with the variance and standard deviation of the concerned factor to determine if the answers are fairly the same or that the answers of respondent 7 and 15 differ compared with the rest of the respondents. The results demonstrates that the answers are almost all the time located within the standard deviation and are relatively the same as the other responses.

The answers of respondent 7 and 15 is considered as valid and are included in the results due to the above threefold reasoning.

4.5.3. Results FDM

The calculations are performed based on the equations stated in section 4.3.3. A selection is made of relevant OC factors which can be selected from the numerous OC factors by setting a threshold 0,710. The number of OC factors are scrutinized and ranked based on these FDM results. Table 6 represents the average opinions of all 21 respondents for every OC factor.

4.5.3.1. Threshold value

Literature does not provide one standard rule for setting a threshold as mentioned in 4.3.3. Setting the threshold value in this research is drawn based on the following reasoning. First of all, the mean was determined of all single derived numbers of all OC factors. The mean of all defuzzified OC factors is 0,696. Therefore a threshold of 0,696 seems to be appropriate for this research. All the crisp numbers of the OC factors are examined against this mean. It is argued that there should be a significant difference between two values where the threshold will be set. It does not makes much sense to not select a OC factor because is scored for example 0,002 lower than the factor above. Therefore, Table 7 provides the overall ratings and rankings of all single OC factors. Please note, around the threshold 0,696 there are no significant differences between the factors PV2, IP8 and PV3. Therefore, OC factor PS11 (0.717) is significantly weighted higher than the OC factors below (PV2, 0.703). To set the threshold between those factors is valid. Lastly, by setting this threshold, the derived number

of important OC factors is manageable for further research that can give more insight on the factors. Based on the above reasoning, the OC factors that contribute the most to the complexity in the frond-end phase of a SUE project will be selected by setting the threshold 0.71. This is supported by the mean value of column b in Table 6 which is 0.71 which is at times used to set the threshold. The principle of screening is as follows:
if $sj \geq 0.71$, then No. j OC factor is very important and included for further research.
if $sj < 0.71$, then No. j OC factor is less important and not included for further research.

After the application of the FDM, 25 out of the 56 OC factors are accepted that contribute the most to the organizational complexity in the frond-end phase of SUE projects. 31 OC factors are rejected. Table 6 provides an overview of the FDM results for every OC factor and if a factor is accepted or rejected. Column a, b and c displays the aggregated fuzzy numbers of each OC factor and column S provide the defuzzified number for each OC factor. Table 6 also provides the total score for every OC category. Table 7 represents all the OC factors and their corresponding ranking. It presents the final result including a hierarchical framework of the OC factors. It provide a clear perspective of where the threshold has been set and the differences in result.

4.5.3.2. Analysis FDM results

Table 6 and Table 7 provides insights and an overview of the FDM results. It shows to what degree, on a range from 0 – 1, each OC factor could contribute to the OC of a SUE project and how important those factors are. The variance within all the respondents for every OC factor has been reviewed to determine the suitability of the results for every OC factor. In general, the variance lies between 0.02 and 0.05. It means that that the answers of the respondents are fairly the same.

Based on the set threshold, 25 OC factors are accepted from the 56 identified OC factors from the literature and expert interviews. 25 factors is still a large amount of factors but beforehand it was expected that the result would include around 25 factors instead of for example 10 factors. This can be explained due to a twofold reasoning. First, numerous researches in the literature all provided at least more than +/-10 complexity factors that could influence projects. It was expected that the same would apply for this research also because the literature explicit mention the organizational issues and organizational complexities in smart city / SUE projects. Secondly, if for example +/- 10 factors would have been selected then the threshold value should have been set higher. Consequently, there is a major change that certain OC factors will be excluded which could have a noteworthy influence on a specific SUE project. The threshold is set based on certain guidelines from the scientific literature. If it was decided to set the threshold higher than certain OC factors were possibly missing and it would have been against the guidelines in the scientific literature. It is of great importance that the most important OC factors are identified for this research but also for further research.

What is compelling to see in the overall results is that all the scores for every individual OC factor are relative high. All OC factors are to a greater or lesser extent important to the experts. The overall defuzzified average of all factors is 0.696 with a possible range from 0 to 1. All OC factors are at least above a defuzzified number of 0,48. Of all 56 OC Factors, the lowest rated OC factor is ‘variety of project management methods and tools applied’ (PV8) with a score of 0,484. This score corresponds closely to a neutral score (0.5).

Table 6: Overall rating of the OC factors in SUE projects based on the Fuzzy Delphi Method.

Abbreviations	OC factor	Fuzzy numbers W = (a, b, c) a	b	c	Defuzzified number S S	Result	Rank
PS1	*Duration of the project	0.50	0.68	0.84	0.671	Rejected	39
PS2	*Number of activities	0.66	0.84	0.96	0.822	Accepted	3
PS3	*Number of deliverables	0.59	0.76	0.90	0.749	Accepted	12
PS4	*Number of decisions to be made	0.58	0.76	0.90	0.749	Accepted	12
PS5	*Number of investors	0.54	0.70	0.82	0.687	Rejected	31
PS6	*Largeness of capital investment (CAPEX)	0.44	0.62	0.78	0.613	Rejected	47
PS7	*Division/sharing risks	0.61	0.80	0.92	0.779	Accepted	10
PS8	*Number of information/data systems	0.56	0.75	0.90	0.735	Accepted	17
PS9	*Number and hierarchy of stakeholders	0.67	0.84	0.94	0.817	Accepted	5
PS10	*Number and clarity of project objectives	0.65	0.81	0.92	0.795	Accepted	8
PS11	*Hierarchy of project objectives	0.55	0.73	0.88	0.717	Accepted	25
PS12	*Number of directly involved project participants / partners	0.58	0.76	0.89	0.740	Accepted	15
PS13	*Number of groups / teams / structures to be coordinated	0.67	0.84	0.95	0.821	Accepted	4
PS14	*Number of hierarchical levels	0.52	0.70	0.85	0.692	Rejected	29
PS15	*Number, diversity and clarity of contract types	0.52	0.70	0.84	0.687	Rejected	31
PS16	*Number of companies/projects sharing their resources	0.57	0.75	0.89	0.733	Accepted	18
PS17	*Number of departments involved	0.49	0.69	0.85	0.676	Rejected	38
	Total project scope (PS):	**0.57**	**0.75**	**0.88**	**0,734**		
PV1	*Variety of the interests of the stakeholders (collective/individual and long/short term	0.67	0.83	0.94	0.814	Accepted	6
PV2	*Variety of the stakeholders' status	0.53	0.71	0.87	0.703	Rejected	26
PV3	*Variety of information/data systems to be combined	0.51	0.70	0.87	0.695	Rejected	28
PV4	*Types of (organizational) skills required	0.45	0.65	0.84	0.648	Rejected	42
PV5	*Variety (or lack of variety) of involved project participants/partners (experience, social background or references)	0.55	0.73	0.88	0.719	Accepted	22
PV6	*Variety of organizational interdependencies	0.56	0.73	0.86	0.717	Accepted	24
PV7	*Variety of financial resources	0.43	0.63	0.80	0.619	Rejected	46
PV8	*Variety of project management methods and tools applied	0.30	0.49	0.67	0.484	Rejected	56
PV9	*Variety of hierarchical levels within the organization	0.38	0.57	0.75	0.568	Rejected	54
PV10	*Geographical location of the stakeholders	0.30	0.50	0.68	0.494	Rejected	55
	Total project variety (PV):	**0.47**	**0.66**	**0.82**	**0,646**		
IP1	*Interdependence between partners/actors	0.51	0.69	0.84	0.683	Rejected	36
IP2	*Interdependence of objectives / interests	0.50	0.70	0.86	0.683	Rejected	35
IP3	*Interdependence of information/data systems	0.45	0.65	0.82	0.643	Rejected	43
IP4	*Interdependence of processes	0.46	0.82	0.53	0.603	Rejected	51
IP5	*Team cooperation and communication	0.56	0.73	0.87	0.719	Accepted	22
IP6	*Trust	0.73	0.88	0.95	0.854	Accepted	1
IP7	*Interdependence between companies, departments and and/or sites	0.45	0.65	0.82	0.640	Rejected	44
IP8	*Availability of people, material and of any resources due to sharing	0.53	0.71	0.85	0.698	Rejected	27
IP9	*Level of interrelations between phases	0.40	0.58	0.76	0.578	Rejected	52
IP10	*Dependencies between schedules	0.42	0.61	0.78	0.606	Rejected	49
IP11	*Stakeholders interrelations	0.56	0.74	0.89	0.729	Accepted	20
IP12	*Dependencies with the environment	0.51	0.70	0.85	0.687	Rejected	31
IP13	*Involvement of users / citizens / community	0.49	0.67	0.82	0.657	Rejected	41
IP14	*Dynamic and evolving partners / team structure	0.50	0.69	0.84	0.678	Rejected	37
IP15	*Commitment and support (top management, users, partners, etc.)	0.71	0.88	0.97	0.852	Accepted	2
IP16	*Project leadership and ownership	0.66	0.83	0.94	0.810	Accepted	7
IP17	*Number of interfaces in the project organization	0.48	0.67	0.83	0.662	Rejected	40
IP18	*Structural formalization	0.39	0.58	0.74	0.570	Rejected	53
IP19	*Protection of intellectual property	0.44	0.62	0.78	0.611	Rejected	48
IP20	*Interconnectivity and feedback loops in the task and project networks	0.44	0.62	0.80	0.619	Rejected	45
	Total interdepencies within the project (IP):	**0.51**	**0.70**	**0.83**	**0,679**		
EC1	*Degree of innovation	0.59	0.76	0.90	0.749	Accepted	12
EC2	*Environment complexity (networked environment)	0.57	0.74	0.88	0.730	Accepted	19
EC3	*Level of competition (between stakeholders)	0.60	0.78	0.90	0.763	Accepted	11
EC4	*Local and / or new laws and regulations	0.57	0.75	0.90	0.738	Accepted	16
EC5	*Institutional configuration	0.51	0.70	0.87	0.692	Rejected	30
EC6	*Cultural configuration and variety	0.41	0.61	0.79	0.605	Rejected	50
EC7	*Commercial newness of the project	0.51	0.70	0.85	0.687	Rejected	31
EC8	*Political situation and influence	0.62	0.81	0.93	0.789	Accepted	9
EC9	*Upscaling the project	0.56	0.74	0.86	0.721	Accepted	21
	Total elements of context (EC):	**0.55**	**0.73**	**0.88**	**0,719**		
	Total:	**0.53**	**0.71**	**0.85**	**0,696**		
	Threshold value				**0.716**		

In the overall ratings, two OC factors are significant more important in the front-end phase in SUE projects: ‘trust’ and ‘commitment and support’. The highest score is ‘trust’ (IP6) with a score of 0,854 which corresponds to a score of significant importance.
The relative high averages of all factors is not necessarily wrong. The relative high averages details that the provided and selected OC factors from the literature and expert interviews are relevant and contribute to the OC in innovative SUE projects. There could be other reasons for the relative high averages scores which are discussed in the discussion part (chapter 4.6). Another observation based on the results is that there are no major differences in the average scores between following up OC factors. The averages are quiet close to each other due to the relative high averages.

Comparison results with the literature and expert interviews
As previously discussed, Table 6 represents the different categorizations within the OC and its scores per factor. What is compelling to notice is the differences in scores and in the number of accepted factors in de four different categorizations. Resulting from the FDM, the number of accepted OC factors per category and the average defuzzified number (S) per category is:

- PS: 11 OC factors accepted | 6 OC factors rejected | overall S = 0,734;
- PV: 3 OC factors accepted | 7 OC factors rejected | overall S = 0,646;
- IP: 5 OC factors accepted | 15 OC factors rejected | overall S = 0,679;
- EC: 6 OC factors accepted | 3 OC factors rejected | overall S = 0,719.

Among the four categorizations, the category ‘project scope’ (PS) contributes most to the OC according to the results and due to the fact that most accepted OC factors are within this category. The category ‘project variety’ (PV) has the lowest mean score and it seems that this category has the least contribution and is less applicable to the OC. This is also reflected in the number of accepted factors which is only 3. The mean of the category ‘interdependencies within the project’ (IP) is relatively low which is also reflected in the accepted OC factors. Only 5 out of 20 OC factors are accepted within this category. Lastly, the category ‘elements of context’ (EC) has the second highest mean score and 6 factors out of 9 are accepted.

To provide more insights, the results are visualized per category and further discussed below. Additionally, the results per category are compared with the other categories, the literature and expert interviews.

Project scope (PS)
The defuzzified scores of all respondents for every OC factor in the category project scope is represented in Figure 4-6. The blue line represents the defuzzified score per OC factor. The number on the x-axis corresponds with the same number in Table 6. The orange line represents the set threshold of 0,71.

The smart city literature explicitly refers that project scope is a major challenge in such initiatives as discussed in chapter 2. The scope should be clear and shared by all partners especially when multiple partners are involved. With this in mind, it is no surprise that the three OC factors that scored highest and above 0,8, are ‘number of activities’, ‘number and hierarchy of stakeholders’ and ‘number of groups/teams/structures to be coordinated’. Additionally, those three factors are almost all the time mentioned in different complexity literature. Moreover, the remaining accepted factors in this category also scored significant

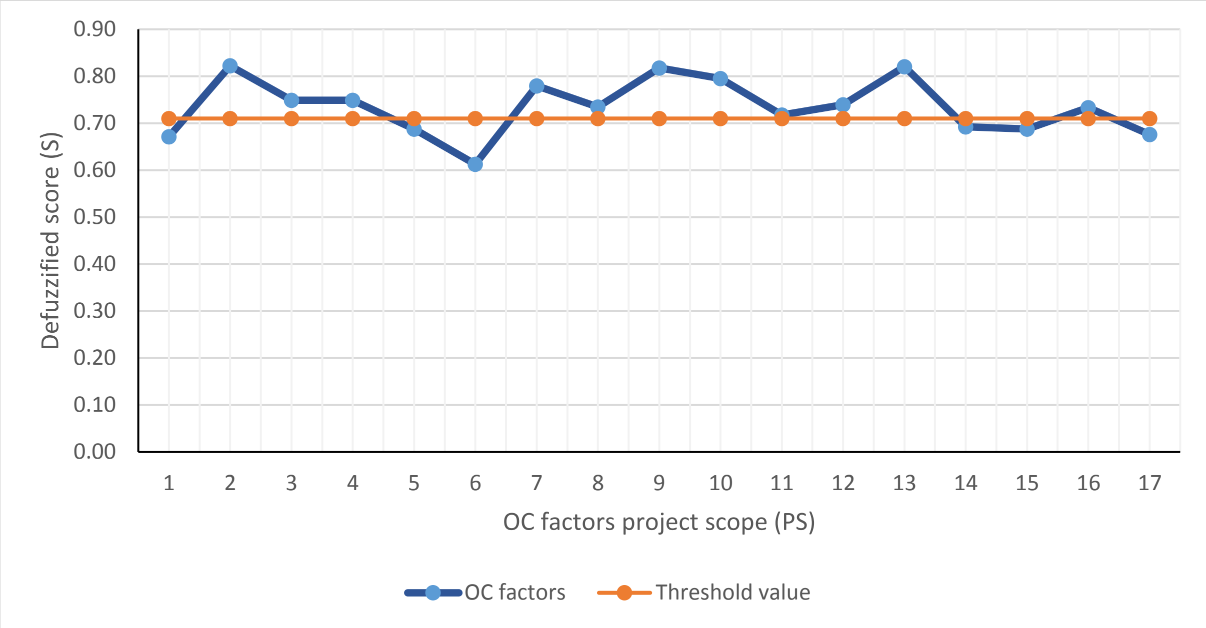

Figure 4-6: Defuzzified scores of the category 'project scope' by all respondents.

above the threshold which makes them significant important. The accepted factors are all strongly related to the project scope and the collaboration between the partners.
Apparently, the 'largeness of capital' and 'number of investors' are not as important as other factors. The scores of 0,613 and 0,687 shows a tendency towards importance with their score but are not accepted with the set threshold. The equivalent applies for 'number of departments' involved and 'number of hierarchical levels'. Noticeable is that the smart city literature does not mention those factors. Due to cross sectoral cooperation and equivalent partnerships in such projects it was expected that those actors would score lower than the other factors. It was expected that those factors are less subject to attention in innovative SUE projects. Remarkably, 'number, diversity and clarity of contract types' (PS15) is not accepted with the used threshold. This OC factor was stated during one expert interview as very important. The variance and standard deviation is judged of the rejected factors. It can be concluded that those factors should not be selected and that there is a consensus by the experts. The variance of PS11 is also judged due to the fact that it is just above the threshold line. With a variance of 0,03 consensus was reached.

Project variety

The defuzzified scores of all respondents for every OC factor in the category project variety is represented in Figure 4-7. The blue line represents the defuzzified score per OC factor. The number on the x-axis corresponds with the same number in Table 6. The orange line represents the set threshold of 0,71

Three of the total ten factors are accepted within this category. Figure 4-7 visualizes the scores against the threshold value. Almost all scores are significant above or significant below the threshold line. 'Variety of interest' PV1 contributes significant to the OC with a score of 0,814. This is in line with the expert interviews. All the experts considered the variety of interests as one of the most important complexity factors which could cause issues and complexity. The two other accepted factors are accepted with a score of 0,719 and 0,717 which is just above the threshold value. Assessing the variance of these factors there can be concluded that consensus is reached by the experts. The consensus was especially expected for the factor 'variety of involved project partners' due to the often cross-sectoral collaboration in SUE projects. The literature consider diversity of the team and partners and conflicting goals as an important issue and challenge for smart city projects. This is clearly reflected in the three accepted OC factors within this category.

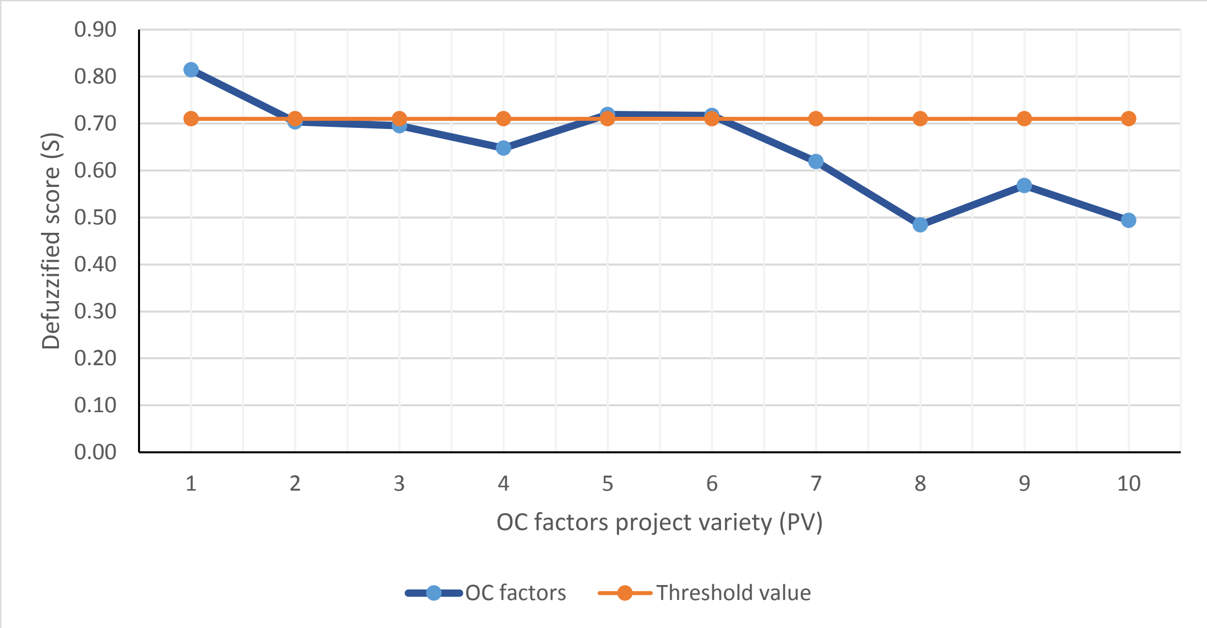

Figure 4-7: Defuzzified scores of the category 'project variety' by all respondents.

Surprisingly, 'variety of information systems/data systems to be combined' (PV3) is rejected with the use of the FDM. Combining a variety of information/data systems was expected to contribute to the complexity based on the literature review in terms of ownership, privacy, sharing and security. Especially because the number of information/data systems (PS8) was accepted in the project scope category. With a variance of 0,03, the results provide clear consensus among the experts. Reason could be that combining the variety of information/data systems does not contribute to the complexity in the front-end phase but more in the execution phase. The other rejected factors are significant lower in score then the threshold and are in line with the rejected factors in the project scope category. The three OC factors that are ranked lowest of all factors are found in this category (PV8/0.484, PV9/0,568 and PV10/0,494). The category project variety contributes the least to the complexity in SUE projects according to the results .

Interdependencies within the project

The defuzzified scores of all respondents for every OC factor in the category interdependencies is represented in Figure 4-8. The blue line represents the defuzzified score per OC factor. The number on the x-axis corresponds with the same number in Table 6. The orange line represents the set threshold of 0,71.

As Figure 4-8 details, there are three peaks in this category and several falls in comparison with the threshold line. Despite that this category has a relatively low mean, the top two ranked OC factors (Table 7) of all OC factors are within this category. Those two OC factors are significant more important in the front-end phase in SUE projects than the others. These are 'trust' and 'commitment and support'.

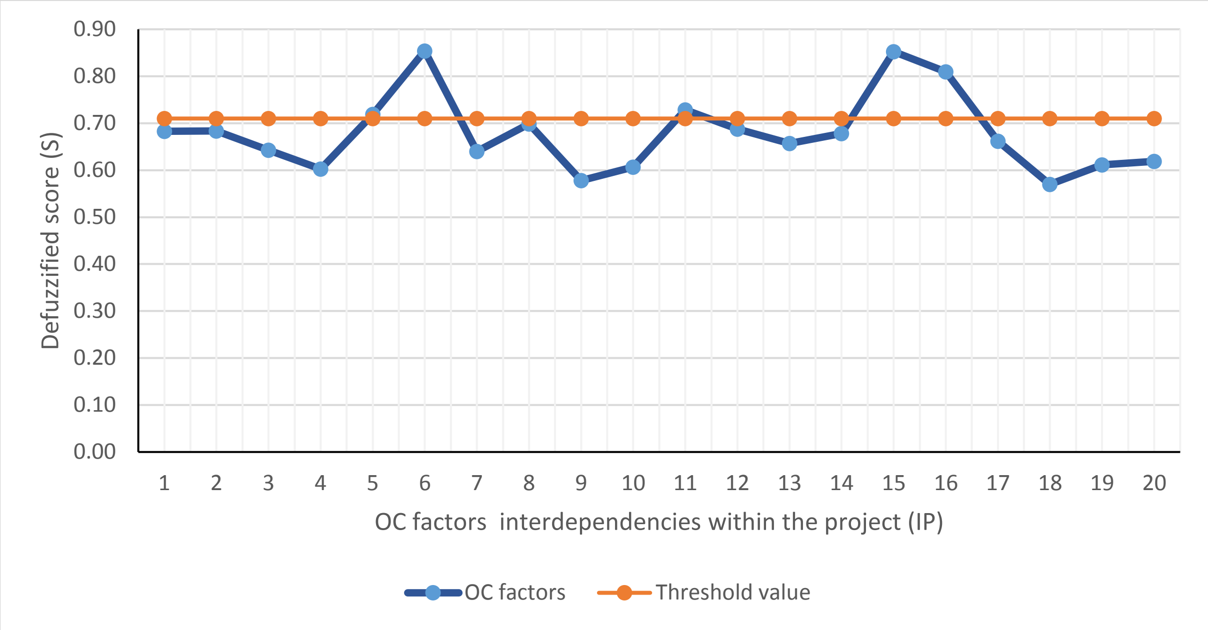

Figure 4-8: Defuzzified scores of the category 'interdependencies within the project' by all respondents.

The same applies for IP16 (project leadership and ownership) which also contributes significant to the OC with a score of 0,810.
The smart city literature and complexity literature shows that interdependencies in the project results in complexities and challenges. Next to the important factors in this category, there are also 15 factors rejected. It was expected that several factors resulting from the project complexity theory would be rejected due to the fact that those factors in general apply on major infrastructure projects. What is remarkable is that interdependence between partners (IP1), involvement of users/citizens (IP13) and dynamic and evolving partners (IP14) are not ranked in the top and are also not accepted with the used threshold. Those OC factors are considered as important according to the literature and/or expert interview(s) but are not judged as significant contributing to the OC in the front-end phase in SUE projects. The variance and standard deviation are assessed for those three factors to judge the consensus and reliability of the answers of the experts. It can be concluded that for those factors consensus is reached by the experts.

Elements of context
The defuzzified scores of all respondents for every OC factor in the category elements of context is represented in Figure 4-9. Again, the blue line represents the defuzzified score per OC factor. The number on the x-axis corresponds with the same number in Table 6. The orange line represents the set threshold of 0,71.

Beforehand, it was expected that many factors in this category would be accepted. Many OC factors from the smart city literature are situated in this category. The chance that those factors would apply for this research were higher than for the factors from the project complexity literature.
The results supports this assumption. Six out of nine factors in this category are accepted. As Figure 4-9 details, those factors are not considered as the most important OC factors.

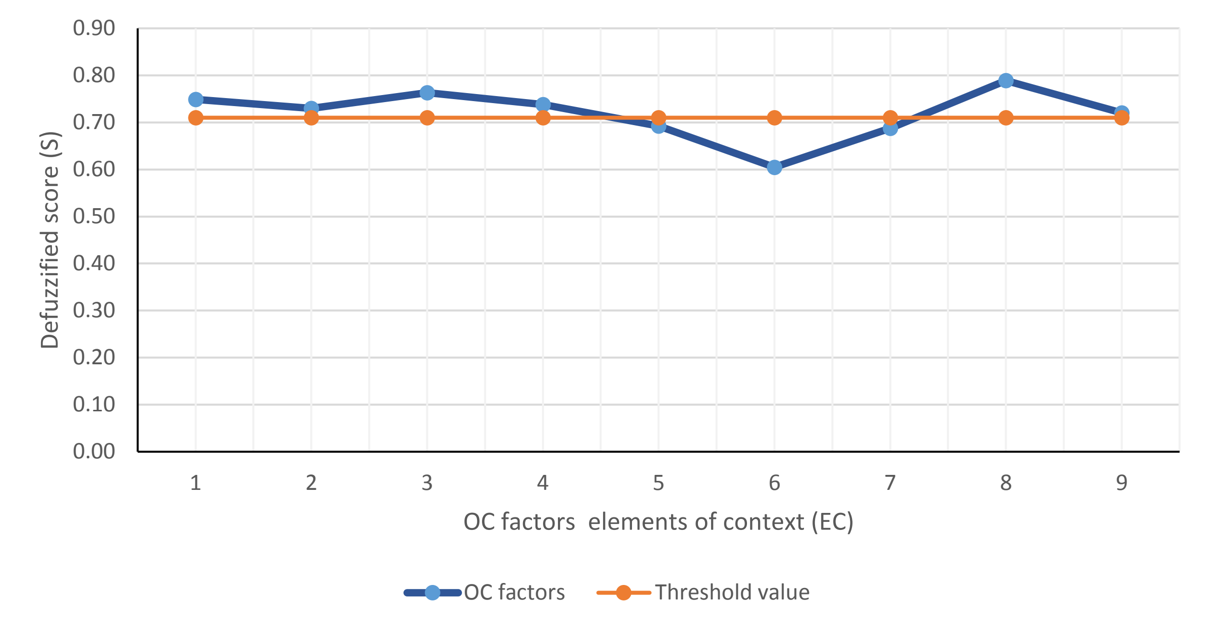

Figure 4-9: Defuzzified scores of the category 'elements of context' by all respondents.

Only one factor is ranked within the top 10 of most important factors (political situation and influence, EC8). But the figure also details that the accepted factors are significant above the threshold line. The accepted factors are in line with the literature and expert interviews. Especially the laws and regulations, political situation and upscaling were mentioned in the literature but also in the expert interviews. The results of this category are in line with the literature and expert interviews.

Overall ranking all OC factors

In total, 25 OC factors out of 56 OC factors are accepted that contribute the most to the organizational complexity in the frond-end phase of SUE projects. Table 7 represents all the structured OC factors, their scores and their corresponding ranking. It presents the final result including a hierarchical framework of the OC factors. It provides a clear perspective of where the threshold has been set and the differences between the OC factors and their contribution to the OC. The 25 accepted OC factors are still a lot factors but those are necessary to capture the essence of this research. Table 7 details in a clear way that there are almost no low scores and that many factors are almost equally contributing to the OC. The fact that there are no very low scores might be is a sign that many factors could contribute to the OC in SUE projects. Furthermore, it might be a sign that an innovative SUE project is very complex in the organizational field and that the complexity exists of a combination of many different OC factors which also might influence each other. Therefore framework should not be an end in itself, but a means to provide guidance. The OC framework is not a blueprint regarding the OC but is serves as a means to see where the OC most likely will be situated and what you have to take into account. Therefore the quantified framework serves as a reference list that serves as a good starting point to identify the OC in a SUE project.

Table 7: OC factors ranked based on the Fuzzy Delphi Method.

Abbreviations	OC factor	Fuzzy numbers W = (a, b, c) a	b	c	Defuzzified number S	Result	Rank
		a	b	c	S		
IP6	*Trust	0.73	0.88	0.95	0.854	Accepted	1
IP15	*Commitment and support (top management, users, partners, etc.)	0.71	0.88	0.97	0.852	Accepted	2
PS2	*Number of activities	0.66	0.84	0.96	0.822	Accepted	3
PS13	*Number of groups / teams / structures to be coordinated	0.67	0.84	0.95	0.821	Accepted	4
PS9	*Number and hierarchy of stakeholders	0.67	0.84	0.94	0.817	Accepted	5
PV1	*Variety of the interests of the stakeholders (collective/individual and long/short term	0.67	0.83	0.94	0.814	Accepted	6
IP16	*Project leadership and ownership	0.66	0.83	0.94	0.810	Accepted	7
PS10	*Number and clarity of project objectives	0.65	0.81	0.92	0.795	Accepted	8
EC8	*Political situation and influence	0.62	0.81	0.93	0.789	Accepted	9
PS7	*Division/sharing risks	0.61	0.80	0.92	0.779	Accepted	10
EC3	*Level of competition (between stakeholders)	0.60	0.78	0.90	0.763	Accepted	11
PS3	*Number of deliverables	0.59	0.76	0.90	0.749	Accepted	12
PS4	*Number of decisions to be made	0.58	0.76	0.90	0.749	Accepted	12
EC1	*Degree of innovation	0.59	0.76	0.90	0.749	Accepted	12
PS12	*Number of directly involved project participants / partners	0.58	0.76	0.89	0.740	Accepted	15
EC4	*Local and / or new laws and regulations	0.57	0.75	0.90	0.738	Accepted	16
PS8	*Number of information/data systems	0.56	0.75	0.90	0.735	Accepted	17
PS16	*Number of companies/projects sharing their resources	0.57	0.75	0.89	0.733	Accepted	18
EC2	*Environment complexity (networked environment)	0.57	0.74	0.88	0.730	Accepted	19
IP11	*Stakeholders interrelations	0.56	0.74	0.89	0.729	Accepted	20
EC9	*Upscaling the project	0.56	0.74	0.86	0.721	Accepted	21
PV5	*Variety (or lack of variety) of involved project participants/partners (experience, social background or references)	0.55	0.73	0.88	0.719	Accepted	22
IP5	*Team cooperation and communication	0.56	0.73	0.87	0.719	Accepted	22
PV6	*Variety of organizational interdependencies	0.56	0.73	0.86	0.717	Accepted	24
PS11	*Hierarchy of project objectives	0.55	0.73	0.88	0.717	Accepted	25
PV2	*Variety of the stakeholders' status	0.53	0.71	0.87	0.703	Rejected	26
IP8	*Availability of people, material and of any resources due to sharing	0.53	0.71	0.85	0.698	Rejected	27
PV3	*Variety of information/data systems to be combined	0.51	0.70	0.87	0.695	Rejected	28
PS14	*Number of hierarchical levels	0.52	0.70	0.85	0.692	Rejected	29
EC5	*Institutional configuration	0.51	0.70	0.87	0.692	Rejected	30
PS5	*Number of investors	0.54	0.70	0.82	0.687	Rejected	31
PS15	*Number, diversity and clarity of contract types	0.52	0.70	0.84	0.687	Rejected	31
IP12	*Dependencies with the environment	0.51	0.70	0.85	0.687	Rejected	31
EC7	*Commercial newness of the project	0.51	0.70	0.85	0.687	Rejected	31
IP2	*Interdependence of objectives / interests	0.50	0.70	0.86	0.683	Rejected	35
IP1	*Interdependence between partners/actors	0.51	0.69	0.84	0.683	Rejected	36
IP14	*Dynamic and evolving partners / team structure	0.50	0.69	0.84	0.678	Rejected	37
PS17	*Number of departments involved	0.49	0.69	0.85	0.676	Rejected	38
PS1	*Duration of the project	0.50	0.68	0.84	0.671	Rejected	39
IP17	*Number of interfaces in the project organization	0.48	0.67	0.83	0.662	Rejected	40
IP13	*Involvement of users / citizens / community	0.49	0.67	0.82	0.657	Rejected	41
PV4	*Types of (organizational) skills required	0.45	0.65	0.84	0.648	Rejected	42
IP3	*Interdependence of information/data systems	0.45	0.65	0.82	0.643	Rejected	43
IP7	*Interdependence between companies, departments and and/or sites	0.45	0.65	0.82	0.640	Rejected	44
IP20	*Interconnectivity and feedback loops in the task and project networks	0.44	0.62	0.80	0.619	Rejected	45
PV7	*Variety of financial resources	0.43	0.63	0.80	0.619	Rejected	46
PS6	*Largeness of capital investment (CAPEX)	0.44	0.62	0.78	0.613	Rejected	47
IP19	*Protection of intellectual property	0.44	0.62	0.78	0.611	Rejected	48
IP10	*Dependencies between schedules	0.42	0.61	0.78	0.606	Rejected	49
EC6	*Cultural configuration and variety	0.41	0.61	0.79	0.605	Rejected	50
IP4	*Interdependence of processes	0.46	0.82	0.53	0.603	Rejected	51
IP9	*Level of interrelations between phases	0.40	0.58	0.76	0.578	Rejected	52
IP18	*Structural formalization	0.39	0.58	0.74	0.570	Rejected	53
PV9	*Variety of hierarchical levels within the organization	0.38	0.57	0.75	0.568	Rejected	54
PV10	*Geographical location of the stakeholders	0.30	0.50	0.68	0.494	Rejected	55
PV8	*Variety of project management methods and tools applied	0.30	0.49	0.67	0.484	Rejected	56
	Total:	**0.527**	**0.713**	**0.850**	**0.696**		
	Threshold value:				**0.716**		

4.6. Discussion

The Fuzzy Delphi Methodology proofed to be able to identify a vast variety of OC factors and then scrutinize them to the manageable number assuring that all effective OC factors are included in development appraisal of SUE projects. As a result of different steps 56 OC factors were selected for the application of the FDM. The application of the FDM resulted in 25 OC factors that influence the project performance of innovativeSUE projects the most. However, some things needs to be discussed.

In general, the importance of the OC factors corresponds with the literature and expert interviews. However there are some discrepancies which was unexpected considering the literature and expert interviews ('Variety of information systems/data systems to be combined' (PV3), 'Interdependence between partners' (IP1), 'Involvement of users/citizens' (IP13) and 'Dynamic and evolving partners' (IP14). It is most likely that the discrepancy is that those OC factors are not necessarily applying in the frond-end phase of SUE projects but are more likely to cause complexity in the execution phase of such projects. Those OC factors are derived mainly from the smart city literature. Another assertion could be that those factors cause issues and complexity in smart city projects and are less applicable for SUE projects. The 25 selected criteria by using the FDM can be regarded as most important OC factors.

The questionnaire results are consistent with the literature. However, the defuzzified means are quiet high and the OC factors are considered to be of great influence on the OC. The high averages are not per definition wrong but it could be that respondents are pushed towards an answer which corresponds to a higher score due to the formulation of the questionnaire. The experts were asked to assess to what extend a factor could potentially contribute to the OC. It could be that experts interpreted the word 'potentially' in a different way. Potentially all factors could contribute to the OC, but they do not necessarily have to apply to every project. Although the formulation of the question is checked by several experts it could be that experts does interpreted it differently. The questionnaire data does not show that this is the case but a small adjustment in the question could make it even more clear.
Furthermore, it would have been interested to compare how different groups involved in SUE projects would rate the factors. This was not possible because of the number of responses and because the different response groups cannot be seen as homogenous. There is a need for more and diverse responses to assess this..

The value of the final results is that it provide a footprint of where the OC can be expected in a SUE project. The framework can be applied by practitioners in the SUE industry as a and can serve as a decision-making tool on where the complexity could be situated and for assessing the OC related risks. It results in a understanding of the critical OC factors and it allows them to pay attention to the factors that are worth more attention in order to facilitate and accelerate the successful development and management of SUE projects. Additionally, linguistic complexity terms are translated into a more systematic quantitative-basis where previous research is more of a qualitative nature. Top OC factors are identified where ambiguity, subjectivity and imprecision in complexity judgements are reduced. However, the 25 accepted factors do not have to be the absolute truth. It should be discussed that, as the results show, the rejected factors could still have an influence on certain (specific) projects. Those rejected OC factors cannot be totally neglected. Therefore the quantified framework serves as a reference list that serves as a good starting point to identify the OC in a SUE project.

5. Design and application of the OC related Risk Diagnosis Model (OCRDM)

Abstract: *Getting insights into the mechanisms of the OC and related risks and to detect the factors that could jeopardize the successful realization of the project objectives is necessary for project success. This section presents the OC related risk diagnosis model (OCRDM) that aims at assessing and diagnosing systematically potential risks in innovative SUE projects. The OCRDM was initiated and developed based on the FDM results. The OCRDM was applied on an innovative SUE project (Interflex project) for getting interesting insights, understanding mechanisms and exploring the practicality and quality of the model. This section describes how the model was applied on the innovative Interflex case. The OCRDM proved to be very useful in assessing and diagnosing OC related risks. The results proved to be in line with the reality and were endorsed by the project team. The results also supported the findings from the FDM in the previous section. The OCRDM enabled to identify the critical risk factors on an individual but also in a holistic way. The model allows the project team to focus on the important risks and could serve as a decision-making tool.*

Keywords: *OC related risk diagnosis model; Interflex; Horizon 2020; Risk topography;*

5.1. Introduction

This section aims at getting insights into the mechanisms of the OC related risks and to detect the factors that could jeopardize the successful realization of the project objectives. It provides a practical application of the FDM results which resulted in several interesting insights. In chapter 4 the FDM has been used to scrutinize and assess the most important OC factors from the literature that apply for SUE projects. It also provided a ranking and a quantitative score of the most important OC factors in SUE projects that could influence the project performance. Based on the literature review and FDM outcomes, this section aims at developing a OC related risk diagnosis model to diagnose and assess systematically the contribution and influence of those OC factors on the project performance by converting them into OC related risks. The model aims at getting more insights into the mechanisms of the OC related risks and to detect the factors that could jeopardize the successful realization of the project objectives in the front-end phase of an innovative SUE projects. This section is the qualitative part of the research. As such, this part is a more explorative research due to the use of one case-study and the limited number of respondents. It will concentrate on getting interesting insides, understanding mechanisms and exploring the qualities of the developed model. The developed OCRDM is applied on the innovative Interflex case to ensure practicability and quality of the presented model for assessing the OC related risks. This chapter aims at answering the following guiding research questions:

5. How are the OC related risks factors contributing and influencing the project performance in the selected SUE case experienced by the different project professionals?
    a) How does the OC related risks influence the project performance according to the different project professionals?
    b) Is there a difference in perception regarding the OC related risks and their influence on project performance between the different involved professionals with different backgrounds in SUE developments?

Section 5.2. describes and discuss the OC based RDM questionnaire design and model based on the FDM results in chapter 4. Subsequently, the model is applied on an innovative SUE case.

The model is applied on the Interflex project in Strijp-S Eindhoven. Section 5.3 explains the project and its objectives. The results of the questionnaire and the model will be presented in section 5.4. To conclude, the results are discussed in section 5.5.

5.2. Questionnaire OC related RDM

The questionnaire is based on the FDM results from chapter 4. Those results are transferred into OC related risks to ensure a practical application of the FDM results. Based on the literature review and FDM outcomes, the OC related risk diagnosis model is developed to diagnose and assess systematically the contribution and influence of those OC factors on the project performance of the project Interflex. The model aims at getting more insights into the mechanisms of the OC related risks and to detect the factors that could jeopardize the successful realization of the project objectives in the front-end phase of an innovative SUE projects

5.2.1. Questionnaire design

The questionnaire consists of two main parts:

1. Introduction;
2. OC based risk statements developed based on the FDM results.

1. Introduction

The introduction provides a description and purpose of the research, the OCRDM and what is expected from the respondent. The OCRDM is has a more qualitative nature and will be applied on a real life case. This means that experts/respondents will be specifically targeted. Those will be the persons that participate in the project team of the specific case which make them eligible.

2. *OC related risks questionnaire design based on the FDM results.*

The second part of the questionnaire contains the input from the FDM results. The FDM resulted in a comprehensive list of OC factors that could affect the project performance in an innovative SUE project. All relevant OC factors has been identified with the use of the FDM. The focus of the OCRDM changes from identification (FDM, chapter 4) to assessment of the OC related risks for a specific SUE project. In the previous chapter, 25 OC factors are identified and selected resulted from the FDM. The identified OC factors are processed into a OC related risk questionnaire.

Processing the OC factors and development of the OC related RDM questionnaire

The critical OC factors identified from the FDM results are processed into the RDM questionnaire. The identified OC factors are translated into positive OC based risk statements of ‘objectives to be realized’. For example: the OC factor ‘trust’ was identified as the most important OC factor in SUE projects. The OC factor ‘trust’ is formulated as follows: ‘*Trust between the partners and stakeholders is formed, built and sustained over time.’* It is translated into a positive and objective oriented statement. As mentioned in section 4.4. , negative statements are avoided because negative framing induces more positive perceptions than positive framing according to the prospect theory (Kahneman & Tversky, 2013; Keizer, Halman, & Song, 2002). In the case of OC related risk assessment it is preferred that people do not accept complexity and OC related risks too easily. That is why positive statements are preferred above negative ones. The respondents will be asked to individually rate each OC related risk statement on three parameters on a five-point scale:

- Level of certainty that the OC based risk statement will be true;
- Ability to influence course of action within time and resource limits;
- Relative importance of the statement for obtaining project success.

The reasoning for choosing these parameters and scale are provided in section 4.4. Figure 5-1 provide a part of the developed questionnaire. The whole questionnaire is verified and approved by three external researches including the original developer of the RDM. Every statement is clearly validated on their formulation, readability and understandability. This is important before going into assessment. The complete OC related risk questionnaire is shown in appendix H.

Organizational complexity related risk statements:	What is the ***level of certainty*** that the statement will be true?					***Ability of team to influence*** course of actions within time & resource limits.					***Relative importance*** of statement for obtaining project success.				
	Low				High	Low				High	High				Low
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**5**	**4**	**3**	**2**	**1**
PROJECT SCOPE STATEMENTS															
1. The number and scope of activities are known, feasible and focused. The numerous project tasks and activities will be effectively managed and coordinated and the behavior of the project is well defined and understandable for everyone.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2. The number and scope of the deliverables are defined, clear and feasible for the partners. The deliverables will be (simultaneously) controlled and achieved properly.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3. The number of the decisions to be made are known and the decision making process is effective. The prevision of the impact of these decisions are clearly understood and will be coordinated effectively.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 5-1: Example of a part of the OC related risk questionnaire.

Assessment of the OC based risk questionnaire by project participants.

Once the questionnaire was developed and approved in the previous step, the RDM method was started in the second step in which the focus changed from identification to valuation the impact of the OC related risks via the developed questionnaire. The goal was to develop a model that can assess the influence and impact of the OC related risks on the project performance experienced by the different project professionals.

The questionnaire supports the assessment of the current OC related risk level of project by assessing the influence and impact on the project at a particular point in the project life cycle. It can be used for different phases of a project and supports to implement proper management strategies relevant to the identified complexity and risks. It helps organizations in reducing the likelihood that the associated OC based risk will cause poor performance of the project. Normally risks are evaluated depending on is likelihood of occurring and the impact if it does occur. In the RDM, the assumption is made that the impact is not only depending on those two factors but also on the ability to influence the specific situation. Therefore, according this the respondents of the questionnaire are asked to judge the developed OC based risk statements on three five-point scales accordance with (Halman & Keizer, 1994; Keizer, Halman, & Song, 2002) :

- Level of certainty that the OC based risk statement will be true. As stated in the literature review, uncertainty is seen as an element and driver of complexity and risk;

- Ability to influence course of action within time and resource limits: ability of the team to reach an appropriate solution using the project's allotted time and resources;
- Relative importance of the statement for obtaining project success.

It could occur that a statement will not be relevant or that the respondent have no opinion about it then the respondents are asked to not respond on it.

5.2.2. Distribution and retrieval of the questionnaire

A risk team should be formed to carry out the RDM. This team should consist of the members of the project team and could be extended if necessary with external expertise (Halman & Keizer, 1994). The questionnaire is presented to seven members of the project team in the development (front-end phase) of the Interflex project. The questionnaire was send out to the individual project participants by mail and was shared by the project leader of the project. The team that would participate were carefully selected together with the project leader of the project. Those selected participants are all member of the Interflex project team. The assessment was carried out by different cross-sectoral project team participants. This ensures that the results more reliable and consistent with the research but also with the Fuzzy Delphi Method which is also assessed by cross-sectoral experts with different backgrounds. The identification and valuation took place on an individual basis. This is a striking character of the model due the fact that whether something is risky or not is influenced by constitution and by relationships within a project team/partnership. This carefully selection of participants with the project leader ensured that the respondents are suitable for the research and that there will be a diversity in type of organizations and backgrounds. The questionnaire was send to the project participants as an excel file attached in the email. The participants were asked to fill in the excel file and send it back to the researcher. In total, 5 out of 7 participants filled in the whole questionnaire.

5.3. INTERFLEX Strijp-S - case

5.3.1. Introduction EU INTERFLEX

INTEFLEX is an EU pilot/demonstration project which is part of the biggest EU research- and innovation program, Horizon 2020. The whole project aims to empower distribution network operators in the transition to more flexible local energy systems. It focuses on system integration in the energy supply. In other words, how is it possible to interconnect energy networks in an urban environment. The project aims to develop the next generation of smart grids in Eindhoven and elsewhere in Europe to accelerate the energy transition. The planning of the program is to run six pilots in five European countries. The InterFlex project in the Netherlands is being carried out at Strijp-S, a neighborhood in Eindhoven. This is a subproject of the European InterFlex project.

5.3.2. Rationale INTERFLEX project

The pressure on the Dutch electricity grid will increase over the coming years due to the sustainability ambitions of the government and municipalities. The objective is to increase the use of electricity for transport and for heating homes, factories and offices. Reason for this is because the energy generation changes from a central to decentral sources. Sources whose yields fluctuate more than those of traditional central power plants. On certain moments there could arise a great supply of electricity while on other moments there could be a major demands for electricity. There are roughly two options to overcome this. Firstly, to reinforce the cables in the ground with more capacity (costly) or to look for smarter alternatives to reduce demand and supply peaks. Interflex focusses on the last option. Interflex is a project where alternatives will be tested in practice in order to come up with sustainable smart solutions for the availability and affordability of energy (Interflex, n.d.).

Objectives

The focus of the Dutch Interflex pilot is mainly on flexibility from storage and electric transport in combination with a trade system based on flexibility in energy flows. Next to the main aim of the project itself, the project led to specific SUE objectives. These are:

- Energy conversation;
- Energy and resource efficiency;
- Renewable energy: PV panels will be used.
- Affordability;
- Resilience;

All those objectives have the aim to improve the economic, environmental and social sustainability of Eindhoven city and to improve the quality of life.

How and smart urban energy domains

They are trying to achieve this by using a combination of local storage, electric vehicles, smart charging, smart meters and distribution automation. The next main solutions will be used:

- **Smart energy storage via a battery:** The purpose is to test technically, economically and contractually whether the smart storage can be used in the form of commercial storage. Centralized storage must be valued with the help of all parties involved: the national network operator, local grid operator, storage manager, prosumers. It demonstrates the applicability of having storage units on a large scale at substations or at street level, in order to control energy demand.
- **Flexibility by electric transport:** The peak demand for electricity can be reduced through stimulating people to shift their energy use. For example by charging the electric vehicles by night instead of by day. This increases the flexibility in the electricity system.
- **Flexibility in the energy demand and consumption management via local marketplace:** In order to reduce the daily peaks in energy demand, Interflex is testing a concept for a local market place where the grid operator can negotiate with providers of services that can control the consumption of energy (such as the provider of an app for the charging of electric cars). The grid operator is going to subsidize it via the marketplace for moving the energy consumption of their customers. For example, if these companies ensure that their customers load the car at night instead of during the day. The flexibility will not be organized on individual level. In this way, the grid operator can drastically reduce the load on the electricity grid at peak times and the network does not have to be increased.

The project corresponds with the three principles resulting from the literature in chapter 2. Innovative technologies will be applied and in particular ICT solutions to assure the flexibility in energy demand and to organize consumption management via a local marketplace. The intervention will be integrated with different smart city domains. The project will be integrated with the following domains: buildings, transportation and mobility, energy and ICT, data & energy management and consumer (prosumer) behavior management. It is essential that these solutions will be integrated with the current (energy) system to improve the interoperability of the project. And the third principle, active collaboration between stakeholders is needed and applied in this project to make it a success and to ensure effective implementation.

5.3.3. The partnership

The Interflex project has a duration period of 36 months. The tender was issued around November 2017. In 2018, the first deliverables will be completed and in 2019 the entire system needs to be running. Subsequently, the system will be tested if the solutions have the intended results . A total of nine partners are involved in the project partnership where Enexis group is leading partner. Interflex is a project in which Enexis Netbeheer and project partners TNO and ElaadNL participate. The systems and the local marketplace are being built in collaboration with the aggregators, Jedlix, Sympower and Croonwolter & dros. Next to that, the partnership includes three collaboration partners which act more from a distance. These are Eindhoven University of Technology, Park Strijp Beheer and the municipality Eindhoven. The project brings together a broad range of partners as depicted in Figure 5-2. The partnership is very diverse which is a characteristic of a SUE project. This composition ensures connecting knowledge from different fields, cross-sectoral collaboration but also different interests.

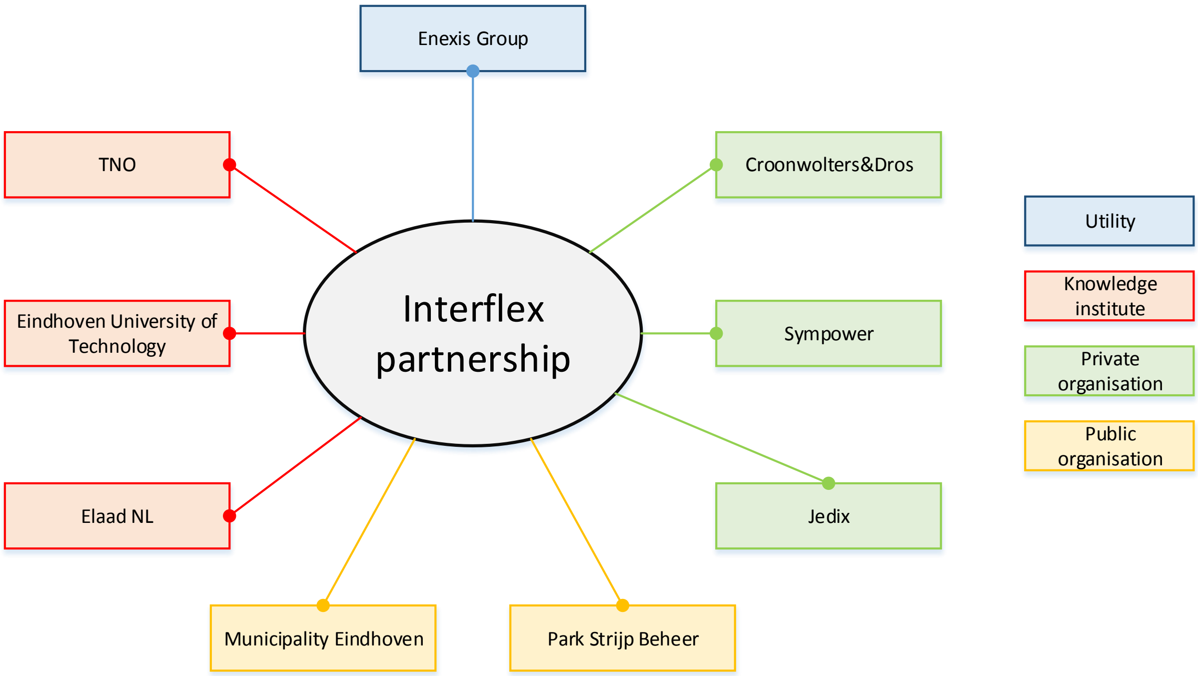

Figure 5-2: Visualization of the Interflex partnership

Below a small explanation of each partner and classification (based on chapter 2):

- Enexis group (Utility): Grid operator
- TNO (knowledge institute): research organization that connects people and knowledge to create innovations that sustainably strengthen the competitiveness of companies and the well-being of society.
- Elaad NL (knowledge institute): Knowledge and innovation center researches and tests the possibilities for Smart Charging.

- Croonwolter&Dros (Private organization): contribute with their intelligent technological electro technical, mechanical engineering and automation and computerization solutions to the sustainable performance of its customers.
- Jedlix (Private organization): Jedlix arranges the charging of electric cars by choosing the right charging moments based on the supply and consumption of sustainable energy.
- Sympower (Private organization); contribute to balancing the electricity grid sustainably through their automated software system.
- Municipality Eindhoven (public organization)
- Park Strijp Beheer (semi-public organization): collaboration between VolkerWessels and the municipality Eindhoven. Responsible for the development of Strijp-S.
- Eindhoven University of Technology (knowledge institute).

5.4. Results OC related RDM based on case investigation

For the creditability and practicality of the model, the model is applied on the innovative Interflex case. The calculations and results are performed based on the procedures and guidelines stated in section 4.4. The individual completed questionnaires are merged and processed with help of the methodology. As a result, a project OC related risk topography emerged. The results are presented and discussed with the project leader and an Interflex project participant. The main aim was to review the results and to discuss the added value of the model for the Interflex project. The topography and data of the Interflex project and the discussion with the project participants resulted in some interesting insights.

OC related risk topography

The responses of the five project participants are processed and compiled in a OC related risk topography. The results of all the questionnaires and the complete OC related risk profile for the Interflex project can be seen in Figure 5-3 and Figure 5-4. The complete topography in Figure 5-3 and Figure 5-4 indicates to what degree the majority of the respondents interpreted a statement as risky or not. The inter-subjective judgement of all participating project participants regarding the OC related risks of the Interflex project is reflected in this topography. It displays the distribution of the respondents assessment and how their judgement differ concerning a certain statement.

Analysis results

Some aspects are interesting to see and important to notice when evaluating and discussing the results and the risk-topography shown Figure 5-3 and Figure 5-4:

- **Parameter A (Certainty)**:

Nearly all statements score a 3 or a 4 (high) on the level of certainty that the statement will be true. Only statement 3, 24 and 25 score relatively low with a score of 2. It implies that most statements will be certain which and in consequence less risky. This was expected upfront. In general, the further the project develops over time the lesser the uncertainty becomes and the more information is available. During the discussion of the Interflex results it was mentioned that the project is already far in their development process and most of the deliverables are known and certain. The planning is that the pilot phase will start in the beginning of August and they will run several scenario's in October.

Due to the fact that the project is already quite far in the process it was expected that most statements already had a decent level of certainty to be true. This was confirmed by the Interflex project team. It was also confirmed that statement 24 and 25 includes a higher level of uncertainty. The Interflex project is part of the EU research- and innovation program. The main interest from the EU is how to translate new innovations into new regulations and laws. This results in uncertainty for statement 24 and 25 for the Interflex project team.

> *''If the model was applied +/- 1 year ago then the results would have been different. Much more uncertainties would occur and the controllability would be lower''*
> *- Project participant Interflex*

It was not expected that there would occur extreme results for this parameter. The Interflex project is already far in the development phase. The results are consistent with the perceived reality as confirmed by the project member and project leader of the project.

- **Parameter B (Ability to influence):**

The same applies for parameter B as for parameter A. All statement, except for statement 25, score a 3, 4 or 5 on the ability to influence the course of action. This implies that the project team can influence and control most statements which makes them less risky. Again, the Interflex is already far in the process which results in more available information. Therefore, it was expected that the controllability and ability to influence those risks was rather high then low.

> *''Much information is available at this this stage and the project scope and resources are well defined. This would be different earlier in the development phase where the ability to influence would be much lower.*
> *- Project participant Interflex*

The results and the degree of influence is in line with the reality and were endorsed by the project team. As mentioned by the project leader, If the model was applied for example in the initiation phase then the scores would be situated more to the low side which made them more risky.

- **Parameter C (relatively importance):**

Nine statements reached a score of 3. The other 17 statements reached a score of 4 or 5 which refers to a high score. It implies that have a relative high importance for obtaining project success which makes the statements more risky. Although the applied OC related risk diagnosis involved only one SUE project (Interflex) the results supports the findings from the FDM in section 4.5.3. The FDM results showed that many OC factors are important and could influence project success. The applied results from the FDM on the Interflex project shows that those results are also applicable in applying the results in a qualitative way for SUE projects. Those FDM findings are reflected in the high score on importance for obtaining project success. It also means that the identified OC factors are valuable and should not be neglected.

	OC related risk statement		A. Certainty					B. Influencibility					C. Importance					D	E. Score			F. 1 cel
			What is the level of certainty that the statement will be true?					Ability of team to influence course of actions within time & resource limits.					Relative importance of statement for obtaining project success.					Risk-Class				
			Low				High	Low				High	High				Low					
			1	2	3	4	5	1	2	3	4	5	5	4	3	2	1		A	B	C	
	PROJECT SCOPE STATEMENTS																					
1	The number and scope of activities are known, feasible and focussed. The numerous project tasks and activities will be effectivily managed and coordinated and the behavior of the project is well defined and understandable for everyone.	n-resp	1	1	1	1	1	0	0	1	2	2	2	2	0	1	0	L-H	?	o	*	?o*
		cum %	20	40	60	80	100	0	0	20	60	100	40	80	80	100	100					
		50% sc.			*						*			*								
2	The number and scope of the deliverables are defined, clear and feasible for the partners. The deliverables will be (simultaneously) controlled and achieved properly.	n-resp	0	1	1	2	1	0	0	2	2	1	3	2	0	0	0	L	o	o	*	oo*
		cum %	0	20	40	80	100	0	0	40	80	100	60	100	100	100	100					
		50% sc.				*					*		*									
3	The number of the decisions to be made are known and the decision making process is effective. The prevision of the impact of these decisions are clearly understood and will be coordinated effectivily.	n-resp	1	2	1	1	0	0	0	1	1	3	1	1	2	0	1	L-H	*	o	?	*o?
		cum %	20	60	80	100	100	0	0	20	40	100	20	40	80	80	100					
		50% sc.		*								*			*							
4	Risks and returns are divided and shared among partners in an appropriate way and everyone agrees to that.	n-resp	1	1	1	1	1	0	0	2	1	2	2	1	2	0	0	L-H	?	o	*	?o*
		cum %	20	40	60	80	100	0	0	40	60	100	40	60	100	100	100					
		50% sc.			*						*			*								
5	The amount of (different) information/data systems in the project are known and feasible and can be controlled and coordinated effectivily in terms of e.g. ownership, privacy, sharing, security.	n-resp	1	0	1	2	1	0	1	0	2	2	2	0	2	1	0	S-H	?	o	?	?o?
		cum %	20	20	40	80	100	0	20	20	60	100	40	40	80	100	100					
		50% sc.				*					*				*							
6	The number and hierarchy of stakeholders is clear and feasible and easy to coordinate. The decision-making process in the project is effective and clear in terms of pace and structure.	n-resp	1	1	1	1	1	0	1	2	0	2	2	1	0	1	0	M-H	?	M	*	?M*
		cum %	20	40	60	80	100	0	20	60	60	100	50	75	75	100	100					
		50% sc.			*					*			*									
7	All project goals and objectives (individual and jointly) are clear, transparent and consistent. The objectives are feasible in number and will be controlled and accepted among partners.	n-resp	0	1	3	1	0	0	0	3	1	1	2	2	1	0	0	M	M	M	*	MM*
		cum %	0	20	80	100	100	0	0	60	80	100	40	80	100	100	100					
		50% sc.			*					*				*								
8	The hierarchy of the project objectives is clear and accepted which makes the decision-making process in the project is effective.	n-resp	0	1	1	2	1	1	0	1	2	1	1	1	1	2	0	S-M	o	?	?	o??
		cum %	0	20	40	80	100	20	20	40	80	100	20	40	60	100	100					
		50% sc.				*					*				*							
9	The number of directly involved participants/partners is clear and feasible. It is coordinated effectivily without loss of information and decisionmaking is clear.	n-resp	0	1	1	2	1	0	0	3	1	1	2	0	3	0	0	L-M	o	M	?	oM?
		cum %	0	20	40	80	100	0	0	60	80	100	40	40	100	100	100					
		50% sc.				*				*					*							
10	There are no difficulties in the coordination of the (high) number of teams / groups / structures.	n-resp	0	1	1	1	1	0	1	1	1	1	2	1	1	0	0	M	M	M	*	MM*
		cum %	0	25	50	75	100	0	25	50	75	100	50	75	100	100	100					
		50% sc.			*					*			*									
11	There will be effective coordination of the number of partners that commit and share their resources. Required resources (money, time, human resources) estimations are reliable and feasible and will be available and shared when required.	n-resp	0	2	0	2	1	0	2	2	0	1	1	2	0	2	0	M	o	M	*	oM*
		cum %	0	40	40	80	100	0	40	80	80	100	20	60	60	100	100					
		50% sc.				*				*				*								
	PROJECT VARIETY STATEMENTS																					
12	The variety of interests of the partners and stakeholders (collective/individual and long/short term) enhances the cooperation and acceptance among partners. Each partner is explicit and transparent about its intended interest and there will be an adequate anticipation on conflicting interests.	n-resp	0	0	2	1	2	0	0	2	2	1	2	2	1	0	0	L	o	o	*	oo*
		cum %	0	0	40	60	100	0	0	40	80	100	40	80	100	100	100					
		50% sc.				*					*			*								
13	The diverse project team is sufficiently authorized and qualified for the project and effectively utilize the knowledge and experience of the participants/partners. The degree of variety in the project team in terms of experience, social span, culture and/or references enhances the project coordination and control.	n-resp	0	0	1	2	2	0	0	2	1	2	2	1	2	0	0	L	o	o	*	oo*
		cum %	0	0	20	60	100	0	0	40	60	100	40	60	100	100	100					
		50% sc.				*					*			*								
14	The amount of different organizational interdependencies and interfaces in the project is clear and feasible.	n-resp	0	1	3	0	1	0	1	2	1	1	1	1	1	2	0	M	M	M	?	MM?
		cum %	0	20	80	80	100	0	20	60	80	100	20	40	60	100	100					
		50% sc.			*					*					*							

Figure 5-3: Results Interflex project and OC related risk- topography (part 1)

	PROJECT INTERDEPENDENCIES STATEMENTS																					
15	Cooperation and communication within the project team and between members is effective. E.g. project strategies, decisions, objectives and processes are shared, accepted and communicated effectively by the project team.	n-resp	0	0	2	2	1	0	0	1	2	2	1	3	1	0	0	L	o	o	*	oo*
		cum %	0	0	40	80	100	0	0	20	60	100	20	80	100	100	100					
		50% sc.				*					*			*								
16	Trust between the partners and stakeholders is formed, built and sustained over time.	n-resp	0	0	1	3	1	0	0	2	1	2	3	0	2	0	0	L	o	o	*	oo*
		cum %	0	0	20	80	100	0	0	40	60	100	60	60	100	100	100					
		50% sc.				*					*		*									
17	The interrelations with stakeholders will be assured and effectively managed and if needed adequately anticipated (e.g. objectives may for instance be redefined by stakeholders due to their evolving relationships or the value that a stakeholder expects to create could change during a project).	n-resp	0	1	2	1	1	0	0	2	2	1	1	2	2	0	0	M	M	o	*	Mo*
		cum %	0	20	60	80	100	0	0	40	80	100	20	60	100	100	100					
		50% sc.			*						*			*								
18	Top management actively support and are committed to the project on the short and the long term.	n-resp	2	0	1	1	1	0	1	1	2	1	1	1	1	1	1	S-H	?	o	?	?o?
		cum %	40	40	60	80	100	0	20	40	80	100	20	40	60	80	100					
		50% sc.			*						*				*							
19	All partners are highly motivated and committed to the project on the short and the long term. All partners have clear incentives in joining the project.	n-resp	0	0	1	2	2	0	0	1	1	3	2	2	1	0	0	L	o	o	*	oo*
		cum %	0	0	20	60	100	0	0	20	40	100	40	80	100	100	100					
		50% sc.				*						*		*								
20	The ownership in the project is clear and feasible and strong committed project leadership is present throughout the process who drives the project forward.	n-resp	0	0	2	2	1	0	0	3	0	2	3	0	2	0	0	M	o	M	*	oM*
		cum %	0	0	40	80	100	0	0	60	60	100	60	60	100	100	100					
		50% sc.				*				*			*									
	ELEMENTS OF CONTEXT STATEMENTS																					
21	The innovativeness of the project is clearly understood and contributes to reaching the objectives. Processes/tasks are known and specified, the behavior of the project is formulated and there is experience to deal with the innovativeness.	n-resp	0	0	1	3	1	0	0	1	1	2	1	2	1	0	0	L	o	o	*	oo*
		cum %	0	0	20	80	100	0	0	25	50	100	25	75	100	100	100					
		50% sc.				*					*			*								
22	Possible reactions and challenges from the (network) environment will be monitored and adequately anticipated.	n-resp	0	1	1	2	1	0	0	2	0	2	1	1	1	1	0	M	o	M	*	oM*
		cum %	0	20	40	80	100	0	0	50	50	100	25	50	75	100	100					
		50% sc.				*				*				*								
23	The competitive context and the level of competitin between stakeholders are in favor of this project. Partners/stakeholders effectively share their knowledge, experience and information between each other and are transpartent.	n-resp	0	1	2	1	1	0	1	2	0	2	2	2	0	1	0	M	M	M	*	MM*
		cum %	0	20	60	80	100	0	20	60	60	100	40	80	80	100	100					
		50% sc.			*					*				*								
24	Local and/or new laws and regulations will be adequately anticipated.	n-resp	1	2	2	0	0	2	0	2	1	0	0	1	1	1	1	M-H	*	?	M	*?M
		cum %	20	60	100	100	100	40	40	80	100	100	0	25	50	75	100					
		50% sc.		*						*					*							
25	The political climate is stable and in favor of this project. Long-term and consistent energy plans and policies will be assured as well as full local political commmitment and support.	n-resp	1	2	2	0	0	2	1	2	0	0	0	1	3	0	0	H	*	*	M	**M
		cum %	20	60	100	100	100	40	60	100	100	100	0	25	100	100	100					
		50% sc.		*					*						*							
26	The project includes scale-up potential (roll-out, expansion, replication) given the unique contextual factors in which the project will be developed.	n-resp	0	0	2	2	1	0	0	3	1	1	1	0	2	2	0	L-M	o	M	?	oM?
		cum %	0	0	40	80	100	0	0	60	80	100	20	20	60	100	100					
		50% sc.				*				*					*							

Figure 5-4:: Results Interflex project and OC related risk- topography (part 2)

- **The lack of consensus**:

There are several statements in the topography judged in a very diverse way by the respondents. It occurred more than once that a team participant or multiple participants of the Interflex project have clear divergent judgements. For example statement 1, in the certainty parameter, are scored by the five respondents all in a different way. It happens most often in the certainty parameter. There seems to be more consensus on the influence and importance parameter (B and C) but it also occurs in those two parameters. This lack of consensus and divergent judgements is also reflected in the risk class in which every statement is classified. This is especially the case in statement 5 and 18. Those statements are classified in the risk class S – H (safe – high) where there is a lack of consensus on all three the parameters.

> *'The diverse answers on statement 18 occurs mainly because we are working with big corporates but also with start-ups. The perception of supporting and committed top management is totally different. The project members from a start-up are also the top management of the company.'*
> - *Project participant Interflex*

Additionally, the lack of consensus is not necessarily wrong. It is very valuable information and should not be neglected. Keizer, Halman, & Song (2002) describes in their paper that unambiguous risks will be no surprise but that you should be very conscious of ambiguous risks. Those risks, where one or more team members perceive it as risky and where others do not could be truly threatening. Project failures often linked to the inability or unwillingness of team participants to communicate about those ambiguous risks that could jeopardize project success (Keizer, Halman, & Song, 2002). Therefore, divergent results in Figure 5-3 Figure 5-4 are very valuable. Those divergent results were discussed with the project team. The results represents the reality according to the team. As an example:

- Statement 5: The core business and interest is different for the different partners in the project regarding the data and information systems to obtain project success.
- Statement 18: The partnership includes different type of companies from start-ups to major corporates. Those projects are important for start-ups and their top management. Often the project participants are also the top management of the company. This is totally different for a party like Enexis. Interflex is not their core business and they are not dependent on such projects. This leads to divergent opinions.

Those divergent judgements and the lack of consensus shows a possible weaknesses and it represents each other concerns and opinions.

Result in general

Table 8 represents the risk class (level of riskiness) for every OC related risk statement that is assessed by the experts. Those risks are ordered by risk classes from highest risk to lowest.

Table 8: Interflex project perceived risks ordered from highest to lowest.

Ranking	# statement	OC related risk statement	E. Risk class
1	EC25	The political climate is stable and in favor of this project. Long-term and consistent energy plans and policies will be assured as well as full local political commmitment and support.	High
2	PS6	The number and hierarchy of stakeholders is clear and feasible and easy to coordinate. The decision-making process in the project is effective and clear in terms of pace and structure.	Medium - High
3	EC24	Local and/or new laws and regulations will be adequately anticipated.	Medium - High
4	PS4	Risks and returns are divided and shared among partners in an appropriate way and everyone agrees to that.	Low - High
5	PS1	The number and scope of activities are known, feasible and focussed. The numerous project tasks and activities will be effectivily managed and coordinated and the behavior of the project is well defined and understandable for everyone.	Low - High
6	PS3	The number of the decisions to be made are known and the decision making process is effective. The prevision of the impact of these decisions are clearly understood and will be coordinated effectivily.	Low - High
7	IP18	Top management actively support and are committed to the project on the short and the long term.	Safe - High
8	PS5	The amount of (different) information/data systems in the project are known and feasible and can be controlled and coordinated effectivily in terms of e.g. ownership, privacy, sharing, security.	Safe - High
9	PS7	All project goals and objectives (individual and jointly) are clear, transparent and consistent. The objectives are feasible in number and will be controlled and accepted among partners.	Medium
10	IP20	The ownership in the project is clear and feasible and strong committed project leadership is present throughout the process who drives the project forward.	Medium
11	PS10	There are no difficulties in the coordination of the (high) number of teams / groups / structures.	Medium
12	PS11	There will be effective coordination of the number of partners that commit and share their resources. Required resources (money, time, human resources) estimations are reliable and feasible and will be available and shared when required.	Medium
13	PV14	The amount of different organizational interdependencies and interfaces in the project is clear and feasible.	Medium
14	IP17	The interrelations with stakeholders will be assured and effectively managed and if needed adequately anticipated (e.g. objectives may for instance be redefined by stakeholders due to their evolving relationships or the value that a stakeholder expects to create could change during a project).	Medium
15	EC22	Possible reactions and challenges from the (network) environment will be monitored and adequately anticipated.	Medium
16	EC23	The competitive context and the level of competitin between stakeholders are in favor of this project. Partners/stakeholders	Medium
17	PS9	The number of directly involved participants/partners is clear and feasible. It is coordinated effectivily without loss of information and decisionmaking is clear.	Low - Medium
18	EC26	The project includes scale-up potential (roll-out, expansion, replication) given the unique contextual factors in which the project will be developed.	Low - Medium
19	PS8	The hierarchy of the project objectives is clear and accepted which makes the decision-making process in the project is effectiv	Safe - Medium
20	PV12	The variety of interests of the partners and stakeholders (collective/individual and long/short term) enhances the cooperation and acceptance among partners. Each partner is explicit and transparent about its intended interest and there will be an adequate anticipation on conflicting interests.	Low
21	PV13	The diverse project team is sufficiently authorized and qualified for the project and effectively utilize the knowledge and experience of the participants/partners. The degree of variety in the project team in terms of experience, social span, culture	Low
22	IP16	Trust between the partners and stakeholders is formed, built and sustained over time.	Low
23	PS2	The number and scope of the deliverables are defined, clear and feasible for the partners. The deliverables will be (simultaneously) controlled and achieved properly.	Low
24	IP15	Cooperation and communication within the project team and between members is effective. E.g. project strategies, decisions, objectives and processes are shared, accepted and communicated effectively by the project team.	Low
25	IP19	All partners are highly motivated and committed to the project on the short and the long term. All partners have clear incentives in joining the project.	Low
26	EC21	The innovativeness of the project is clearly understood and contributes to reaching the objectives. Processes/tasks are known and specified, the behavior of the project is formulated and there is experience to deal with the innovativeness.	Low

The political climate is perceived as the highest risk in the Interflex project and received the risk class high. Ten risks received a distributed risk class which varies between safe and high. Eight risks are classified as medium and seven as low. The two most striking conclusions based on Table 8 and the discussion with the project team are:

> *'"The main interest of the European Union is how to effectively implement those new developments within the EU regulations and laws. The project has a vast political factor also because it is subsidized."*
> *- Project participant Interflex*

1. The project is political sensitive which must be taken into account. The project is subsidized by the European Union and the project team has responsibilities towards the EU. This is reflected in the results. Statement 25 (political climate) and statement 24 (laws and regulations) are of high risk which was confirmed by the project team. The EU objective is to implement the new developments into their laws and regulation. Those two factors are especially of high risk on the first two parameters.

2. Almost all the statements that are related to the collaboration in the project team and partnership are classified as low risk. This implicates that the collaboration is going very well in the project. This was confirmed during the interview. There were not many problems in the partnership and everyone was eager to help each other. The selection procedure for partners for the initiation and development of the project was conducted in a thorough manner.

> *''The collaboration between the partners is going very well. Everyone is transparent and is eager to help each other.''*
>
> *''Many events were organized to build trust in each other.''*
>
> - *Project participant Interflex*

Across the Interflex project, the analysis enabled to determine the issues that the project participants overall perceived as most risky for each of the three individual parameter. Tables 9 – 11 represents the ten highest perceived risks on the three parameters for the Interflex project. It details the difference in judgement across the three different parameters. The tables represents the mean, standard deviation and median for every statement. Issues which are supposed as risky on one parameter are not automatically perceived as risky on the other two parameters. The complete scores for every parameter for every specific OC related risk statement can be found in appendix I.
Table 9 shows the highest risks measured on the 'level of certainty' parameter. *Local and new laws (EC4)* and the *political climate (EC5)* are perceived as most uncertain with a mean of 2.2. Furthermore, *the number of decisions (PS3)* is also perceived as uncertain.
Table 10 shows the risks on the second ability to influence parameter. It is no surprise that the statements *Local and new laws (EC4) and* the *political climate (EC5)* are perceived as risky in terms of ability to influence since it is almost completely out of the project team's ability to influence this. For most statements there is a high ability to influence to influence the course of action. Table 10 also provide some risks for which commitment and combined efforts of several partners is required. For example *partners that commit resources (PS11)* and *clear project objectives (PS7).*
Lastly, table 11 presents the highest risks on the impact parameter. All mean scores are high, especially in comparison with the other parameters. This makes the statements important to be realized for project success.

> *''The results are reliable and in line with the reality and current state of the Interflex project.''*
> - *Project participant Interflex*

Table 9: Perceived Interflex issues as highly uncertain (based on scale 1= low certainty, 5 = high certainty).

		Certainty 1 = low, 5 = high		
Risk category	**Specific risks**	**Mean**	**St. Dev.**	**Median**
EC4	Local and/or new laws and regulations will be adequately anticipated.	2.2	0.84	2.0
EC5	The political climate is stable and in favor of this project. Long-term and consistent energy plans and policies will be assured as well as full local political commmitment and support.	2.2	0.84	2.0
PS3	The number of the decisions to be made are known and the decision making process is effective. The prevision of the impact of these decisions are clearly understood and will be coordinated effectivily.	2.4	1.14	2.0
IP4	Top management actively support and are committed to the project on the short and the long term.	2.8	1.79	3.0
PS1	The number and scope of activities are known, feasible and focussed. The numerous project tasks and activities will be effectivily managed and coordinated and the behavior of the project is well defined and understandable for everyone.	3.0	1.58	3.0
PS4	Risks and returns are divided and shared among partners in an appropriate way and everyone agrees to that.	3.0	1.58	3.0
PS6	The number and hierarchy of stakeholders is clear and feasible and easy to coordinate. The decision-making process in the project is effective and clear in terms of pace and structure.	3.0	1.58	3.0
PS7	All project goals and objectives (individual and jointly) are clear, transparent and consistent. The objectives are feasible in number and will be controlled and accepted among partners.	3.0	0.71	3.0
PV3	The amount of different organizational interdependencies and interfaces in the project is clear and feasible.	3.2	1.10	3.0
PS5	The amount of (different) information/data systems in the project are known and feasible and can be controlled and coordinated effectivily in terms of e.g. ownership, privacy, sharing, security.	3.4	1.52	4.0

Table 10: : Perceived Interflex issues as low controllability. (based on scale 1= low influencibility, 5 = high influencibility).

		Influencibility 1 = low, 5 = high		
Risk category	**Specific risks**	**Mean**	**St. Dev.**	**Median**
EC5	The political climate is stable and in favor of this project. Long-term and consistent energy plans and policies will be assured as well as full local political commmitment and support.	2.0	1.00	2.0
EC4	Local and/or new laws and regulations will be adequately anticipated.	2.4	1.34	3.0
PS11	There will be effective coordination of the number of partners that commit and share their resources. Required resources (money, time, human resources) estimations are reliable and feasible and will be	3.0	1.22	3.0
PV3	The amount of different organizational interdependencies and interfaces in the project is clear and feasible.	3.4	1.14	3.0
PS8	The hierarchy of the project objectives is clear and accepted which makes the decision-making process in the project is effective.	3.4	1.52	4.0
PS10	There are no difficulties in the coordination of the (high) number of teams / groups / structures.	3.5	1.29	3.5
IP4	Top management actively support and are committed to the project on the short and the long term.	3.6	1.14	4.0
PS6	The number and hierarchy of stakeholders is clear and feasible and easy to coordinate. The decision-making process in the project is effective and clear in terms of pace and structure.	3.6	1.34	3.0
PS7	All project goals and objectives (individual and jointly) are clear, transparent and consistent. The objectives are feasible in number and will be controlled and accepted among partners.	3.6	0.89	3.0
EC3	The competitive context and the level of competitin between stakeholders are in favor of this project. Partners/stakeholders effectively share their knowledge, experience and information between each other and are transpartent.	3.6	1.34	3.0

Table 11: : Perceived Interflex issues as having the highest impact on project success (based on scale 1= high impact, 5 = low impact).

		Importance 5 = High, 1 = Low		
Risk category	**Specific risks**	**Mean**	**St. Dev.**	**Median**
EC4	Local and/or new laws and regulations will be adequately anticipated.	4.6	0.55	5.0
EC3	The competitive context and the level of competitin between stakeholders are in favor of this project. Partners/stakeholders effectively share their knowledge, experience and information between each other and are transpartent.	4.3	0.96	4.5
IP4	Top management actively support and are committed to the project on the short and the long term.	4.2	0.84	4.0
EC6	The project includes scale-up potential (roll-out, expansion, replication) given the unique contextual factors in which the project will be developed.	4.2	0.84	4.0
PV1	The variety of interests of the partners and stakeholders (collective/individual and long/short term) enhances the cooperation and acceptance among partners. Each partner is explicit and transparent about its intended interest and there will be an adequate anticipation on conflicting interests.	4.2	1.10	5.0
EC2	Possible reactions and challenges from the (network) environment will be monitored and adequately anticipated.	4.2	0.84	4.0
IP2	Trust between the partners and stakeholders is formed, built and sustained over time.	4.2	1.10	5.0
EC5	The political climate is stable and in favor of this project. Long-term and consistent energy plans and policies will be assured as well as full local political commmitment and support.	4.0	1.22	4.0
PV3	The amount of different organizational interdependencies and interfaces in the project is clear and feasible.	4.0	1.00	2.0
PS10	There are no difficulties in the coordination of the (high) number of teams / groups / structures.	4.0	1.41	4.5

Quantification OC related risk profile for the project as a whole

The OC related risks are quantified for the project as a whole. A weight is determined to each of the risk classes. The different risk classes are valued in the following way: S=0, L=1, M=2, H=3 and F=4 where 3 assumptions are taken into account:

- The classes symbolize spots on a OC related risk dimension ranging from safe to fatal.
- The spots on this OC related risk dimension have equal distances from each other.
- Class S is assumed to be safe, and is given the weight of 0.

As discussed before, statements have distributed assessments scores (e.g. L-H, M-H, etc.) due to the different opinions of the respondents. For these scores a pessimistic and an optimistic scenario is established. The total OC related riskiness as a whole is quantified on a 0-100% risk scale according the guidelines expressed in section 4.4.

Table 12 details the quantification of the risk profile as a whole for the Interflex project expressed in a risk score an in an risk score in percentage. Based on the results, an optimistic and a pessimistic scenario is calculated. The optimistic scenario (35%) is located between the risk class low-medium where it is situated more towards the low risk class. The pessimistic scenario (53%) is located just above the medium risk score of 52%. Therefore, it can be concluded that the complete Interflex project can be classified as semi-medium risky. Figure 5-5 shows a graphic representation of the two scenario's and where those scenarios are located with respect to the risk classes.

Table 12: Interflex risk profile as a whole based on the questionnaire results

Risk class	Risk score	Risk score in %
Safe – Low	0 – 26	0 – 25 %
Low - Medium	26 – 52	25 – 50 %
Medium - High	52 – 78	50 – 75 %
High - Fatal	78 – 104	75 – 100 %
Fatal	104	100 %
Optimistic scenario	35	33,7 %
Pessimistic scenario	53	51,0 %

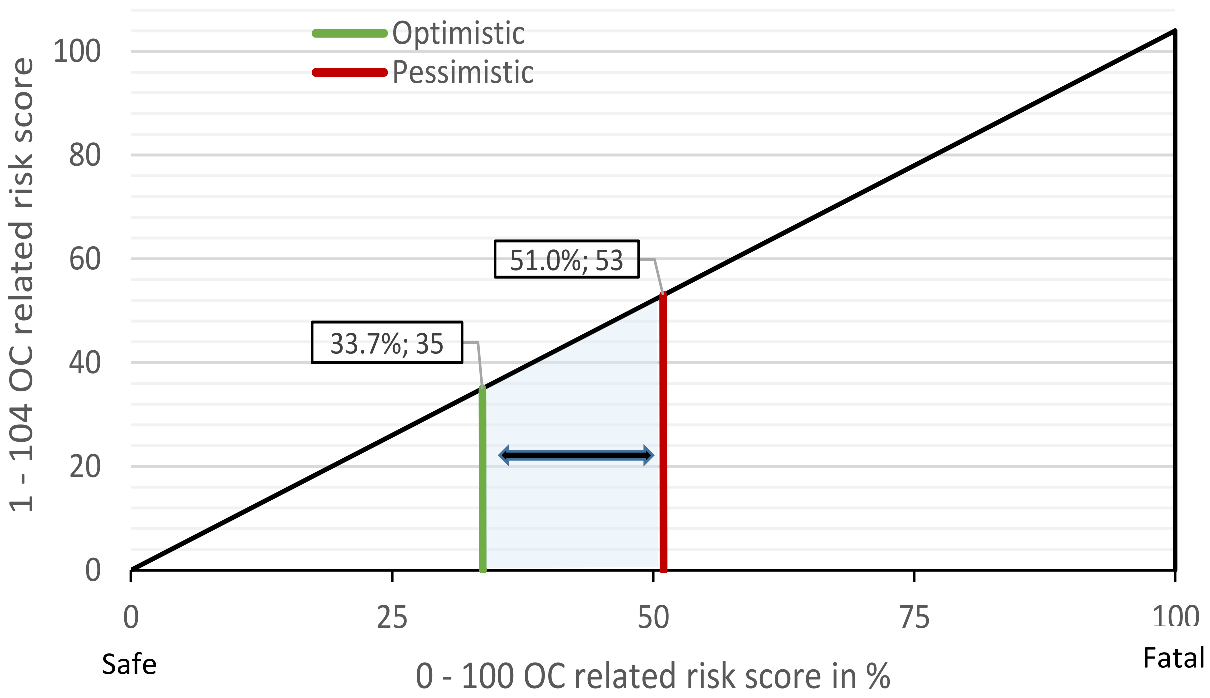

Figure 5-5: Graphic representation of the Interflex OC related risk profile as a whole on 0-100 scale in % based on the results.

Added value OCRDM

The added value of the model and results were discussed with two project participants. Those project participants were asked what their perceived value was concerning the OCRDM and the OC framework. The following aspects were mentioned:

- The model creates awareness among the project team. It is a model which is very useful for communicating risks in a clear way within the project team. It enables to take a look at the risks in a holistic way but also on an individual way.
- Concerns about certain statements will be clear on individual and team basis. There will be more mutual understanding of each other different point of views;
- The model enables to identify and focus on the critical risk factors and could serve as a decision-tool.
- Almost all the time, a risk analysis is carried out by only the project leader. This model enables it to perform a risk analysis with multiple cross-sectoral people where they could express their concerns in an equal unbiased way.
- The OC framework was very helpful and clear. Most of the time only the standard company risks are mentioned. The list forces the team to look at risks which are unknown or unforeseen. Additionally, people need to look beyond their own expertise.

6. Conclusion

The final chapter concludes this graduation study and the most important findings are briefly explained. This thesis offers added value to the development of innovative Smart Urban Energy projects by providing insights into the OC in SUE projects and shows the importance of understanding and examining the sources and mechanisms of OC and OC related risks in the front-end phase of such projects.

In the first section, the main research question will be answered and the relevance of the research will be established both on the societal and scientific area concerning SUE developments. The second section provides recommendations for further research and a reflection on the study.

6.1. Research question

The main aim of this thesis is to characterize, understand and examine the sources of organizational complexity (OC) and associated risks in innovative SUE projects. It aims at developing a model to assess the mechanisms of the OC related risks and to detect the factors that could jeopardize the successful realization of the SUE project objectives. There is a call for developing our cities into intelligent and sustainable environments and enhancing sustainability and energy efficiency in urban areas is of high priority for sustainable development. The recognizing the OC is a great challenge and of importance in the management of today's projects and to enhance the development of Innovative SUE projects. The most important OC factors and categorization have been identified that influence the development of innovative SUE projects in the front-end phase. This thesis introduces a hierarchical framework consisting of OC factors identified from the literature that has been validated and quantified by experts from the field with the Fuzzy Delphi Method. Those OC factors are incorporated in the OC related risk diagnosis model, particularly developed to apply on innovative SUE projects, that can be used to identify potential difficulties experienced by the different project professionals. Using the obtained information and results of this research the main research question can be answered:

What are the most important sources of organizational complexity linked to the frond-end phase of innovative SUE developments and how do the organization complexity and related risks influence the successful development and performance of innovative SUE developments?

It became clear that innovative SUE developments is not only the use of innovative technologies. Technology is most of the time not the problem but the organizational and management part is the key challenge for project success. It is about integral collaboration and co-creation where several partners from different sectors are working together with their own incentives, objectives but also with their own organizational cultures. Moreover, it is challenging because of the complex city, all the systems that are dependent and interrelated with each other as well as the many different stakeholders. It requires a different way of working from the organizations and people. The cooperation between multiple parties in innovative SUE projects results in organizational complexities and complex processes. Therefore it is necessary to have insights in the OC that could arise in such projects and to predict and deal with it in advance during the early phases of a project to avoid that it jeopardizes the project success.

The approach by combining literature insights supported by the semi-structured interviews with experts from the field resulted in a comprehensive OC framework of 56 OC factors that describe the richness of the OC in innovative SUE projects. Quantifying the OC factors in this framework using the Fuzzy Delphi Method resulted in structuring and rating the identified OC factors. The results showed that 25 OC factors contribute the most to the OC that could influence the development of innovative SUE projects. All factors can be classified in the four areas: Project Scope, Project Variety, Interdependencies within the Project and Elements of Context. Deliberately, the OC factors in the framework have been quantified with the FDM because agreed knowledge is lacking and the perception differ among parties involved. Additionally, the results are more reliable and it makes it more manageable to discuss the results on various levels with different involved stakeholders in an innovative SUE project. The 25 OC factors should not be an end in itself, but a means to provide guidance between various partners in the decision making process about the organizational complexities.
Linguistic complexity terms are translated, using the FDM, into a quantitative-basis. Top OC factors have been identified and the ambiguity, subjectivity and imprecision in complexity judgements are reduced due to the chosen methods. The results shows that all OC factors in the framework are to a greater or lesser extent important and could influence the development of innovative SUE project. The relative high averages details that the OC factors are relevant, contribute to the OC and influence the successful development of innovative SUE projects. The quantification resulted in a ranking and a hierarchical framework of the OC factors. In the overall ratings, two OC factors are significant most important in the front-end phase in SUE projects. *'Trust in and between the project team and stakeholders'* and '*commitment and support of top management, users, partners'* contributing the most to the OC. Further, the results shows that out of the four categories, the category *'project scope' (PS)* contributes the most to the OC. Most OC factors are accepted within this category. The category *'project variety' (PV)* has the least contribution and is less applicable to the OC. Please note, the OC framework is not a blueprint regarding the OC but is serves as a means to see where the OC most likely will be situated and what you have to take into account. Therefore the quantified framework serves as a reference list that serves as a good starting point to identify the OC in a SUE project.

The root contributors to the OC (25 OC factors) of SUE projects have been processed in the OC related risk diagnosis model (OCRDM). This proved to be very useful in assessing and diagnosing the mechanisms OC related risks. The model enabled it to identify and focus structural weaknesses in the innovation process and it serves as a decision-making tool. The results showed several times a lack of consensus between the experts which is valuable information and should not be neglected. The model forced the team to look at OC related risks which are unknown or unforeseen and experts needed to look beyond their own expertise. The model created awareness among the project team and it enables to take a look at the risks in a holistic way but also on an individual way. It enabled to perform an analysis with multiple cross-sectoral people where they could express their concerns in an equal unbiased way. Diverse experts groups were incorporated in this model and translated into a single derived number resulting in a mutual understanding of each other's concerns.

Applying both methods showed that the results are in line with each other. However, the 25 accepted OC factors do not have to be the absolute truth. As the results show, the remaining rejected factors could still have an influence on certain (specific) projects. Those rejected OC factors cannot be totally neglected. Therefore, this research and 25 accepted OC factors does not contain a blueprint for future innovative SUE developments. On the contrary, this study illustrates the importance of recognizing the main drivers of complexity and front-end analysis of complexity and risks in order to facilitate and accelerate the successful development and management of innovative SUE projects. It illustrates that such projects is real human work and that organizing SUE developments does not only requires insights in the process but also requires other skills. It is also about new management and networking competencies and you should be able to make connections and to build bridges between people. The developed framework and model should not be an end in itself, but a means to provide guidance between various partners in the decision making process about the organizational complexities and related risks.

6.2. Research relevance

6.2.1. Societal relevance

The most difficult part in developing innovative SUE projects are the organizational and management issues. The research provides valuable guidance for the management of the OC and OC related risks and it supports professionals in various management and strategic decisions concerning the OC to anticipate on potential difficulties. Moreover, scarce resources can be allocated efficiently based on the results. Eventually it contributes to the successful management of innovative SUE projects and it facilitates and accelerates the development of intelligent and sustainable environments which is necessary for handling the climate change, natural resource scarcity and the growth of population in urban areas.

The developed OC framework and OCRDM can be used and applied by practitioners in the SUE industry and serves as a decision-making tool on how complex on the organizational field a SUE project is and where this complexity and associated risks will be situated. The results and the model allows practitioners to pay attention to the OC factors and risks that are worth more attention. Addressing the OC and associated risks create more certainty and awareness and makes developing SUE projects more manageable. The ultimate goal is to manage and master project complexity which should result in a decrease of project failures and an increase in project performance. Furthermore, it offers a way to deal with the difficulties as integral and cross-sectoral cooperation. The models enables practitioners to create awareness among the integral project team it enables to take a look at the OC and related risks in a holistic way but also on an individual way. It enables to perform a risk analysis with multiple cross-sectoral people where they could express their concerns in an equal unbiased way.

6.2.2. Scientific relevance

During the past years many research is done according smart cities. Most important, the smart city and especially the SUE subject has been poorly addressed in the literature from the managerial and organizational points of view whilst the literature emphasizes that the organizational part is the key challenge. The underlying factors that influence this are not well understood. Additionally, literature expresses the importance of front-end analysis of complexity and risks Recognizing the main drivers of complexity is the start of a successful project while recognition complexity is subjective and dynamic. The science does not stress out what contributes to organizational difficulties in innovative SUE projects while it is such an emerging topic.

The results and true scientific value of this study is the OC framework that is specifically generated for innovative SUE projects which can be used as a basis to examine the OC of innovative SUE projects. It provides a footprint of where the OC is and can be expected. This study result in more theory building, increased understanding of the mechanisms of the OC factors and associated risks and it provide insights in the OC factors that could jeopardize the successful realization of the project objectives in the front-end phase of an innovative SUE projects. This study is quantitative in nature where linguistic complexity terms are transformed into a systematic quantitative-based analysis. The strength of numbers is that it explains more than words. Top OC factors are identified and discussed. The judgement of assessing the complexity and risk is mainly linked to the subjectivity of the observer. Ambiguity, subjectivity and imprecision in complexity and risk judgements are to a certain amount reduced using the developed methods. The developed methods enables it to assess the OC and related risks in a less subjective way. Also, this research has laid grounds for further quantitative research concerning the topic which could provide valuable information to build management and decision support tools.

6.3. Recommendations

The current study can be seen as an exploratory study, both qualitative as quantitative, concerning the organizational aspect in innovative SUE projects. The study showed that the complexity topic is a broad and extensive subject which is of great importance in today's fast changing world. Additional and extending research is needed for increasing the knowledge and for making innovative SUE projects more successful. Therefore below several recommendations to fulfil the full potential of this research.

In this research , the selected OC factors have been based on the factors that are selected from the FDM. The data from the 21 respondents have been used as one group also because cross-functional perspective was desired. The number of respondents did not allow to conclude separate conclusions per homogeneous group. However, to extent and broader the result, the research could be extended with the judgements of different homogeneous expert groups for comparison and to identify the differences in the judgement and identification of the OC and related risks.

The developed OCRDM has been applied on one SUE case due to the lack of time. Although the results showed some valuable insights it is recommended to apply the model on more practical cases for better results. Testing the model on multiple cases will result in more insights and firm conclusions also in terms of completeness, repeatability and reproducibility

This research does not contain a blueprint for the OC in future innovative SUE developments. Because of the dynamics of OC, repeated use in different project phases is foreseen. As mentioned by the experts, the complexity changes through time and through different project phases. For better use through the different project stages it is desired to have a dynamic and flexible model so it can be used in different project phases. This study quantifies the OC related risks but future research could extent the OC framework by measuring the OC.

Additionally, the first part of the study focuses on the identification and quantification of the OC factors. Those factors are used as input for the OCRDM. All the factors are used as standalone OC factors while it could be plausible that the OC factors are interrelated and influence each other. For better understanding of the OC in SUE projects, the study could be extended by modelling the OC factors and their interrelationships.

Further, mainly focusses on the identification and assessment of the OC and related risks. The next step is managing and mastering the OC and related risks. A follow-up study could be how to manage the OC that you face in a particular project and how to adapt your processes to fit the OC to maximize the value for an innovative SUE project and to fully realize the project's potential but also the stakeholders potential.

Finally, this study focuses on the OC but the complexity of such projects consists of more than only the organizational dimension. The framework and model can be extended with complexities from other domains, for example technical, to assess the complexity as a whole.

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Appendices

Appendix A: search strategy

The aim of the literature review is to systematically review the existing and relevant literature concerning the research topic and to provide insights, knowledge and information about the topic of interest based on previous studies. These insights, knowledge and information about the field of interest is required to answer the research questions 1, 2 and 3 outlined in section 1. A structured approach is used to determine the literature material for the review and for answering research question 1, 2 and 3. The structured approach basically consists of three steps.

1) First of all the **keyword search strategy** is used for finding relevant literature. Different databases are used like ABI/Inform (ProQuest), google scholar, Web of science, Science direct, etc. to find the major contributions to the topic of interest. In addition, the used keywords should be in line with the research questions. Those keywords is also applied with different combinations to narrow the results.
2) The second step is **going backwards** by reviewing the citations in the identified studies from step 1. With this step, prior articles are found and considered.
3) The third step is **going forwards** using the identified articles in step 1 and 2. New scientific articles are found based on the citing of the key articles identified in the previous steps. Conducting these three steps results in a final selection of scientific papers about the topic of interest.

Besides the selection of scientific papers originating from the search strategy it is important to define the quality of the papers. The final selection from the potential papers is based on the relevance of the paper which is assessed on the quality criteria: title, abstract, key words, type of journal and conclusion. Additionally, the year of publications is preferably after 1995. The studies are also assessed on the times they are cited in the literature. Applying some criteria is preferably to converge the literature to a more applicable and usable number of studies. The final literature review for every research topic is translated to a matrix which gives an overview of the selected studies. It provides insights in the research topic, method, concepts and focus group. This research strategy is visualized in Figure 0-1.

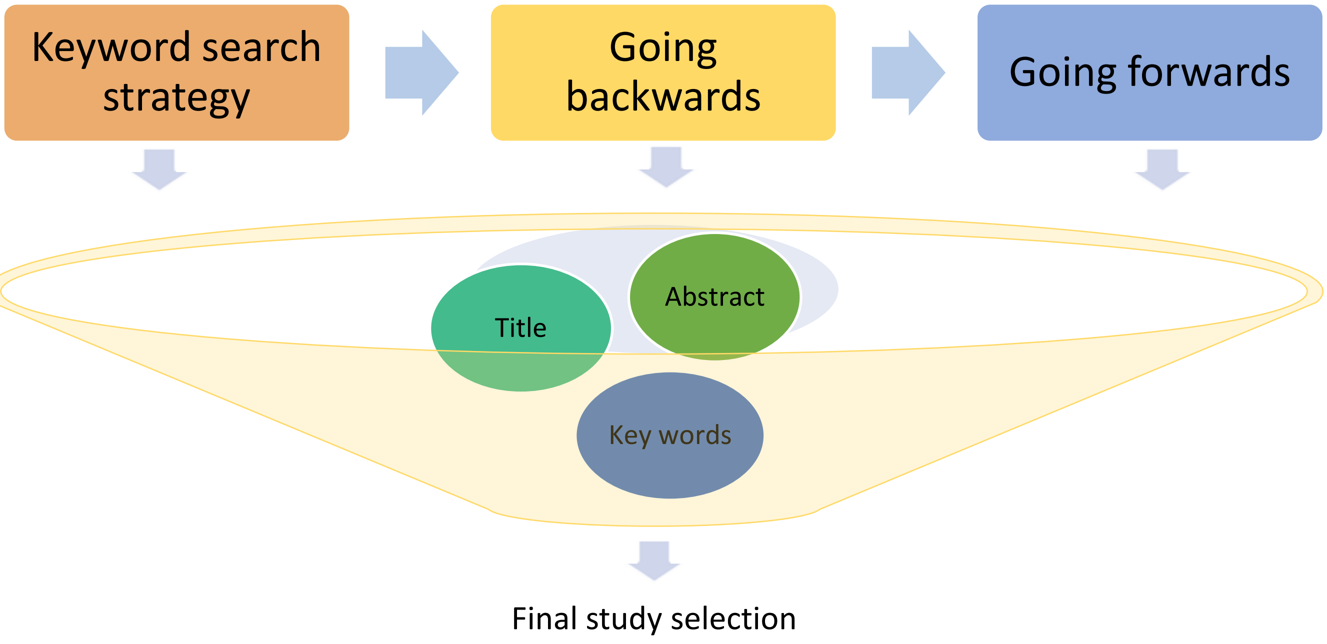

Figure 0-1: Search strategy literature review

Appendix B: Research comparison SUE developments

Table 9: Research comparison SSUE developments .

Author	Year	Defining smart city	Smart (energy) city and sustainable city	Domains of SC and/or SEC	Smart energy city developments	Determining success factors/barriers	Defining smart energy city/system	Research topic	Literature review	Questionnaire	Interviews	Case study	Statistical analysis	Focus group	Cited	Journal
CONCERTO	2010				x	x		A cities' guide to a sustainable built environment based on executed concerto projects.				x		Policy makers and city developers	X	X
Nam & Pardo	2011	x		x	x	x		Conceptualizing smart city with dimensions of technology people and institutions.	x				x	institutional improvement and citizen engagement	704	Proceedings of the 12th annual international digital government research conference: digital government innovation in challenging times
Chai, Wen, Nathwani & Rowlands	2011				x		x	Concept development for smart energy networks	x		x		x	Sustainable energy developers	2	Waterloo Institute for Sustainable Energy
Chourabi, Nam, Walker, Gil-Garcia, Mellouli, Nahon, Pardo & Scholl	2012	x		x		x		Defining the smart city concept and researching the critical factors of smart city initiatives. Translated into a framework.	x					Smart city research and governmental professionals	839	System Science (HICSS), 45th Hawaii International Conference
Friuli Venezia Giulia Region	2013				x	x	x	Research about integrated energy management and governance capabilities for succesfull smart city initiatives; Involved stakeholders				x		Governance	X	X
Nielsen, Ben Amer & Halsnæs	2013				x	x	x	Defining of a smart energy city and their key elements			x	x		EU-FP7 TRANSFORM projects	1	X
Belanger & Rowlands	2013						x	Defining smart energy city	x					Sustainable energy developers	1	Waterloo Institute for Sustainable Energy
Lund	2014				x		x	Defining smart energy systems; Renewable solutions.	x			x		Politics, technical and social science	224	Book
Vanola	2014	x		x				Researching the concept of the smart city.	x			x		Developers of smart city projects	253	Urban Studies
Mosannenzadeh & Vettorato	2014	x		x	x			Researching and defining a smart city. Developed a conceptual framework based on keyword analysis	x					Academic, industrial and governmental literature	38	Tema. Journal of Land Use, Mobility and Environment
Neirotti, De Marco, Cagliano, Mangano & Scorrano	2014	x		x				Researching smart city initiatives, development trends and the hard and soft domains	x			x		Policy makers and city developers	424	Cities
Perboli, De Marco, Perfeti & Marone	2014	x			x	x		Research about the classification of smart cities, highlighting success factors and analyzing new trends in smart city.	x					Initiators smart cities	247	Journal of Urban Technology
Albino, Berardi & Dangelico	2015	x		x				Researching smart city definitions, dimensions performance and initiatives	x					Smart city developments	247	Journal of Urban Technology
Mosannenzadeh, Bisello, Diamantini, Stellin & Vettorato	2017				x		x	Predicting barriers to the implementation of smart and sustainable urban energy projects based on case-learning methodology .	x			x	x	European Commission - Concerto projects	4	Cities
Mosannenzadeh, Bisello, Vaccaro, D'Alonzo, Hunter & Vettorato	2017	x	x	x	x		x	Researching smart energy city developments and their characterisation from the viewpoint of urban planners	x		x			Urban planners	2	Cities
Bibri & Krogstie	2017	x	x	x				Researching the field of smart (and) sustainable cities.	x					Urban planners	7	Sustainable Cities and Society
Ahvenniemi, Huavila, Pinto-Seppa & Airaksinen	2017	x	x					Research about the differences between sustainable and smart cities	x					Decision makers	30	Cities
Mosannenzadeh, DI Nucci & Vettorato	2017			x	x	x	x	Research about identifying and prioritizing barriers to implementation of SEC projects in Europe	x			x		Policy makers	1	Energy Policy

Appendix C: Research comparison organizational complexity

Table 10: Research comparison of the organizational complexity theory

Author	Year	Complexity theory	Project complexity	Innovation ecosystem	Remaining and grey literature	Research topic	Literature review	Questionnaire	Interviews	Case study	Statistical analysis	Focus group	Cited	Journal
Anderson	1999	x				Research about the complexity theory and organization science	x					Organizations in general	2241	Journal of change management
Boisot & Child	1999	x				Organizational complexity theory and linking this to I-Space framework	x			x		Organizations	708	Organization Science
Pawani	2002	x				An introduction to complexity;	x					Students	12	National University of Singapore
Burnes	2004	x				Review of two approaches including the complexity theory applied for organizational change.	x					Organizations in general	276	Journal of change management
Burnes	2005	x				Review of the complexity theory and their importance and implications for organizations	x					Organizations in general	434	International Journal of Management Reviews
Stacey	2007	x				Book about strategic management and organizational dynamics	x					General	3286	Book
Garud, Gehman, & Kumaraswamy	2011	x	x			Complexity within innovation processes and types of complexity	x		x	x		Innovation processes	146	Organization Studies
Hatch & Cunliffe	2012	x				Oranization Theory applied for organizations and organizing processes	x					Organizations	4721	Oxford University press
Meulman	2017	x				Systematic understanding of organizational complexity and control	x		x	x		Mangers	X	Eindhoven Technical University TU/e
Baccarini	1996		x			Literature review on project complexity relevant to project management, with emphasis towards the construction industry.				x		Construction industry	917	International journal of project management
Bruijn, Jong, Korsen, & Zanten	1996		x			Book about ecision making and management big projects; Emphasizes project complexity and organizational complexity	x					Large projects	42	Book
Williams	1999		x			Discusss what constitutes project complexity; Structural; Uncertainty.	x					Project managers	647	International journal of project management
Geraldi & Adlbrecht	2007		x			Discusses the concepts of complexity of faith, fact, and interaction and those are defined, described, discussed,	x	x				Project managers of a Multi-National Plant Engineering Company Q:8	113	PMI
Vidal & Marle	2008		x			Identified, defined and modeled complexity within the field of project management; Implications for project management; risk; system analysis	x			x		Project managers	169	Kybernetes
Vidal, Marle & Bocquet	2011		x			Defining a measure of project complexity; ; Delphi study; AHP.	x	x		x	x	Project Managers Q: 38	138	International journal of project management
Bosch-Rekveldt, Jongkind, Mooi, Bakker & Verbrack	2011		x			Framework for characterising project complexity in large engineering projects. TOE framework was developed (technical, organizational and Environment)	x		x	x		Large engineering projects Process engineering industry I: 18 C: 6	217	International journal of project management
Bosch-Rekveldt, Mooi, Bakker & Verbrack	2012		x			Evaluating the TOE complexity framework from a practitioners point of view on the aspects technical, organizational and environment		x			x	Large engineering projects Process engineering industry Q: 67	X	TU delft
Bosch-Rekveldt	2013		x			Applying the TOE framework for big construction projects		x		x	x	Large construction projects C: 35 Q: 164	X	TU delft
Qureshi & Kang	2015		x			Identifying and modelling the organizational complexity factors and their interrelationship between them; structural equational modelling	x	x			x	Project Managers in different sectors Q: 150	47	International journal of project management
Bakhshi, Ireland & Gorod	2016		x			Exploration historical development of project complexity; PMI,; System of systems; Complexity theories; Histogram analysis.	x					Project managers; Management of complex projects.	8	International journal of project management
Rebentisch, Schuh, Sinha, Rudolf, Riesener, Mattern & Stracke	2016		x			Measurement model for organizational complexity; Mathematical model;	x			x	x	Product development projects	1	Management of Engineering and Technology (PICMET)
Stracke	2016		x			Measurement model for organizational complexity; Mathematical model;	x			x	x	Product development projects	-	Management of Engineering and Technology (PICMET)
Galen	2015			x		Research about factors that influence how innovation ecosystem stakeholders reach alignment	x		x			Innovative ecosystems with a special focus on the Dutch public charging ecosystem for electric vehicles	X	TU Eindhoven
Edelstam	2016			x		Smart cities and their focus and interaction between regional and local level in the innovation system				x		Smart city initiators	X	EU document
Gil-Garcia & Paro	2005				x	E-government success factors.	x					Public sector	770	Government information quarterly
Ebrahim and Irani	2005				x	Technological challenges related to the organizational dimension in E-government adoption	x					Public sector	649	Business process management journal
Chourabi, Nam, Gil-Garcia, Mellouli, Nahon & Scholl	2012				x	Research about the relationships and influencing factors in smart city initiatives.	x					Smart city initiators	839	System Science (HICSS), 45th Hawaii International Conference
Winden, Oskam, Buuse, Schrama, & Dijck	2016				x	Analysis of smart city projects related to urban sustainability on their managerial angle			x	x		Smart city initiators	X	Smart city Amsterdam
European Innovation Partnership on Smart Cities & Communities	2017				x	Issues related to smart city projects in Amsterdam			x	x		Smart city initiators	X	Video European Commission

Appendix D: Organizational complexity subdivisions and factors

Table 11 shows the subdivisions that are used in the literature to divide the organizational complexity factors. Table 12 details the organizational complexity factors mentioned in the literature. It also shows for every factor in which division it is divided and if neglected it shows the reasoning for declining the item. .

For example if you look at number 2 (interdependence between actors) then you can see that Vidal & Marle (2008) placed this factor in the subdivision Interdependencies (I).

Furthermore, there are three other aspects to mention in table 4:

- The Vidal, Marle & Bocquet (2011) column shows the following signs which results from their research :
    - ! : extra important factor.
    - - : less important factor.
    - No sign is not extra or less important.
- The Bakhshi, Ireland & Gorod (2016) column shows results from their research. It shows the number of times that a factor is mentioned in the literature according to Bakshi, Ireland & Gorod (2016). The more times it is mentioned the more reliable the factor is.
- The Bosch-Rekveldt et al., (2011) column shows some O signs. This results from their research. Bosch-Rekveldt et al., (2011) consider this factor not exclusive as an organizational complexity factor but their research showed significant relation and correlation between factors from other categorizations (technical and environmental) with the organizational categorization.

Table 11: subdivisions organizational complexity

	Source	Interdependency	Size	Elements of context	Variety	Diversity	Ambiguity	Flux	Resources	Project team	Trust	Risk	Belonging	Emergency	Autonomy	Research area	Perspective of complexity	Reasoning dimensions
Source	Stracke (2016)*	x				x	x	x								Product development projects	Organizational complexity	Literature review; *Cluster analysis;
	Vidal & Marle (2008)	x	x	x	x											Project management	Project complexity	Literature review;
	Vidal, Marle & Bocquet (2011)	x	x	x	x											Project management	Project complexity	Based on Vidal & Marle (2008)
	Bosch-Rekveldt et al., (2011)		x						x	x	x	x				Large engineering projects	Project complexity	Literature review; Case studies;
	Qureshi & Kang (2015)	x	x	x	x											Project Management; Construction; Textile; IT; Automobile; R&D.	Organizational complexity	Literature review;
	Bakhshi, Ireland & Gorod (2016)	x	x	x		x							x	x	x	Project management; System of system; Complexity theories	Project complexity	Literature view;
	Total:	5	5	4	3	2	1	1	1	1	1	1	1	1	1			

* Extra sub-division of dimensions

*Sub-division
1. Complexity context;
2. Culture;
3. Information systems;
4. Interdependence;
5. Location;
6. Management hierarchy;
7. Objective (incentive) alignment;
8. Operating standard procedure;
9. Personality.

Leganda:
1: Not able to discriminate
2: Not operational and meaningful for SSUE projects
3: Redundant: double counting
4: Few in number
5: Not frequently mentioned in the literature
6. Could be combined.
7. Experts reasoning
! = important
- less important, the number is the amount stated in the literature
O is the relation with the OC

Table 12: OC factors identified from the literature

	Organizational complexity factors	Stracke (2016)	subdivision	Vidal & Marle (2008)	subdivision	Vidal, Marle & Bocquet (20	subdivision		Qureshi & Kang (2015)	subdivision	Bakhshi, Ireland & Gorod (2	subdivision		Bosch-Rekveldt et al., (2011	subdivision		Total	Approved ?
1	Variety of information systems to be combined	x	D-1	x	V	x	V	!	x	V	x	D	11			O	6	Yes
2	Interdependence between actors	x	I-4	x	I	x	I		x	I	x	A	13			O	6	Yes
3	Interdependence of objectives / interests	x	I-4	x	I	x	I	!	x	I	x	A	16			O	6	Yes
4	Interdependence of information systems	x	I-4	x	I	x	I	!	x	I	x	A	11			O	6	Yes
5	Number of stakeholders	x	D-6	x	S	x	S	!	x	S	x	S	23			O	6	Yes
6	Variety of the interests of the stakeholders	x	D-7	x	V	x	V	!	x	V	x	D	18			O	6	Yes
7	Number and clarity of project objectives	x	D-7	x	S	x	S		x	S	x	E/S	17/14			O	6	Yes
8	Number of decisions to be made	x	D-1	x	S	x	S	-	x	S	x	S	10				5	Yes
9	Number of activities	x	D-1	x	S	x	S	-	x	S	x	S	15			O	6	Yes
10	Cultural configuration and variety	x	D-2	x	C	x	C	!			x	C	19			O	5	Yes
11	Number of information systems	x	D-1	x	S	x	S		x	S	x	D	13				5	Yes
12	Dependencies between schedules	x	I-4	x	I	x	I	!	x	I	x	A	13				5	Yes
13	Processes interdependence	x	I-4	x	I	x	I	!	x	I	x	A	15				5	Yes
14	Interconnectivity and feedback loops in the task and project networks	x	I-4	x	I	x	I	!	x	I	x	CO	16				5	Yes
15	Interdependence between sites, departments and companies	x	I-4	x	I	x	I	!			x	A	19	x	R		5	Yes
16	Variety of organizational interdependencies	x	D-4	x	V	x	V	-	x	V	x	D	12				5	Yes
17	Geographical location of the stakeholders (and their mutual disaffection)	x	D-5	x	V	x	V	!	x	V	x	C	13				5	Yes
18	Number of hierarchical levels	x	D-6	x	S	x	S	-	x	S	x	S	14				5	Yes
19	Number of structures / groups / teams to be coordinated	x	D-6	x	S	x	S		x	S	x	S	25				5	Yes
20	Variety of organizational skills required	x	D-7	x	V	x	V	-	x	V	x	D	13				5	Yes
21	Number of companies/projects sharing their resources	x	D-7	x	S	x	S		x	S	x	S	16				5	Yes
22	Variety of staff (experience, social span or references)	x	D-9	x	V	x	V				x	D	13	x	R		5	Yes
23	Team cooperation and communication	x	D-9	x	I	x	I	!	x	I	x	A	22				5	Yes
24	Variety of financial resources			x	V	x	V	-	x	V	x	D	14	x	R		5	Yes
25	Variety of project management methods and tools applied			x	V	x	V	-	x	V	x	D	18 C	x	S		5	Yes
26	Largeness of capital investment			x	S	x	S	-	x	S	x	S	11 C	x	S		5	Yes
27	Availability of people, material and of any resources due to sharing			x	I	x	I	!	x	I	x	A	16	x	R		5	Yes
28	Environment complexity (networked environment)			x	C	x	C	!	x	C	x	C	13			O	5	Yes
29	Organizational degree of innovation			x	C	x	C		x	C	x	C	10			O	5	Yes
30	Trust	x	A-7						x		x	B	13	x	T		4	Yes
31	Level of interrelations between phases	x	I-4	x	I	x	I	!			x	A	9				4	yes
32	Variety of hierarchical levels within the organization	x	D-6	x	V	x	V	-			x	D	11				4	yes
33	Number of interfaces in the project organization	x	D-6	x	I	x	I				x	CO	9				4	yes
34	Number of departments involved	x	D-7	x	S	x	S				x	S	22				4	Yes
35	Institutional configuration	x	D-7	x	C	x	C	-			x	C	10				4	Yes
36	Duration of the project			x	S	x	S	-			x	S	18	x	S		4	Yes
37	Staff quantity			x	S	x	S	-			x	S	10	x	S		4	Yes
38	Number of investors			x	S	x	S	-	x	S	x	S	12				4	yes
39	Dependencies with the environment			x	I	x	I	!	x	I	x	A	12				4	Yes
40	Stakeholders interrelations			x	I	x	I		s	I	x	A	12				4	No: 3
41	Level of competition (between stakeholders)			x	C	x	C	-	x	C	x	C	12				4	yes
42	Local laws and regulations (combined with 43)			x	C	x	C	-	x	C	x	C	11				4	yes
43	New laws and regulations (combined with 42)			x	C	x	C	-	x	C	x	C	16				4	yes
44	Variety of timezones	x	D-5								x	D	5	x	PT		3	No: 2, 4
45	Variety of the stakeholders' status			x	V	x	V				x	D	10				3	Yes
46	Number of deliverables			x	S	x	S				x	S	17				3	Yes
47	Combined transportation			x	I	x	I				x	A	9				3	No: 2
48	Dynamic and evolving team structure			x	I	x	I	-			x	A	12				3	Yes
49	Relation with permanent organizations			x	I	x	I	-			x	A	10				3	No: 1, 3
50	HSSE awareness / issues										x	C	7	x	S		2	No: 2, 5
51	Project drive										x	C	7	x	R		2	No: 3
52	Contract types										x	C	10	x	R		2	No: 2,4
53	Organizational risk										x	C	7	x	R		2	No: 2, 4
54	Types of required organizational skills (see 20)	x	D-7														1	No: 3
55	Role variety	x	D-7														1	No: 4, 5
56	Functional boundaries	x	D-7														1	No: 4, 5
57	Protection of intellectual property	x	A-7														1	Yes
58	Organizational boundaries	x	D-7														1	No: 4
59	Standardization of information passing	x	A-8														1	No:4
60	Number of standardized processes	x	A-8														1	Yes
61	Formalization of role-performance (see 62)	x	A-8														1	No: 3, 4, 5
62	Structural formalization	x	A-8														1	Yes
63	Personal fit	x	D-9														1	No: 2, 4, 5
64	Size in engineering hours													x	S		1	No: 2, 4, 5
65	Size of site area													x	S		1	No: 2, 5
66	Number of locations													x	S		1	No: 2, 5
67	Commercial newness of the project										x	C	9				1	No: 4, 5
68	Commitment and support (top management, users, staff members, etc.)										x	C	7				1	Yes
69	Project leadership	rt city and grey literature																Yes
70	User / people and community involvement	Added from smart city and grey literature																Yes

Appendix E: OC framework

Table 13: OC framework

Organizational complexity framework		
Categorization	**OC factor**	**Abbreviations**
1. Project scope (PS)	*Duration of the project	**PS1**
	*Number of activities	**PS2**
	*Number of deliverables	**PS3**
	*Number of decisions to be made	**PS4**
	*Number of investors	**PS5**
	*Largeness of capital investment (CAPEX)	**PS6**
	*Division/sharing risks	**PS7**
	*Number of information/data systems	**PS8**
	*Number and hierarchy of stakeholders	**PS9**
	*Number and clarity of project objectives	**PS10**
	*Hierarchy of project objectives	**PS11**
	*Number of directly involved project participants / partners	**PS12**
	*Number of groups / teams / structures to be coordinated	**PS13**
	*Number of hierarchical levels	**PS14**
	*Number, diversity and clarity of contract types	**PS15**
	*Number of companies/projects sharing their resources	**PS16**
	*Number of departments involved	**PS17**
2. Project variety (PV)	*Variety of the interests of the stakeholders (collective/individual and long/short term	**PV1**
	*Variety of the stakeholders' status	**PV2**
	*Variety of information/data systems to be combined	**PV3**
	*Types of (organizational) skills required	**PV4**
	*Variety (or lack of variety) of involved project participants/partners (experience, social background or references)	**PV5**
	*Variety of organizational interdependencies	**PV6**
	*Variety of financial resources	**PV7**
	*Variety of project management methods and tools applied	**PV8**
	*Variety of hierarchical levels within the organization	**PV9**
	*Geographical location of the stakeholders	**PV10**
3. Interdepencies within the project (IP)	*Interdependence between partners/actors	**IP1**
	*Interdependence of objectives / interests	**IP2**
	*Interdependence of information/data systems	**IP3**
	*Interdependence of processes	**IP4**
	*Team cooperation and communication	**IP5**
	*Trust	**IP6**
	*Interdependence between companies, departments and and/or sites	**IP7**
	*Availability of people, material and of any resources due to sharing	**IP8**
	*Level of interrelations between phases	**IP9**
	*Dependencies between schedules	**IP10**
	*Stakeholders interrelations	**IP11**
	*Dependencies with the environment	**IP12**
	*Involvement of users / citizens / community	**IP13**
	*Dynamic and evolving partners / team structure	**IP14**
	*Commitment and support (top management, users, partners, etc.)	**IP15**
	*Project leadership and ownership	**IP16**
	*Number of interfaces in the project organization	**IP17**
	*Structural formalization	**IP18**
	*Protection of intellectual property	**IP19**
	*Interconnectivity and feedback loops in the task and project networks	**IP20**
4. Elements of context (EC)	*Degree of innovation	**EC1**
	*Environment complexity (networked environment)	**EC2**
	*Level of competition (between stakeholders)	**EC3**
	*Local and / or new laws and regulations	**EC4**
	*Institutional configuration	**EC5**
	*Cultural configuration and variety	**EC6**
	*Commercial newness of the project	**EC7**
	*Political situation and influence	**EC8**
	*Upscaling the project	**EC9**

Table 14: Description of the OC factors

	OC factors	Explanation
PS1	*Duration of the project	The longer a project lasts, the more sources of project complexity there are to influence the project and the more difficult it is to predict the project evolution. But the shorter a project lasts, the more it is constrained, resulting in higher pressure and difficulties to manage the project.
PS2	*Number of activities	When project tasks are numerous, then the project is more complex since numerous activities require higher coordination and finer analysis to formulate and understand the behavior of the project.
PS3	*Number of deliverables	When project deliverables are more numerous, more aspects need to be simultaneously controlled and achieved properly, which makes the project more complex.
PS4	*Number of decisions to be made	The more decisions are to be made, the more the coordination of the project and the prevision of the impact of these decisions is difficult to tell. A high number of decisions might also be an indicator for pressure and stress during the project
PS5	*Number of investors	The more investors, the more people with their own interests and the more people that could influence and decide.
PS6	*Largeness of capital investment (CAPEX)	Project size [budget]. The estimated CAPEX (capital expenditures) of the project. Is there room to fail?
PS7	*Division/sharing risks	Dividing and sharing risks among partners/stakeholders. Is there room to fail also in a non-financial way.
PS8	*Number of information / data systems	This is an organized system for the collection, organization, storage and communication of information/data. When these elements are more numerous, then more aspects must be controlled within the project, which make it more complex.
PS9	*Number and hierarchy of stakeholders	The number of stakeholders (all parties (internal and external) in and around the projects) and the hierarchy of stakeholders. It could make the decision-making complex in terms of pace and structure.
PS10	*Number and clarity of project objectives	When project objectives are more numerous, the more aspects must be simultaneously kept under control.The degree of clarity of goals can create complexity. Think of clearness of the result and understanding each others and jointly objectives.
PS11	*Hierarchy of project objectives	The hierarchy of objectives could make the project complex. Which objective comes first and which objectives last. It also refers to the extent to which project objectives are 'shared'and to what extent the parties can achieve their own objectives.
PS12	*Number of directly involved project participants / partners	The number of persons and partners within the project team. When the project team is more numerous, then project coordination and decision making is more complex. Loss of information is more frequent.This factor has a strong influence on many other pre-cited factors
PS13	*Number of groups / teams / structures to be coordinated	When these elements are more numerous, then more aspects must be controlled within the project, which make it more complex.
PS14	*Number of hierarchical levels	A hierarchical organization is an organizational structure where every entity in the organization, except one, is subordinate to a single other entity. When these elements are more numerous, then more aspects must be controlled within the project, which make it more complex.
PS15	*Number, diversity and clarity of contract types	When there are numerous and diverse contracts, the more aspects must be controlled, which make it more complex. Due to the innovative nature of a project it could also be complex what you should capture in the contracts. On the one hand, juridification is desirable but on the other hand you do not want to capture everything in legal terms in such projects.
PS16	*Number of companies / projects sharing their resources	When these elements are more numerous, then more aspects must be controlled within the project, which make it more complex.
PS17	*Number of departments involved	Number of divisions of (different) organizations. When these elements are more numerous, then more aspects must be controlled within the project, which make it more complex.
PV1	*Variety of the interests of the stakeholders (collective/individual and long/short term)	When the stakeholders interests are varied, in terms of individual / collective interests and short/long term, then project coordination and control is more complex because of conflicting interests that are likely to appear. Also the understanding of each other's interests could become complex just as which interest is most important and leading.
PV2	*Variety of the stakeholders' status	The control of the relationships with the stakeholders may imply varied procedures or behaviors for instance.
PV3	*Variety of information / data systems to be combined	Amount of different information/data systems to be combined. This is an organized system for the collection, organization, storage and communication of information and/or data. Combining data could be complex in terms of ownership, privacy, sharing and security.
PV4	*Types of (organizational) skills required	The more diverse the needed project skills are (either organizational or technical), the more varied the project team is likely to be (notably in terms of scholarship, training, professional background, etc.), which might imply different and sometimes conflicting perceptions of the project.
PV5	*Variety (Or lack of variety) of involved project participants / partners (experience, social background or references)	When the project participants/partners are varied, notably in terms of work experience, social span or references (cultural elements), then the project coordination and control appear to be more complex. But, when the project participants/partners are too similar, competencies could be missing and things could go wrong because of that.
PV6	*Variety of organizational interdependencies	Number of different organisational interdependencies.
PV7	*Variety of financial resources	Number of different types of financial resources. How many different financial resources does the project have (e.g. own investment, bank investment, JV-parties, subsidies, etc.)?
PV8	*Variety of project management methods and tools applied	Amount of different project management methods and tools applied. Compatibility issues could occur regarding project management methodology or project management tools.
PV9	*Variety of hierarchical levels within the organization	Amount of different hierarchical levels within organisation
PV10	*Geographical location of the stakeholders	When stakeholders of the project are far from one another in terms of geographic location, then the project analysis, coordination and prediction could be harder because of numerous effects (loss of information, variety of local contexts of the stakeholders, influence of local geopolitical contexts, lack of information sharing due to their mutual disaffection etc.)

IP1	*Interdependence between partners / actors	Interdependence between partners/actors which execute the project, whatever their nature, make it all the more complex to coordinate the project efficiently. The level of interdependence is likely to be higher in complex projects since 'team integration should be encouraged for complex product development projects'. It refers to the ability to cooperate amid stakeholders, structure of alliances, support of leadership and working under diverse jurisdictions.
IP2	*Interdependence of objectives / interests	The interdependence of project objectives make the project more complex since any change in any project objective might involve changes for the other project objectives, which may make project already produced outcomes inconsistent with the new project objectives
IP3	*Interdependence of information / data systems	It make the project more complex since any dysfunction of any information system may impact the whole information systems architecture of the project
IP4	*Interdependence of processes	Project processes interdepedence, which might result in failure propagation for instance or in loss of information, make it all the more complex to manage a project.
IP5	*Team cooperation and communication	Low team cooperation and communication make it all the more complex to manage the project since project strategies, decisions, objectives and processes may for instance be shared less effectively by the project team. If communication is bad, different and sometimes conflicting perceptions of strategies, decisions, objectives, stakeholders, activities, etc. might coexist in the project
IP6	*Trust	Trust in and between the project team and stakeholders
IP7	*Interdependence between companies, departments and/or sites	Interdependence between companies, departments and sites which are involved in the project make it more complex (schedule compatibility, coordination resources and processes, etc.)
IP8	*Availability of people, material and of any resources due to sharing	Projects may share their people, material and all their resources within the firm. Moreover, within a given project some resources may be shared between people, tasks, etc… Such a nonavailability of resources during a project makes it more complex.
IP9	*Level of interrelations between phases	The more project phases are interrelated, the more decisions made during a phase may impact the following ones. Moreover, this means that a failure occurring during a phase is more likely to have an impact which implies rework in other phases.
IP10	*Dependencies between schedules	Dependencies between schedules make it all the more complex to manage people within a project. For instance, if a change happens in a project team member schedule, then other project team members' schedules may change. But, these schedules are constrained (notably by permanent organizations). As a consequence, the required changes may not be possible, which make project management processes even more complex.
IP11	*Stakeholders interrelations	Project objectives may for instance be redefined by stakeholders because of their evolving relationships or the value that a stakeholder expects to create could change during a project. Managing the relations with stakeholders in complex projects appears to be crucial and complex.
IP12	*Dependencies with the environment	The project environment require a constant monitoring of the changes as they may impact the project evolution and outcomes. Feedback and changes from the environment and dealing with this could cause complexity.
IP13	*Involvement of users / citizens / community	The involvement of users/ citizens / community could make the project complex. It is a multi-layered and ongoing process and different users should be approached in a different way. New roles and and relations could arise. Think of decisions making, acceptance etc.
IP14	*Dynamic and evolving partners / team structure	Changes in the team structure or partners over time generate more difficulty to analyze, predict, and control the behavior of the whole project system, notably because of impartial, or flaw, or absent information.
IP15	Commitment and support (top management, users, partners, etc.)	Commitment and support of top management, users, partners. A lack of clear incentives in joining the project could make a project difficult and complex.
IP16	*Project leadership and ownership	Project ownership and/or (absence of) leadership could cause complexity in the project.
IP17	*Number of interfaces in the project organization	Interfaces in the project organization are a potential source of project complexity. Interfaces are information or material exchange zones which need to be coordinated under some pressure conditions (coming from each part of the interface). These coordination activities, often based on compromise and adaptation, are difficult to analyze and foresee.
IP18	*Structural formalization	The extent to which work roles are structured in an organization, and the activities of the employees are governed by rules and procedures.
IP19	*Protection of intellectual property	Could make it complex due to who owns the intellectual property and how to protect it.
IP20	*Interconnectivity and feedback loops in the task and project networks	Such interconnectivity and feedback loops in the task network and other project networks (communication and information networks, etc.) make it impossible to analyze the recursive phenomena that exist in the project.
EC1	*Degree of innovation	The innovation, either organizational or technological, has an influence on project complexity. The degree of innovation affects the relationship between the number of tasks / processes that have been standardized. For instance, a lack of experience (due to innovation requirements) and more generally the uncertainty associated to innovation makes it more difficult to formulate the behavior of the project, and to formulate reliable targets and processes to reach these targets.
EC2	*Environment complexity (networked environment)	Environment complexity in terms of network might increase project complexity and make its management harder, since the impact of any decision is likely to ropagate through this networked environment. How do you deal with the feedback from the (network) environment
EC3	*Level of competition (between stakeholders)	A competitive context is a more demanding and complex one since the targeted business is likely to choose the best products, processes, etc. in terms of expected values. Competition can be either technological or organizational, but the pressure it exerts on the reaching of outcomes contributes to project complexity. Also, sharing knowledge between competitive parties could create complexity.

EC4	*Local and / or new laws and regulations	Local and new laws and regulations can increase project complexity since they may impact notably some differentiation in the project processes/outcomes, depending on the geographical zone where they are performed/created. New laws can increase project complexity since they may result in the need for changes in the processes/outcomes given the new requirements.
EC5	*Institutional configuration	A more complex institutional configuration increases the complexity of the project since one is likely to cope with higher coordination difficulties.
EC6	*Cultural configuration and variety	Number of different cultures (company/countries). A project with a variety of cultures (social, technological, organizational, etc.) which need to be managed altogether appears to be more complex since differences of perception are likely to occur. Cultural configuration and variety can appear within the project or in its environment.
EC7	*Commercial newness of the project	The newness of the project on the commercial dimension could cause complexity in and during the project. For example creating a feasible business case
EC8	*Political situation and influence	Dynamics of the political situation could create complexity. The type of councillors and their beliefs could result in different possibilities and different degrees of influence. Furthermore, the task and role of the councilor could fluctuate together with political system and idealism (European, nation or local level).
EC9	*Upscaling the project	Upscaling the project could be complex. It could be very hard to have clear-cut or readily available answers about upscaling, given the unique contextual factors in which each project will be developed. Upscaling is a multi-layered process and cannot prosper without sharing knowledge.

Appendix F: Fuzzy Delphi Method questionnaire

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Smart Urban Energy Projects

Page: Introduction

Welcome and thank you for participating in this graduation research for the TU/e

Before further explanation about the questionnaire, I want to emphasize that your completed results will be processed anonymously! The total completion time will be +/- 10 minutes.

Research introduction

The purpose of this questionnaire is to identify the most important drivers of organizational complexity in the front-end phase (initiation - development) of innovative smart city projects that could affect the project performance.

As an expert in developing smart city project(s), you are asked to what extent, on a scale from 1 till 7, each organizational factor could potentially contribute to the complexity in the front-end phase (initiation - development) of a smart city project. With a special focus on smart urban energy projects.

Questionnaire introduction

The questionnaire consists of two parts:

1. General questions
2. Questions about the factors contributing to the organizational complexity in smart city projects.Divided in 5 categories:
   - *Project scope (17)*
   - *Project variety (10)*
   - *Interdependencies within a project (20)*
   - *Elements of context (9)*
   - *Flux (5)*

While completing the questionnaire you can customize your answers. When you click on submit, your answers will be saved and you will not be able to change them again

Kind regards,

Stijn Kusters
Eindhoven University of Technology

Start

TU/e Technische Universiteit Eindhoven University of Technology

Smart Urban Energy Projects

Page: General_questions

General questions

Do you have any experience in developing smart city projects?

- Yes
- No

In what way is/was your organization involved in a smart city project?

- From a public organization
- From a private organization
- From an utility organization
- From a non-governmental organization (NGOs)
- From a knowledge institute
- Other

If other, please specify:

What was your role within such a smart city project (e.g. project manager / consultant / engineer)? Please describe briefly.

In which smart city domain(s) are/were you involved (multiple answers are possible)?

- Energy & Natural resources
- Transportation & Mobility
- Buildings
- Living
- Governance & Policy
- Community & Citizens
- Other

If other, please specify:

If you are/were involved in a smart urban energy project (domain energy), in what type of smart urban energy project are/were you involved? (If applicable, multiple answers are possible)

- Building(s) and district(s)
- Transportation and mobility
- Energy and ICT infrastructure
- Collaborative planning
- Consumer (prosumer) behaviour management
- Data and energy management
- Other

If other, please specify:

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Smart Urban Energy Projects

Page: Factoren projectomvang

Factors Project scope

To what extent could each of the factors below potentially contribute to the organizational complexity of a typical smart city (urban energy) project?

**For additional explanation of a factor then move your cursor and stand on the corresponding factor.*

	Not at all 1	2	Little 3	4	Substantial 5	6	Very much 7
Duration of the project							
Number of activities							
Number of deliverables							
Number of decisions to be made							
Number of investors							
Largeness of capital investment (CAPEX)							
Division/sharing risks							
Number of information/data systems							
Number and hierarchy of stakeholders							
Number and clarity of project objectives.							
Hierarchy of project objectives							
Number of directly involved project participants / partners							
Number of groups / teams / structures to be coordinated							
Number of hierarchical levels							
Number, diversity and clarity of contract types							
Number of companies/projects sharing their resources							
Number of departments involved							

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Smart Urban Energy Projects

Page: Factoren project variëteit

Factors project variety

To what extent could each of the factors below potentially contribute to the organizational complexity of a typical smart city project (e.g. smart urban energy)?

**For additional information/explanation of a factor then move your cursor and stand on the corresponding factor.*

	Not at all 1	2	Little 3	4	Substantial 5	6	Very much 7
Variety of the interests of the stakeholders (collective/individual and long/short term)							
Variety of the stakeholders' status							
Variety of information/data systems to be combined							
Types of (organizational) skills required							
Variety (Or lack of variety) of involved project participants / partners (experience, social background or references)							
Variety of organizational interdependencies							
Variety of financial resources							
Variety of project management methods and tools applied							
Variety of hierarchical levels within the organization							
Geographical location of the stakeholders							

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Page: Factoren project afhankelijkheden

Interdependencies within a project

To what extent could each of the factors below potentially contribute to the organizational complexity of a typical smart city project (e.g. smart urban energy)?

**For additional information/explanation of a factor then move your cursor and stand on the corresponding factor.*

	Not at all 1	2	Little 3	4	Substantial 5	6	Very much 7
Interdependence between partners/actors							
Interdependence of objectives / interests							
Interdependence of information/data systems							
Interdependence of processes							
Team cooperation and communication							
Trust							
Interdependence between companies, departments and/or sites							
Availability of people, material and of any resources due to sharing							
Level of interrelations between phases							
Dependencies between schedules							
Stakeholders interrelations							
Dependencies with the environment							
Involvement of users / citizens / community							
Dynamic and evolving partners / team structure							
Commitment and support (top management, users, partners, etc.)							
Project leadership and ownership							
Number of interfaces in the project organization							
Structural formalization							
Protection of intellectual property							
Interconnectivity and feedback loops in the task and project networks							

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Page: Factoren Elements of context

Factors elements of context

To what extent could each of the factors below potentially contribute to the organizational complexity of a typical smart city project (e.g. smart urban energy)?

**For additional information/explanation of a factor then move your cursor and stand on the corresponding factor.*

	Not at all 1	2	Little 3	4	Substantial 5	6	Very much 7
Degree of innovation							
Environment complexity (networked environment)							
Level of competition (between stakeholders)							
Local and / or new laws and regulations							
Institutional configuration							
Cultural configuration and variety							
Commercial newness of the project							
Political situation and influence							
Upscaling the project							

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Page: Einde

You have reached the end of this questionnaire.
Please enter the ***submit*** button to submit your results. After submitting your results, you can close your webbrowser.

Thank you very much for your effort and kind cooperation! Your contribution is very valuable for the research.

If you have any questions regarding the research, please contact me at kusters.sta@gmail.com
The final results of this research will be published on: www.repository.tue.nl

Yours sincerely,

Stijn Kusters
Eindhoven University of Technology
Master Construction Management and Engineering

Previous | Submit

Appendix G: Decision rules for classification into complexity/risk classes

Table 15: Decision rules for classification. Reprinted from (Keizer, Halman, & Song, 2002).

Score:
* = At least 50% of the scores is found in 1st and/or 2nd column and none in 5th column;
0 = At least 50% of the scores is found in 4st and/or 5th column and none in the 1th column;
M = At least 50% of the scores is found in 3rd column;
? = For all the remaining cases (side distribution in opinions or remarkable deviating opinions).

Score			**Complexity / Risk class**	**Score**			**Complexity / Risk class**
Certainty	Ability of team to influence course of action	Relative importance to project success		Certainty	Ability of team to influence course of action	Relative importance to project success	
*	*	*	F	*	*	?	M-F
*	*	0	L	*	?	*	H-F
*	0	*	M	?	*	*	M-F
0	*	*	H	*	?	?	L-F
0	0	*	L	?	*	?	L-F
0	*	0	L	?	?	*	L-F
*	0	0	L	?	?	?	S-F
0	0	0	S	?	0	0	L
*	*	M	H	0	?	0	L
*	M	*	H	0	0	?	L
M	*	*	H	?	?	0	S-M
*	M	M	M	?	0	?	S-H
M	*	M	M	0	?	?	S-M
M	M	*	M	*	?	0	L-M
M	M	M	M	*	0	?	L-H
0	*	M	M	0	*	?	L-M
*	0	M	M	0	?	*	L-M
0	M	*	M	?	0	*	L-H
*	M	0	M	?	*	0	L-M
M	*	0	M	*	?	M	M-H
M	0	*	M	*	M	?	M-H
0	0	M	L	M	?	*	M-H
0	M	0	L	M	*	?	M-H
M	0	0	L	?	M	*	M-H
0	M	M	M	?	*	M	M-H
M	M	0	M	M	?	0	L-M
M	0	M	M	M	0	?	L-M
				0	?	M	L-M
				0	M	?	L-M
				?	0	M	L-M
				?	M	0	L-M
				?	M	M	L-M
				M	?	M	M
				M	M	?	M
				?	?	M	L-H
				?	M	?	L-H
				M	?	?	L-H

F = Fatal;
H = High;
M = Medium;
L = Low.
S = Safe.

A combination of classes means that the project team should work out whether the disagreement can be resolved and hence a single classification can be achieved. If consensus cannot be achieved the worst possible case should be assumed.

Appendix H: Questionnaire OCRDM - Interflex

Introduction and application of the research & model

Welcome and thank you for participating in this graduation research for the TU/e. Before further explanation about the questionnaire, I would like to emphasize that your completed results will be processed anonymously! The total completion time will be +/- 15 minutes.

Introduction research and organizational complexity related risk diagnosis model (OCRDM)

Based on the critical organizational complexity, a Risk Diagnostic Model (RDM) has been developed with the aim to gain insight into the mechanisms of the OC-based risks and to detect the factors that could jeopardize the successful realization of the project objectives in the front-end phase (initiative and development) of an innovative smart urban energy projects.

You as a project participant in the Interflex project will be asked to assess the OC-based risk statements in the developed questionnaire. You will be asked to rate each statement on three evaluation parameters with a scale of 1-5. Please select the box that you think is most applicable for every parameter. *WARNING: the scale for the third evaluation parameter 'relative importance' is changed consciously.* The questionnaire consists of 26 statements within 4 different categories. It is possible that a statement is irrelevant or that you have no opinion about it. In that case, please do not to respond and leave it open. The questionnaire can be found by selecting the tab 'OCDM_NL' in the left corner of this page.

Please save your results at the end of this questionnaire and send them to **kusters.sta@gmail.com .** Mention your name and company in the mail.

Thank you very much for your participation and do not hesitate to contact me when there are uncertainties or questions.

Kind regards,

Stijn Kusters
Technische Universiteit Eindhoven
+31 (0) 6 51 32 47 37
kusters.sta@gmail.com

Organizational complexity related risk statements:	What is the ***level of certainty*** that the statement will be true?					***Ability of team to influence*** course of actions within time & resource limits.					***Relative importance*** of statement for obtaining project success.				
	Low				High	Low				High	High				Low
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**5**	**4**	**3**	**2**	**1**
PROJECT SCOPE STATEMENTS															
1. The number and scope of activities are known, feasible and focused. The numerous project tasks and activities will be effectively managed and coordinated and the behavior of the project is well defined and understandable for everyone.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2. The number and scope of the deliverables are defined, clear and feasible for the partners. The deliverables will be (simultaneously) controlled and achieved properly.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3. The number of the decisions to be made are known and the decision making process is effective. The prevision of the impact of these decisions are clearly understood and will be coordinated effectively.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4.. Risks and returns are divided and shared among partners in an appropriate way and everyone agrees to that. There is also room to experiment and even to fail.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5. The amount of (different) information/data systems in the project are known and feasible and can be controlled and coordinated effectively in terms of e.g. ownership, privacy, sharing, security.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6. The number and hierarchy of stakeholders is clear and feasible and easy to coordinate. The decision-making process in the project is effective and clear in terms of pace and structure.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7. All project goals and objectives (individual and jointly) are clear, transparent and consistent. The objectives are feasible in number and will be controlled and accepted among partners.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8. The hierarchy of the project objectives is clear and accepted which makes the decision-making process in the project is effective.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
9. The number of directly involved participants/partners is clear and feasible. It is coordinated effectively without loss of information and decision-making is clear.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10. There are no difficulties in the coordination of the (high) number of teams / groups / structures.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
11. There will be effective coordination of the number of partners that commit and share their resources. Required resources (money, time, human resources) estimations are reliable and feasible and will be available and shared when required.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

PROJECT VARIETY STATEMENTS															
12. The variety of interests of the partners and stakeholders (collective/individual and long/short term) enhances the cooperation and acceptance among partners. Each partner is explicit and transparent about its intended interest and there will be an adequate anticipation on conflicting interests.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
13. The diverse project team is sufficiently authorized and qualified for the project and effectively utilize the knowledge and experience of the participants/partners. The degree of variety in the project team (e.g. experience, social span, culture, references) enhances the project coordination and control.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
14. The amount of different organizational interdependencies and interfaces in the project is clear and feasible.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
PROJECT INTERDEPENDENCIES STATEMENTS															
15. Cooperation and communication within the project team and between members is effective. E.g. project strategies, decisions, objectives and processes are shared, accepted and communicated effectively by the project team.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
16.Trust between the partners and stakeholders is formed, built and sustained over time.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
17. The interrelations with stakeholders will be assured and effectively managed and if needed adequately anticipated (e.g. objectives may for instance be redefined by stakeholders due to their evolving relationships or the value that a stakeholder expects to create could change during a project).	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
18. Top management actively support and are committed to the project on the short and the long term.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
19. All partners are highly motivated and committed to the project on the short and the long term. All partners have clear incentives in joining the project.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
20. The ownership in the project is clear and feasible and strong committed project leadership is present throughout the process who drives the project forward.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ELEMENTS OF CONTEXT STATEMENTS															
21. The innovativeness of the project is clearly understood and contributes in reaching the objectives. Processes/tasks are known and specified, the behavior of the project is formulated and there is experience to deal with the innovativeness.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
22. Possible reactions and challenges from the (network) environment will be monitored and adequately anticipated.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
23. The competitive context and the level of competition between stakeholders are in favor of this project. Partners/stakeholders effectively share their knowledge, experience and information between each other and are transparent.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
24. Local and/or new laws and regulations will be adequately anticipated.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
25. The political climate is stable and in favor of this project. Long-term and consistent energy plans and policies will be assured as well as full local political commmitment and support.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
26. The project includes scale-up potential (roll-out, expansion, replication) given the unique contextual factors in which the project will be developed.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

You reached the end of the questionnairet. Please save your results and send them to kusters.sta@gmail.com.

Thank you for you participation and your contribution to the succes of my graduation research. Your contribution is very valuable for this research.

Appendix I: Data analysis and issues OCRDM - Interflex

Table 16: Perceived Interflex project issues based on scale of 1 -5. Results based on the expert questionnaires.

		Certainty 1 = low, 5 = high			Influencibility 1 = low, 5 = high			Importance 5 = High, 1 = Low		
Risk category	**Specific risks**	**Mean**	**St. Dev.**	**Median**	**Mean**	**St. Dev.**	**Median**	**Mean**	**St. Dev.**	**Median**
PS1	The number and scope of activities are known, feasible and focussed. The numerous project tasks and activities will be effectivily managed and coordinated and the behavior of the project is well defined and understandable for everyone.	3.0	1.58	3.0	4.2	0.84	4.0	4.0	1.22	4.0
PS2	The number and scope of the deliverables are defined, clear and feasible for the partners. The deliverables will be (simultaneously) controlled and achieved properly.	3.6	1.14	4.0	3.8	0.84	4.0	4.6	0.55	5.0
PS3	The number of the decisions to be made are known and the decision making process is effective. The prevision of the impact of these decisions are clearly understood and will be coordinated effectivily.	2.4	1.14	2.0	4.4	0.89	5.0	3.2	1.48	3.0
PS4	Risks and returns are divided and shared among partners in an appropriate way and everyone agrees to that.	3.0	1.58	3.0	4.0	1.00	4.0	4.0	1.00	2.0
PS5	The amount of (different) information/data systems in the project are known and feasible and can be controlled and coordinated effectivily in terms of e.g. ownership, privacy, sharing, security.	3.4	1.52	4.0	4.0	1.22	4.0	3.6	1.34	3.0
PS6	The number and hierarchy of stakeholders is clear and feasible and easy to coordinate. The decision-making process in the project is effective and clear in terms of pace and structure.	3.0	1.58	3.0	3.6	1.34	3.0	4.0	1.41	4.5
PS7	All project goals and objectives (individual and jointly) are clear, transparent and consistent. The objectives are feasible in number and will be controlled and accepted among partners.	3.0	0.71	3.0	3.6	0.89	3.0	4.2	0.84	4.0
PS8	The hierarchy of the project objectives is clear and accepted which makes the decision-making process in the project is effective.	3.6	1.14	4.0	3.4	1.52	4.0	3.2	1.30	3.0
PS9	The number of directly involved participants/partners is clear and feasible. It is coordinated effectivily without loss of information and decisionmaking is clear.	3.6	1.14	4.0	3.6	0.89	3.0	3.8	1.10	3.0
PS10	There are no difficulties in the coordination of the (high) number of teams / groups / structures.	3.5	1.29	3.0	3.5	1.29	3.5	4.3	0.96	4.5
PS11	There will be effective coordination of the number of partners that commit and share their resources. Required resources (money, time, human resources) estimations are reliable and feasible and will be available and shared when required.	3.4	1.34	3.5	3.0	1.22	3.0	3.4	1.34	4.0
PV1	The variety of interests of the partners and stakeholders (collective/individual and long/short term) enhances the cooperation and acceptance among partners. Each partner is explicit and transparent about its intended interest and there will be an adequate anticipation on conflicting interests.	4.0	1.00	4.0	3.8	0.84	4.0	4.2	0.84	4.0
PV2	The diverse project team is sufficiently authorized and qualified for the project and effectively utilize the knowledge and experience of the participants/partners. The degree of variety in the project team in terms of experience, social span, culture and/or references enhances the project coordination and control.	4.2	0.84	4.0	4.0	1.00	4.0	4.0	1.00	4.0
PV3	The amount of different organizational interdependencies and interfaces in the project is clear and feasible.	3.2	1.10	3.0	3.4	1.14	3.0	3.2	1.30	3.0
IP1	Cooperation and communication within the project team and between members is effective. E.g. project strategies, decisions, objectives and processes are shared, accepted and communicated effectively by the project team.	3.8	0.84	4.0	4.2	0.84	4.0	4.0	0.71	4.0
IP2	Trust between the partners and stakeholders is formed, built and sustained over time.	4.0	0.71	4.0	4.0	1.00	4.0	4.2	1.10	5.0
IP3	The interrelations with stakeholders will be assured and effectively managed and if needed adequately anticipated (e.g. objectives may for instance be redefined by stakeholders due to their evolving relationships or the value that a stakeholder expects to create could change during a project).	3.4	1.14	3.0	3.8	0.84	4.0	3.8	0.84	4.0
IP4	Top management actively support and are committed to the project on the short and the long term.	2.8	1.79	3.0	3.6	1.14	4.0	3.0	1.58	3.0
IP5	All partners are highly motivated and committed to the project on the short and the long term. All partners have clear incentives in joining the project.	4.2	0.84	4.0	4.4	0.89	5.0	4.2	0.84	4.0
IP6	The ownership in the project is clear and feasible and strong committed project leadership is present throughout the process who drives the project forward.	3.8	0.84	4.0	3.8	1.10	3.0	4.2	1.10	5.0
EC1	The innovativeness of the project is clearly understood and contributes to reaching the objectives. Processes/tasks are known and specified, the behavior of the project is formulated and there is experience to deal with the innovativeness.	4.0	0.71	4.0	4.3	0.96	4.5	4.0	0.82	4.0
EC2	Possible reactions and challenges from the (network) environment will be monitored and adequately anticipated.	3.6	1.14	4.0	4.0	1.15	4.0	3.5	1.29	3.5
EC3	The competitive context and the level of competitin between stakeholders are in favor of this project. Partners/stakeholders effectively share their knowledge, experience and information between each other and are transpartent.	3.4	1.14	3.0	3.6	1.34	3.0	4.0	1.22	4.0
EC4	Local and/or new laws and regulations will be adequately anticipated.	2.2	0.84	2.0	2.4	1.34	3.0	2.5	1.29	2.5
EC5	The political climate is stable and in favor of this project. Long-term and consistent energy plans and policies will be assured as well as full local political commmitment and support.	2.2	0.84	2.0	2.0	1.00	2.0	3.3	0.50	3.0
EC6	The project includes scale-up potential (roll-out, expansion, replication) given the unique contextual factors in which the project will be developed.	3.8	0.84	4.0	3.6	0.89	3.0	3.0	1.22	3.0