Reducing CO$_2$ Emissions by Smart City Governance?

An Empirical Analysis of Smart City Governance in Three Smart City Projects

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Colophon

Abstract

Many cities are facing increasing environmental challenges regarding air pollution, congestion, waste management, and human health. Over the last decade, the concept of 'smart cities' has been gradually given attention to, in hope that the use of new technologies could help to effectively address and solve these challenges. However, it has become clear that the sole use of technologies is not sufficient to manage a smart city and overcome challenges. In the context of a smart city, a new, innovative, and ICT-based form of governance has been conceptualized as smart city governance. This concept has been considered the solution to successfully govern the smart city. The small amount of literature on smart city governance, and the unclear concepts and definitions derived from this literature led to the creation of a new smart city governance model that could be applied in practice. This model consists of eight elements, and governance challenges, which can influence the aspired outcome. For this research, a specific focus was laid on the CO_2 mitigation outcome, as this is currently being seen as one of the most important objectives of the smart city. Therefore, this thesis researched the influence smart city governance can have on CO_2 mitigation. The model has been tested in three smart city projects in Rotterdam, Umeå, and Glasgow, consisting of 32 smart initiatives, where CO_2 mitigation was one of the main objectives. A questionnaire and interviews were held among three different stakeholder groups in the city projects, namely government stakeholders, private companies, and researchers. This allowed assessing the presence of smart city governance in the city projects, identifying the challenges and successes, and comparing different perspectives.

Comparing the three cities showed that in the in city project with the lowest presence of smart city governance, the most challenges were identified, which could endanger the CO_2 mitigation goals in the project. It is concluded that smart city governance indirectly contributes to reducing CO_2 emissions and reaching CO_2 mitigation goals of smart city projects, as it can play an important role to which extent an initiative will succeed. Different smart city governance elements can have a different amount of influence on this. Finally, it was argued that smart city governance can help to address and redress the challenges and help to increase the chance of smart city projects successfully reaching their CO_2 mitigation goals.

Preface

I first came across the topic of Smart Cities during an internship I did at the ministry of Infrastructure and Environment after graduating from my Bachelor's program. Little did I know that it would be such an interesting topic, and would inspire me enough to write about it for my Master thesis. This inspiration was strengthened by Alexander Woestenburg and Adriaan Slob, who suggested I write about this topic, and be involved in a big European project called Ruggedised, at what came to be my internship organization: TNO. This provided me with the knowledge and network to be able to go in-depth into the topic, and made me even more enthusiastic about being involved in such a big project. The topic is relatively new and has been an interest of many researchers and practitioners. Between my internship and this thesis, a lot of research has been done about smart cities with attention being given to an even newer topic within smart cities, namely smart city governance. Unexplored topics are of interest to me as I would like to come up with new and inspiring results that can contribute to research and society. My interest for environmental sustainability has made me link smart city governance to CO_2 mitigation, as I would like to help cities with the problems they face to find new ways to provide healthy, safe, and sustainable cities. Therefore, I hope this thesis will make a valuable contribution for research and practice towards smart city governance and environmental sustainability.

As this is a very new and fuzzy topic, a lot of time went into understanding and analyzing the current literature. This resulted in some delay and frustration finding the right methods in order to perform my research. Eventually, thanks to several people, I was able to create my own perspective on the concept of smart city governance, which I think has currently not been written down more clearly in research papers, than in this thesis. For this, I would like to thank my girlfriend Ellen, who had to put up with me during the full process of this thesis, and who also greatly supported me after moving back to the United States. I want to thank my sister Femke, who has helped me greatly by brainstorming with me about the research when I needed it the most. Hens Runhaar, I would like to thank you for guiding me in the scientific process of the research. Your critical remarks have helped me to stay focused and focus on what was important, and your questions encouraged me to think twice. Alexander Woestenburg and Adriaan Slob, I would like to thank you for supporting me during this thesis and providing me the necessary contacts to be able to perform this research. I have learned a lot during my internship and this is partly due to you. I would also like to thank them for their understanding and support during some difficult private circumstances while writing this thesis.

Finally, I am grateful I had the opportunity to speak to so many people that were involved in the project. Many people were willing to share their experience and perspective with much enthusiasm. I would like to thank them for their time and knowledge that allowed me to get an understanding of how city projects work in practice.

I hope you will enjoy reading my MSc thesis, and that it will be of value for scientists and practitioners alike.

Nick Schasfoort

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1. Introduction

1.1 The Need for Smart City Governance

An increasing amount of the world population is living in cities, resulting in a wide range of challenges for city governments. They have to create a healthy, safe and sustainable urban environment while also focusing on generating wealth and innovation (Ahvenniemi, Huovila, Pinto Seppä, & Airaksinen, 2017; Meijer & Bolívar, 2016). However, it is not easy to implement strategies for urban development, as cities are complex, rapidly changing systems with many interconnections between actors, infrastructures, services and domains (Castelnovo, Misuraca, & Savoldelli, 2016; Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014). On top of that, cities face certain barriers such as institutional, financial, cultural, administrative, legal, governance, and political barriers, which are important obstacles in solving the issues cities currently face (IPCC, 2014; Reckien, Flacke, Olazabal & Heidrich, 2015). Over the last decade, an increasing amount of attention among academics, urban politicians and professionals around the world has been given to the concept of 'smart cities' where the use of new technologies could help to effectively address these barriers and solve challenges cities face (Bolívar & Meijer, 2016). Although this concept is increasingly being used both by practitioners and academia, it is still unclear and not used consistently within literature. In this context, technologies range from energy technologies (smart grids) to transport systems and traffic regulation systems. However, it must be noted that a recurring aspect and focus in the smart city literature is a specific type of technology, namely the use of ICTs (Lee, Phaal, & Lee, 2013; Odendaal, 2003; Walravens, 2012). ICTs can help city officials and other stakeholders to, for example, interact directly with citizens through the creation of an open data platform, monitor city infrastructure, and collect data, for instance, through the use of sensors integrated with real-time monitoring systems, or from citizens' mobile devices. It can help to provide new solutions to problems such as poverty, social deprivation, and poor environment; and have an essential role in improving environmental sustainability by decreasing greenhouse gas emissions and improving energy efficiency of cities through the use of, for example, automated energy grids and power management software (Ahvenniemi et al., 2017; Batty et al., 2012; Neirotti et al., 2014). To get a better overview, Meijer and Bolívar (2016) split the smart city concept into three elements: technology, human resources, and governance. They argue these elements are all interconnected influencing each other, and define that "the smartness of a city refers to its ability to attract human capital and to mobilize this human capital in collaborations between the various (organized and individual) actors through the use of information and communication technologies" (p. 398). In literature, common main objectives of smart city projects identified are sustainable development, economic growth, and better quality of life for citizens (Castelnovo et al., 2016).

The three elements as mentioned above are all of importance in a smart city. Meijer and Bolívar (2016) argue however that many papers have been giving attention to technology and in lesser extent human resources as the defining characteristics of a smart city. However not a lot of research has focused on the governance element of the smart city, while cities feel an increased need for better governance to manage smart city projects. It has become clear that the sole use of technologies is not sufficient to manage a smart city. An example is given by Nam and Pardo (2011) who emphasize the fact that 85% of IT public projects in cities failed mainly due to non-technical factors and a lack of governance such as organization, policy, and management. Generally, the current governance concept refers to "all processes of governing, whether undertaken by a

government, market or network, whether over a family, tribe, formal or informal organization or territory and whether through the laws, norms, power or language" (Bevir, 2012, p. 1). However, the use of ICTs, the increasing interactions between stakeholders, and many of the challenges faced by smart cities "surpass the capacities, capabilities, and reaches of their traditional institutions and their classical processes of governing, and therefore new and innovative forms of governance are needed to meet these challenges" (Bolívar, 2016a, p. 312). Walters (2011) stresses the need for governance that can address and redress the possible outcomes of ICT applications and use, and can lead smart city projects in the right direction (Walters, 2011).

In the context of a smart city, the new, innovative, and ICT-based form of governance has been conceptualized as smart city governance (Meijer, Gil-Garcia, & Bolívar, 2016). Smart city governance involves using ICTs, allowing city governments and other stakeholders to function more effectively and efficiently, addressing and redressing the possible outcomes of technologies, while actively involving and collaborating with all relevant stakeholders. It can help governments to design new governance instruments that enable an effective management of smart city projects, and of a city's complexity and the challenges it faces. Smart city governance is seen as an important factor in the development and the transition from a city, to a smart city (Belissent, 2011; Chourabi et al., 2012; Giffinger et al., 2007). ICTs can help cities to, for example, simplify and improve interaction between government and other stakeholders, or improve the internal administrative operations of government (Castelnovo et al., 2016), while organizational processes can help to lead smart city projects in the right direction through proper communication and collaboration. Additionally, Aylett (2015) argues that these organizational processes are becoming increasingly important in the governance of cities. He argues that a lack of resources, expertise, and knowledge in city governments causes them to have insufficient capacity to solve the complex challenges cities are facing, and they therefore need to collaborate and communicate with citizens and other stakeholders. Citizens can share their opinions and knowledge, and private companies can bring in developer expertise, financial power, and technology in city projects (EP, 2014). However, similarly to the smart city concept, research about the smart city governance concept is fragmented, which has resulted in an unclear concept with different approaches (Meijer & Bolívar, 2016). Moreover, besides positive effects, smart city governance can also bring unintended or perverse effects such as privacy issues or an unequal division of benefits between stakeholders (Meijer, 2016). Additionally, the smart city governance concept is a rather new theoretical concept that has barely been executed in practice. Therefore it is not clear whether smart city governance, as it is currently described in literature, is a suitable concept for governing the smart city in practice. A more in depth explanation of the smart city governance concept is given in chapter 2.

1.2 The Importance of Environmental Sustainability in Smart Cities

Although there are different objectives of smart city projects, literature shows sustainability plays an increasingly important part in smart cities, as there must be a balance between protection of the environment and growth measures for sustainable urban development (Chatfield & Reddick, 2016; Caragliu, Del Bo, & Nijkamp, 2011; Shahrokni, Lazarevic, & Brandt, 2015; Wey & Hsu, 2014). Sustainability is usually defined by taking into account economic, environmental, and social impacts simultaneously, although many academics, organizations, and governments have increasingly been focusing on the environmental impacts (Ahvenniemi et al., 2017; Aylett, 2015). Cities play a

significant role in the fight against climate change, as more than two-thirds of CO_2 emissions come from urban areas, and urban inhabitants consume over two-thirds of the world's energy (IEA 2008; IEA, 2013). Neirotti et al. (2014) found that using technology, and specifically ICTs, with the goal of increasing environmental sustainability is of major significance in smart city research. Several organizations have performed studies showing that the sole use of ICTs in tackling urban issues already has the potential to reduce CO_2 emissions and energy use by 5 to 17% (Bio Intelligence Service, 2008; GeSI, 2012). Many technologies and smart initiatives[1] in smart cities are related to mitigating CO_2 emissions and energy reduction such as smart energy grids or the implementation of efficient and intelligent street lighting.

There are, however, many challenges regarding how to govern these smart initiatives and to what extent smart city governance can help to contribute to environmental sustainability goals, as only a small amount of research has been done on this, and a clear formulation of the link between smart city governance and environmental sustainability goals is lacking (Bolívar & Meijer, 2016; Gollagher & Hartz-Karp, 2013; Gunningham, 2009; Kim, 2010). Gunningham (2009) gives an example of how smart city governance can have a positive effect on reaching environmental sustainability goals such as CO_2 mitigation and energy reduction. He argues that through collaboration of different actors, sustainability agendas can be created which can identify, address, and tackle environmental problems. Collaboration can also bring different groups of stakeholders together to successfully implement smart initiatives that otherwise could not be implemented due to a lack of knowledge, expertise, or financial resources. Through successful collaboration, a smart initiative such as a smart energy grid can be realized, which improves energy efficiency, and reduces CO_2 emissions. These examples stress the connection between smart city governance and environmental sustainability.

1.3 Research Objective

The concept of smart city governance has been considered the solution to successfully govern the smart city, however, it is still unclear if smart city governance can actually help cities to effectively address challenges, as the combination of ICT, and increasing importance of interaction between stakeholders provides a new playing field. The concept as currently described in literature is new and has not been tested empirically yet. Therefore it is important to test smart city governance empirically to determine what and to which extent smart city governance is currently present, what challenges exist, and to better understand what smart city governance could add to the governing of a smart city. Questions arise such as: What challenges in smart initiatives occur, that smart city governance could potentially solve? What role do different stakeholders play in smart city projects? Does every stakeholder have the same vision and goal?

In this research, a connection is being made to environmental sustainability. As has been mentioned before, environmental sustainability is currently being seen as one of the most important objectives of the smart city, however little research has been done on this aspect in relation to smart city governance. A specific focus is laid on CO_2 mitigation goals as this is a goal in the majority of smart initiatives and urban projects, it is linked with energy usage, and it is the primary greenhouse gas (GHG) contributing to climate change (EPA, 2017).

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[1] Smart initiatives are innovative initiatives that involve ICT in order to improve the urban environment in the smart city, and are often part of smart city projects (see also Appendix 8.1).

Additionally, it is important to include the perspective of stakeholders on the smart city governance concept. Besides government stakeholders, other stakeholders such as private companies and citizens are becoming increasingly involved in the governance of a smart city, and it is important to know their visions and the challenges they come across in practice. Understanding different perspectives, how individual stakeholders govern their initiatives, and addressing the issues and challenges can help to identify differences and form solutions in order to successfully reach their goals.

Summarized, this thesis has two objectives:
1. To develop a model that clearly describes the smart city governance concept.
2. To test this model in a practical application and lay the focus on one smart city governance outcome (CO_2 mitigation).

The research objectives are achieved by answering the following research question:

How can smart city governance contribute to CO_2 mitigation goals of smart city projects?

In order to help answer the research question, the following sub questions have been formulated:
1. How can smart city governance be conceptualized?
2. Which and to what extent are smart city governance elements present in smart city projects?
3. Which smart city governance challenges occur when smart city projects want to reach their CO_2 mitigation goals?

In the main research question, smart city governance is the independent variable that affects the dependent variable, CO_2 mitigation. Empirical research will be conducted in an effort to better understand how smart city governance can be best utilized within the scope of smart city initiatives. The elements and model as has been described by Bolívar and Meijer (2016) are used as a basis in this study since they give a representative and comprehensive overview of the smart city governance concept. Although this research is exploratory, in the sense that it will provide further information for research, it also gives stakeholders information and recommendations on how to efficiently manage smart initiatives.

1.4 Research Outline

First, the theoretical background of smart city governance is elaborated upon in chapter 2. The smart city governance elements are explained in detail, governance challenges are addressed, and the connection with environmental sustainability and CO_2 mitigation is made. Second, the methodology and research strategy are explained in chapter 3. In chapter 4, background information on the case study and smart initiatives selected is given, and the results of the empirical research are analyzed, followed by a comparison between the selected city projects. Finally, a conclusion is given, and the limitations of the research, the contributions to the scientific debate and practice, and future recommendations are made.

2. Theoretical Background and Research Framework

2.1 Introduction

Smart city governance literature is still relatively new with most literature dating from over the last couple of years. The concept is still not clear, and literature is still in the phase of trying to define the concept of smart city governance, while there is a need for more theoretical and empirical research to solve (new) governance issues in smart cities. This chapter covers the concept of smart city governance, and additionally explains the connection to environmental sustainability. The connection between smart city governance with environmental sustainability is only made in a few papers, although a concrete and clear explanation of this connection is lacking. The smart city concept is also briefly explained in order to get a better understanding of the smart city governance concept. Therefore, this chapter gives a theoretical background in 1) the smart city concept, 2) the smart city governance concept, 3) the connection between smart city governance and environmental sustainability, and 4) the challenges and issues of smart cities and smart city governance regarding environmental sustainability. These topics are discussed to give a clear and comprehensive overview of the currently existing literature.

2.2 The Smart City Concept

To understand smart city governance better, it is important to understand what role it plays in the smart city. It must be stressed that smart city governance cannot be seen as a separate element, as it is interconnected with other elements in the smart city. As has been mentioned before, the smart city consists of three elements: technology, human resources, and governance with the objectives of sustainable development, economic growth, and better quality of life for citizens (Castelnovo et al., 2016; Bolívar & Meijer, 2016). The three elements of the smart city concept mentioned are briefly discussed below:

Technology

For many academics and practitioners, the concept of the smart city is about how technology can contribute to improving the smart city and to effectively address its challenges (Meijer & Bolívar, 2016). Authors that take a technological approach to the smart city concept argue that ICT is central and is the starting point for rethinking issues in the city such as urban sustainability, the role of creative industries in urban growth, and the importance of social capital (Meijer & Bolívar, 2016). In this context, the smart city refers to an urban environment where digital systems can monitor, manage and strengthen the city. Technologies range from energy technologies (smart grids) to open data platforms and traffic regulation systems (Meijer & Bolívar, 2016). This ICT infrastructure is needed to collect and manage new data, perform analyses, and finally use connected devices to manage cities in a new manner. Data, and especially big data[2], are an outcome of this infrastructure, which requires new data analytical tools and instruments to convert these data into operational information (Batty et al., 2012). Several authors (e.g. Dirks, Keeling & Dencik, 2009; Washburn et al., 2010) also mention that ICTs are important to make the infrastructure and services of a city more intelligent, interconnected, and efficient. However, it should be mentioned that ICTs are just one of the different input resources for projects and approaches to urban planning, and that more ICT

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[2] Big data consists of massive, dynamic, varied, detailed, inter-related, low cost datasets that can be connected and utilized in diverse ways (Kitchin, 2014, p.3). These data sets are often so large or complex that traditional data processing software cannot process them.

systems and smart initiatives do not necessarily indicate better cities. Several researchers warn of an overly dominant role of ICTs where smart initiatives do not lead to a better urban environment, but make citizens feel observed and analyzed (Caragliu et al., 2011; Neirotti et al., 2014). It could however be said that the number of smart initiatives in a city reflects the effort of a city to improve the urban environment (Neirotti et al., 2014).

Human Resources

Hollands (2008) argues that focusing solely on ICT is not sufficient to make a city smart. Citizens in a city play a very important role regarding a city's development, and can help to overcome urban challenges. Different academics argue that knowledge exchange and innovation provided by citizens are a crucial element of the smart city concept (e.g. Papa, Gargiulo & Galderisi, 2013; De Wijs, Witte & Geertman, 2016). The knowledge economy, creativity of citizens, their engagement in the decision-making process, human capital, and cooperation among relevant stakeholders can generate 'smart solutions' that can improve the smart city (Kourtit, Nijkamp & Arribas, 2012; De Wijs et al., 2016; Nam & Pardo, 2011). Several authors stress the importance of smart citizens, as a city must have a smart workforce with a large share of the population having had higher education in order for urban growth (Nam & Pardo, 2011; Shapiro, 2006).

Governance

Governance plays an important role in the smart city as it can address and redress the possible outcomes of ICT applications and use, and can lead SC initiatives in the right direction (Walters, 2011). Governance can also enable (through the use of ICTs), collaboration, and participation of different stakeholders in the decision-making process and support transparency in governance (De Wijs et al., 2016). The governance element will be discussed in-depth in section 2.3 of this research.

Meijer and Bolívar (2016) argue that the above-described elements must be present when defining the smartness of a city. One of the most cited definitions of the smart city concept used over 1400 times and created by Caragliu et al. (2011), includes these three elements, and defines a city as 'smart' when "investments in human and social capital, and traditional (transport) and modern (ICT) communication infrastructure, fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (p. 70). This definition is often used in literature because it is comprehensive and in line with the thoughts expressed by many authors (e.g. Kourtit et al., 2013; Batty et al., 2012; Neirotti et al., 2014; De Wijs et al., 2016). Meijer and Bolívar (2016) argue however that this definition can qualify a city as 'stupid' or 'smart' and state that it is important to see smartness as a gradual concept. Therefore, they present their own definition of a smart city: "the smartness of a city refers to its ability to attract human capital and to mobilize this human capital in collaborations between the various (organized and individual) actors through the use of information and communication technologies" (p. 398). This definition clearly includes the interconnectedness of the three elements and is therefore used in the rest of this research.

2.3 The Smart City Governance Concept

Currently, a relatively little amount of literature has focused on smart city issues related to governance. Previous research has been mainly focused on the implementation of ICTs in order to improve smart city initiatives (Bolívar, 2016a). There have been many articles trying to define smart city governance in different ways, which has resulted in an unclear concept with many definitions. Therefore, in order to understand the complexity of this concept, a more detailed explanation of the smart city governance concept is given. Instead of giving one definition of smart city governance, a model of smart city governance of Bolívar and Meijer (2016) is used as a basis to generate a broad understanding of the concept (figure 1). This model explains the different stages in smart city governance and summarizes the most important factors of smart city governance according to current literature. The model consists of three parts, namely the strategies that are necessary to implement smart city governance, the smart governance arrangement including the defining elements, and the aspired outcomes of smart city governance. The implementation strategies can be seen as the independent variable affecting the dependent variable, namely the defining elements. This can result in different approaches to smart city governance in different cities. The defining elements can also be considered as the independent variable affecting the dependent variable which includes the different outcomes and impacts of smart city governance.

Noteworthy is that Bolívar and Meijer (2016) added the 'innovation capacity' element after their literature review. This element was often mentioned in smart city governance literature, but was not seen as a defining element. Due to the fact that it was often mentioned in interviews with practitioners, Bolívar and Meijer (2016) added the element.
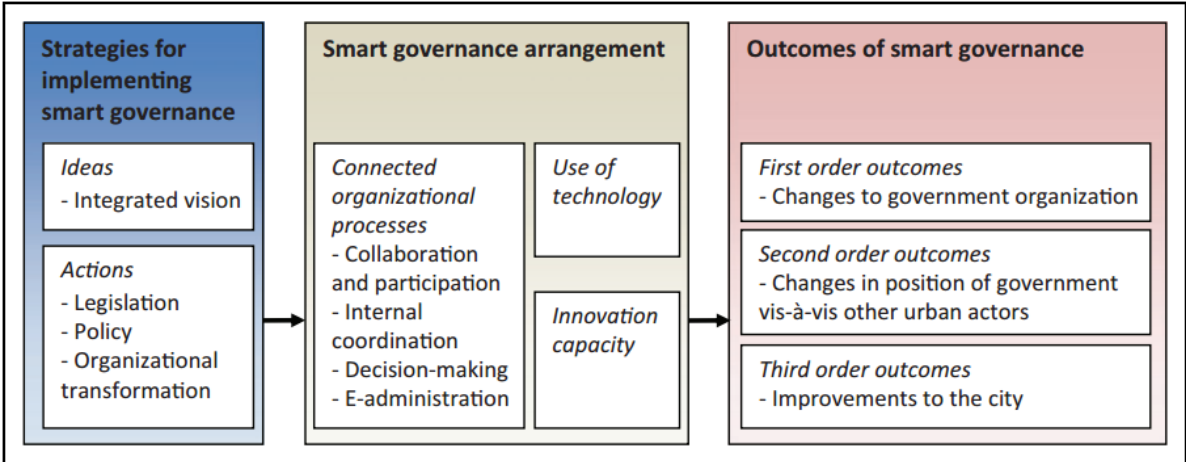
Figure 1: The Smart City Governance Model (Bolívar & Meijer, 2016).

2.3.1 Conceptual Model

The model of Bolívar and Meijer (2016) gives a proper basis for defining the smart city governance concept, however the model is indistinct about certain aspects, as they give for example no concrete explanations about the elements and the connection between the three parts. Therefore a new conceptual model has been made that includes several improvements to the model and is suited for this research (figure 2).
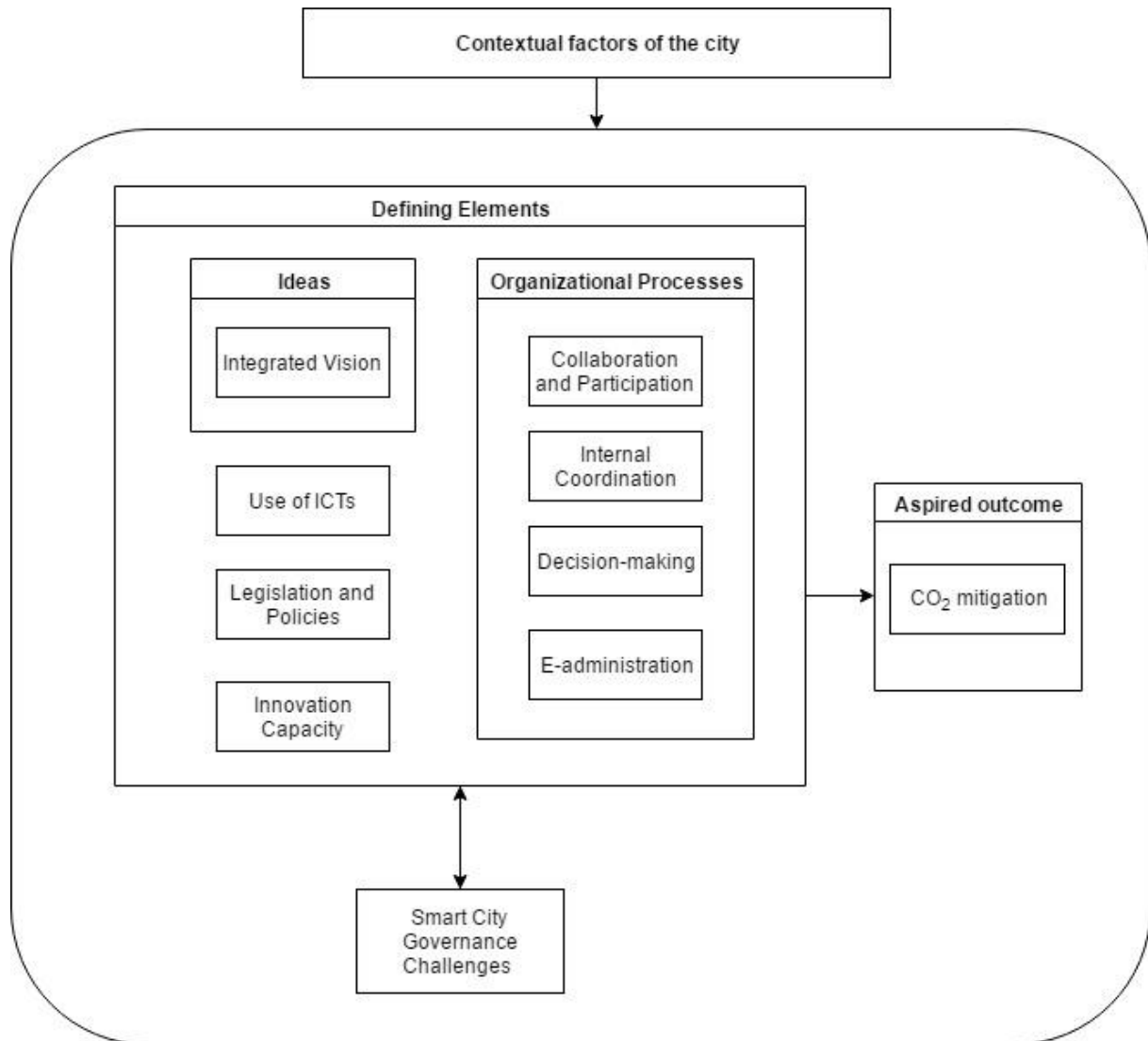
Figure 2: Adapted Smart City Governance model based on own findings.

It should be noted that in this conceptual model, only the CO_2 mitigation outcome is displayed, as this is the focus of this research. This element can be changed based on the specific goals of other research. Apart from this, several other changes have been made to improve the model of Bolívar and Meijer (2016):

- Bolívar and Meijer (2016) are inconsistent in explaining elements and naming them accordingly. For example, in the model they name the 'use of technology' element in the 'smart governance arrangement' category while smart city governance literature has shown that the specific use of ICTs is considered one of the main elements of the smart city governance concept. They also use different terms and definitions interchangeably, such as 'smart governance arrangement' in the model, while it is named 'defining elements' in the article itself. The 'defining elements' term has been chosen, as it visibly indicates that it contains the actual elements defining smart city governance. Additionally, the category 'actions' has been removed and the elements have been divided over the rest of the model. This category was removed as it was not clear what was understood by 'actions'. Bolívar and

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Meijer (2016) described this as the actions that are required to implement smart city governance, however they never described precisely how these actions are taken.

- The 'strategies for implementing smart city governance' category has been included in the defining elements part of the model as it is rather unclear what the relationship and difference is between the strategies and defining elements of smart city governance. Bolívar and Meijer (2016) state that "the smart governance configurations are the explanandum, and ideas and actions are proposed as explanations for the variation in Smart governance configurations" (p. 688). This explanation is rather vague and a concrete explanation is not given between the connection of strategies and defining elements. Moreover, there could also be other reasons for variations in smart governance configurations not described by Bolívar and Meijer (2016). The elements in the model all influence each other, and this cannot only be limited to the elements of policies, legislations, integrative vision, and organizational transformation. Besides this, contextual factors differ per city such as history, stakeholders, urban environment, government structure, and politics which can also affect the smart governance elements. It is difficult to name a limited amount of strategies that specifically influence other elements, because all elements are interconnected and can influence each other. However, literature research shows that the policies, legislations, and integrative vision are important in smart city governance, and they are therefore included as defining elements of smart city governance in the conceptual model (e.g. Bolívar & Meijer, 2016; Leydesdorff & Deakin, 2011, Batty et al., 2012; Nam and Pardo, 2011; Goh, 2015).

- Bolívar and Meijer (2016) state that the organizational transformation element was added "to stress the relevance of the actions that are needed to transform the organization toward forms of Smart governance" (p. 687). As this might be necessary, they have not explained this element in detail, how the organization has to be transformed, and they do not state what this element exactly entails. They argue that organizational transformation does not necessarily have to be a necessity for successful smart city governance as this depends on the different contexts per city. Due to this element being fuzzy and explained insufficiently, it has been removed. Besides this, the other elements already give a proper indication how an organization needs to be transformed.

- Besides improving and changing the inconsistencies and names in the model, two other elements have been added. The first one is the different contextual factors per city, as every city has different stakeholders, policies, legislations, culture, and an urban environment, which can influence the governance of a city. These differences can contribute to difficulties in implementing the same smart initiatives across different cities successfully. This can also influence the challenges and aspired outcomes of smart city governance. Subsequently, based on the literature study, the 'smart city governance challenges' element has been added as mapping challenges are of great importance for successful governance. The different elements create various challenges for smart city governance. Vice versa, it must be noted that most, if not all of these challenges affect or can be solved by smart city governance and are therefore mutually related. Different challenges such as privacy, financial or technical challenges can negatively influence the outcome when neglected or not solved. For example, when different stakeholders cannot agree financially, for instance when

creating a new business case to implement the initiative, the initiative can be cancelled resulting in no outcome at all. Finally, the element's legislation and policies have been added together due to their similarities and relationship with each other, which is further elaborated upon in the next section.

In this study it is argued that the defining elements influence the aspired outcome of CO_2 mitigation. Therefore it is hypothesized when all the elements and challenges as described in this model for smart city governance are present, accounted for and dealt with, this will result in the best possible mitigation of CO_2 emissions. However it is difficult to prove whether other external factors influence CO_2 emissions. Despite this, it is argued that this model is comprehensive and therefore its elements influence CO_2 mitigation the most.

Because of the inconsistencies and lack of information describing the elements in the model of Bolívar and Meijer (2016), each of the elements in this model will be elaborated upon through findings in literature. This will provide a structured and clear overview of the smart city governance literature. Subsequently, more information on the role and importance of stakeholders is given as Bolívar and Meijer (2016) do not elaborate on this factor in their model and article, while stakeholders are seen as a key factor in the governance of a smart city.

2.3.2 Defining Elements of Smart City Governance

Because it is important to know what the smart governance concept entails, first the defining elements are discussed. In total there are eight key elements of smart city governance based on Bolívar and Meijer's (2016) literature review. These elements are explained as briefly, and clearly as possible:

1) Integrated vision

An integrated vision is seen as a key factor to realizing a smart city. The integrated vision is the guiding idea that should always be taken into account in the other smart city governance elements. Different visions can conflict with each other; however modern cities must be able to combine multiple visions (Nam & Pardo, 2011). Smart city governance can help to coordinate the various components in a smart city. It has the ability to combine principles, factors, and capacities from various stakeholders, and can cope with the conditions and demands of a knowledge society (Willke, 2007). Nam and Pardo (2011) argue that, for example, an objective to increase accessibility of transportation and an objective to improve air quality contradict each other but through an integrated vision, policies can be made that addresses both objectives. Additionally, visions must have a long-term strategy where an analysis of a city's context and metabolism must be made to see whether strategies match the needs of the city to avoid unnecessary development of, for example ICTs (Goh, 2015; Nam & Pardo, 2011; Shelton, Zook & Wiig, 2015).

2) The use of ICTs

Many authors define ICTs as one of the main elements of smart city governance. Batty et al. (2012) argue that one of the first main shifts of smart cities is the development and implementation of information infrastructure that can help to improve the smart city. City governments have to start transformation projects of city services that have to accomplish policy goals and organizational goals (Walravens, 2012, p. 125). ICTs can play an important role in developing policies by collecting

information from for example, sensors or smart grids. This information can help to gain a better view of situations in which policies can be changed or new policies can be developed. ICT can also help to, for example, let more citizens participate in the decision-making process of a city, and let their voice be heard through online surveys or platforms. Meijer (2016) argues however that "the overall objective of smart city governance is not to make use of new technologies but to contribute to the objective and subjective quality of the urban environment through new technologies" (p. 73). ICTs can help cities to, simplify and improve interaction between government and other stakeholders, improve the internal administrative operations of government, and can be used to improve the quality, efficiency, and interactivity of urban services (Castelnovo et al., 2016). ICT systems can help to gather and spread data and information more easily and allows obtaining data that would otherwise not be accessible. Gathered data and information can be used for the creation of policies, legislation, to improve the urban environment, or for management of different policy areas. In addition, ICTs can bring together a wide variety of urban actors to create more distributed intelligence (Meijer, 2016). Examples are ICT systems such as open data platforms that can make data exchange and interaction between stakeholders easier while other ICT systems such as traffic monitoring systems with cameras and sensors can provide city governments with detailed information about traffic streams and congestion, which can be used for traffic management (Hoh et al., 2008). It should be noted however that literature generally forgets to mention the negative side of ICT such as privacy violation and digital divide, long-term effects, or hidden costs while this can have a significant impact on the governance of a city (Castelnovo et al., 2016).

3) Legislation and Policies
Once more, the legislation and policy elements have been added together due to their similarities and relationship with each other. To be clear, policies are a course of action that the government or an organization plans to take, however it is not ensured that a policy is successfully followed or implemented. Legislations are laws that are enforceable and must be voted on in order to pass (Difference Between, 2017). Policies are often developed to make sure that the organization or government is following the law therefore they are often related.

Legislation
ICT is central in smart cities, but so are increasingly important issues of responsibility, openness, transparency, access to public data, privacy, and regulations of extra national government agencies. New frameworks are necessary for governance that takes into account the extensive access to information that citizens nowadays have. Legislation plays a key role in this and in how stakeholders can influence the governance of their cities (Batty et al., 2012).

Policies
Policies are seen as a key factor in the implementation of smart city governance. The city government should promote policies that are focused towards improving innovation systems, cultural development, and the urban environment (Bolívar & Meijer, 2016; Leydesdorff & Deakin, 2011). This can be done by collaborating with the relevant stakeholders in the city. Nam and Pardo (2011) stress that policies in smart cities must be integrated as for example policies within and between different levels of government may be badly coordinated, fragmented, overlapping, or conflicting, and therefore produce unhelpful outcomes.

4) Innovation capacity

Innovation capacity can best be described by the potential to keep innovating. Bolívar and Meijer (2016) added this element due to it often being mentioned by practitioners. It is however also an important part in smart city governance literature. There is sometimes not enough capacity for stakeholders to innovate. This could be due to a lack of knowledge and expertise, finances, or hindering regulations. This can partly be solved by collaboration between different stakeholders. With collaboration, knowledge and expertise can be exchanged between different stakeholders in order to keep innovating. Innovation is important in order to keep developing better initiatives and help city governments to meet challenges of urban governance and to improve urban environments (Meijer, 2016).

Different authors use the term 'Innovation Ecosystems' to describe the collective intelligence and co-creation abilities of different stakeholders to improve the urban environment (e.g. Paskaleva, 2011; Schaffers et al., 2011; Zygiaris, 2013). Schaffers et al. (2011) argue that partnerships and clear cooperation strategies between the key stakeholders of a city project are needed to be able to share research and innovation resources such as technologies, methodologies, and knowledge. Zygiaris (2013) argues that cities have urban innovation ecosystems that have a 'green', 'smart', 'open', 'intelligent', and 'innovating' character, aiming towards environmental and social sustainability. Innovation strategists could work together with urban leaders resulting in new businesses opportunities that safeguard a long-term viability of smart city projects. Business models must be clear to each stakeholder and include the involved participants, the functions performed by each participant, the funding and ownership provisions, technology and service assumptions, the main business terms between participants, and which pricing strategies will be used. This way, new alliances or partnerships can be made when city projects are successful and long-term innovation can be ensured. This is especially important in smart city projects where many ICT solutions such as de-carbonization of energy systems require essential and continuous innovation (Zygiaris, 2013).

5) Collaboration and participation

The participation and collaboration between different public and private actors helps to manage relations and make use of their intelligence and knowledge. The increasing collaboration between stakeholders plays an important role in this and has been deemed important for a long time in urban governance (Freeman, 1997; Huxham, Vangen, Huxham & Eden, 2000). Networks and communities can strengthen the intelligence of a city significantly (Meijer, 2016). Citizens can share their opinions and knowledge, and private companies can bring in developer expertise, financial power, and technology in smart city projects (EP, 2014). Therefore, many authors stress the importance of collaboration and participation in smart city governance. For example Chourabi et al. (2012) state smart city governance primarily focuses on enabling participation and collaboration of those involved in the decision-making process (through the use of ICT), which helps stakeholders to achieve a collective goal. Subsequently, Meijer & Bolívar (2016) state smart city governance is about the "crafting of new forms of human collaboration through the use of ICT to obtain better outcomes and more open governance processes" (p. 392). Finally, Kourtit et al. (2012) argue that smart city governance calls for 'pro-active and open-minded governance structures, with all actors involved, in order to maximize the socio-economic and ecological performance of cities, and to cope with negative externalities and historically grown path dependencies' (p. 232).

Several authors mention the concept of 'collaborative governance' as a key factor specifically towards successful smart city governance. As described by Castelnovo et al. (2016), "collaborative governance involves a transformation of governance, but only as regards how governance is exerted, that is, through collective decision-making processes that include both public and private actors and that, in the case of smart cities, are enabled by ICTs" (p. 730). They argue that in the smart city governance context, this includes the definition and implementation of policies, sharing visions and strategies with relevant stakeholders, management of the implementation of smart initiatives, management of city infrastructures, including ICT infrastructures and systems, management of resources necessary for the development of smart cities, management of human assets and of other immaterial capitals (social, relational, intellectual capital, innovation, knowledge and information) (Castelnovo et al., 2016). Additionally, Bartenberger and Grubmuller-Regent (2014) for example highlight more participative and collaborative forms of governance as important elements of smart cities. They found that a specific ICT implementation, namely an open data platform, affects elements of collaborative governance such as decision-making processes, knowledge asymmetries, and trust-building in a positive way. Bolívar and Meijer (2016) found that urban practitioners with an interest in smart city governance, found collaboration the most important factor that was needed for a successful implementation of smart city governance (Bolívar & Meijer, 2016). Additionally, successful collaboration is considered more important in smart governance than in 'traditional' governance, as it is essential to interact with stakeholders and obtain more open governance processes and better outcomes in service provision and delivery (Nam & Pardo, 2011; Meijer & Bolívar, 2016). Collaboration in smart governance is a key factor towards successful smart city governance because successful collaboration can result in partnerships, collective decision-making, efficient communication and data exchange between stakeholders (Chourabi et al., 2016). For example businesses can be involved in public service delivery through the establishment of public-private partnerships to optimize the limited resources city governments have. Subsequently, the increased importance and involvement of non-state actors in smart cities asks for successful collaboration and interaction among urban stakeholders to create an interactive-, participatory- and information-based urban environment with the goal to achieve wealth and public value, and a higher quality of life for citizens (Bolívar, 2015).

6) Internal coordination

Governments are always trying to become more efficient and better-coordinated organizations in order to improve the city. ICT has a significant impact on the administration and organization of different government agencies (Gil-Garcia, 2012). The development of information infrastructure requires coordination so that services can be distributed as effectively as possible (Batty et al., 2012). The increasing complexity and amount of challenges in urban environments and the different components that comprise a smart city requires coordination within organizations and government agencies (Gil-Garcia, 2012). Gil-Garcia (2012) argues that internally coordinated governments and other organizations can lead to a more integrated city where different stakeholders can more effectively collaborate through the use of ICT to achieve collective goals. This is also stated by Willke (2007) who conceptualizes governance as ''the activity of coordinating communications in order to achieve collective goals through collaboration'' (p. 10).

7) Decision-making process

The decision-making process in smart city governance plays an important role as an increased amount of stakeholders participate in the urban development of a city. The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP; 2007) defined governance as "the process of decision-making and the process by which decisions are implemented (or not implemented)" (p. 1). Giffinger et al. (2007) argue that participation of different stakeholders in the decision-making process helps to make decisions that are ultimately most beneficial for the urban environment. Smart city governance engages different stakeholders in the decision-making process in order to make the best decisions. ICT can play an important role in the decision-making process, as there is more complete, readily available, and accessible information for the government to use in decision-making processes (Schuurman, Baccarne, De Marez, & Mechant, 2012). Barrionuevo, Berrone, and Ricart (2012) state that in order to take all key factors into account in smart governance systems, the decision-making process must consist of a three-step process. First, the situation must be diagnosed, then a strategic plan must be developed, and finally action must be taken. This must be transparent, and stakeholders must be able to engage in the process in order to gain the best outcomes.

8) E-administration

Theoretical studies argue that the classic hierarchical model of public administration does not work anymore, and a more collaborative, horizontal, integrative, and innovative approach must be taken in order to successfully govern a city (Bolívar, 2015). E-administration uses ICTs to interconnect and integrate information, processes, institutions, and physical infrastructure in order to improve the urban environment. Administrations need to be innovative in order to cope with the requirements of different policies and in order to improve productivity and performance (Meijer & Bolívar, 2016). Transparency and accountability play an important role here. Different authors argue for example that accountability of smart city projects should always be given to public administrations while they should be transparent in what they are doing (Bolívar, 2016b).

As can be seen, the smart city governance concept in literature mostly focuses on the organizational processes (collaboration and participation, internal coordination, decision-making process, e-administration) instead of laying a focus on laws, administrative rules and judicial rulings as is done in 'traditional' governance. These organizational processes are enabled by ICTs to produce smart outcomes. The next section briefly elaborates on these smart outcomes. To give an overview of the main differences of the smart city and smart city governance concepts, table 1 summarizes the elements of both concepts based on the model of Bolívar and Meijer (2016) and own findings.

Table 1 : Smart City and Smart City Governance Elements.

Smart City Elements	Smart City Governance Defining Elements
• Technology • Human Resources • Governance	• Integrated vision • Use of ICTs • Legislation and Policies • Innovation Capacity • Collaboration and Participation • Internal Coordination • Decision-making process • E-administration

2.3.3 Aspired Outcomes of Smart City Governance

Outcomes in smart city governance can vary per city and initiative. Different stakeholders have different aims in what they aspire to achieve. Bolívar and Meijer (2016) argue that there are generally nine different smart outcomes discussed in literature, which can be grouped in three outcome orders (table 2). It must be noted that in this study, the focus is solely laid on the outcome of CO_2 mitigation, which is a part of the ecological performance outcome. Nonetheless, the other aspired outcomes are also briefly taken into account as most of them can also affect the CO_2 mitigation outcome, while giving a complete overview of what aspired outcomes different stakeholders can have. All the different outcomes are briefly explained in Appendix 8.2. The ecological performance outcome is elaborated upon in section 2.4.

Table 2: Aspired Outcomes of Smart City Governance.

Category	Outcomes
First-order outcomes (changes to the government)	• Efficient government • Readiness for disaster management
Second-order outcomes (changes in the position of government related to other urban actors)	• Improve citizen-centric services • Interact with the public • City branding
Third-order outcomes (improvements to the city)	• Improve economic growth performance • Social inclusion • Improve ecological performance • Boost the amount of highly educated citizens

2.3.4 The Role of City Government and Other Stakeholders

The defining elements and aspired outcomes were briefly discussed in order to give a clear overview of the smart city governance concept in literature. As could be seen, many factors are interconnected and related to each other, which makes it difficult to split them up in different categories. Also, the amount of elements and outcomes is high which makes it impossible for this research to go in-depth in to all of them.

Many of the previously discussed elements and aspired outcomes come back when discussing the role of city government and other stakeholders. However the role of city government and other stakeholders is barely discussed in regards to establishing smart city governance, although the changing roles of city government and other stakeholders are becoming increasingly important as they can significantly influence the governance of a smart city. Local governments are up to a challenging task as they are expected to collaborate and work more with other stakeholders in networks in which they have less authority and resources, but are still held liable for performances and better outcomes (Span, Luijkx, Schalk & Schols, 2012). The way a city is managed plays a key role here for effective governance (Provan & Kenis, 2008). Citizens can share their opinions and knowledge, and private companies can bring in developer expertise, financial power, and technology in smart city projects (EP, 2014).

There are currently different approaches of governing styles described in literature to the concept of smart city governance, with different roles for local governments and other stakeholders. The two most important approaches which are often used interchangeably in literature and practice, are

'governing the smart city' and 'smart urban governance'. Governing the smart city, follows the approach of institutional conservation, which suggests there is no transformation of governmental structures and processes (Meijer & Bolívar, 2016). Here, governance involves deciding which policy choices are right, and implementing these effectively and efficiently. Batty et al. (2012) argue that in this case, smart governance is basically the governance of a city that promotes itself as smart. In contrast, smart urban governance follows the approach of institutional transformation, which suggests a change of governmental structures and processes (Meijer & Bolívar, 2016). This transformation is not only about the internal organization, but also about the external organization. Batagan (2011) for example argues that 'smart governance means collaborating across departments and with communities, helping to promote economic growth and at the most important level making operations and services truly citizen-centric' (p. 85). Meijer and Bolívar (2016) argue that for an analysis of smart city governance, the level of transformation should be analyzed and then should be related to the success of a smart city. In this way, the impact of the different approaches can be analyzed and compared to show how effective they are as a higher level of transformation does not automatically have to lead to a more effective governance of a smart city (Meijer & Bolívar, 2016). Every city is different with a different organizational structure, different stakeholders, and different challenges and interests, and therefore different approaches might be suitable for each city. The role of the local government seems to be essential in this changing governance process. It can intervene in smart city governance in three ways, by playing 1) the role of coordinator, where local government can bring different interests and stakeholders together in order to form new platforms for collaboration; 2) the role of funder, where local government funds projects and infrastructure; or 3) the role of regulator, where it ensures that stakeholders comply to regulations and standards (Bolívar, 2015). These rolls fit in the different governance models that governments adopt, ranging from adopting a self-governance model where the city is governed by stakeholders that comprise the network, and where the local governments are rather passive than active agents, to a bureaucratic model where local governments lead organizations, manage and monitor the development of the smart city and act as a highly centralized network broker, and where stakeholders have a passive role in smart cities (Bolívar, 2015).

No matter what role or approach a city is taking in smart city governance, it must be recognized that local governments no longer have the capacity to solve the complex challenges cities are facing and therefore need help from citizens and other stakeholders. Governments of smart cities have to cope with complexity and uncertainty, and therefore have to build competencies and attain resilience (Scholl & Scholl, 2014). Bolívar (2016a) argues that governments should keep three things in mind in order to successfully realize smart city projects. First, they need to use the capability of internet-based technologies to better understand the smart society. Second, they need to collaborate with other stakeholders in terms of contracting. Third, leaders of governmental organizations can no longer deny that digital technologies are now the basis of an extensive range of their activities and therefore have to adjust policymaking processes and innovation. It is important for successful implementation of smart city projects that they have knowledge and show commitment to smart cities (Bolívar, 2016a).

Private stakeholders

As has been mentioned previously, private companies are vital to smart city development as they can bring in developer expertise, financial power, and technology in smart city projects (EP, 2014). Examples of private stakeholders that are involved in smart city projects are ICT companies, energy or grid companies, and consultancy companies. Several authors argue that public-private partnerships have to be created in order to form a stable basis for collaboration (e.g. Chourabi et al., 2016, Nam & Pardo, 2011). Although private stakeholders often only participate when they can make financial profits, they still are of added value when improving the urban environment. Public-private partnerships can help to make agreements between the public and private sector where both sectors can profit. Schaffers et al. (2011) even argue that public-private partnerships may evolve towards a '4P' (Public-Private-People-Partnership) ecosystem due to the importance of citizens in smart cities. This increased involvement and importance of citizens is explained in the next section.

The involvement and importance of citizens

Citizens' engagement is a key factor in smart city governance; despite this, studies about the involvement of people and communities have not been given much attention in current smart city literature (Castelnovo et al., 2015). It is sometimes forgotten how valuable the social infrastructure, such as intellectual and social capital, can be to smart cities (Albino, Berardi & Dangelico, 2015). Creativity and social innovation can be viewed as important drivers of the smart city, and therefore people, education, learning, and knowledge are of vital significance in smart cities (Nam & Pardo, 2011). Castelnovo et al. (2015) describe citizens as smart people who are characterized as a major asset for smart cities and are an important resource that smart city initiatives can depend on to make cities smarter. Smart, educated and informed people can participate and engage with smart city projects in a way they can affect the success of these projects. They can realize this by utilizing available (smart) services, and by participating in the governance and management of the city (Chourabi et al., 2012). They can for example share information about transport or personal energy use which can help local governments to make better decisions based on current situations and actual needs (Smart City Strategy, 2017). Academics and practitioners argue that the current demands around public decision-making and new forms of public participation are important aspects in many smart city governance studies (Meijer & Bolívar, 2016; Chourabi et al., 2012; Castelnovo et al., 2015; Caragliu et al., 2011). Mulligan (2013) stresses that a smart city cannot develop without asking citizens' opinions, and should engage citizens in the process of deciding how these opinions are used.

Current governance structures in most cities and states involve little involvement of citizens in decision-making. Some governments engage citizens to participate in policy decisions however this is suggested and indicated with a typical top-down decision-making process approach (Castelnovo et al., 2016). By giving the citizen a central role in the decision-making process, they can design, adopt, and evaluate city policies and services (Savoldelli, Misuraca & Codagnone, 2014). If a service is capable enough to provide public value and transparency and accountability for the decision-making process, and when citizens and other urban stakeholders are engaged in this process, this can bring positive perceptions of citizens which can lead to an increase of citizens' trust in policy makers and public administration. This can have a positive influence on the adoption of a city's services (Castelnovo et al., 2016).

In a smart city, public services could first be developed by the city government, after which then citizens are engaged, online as well as off-line, to collect their perspectives, criticisms, and suggestions to enhance the services. ICTs, and particularly social media play an important role in broadening the number of participants in the public debate, and allow people to participate in the development of public services, who are usually not willing to, or able to participate in these debates (Castelnovo et al., 2016). This helps policy makers to make choices and policies that fulfill the needs of the population better, and allows them to be aware of the problems that citizens face every day.

2.4 Smart City Governance and Environmental Sustainability

There is currently only a small amount of literature that covers the relationship of CO_2 mitigation and smart city governance. However during the writing of this thesis, the author found more studies being released describing this relationship, which shows the upcoming attention researchers give to the subject (e.g. Giest, 2017; Ahvenniemi et al., 2017; Chatfield & Reddick, 2016; Ringenson & Höjer, 2016).

Cities play a very important role in the fight against climate change and smart city governance is seen as a key factor in decreasing CO_2 emissions and improving energy efficiency of cities (Ahvenniemi et al., 2017). Dameri and Benevolo (2016) argue that an important focus of a smart city is to aim at reducing a city's environmental footprint to create a better quality of life for citizens. Ahvenniemi et al., (2017) even argue that a city is not 'smart' when it, despite ICT implementation, does not have the objective to be sustainable. The smart city concept as viewed by the European Union (EU; 2011) also supports the importance of environmental sustainability as it sees it as one of its foremost goals to reduce greenhouse gas emissions in urban areas through the deployment of innovative technologies and supporting smart initiatives (Ahvenniemi et al., 2017; Albino et al., 2015). Neirotti et al. (2014) argue that it is important for cities to implement environmentally friendly policies as it represents a vital basis for urban living quality. These policies would not only impact environmental sustainability targets, but also influence social and economic factors such as citizen's wellbeing and financial sustainability. They argue that because of this, the availability of green spaces is an important dimension of smartness.

An example to reduce CO_2 emissions and energy use in a smart city is through the use of ICT systems that can enhance logistics and transportation by gaining information about traffic conditions and energy consumption (Neirotti et al., 2014). Users can use this information to save time and improve commuting efficiency, save costs, and reduce CO_2 emissions. Besides this, transport managers and users can communicate with each other in a network to give each other feedback, which leads to an improvement of services and a higher environmental efficiency (EP, 2014). The latter exemplifies that successful collaboration between actors can play a vital role in reaching a smart city's goals regarding environmental sustainability (Gunningham, 2009; Kim, 2010). The importance of stakeholders also comes back in environmental sustainability decision outcomes. Newig and Fritsch (2009) found that environmental sustainability preferences of various stakeholders determine the environmental sustainability decision outcomes. Additionally, Calder and Beckie (2011) found that citizen engagement is vital in order to develop a shared vision and plan for developing more environmentally sustainable communities.

Höjer and Wangel (2015) propose the concept of the smart sustainable city to stress the importance of the sustainability factor in smart cities. They define a smart sustainable city as a city that "meets the needs of its present inhabitants without compromising the ability for other people or future generations to meet their needs, and thus, does not exceed local or planetary environmental limitations, and where this is supported by ICT" (p.342). They stress the importance of ICT, collaboration between stakeholders, and also the role of a coordinating body. They argue however, that ICT in the future can have the same role as infrastructure development in the past, where it can deliver improvements in wellbeing and health, but also possibly ruin ecosystems and exploit natural resources. An example is using ICT to increase traffic flows in cities. Measures can be implemented in order to make travelling easier which can result in more travelling which can cause negative environmental impacts. It is therefore important that counter-measures need to be taken or improvements in traffic may be paired with other measures (Höjer & Wangel, 2015). An integrated vision plays an important role in this to prevent such situations.

Another critical note is given by Higón, Gholami and Shirazi (2017) who state that in theory, besides expecting ICTs to reduce CO_2 emissions, ICTs are also among the sources contributing to the increasing levels of CO_2 emissions in terms of energy consumption, and producing and disposing ICT devices and machinery. They argue that the CO_2 emissions per capita are expected to increase as ICT development continues, while at more advanced stages of ICT development, CO_2 emissions can decline. They found that ICTs in developed countries are already advanced enough at which CO_2 emissions decrease as the level of ICT development improves further, whereas in developing countries this is not the case (Higón et al., 2017). Findings such as these are important to take into account in order to stay critical when analyzing environmental sustainability in smart cities and to avoid only giving attention to the positive outcomes of smart cities, but also making sure to address the negative outcomes.

Currently, most smart initiatives in urban projects are still implemented on a smaller scale. Lafferty (2006) argues that there is a difference between eco-efficiency and eco-effectiveness in this case. Stakeholders are willing to pursue and become eco-efficient in an isolated process, project or product characteristic, while this does not always lead to eco-effectiveness on a larger scale resulting in a limited impact on the environment. This is especially important for smaller scale projects or smart initiatives that might be successful in an isolated environment, however when up scaled, they are not as effective anymore. It is therefore important to look at the possibilities to implement smart initiatives in such a way that they can be up scaled. This can help to create a positive impact on the environment on a large scale.

Cities can also be pushed by national or international agreements or regulations to decrease their CO_2 emissions, which is the case in Europe. Climate targets set by the EU are pressuring European cities and countries. The EU has set several goals regarding environmental sustainability for cities such as climate and energy targets in 2020, 2030 and their ultimate aim to reduce greenhouse gas emissions by 80-95% in 2050 compared to 1990 (EC, 2017a; EC, 2017b; EC, 2017c).

The promotion of smart initiatives is one of the focuses of the EU as they can help to solve urban issues and reach these environmental goals. Europe can be seen as a frontrunner of smart city developments in the world with approximately 240 verifiable smart cities with an increasing amount

of smart initiatives. It must be noted however that most of these smart initiatives are currently in the starting phase of their projects (Albino et al., 2015; EP, 2014). In order for cities to reach these targets, and help cities' development, the European Commission (EC) invests in European cities through for example their research and innovation program Horizon2020. More specifically for smart cities, the EC launched the Smart Cities and Communities (SCC) European Innovation Partnership (EIP) in 2012 which combines ICT, energy management, and transport management and aims to improve citizens' quality of life, increase competitiveness of Europe's industry and innovative small and medium enterprises (SMEs), and contributes to sustainability and the EU's 20/20/20 climate and energy targets (EC, 2013). This is being achieved by implementing integrated, scalable, and sustainable smart city solutions, specifically in areas where energy production, distribution and use; mobility and transport; and ICTs are intimately linked (EC, 2013). Governing this is perceived as a great challenge due to economic pressures, social opportunities, and technological advancements. This requires adoption of new business models, more collaboration, and acceptance of joint operations and risks (EC, 2013). The most notable challenges are discussed in the next section.

2.5 Smart City Governance Challenges

The current concept of smart city governance in literature is described as a solution to many of the problems that occur in governance of smart city projects. However, it should be stressed that the implementation and management of these types of ICT solutions also can bring unintended or perverse effects such as privacy issues or an unequal division of benefits between stakeholders (Meijer, 2016). It is important to have a brief understanding of what these issues and challenges are. Therefore several issues and challenges identified in literature are briefly discussed in this section.

One of the first major challenges with the increasing implementation of new technologies is privacy. Privacy can be an issue for citizens while implementing smart city initiatives. Because of the nature of smart cities, citizens are often required to give sensitive data in order to reap the benefits of a smart system. This can become problematic, as data leakage or misuse can cause large problems for consumers and companies alike (Li, Dai, Ming, & Qiu, 2016). Another issue during smart city projects can be the collaboration between private actors and city government due to different goals. Private actors are concerned mostly with making a profit; city governments, however, must also think about improving the urban environment, and citizen wellbeing, while taking into account the city's finances.

Angelidou (2015) argues that many cities do not include smart city projects in their long-term comprehensive development plans and therefore do not pursue methodical strategic planning. This can have negative consequences in the long-term as smart initiatives might be unnecessary or inefficient in the future. Additionally, Shelton et al. (2015) argue that researchers and practitioners emphasize the minimal effect smart initiatives have to prove their effectiveness. Therefore, it looks like researchers and practitioners are only focused on this aspect while overall it might not be an effective initiative. There is currently no measurement framework for analyzing the impact of smart initiatives, as it difficult to evaluate the benefits or the public value produced by an integrated smart initiative. This is often a major barrier to implement smart initiatives as public and private stakeholders often need to justify the large amount of expenses in smart initiatives (Dameri & Rosenthal-Sabroux, 2014).

Meijer (2015) argues there are several government barriers that are of importance in smart city governance. Barriers such as legal issues, technical, financial, and personnel capacity, and lack of leadership, coordination, and political supports can affect how efficiently governments can operate. Additionally, some local councilors can give resistance to smart initiatives, as they want to stay within traditional boundaries of governance. They can for example question whether citizens can play an important role in the governance of a city, as this is traditionally the task of the local councilor. They will have to rethink their role from a top-down approach, to an approach where they have to collaborate and negotiate with various stakeholders (Inayatullah, 2011).

One of the aspired outcomes of smart city governance is mitigating social inequalities through citizen empowerment and participation, resulting in social inclusion. However, there is a risk that would increase inequalities further when not supported by inclusive strategies and interventions that tackle the digital divide (Zygiaris, 2013; Angelidou, 2015). This digital divide stresses the issue of unequal access and use of ICTs. Measurements or interventions have to increase the accessibility of ICTs in order to reduce socio-economic advantages through for example providing citizens with free broadband access through public access points. Additionally, investing in programs that can educate low-skilled, elderly, or disadvantaged people in ICT use can help to reduce this digital divide (Nam & Pardo, 2011; Wiig, 2015). Another barrier involving citizens is the image citizens have of government. If citizens of a government do not trust or are not satisfied with the government, they might not be willing to interact through digital means (Meijer, 2015).

There are more challenges and issues to be discussed, although these were deemed the most important based on literature. More challenges will come forward in the empirical research of this study.

3. Methodology

3.1 Introduction

This research has two objectives: 1) To develop a model that clearly describes the smart city governance concept, by analyzing scientific literature, and 2) To test this model in a practical application and lay the focus on one smart city governance outcome (CO_2 mitigation). The previous chapter discussed the relevant research concepts and elements. This chapter describes how the model is being applied in practice.

In order to determine what (if any) aspects of smart city governance are present, to better understand the perspectives of stakeholders, and to understand the influence smart city governance can have on CO_2 mitigation, research will be conducted which utilizes projects in different cities with multiple initiatives and stakeholders. Because there is little information about the practice of smart city governance, using an approach which allows for an in-depth picture into the current workings of a real-life smart city project is key to understanding what is already working, what needs to change, and how different stakeholders can, and do, work together in order to achieve their goals. This in-depth picture is achieved by collecting data from different smart initiatives and stakeholders in different smart city projects. For example, based on the presence of the elements, suggestions can immediately be made depending on where elements are present or lacking which can explain the issues or challenges stakeholders are experiencing.

As this research is characterized by intensive, qualitative data generation, an in-depth focus on a small domain consisting of a small number of research units, the embedded multiple case study method is considered most appropriate for this research (Verschuren & Doorewaard, 2010). Yin (2013) states that embedded designs include multiple units of analysis on different levels and looks for consistent patterns of evidence across units. Verschuren & Doorewaard (2010) argue that embedded case studies exist of research units, and observation units or data sources. In this case, the smart city projects of the cities are the research units, and the smart initiatives that are part of these projects are the observation units or data sources (figure 3) (Verschuren & Doorewaard, 2010). Qualitative research is considered necessary to gain in-depth information from the smart initiatives and relevant stakeholders, which will be analyzed, compared and interpreted. Additionally, a quantitative research approach is used in order to create additional criteria in order to research whether smart city governance elements are present in the smart city projects. Consequently, conclusions can be drawn for the smart city projects as a whole (Verschuren & Doorewaard, 2010). After finding these conclusions per city, the main findings can be compared between the different cities to see if there are differences of smart city governance and the perspective of stakeholders in multiple cities. By studying and comparing with other cities, the external validity of the research is strengthened as more data is collected and the results of the study are more generalizable. Multiple cases of the smart city governance concept can corroborate, qualify, or extend the results than were there to be only one case. The in-depth focus of this research is what is currently unique, as little to no research has been done that focuses on such an in-depth level surrounding this topic, as can be concluded after carefully studying the current literature.

This chapter consists of the case selection process and case selected, the data collection methods used, the operationalization of variables and the methods used to analyze the data and results. Finally, the causality, validity, and reliability of the methods chosen are discussed.

Figure 3: Visualization of the embedded multiple case study method in this research.
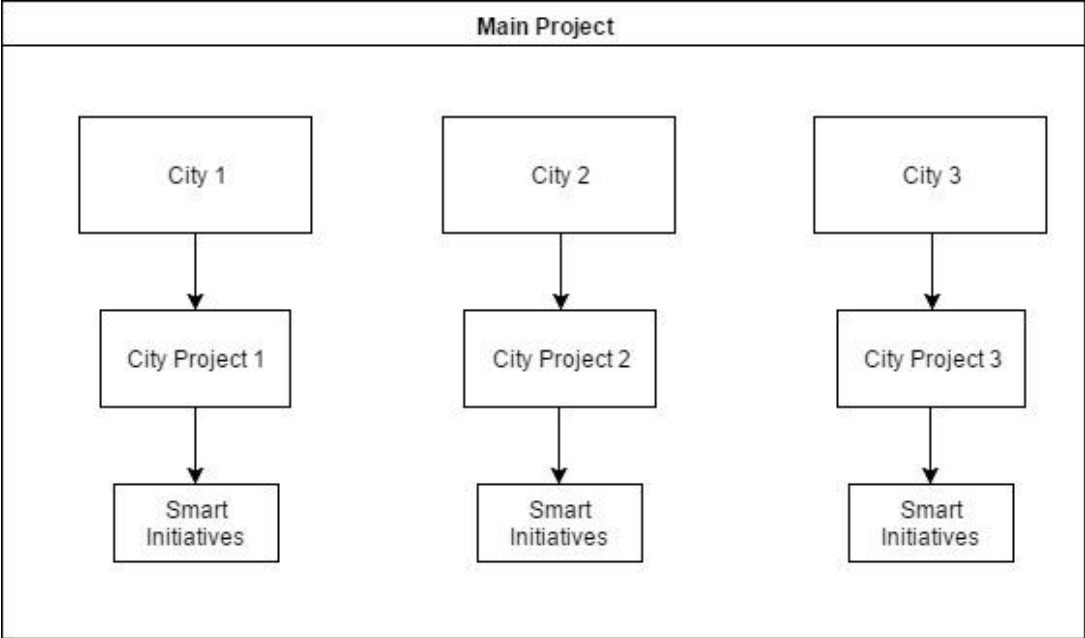
3.2 Cases Selection Process and Selected Cases

3.2.1. A Focus on Europe

The EU has initiated many smart initiatives and is one of the frontrunners in smart city development in the world. Besides this, they face many challenges on different levels of which governance and environmental sustainability play an important role. Most European smart initiatives focus on certain domains such as the environment, mobility, energy, economy, and in particular innovation, while other initiatives are characterized as overall strategies to urban development (Bakici, Almirall, & Wareham, 2013; EP, 2014; Neirotti et al., 2014). Other domains such as education, healthcare, and governance are less represented (EP, 2014; Neirotti et al., 2014). Because of the amount of smart initiatives, smart cities, and relevant domains, a focus is being laid on European cities. There are however many cities in Europe that label themselves as smart. Related to the research question, cities in Europe have to have environmental sustainability high on their agenda. Besides this, a project must be found that consists of multiple smart initiatives involving multiple stakeholders to understand how smart city governance can influence the environmental sustainability. The city projects must also be in the starting phase, as this study analyzes which elements of smart city governance are present, and what factors stakeholders of smart initiatives think are important before, or in the starting phase of a project, to make the project and initiatives successful in terms of environmental sustainability and CO_2 mitigation. Eventually, the scope was narrowed down to the countries of Great Britain, Spain, Italy, the Netherlands, and Sweden as smart initiatives and smart cities in these countries are often characterized by smart city governance and smart environment according to the European Parliament (EP, 2014).

Now, several cities must be chosen from these countries that have smart city projects in which mitigating CO_2 emissions is one of the main goals. There are two ways to choose the cities that are valid for this research. The first one is looking at cities and their smart initiatives and goals independently. This would result in many smart cities in these countries that would be valid for this research. It is however difficult and would take a lot of time to find smart cities with similar projects, initiatives and goals to compare with each other. A criterion would be that all smart cities would need to have similar projects or initiatives that would have to be labeled as 'smart', and have CO_2 mitigation as one of its main goals. As there are many smart initiatives in projects with different goals, this is hard to reach. That is why another approach to select smart cities in these countries has been chosen. As has been mentioned before, the EC launched the Smart Cities and Communities (SCC) European Innovation Partnership (EIP). Under this partnership, there have been many projects subsidized by the Horizon2020 program of the EU. Projects that fall under this partnership all have similar goals involving different smart cities, and are all relatively new projects that have recently been set up (EC, 2013). The call: 'Smart and Sustainable Cities' involves different projects that all involve smart cities with similar goals in environmental sustainability (EC, 2017d).

Under this call, one category was noticed that fit the aim of this research, namely the 'Smart Cities and Communities lighthouse projects' where one if its main goals is CO_2 mitigation and energy reduction (EC, 2017e). In total, two projects fall under this topic namely Ruggedised, and mySMARTLife (EC, 2017f). Ultimately the Ruggedised project was chosen as this involved three of the five countries described above, namely the Netherlands, Great Britain, and Sweden (EC, 2017g). The cities involved in this project are respectively Rotterdam, Glasgow, and Umeå. All these cities have climate targets high on their agenda, and have smart city projects available in their starting phase that consist of multiple initiatives. Moreover, all of these initiatives have similar goals with CO_2 mitigation being one of the most important ones (EC, 2017g). Additionally, choosing this category and call allowed the researcher to retrieve contact information, data, and information of the Ruggedised project by doing an internship at one of the lead supporting partners of this project, the Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (TNO; English: Dutch Organization for Applied Scientific Research). This allows the researcher to be closely involved in this smart city project, retrieve in-depth data and information, and allows for close contact with the relevant stakeholders of the project. This project will be elaborated upon in chapter 4.

3.3 Data collection methods

In order to be able to answer the research question, data must be collected from different stakeholders that are involved in the smart city projects and smart initiatives in the three cities. The aim is to collect quantitative as well as in-depth qualitative data to assess the presence of the smart city governance elements and to be able to identify issues and challenges based on the conceptual model and literature. With this data, a connection to the influence of smart city governance to CO_2 mitigation goals can be made. Three different methods are used to collect and compare data from the stakeholders: 1) background information data about the project and stakeholders is collected from documents and reports; 2) data is collected from online questionnaires with both open and closed questions that are sent to all relevant stakeholders in the city projects; 3) interviews are performed with these same stakeholders where they are asked to elaborate on the answers the stakeholders have given in the questionnaire. The use of multiple methods and sources strengthens the validity and credibility of this research (Verschuren & Doorewaard, 2010). This section explains

each of the used data collection methods, however first it is important to explain how the relevant stakeholders of the project were identified.

Identifying Stakeholders and Data collection method 1: Documents and Reports
First it is important to know what stakeholders are involved in the smart city projects of the three cities. The stakeholders in the area are the respondents and informants. They are data sources as described before in the embedded multiple case study method (Verschuren & Doorewaard, 2010). The choice and amount of stakeholders interviewed were based on collecting information from documents and reports (Verschuren & Doorewaard, 2010). These were a combination of non-publicly available documents, and publicly available documents on the European Commission website describing the Ruggedised project. This method is also of added value in answering the research question as background information retrieved from documents and reports about the project and the city are of major importance in gaining valuable knowledge about the context and state of the art of the project. Here, the smart initiatives and relevant stakeholders can be identified and chosen in order to perform interviews.

The relevant stakeholders are private companies involved in the smart initiatives, the local government, and scientific researchers involved in the project (Ruggedised, 2017a; TNO, personal communication, October 5th, 2016). Citizens were not interviewed. Although they are considered important in smart city governance, the city projects are focused more on the collaboration between government, research, and private stakeholders (Ruggedised, 2017b). Additionally, the other stakeholder groups already offered a perspective about citizen participation as they are the people that are responsible for engaging and the participation of citizens. Instead, the respondents are asked several questions about the role and inclusion of citizens in the project as citizen involvement is deemed important in smart city governance literature, and to get an overview of citizen participation and involvement. Experts such as university researchers or research companies involved in the project are also interviewed to give an outside perspective on the project. Their knowledge of the project and academic point of view can give additional information for analyzing the governance and environmental sustainability of the project.

Subsequently, relevant information from documents and reports can also be used to analyze several elements of smart city governance such as legislations and policies related to the CO_2 mitigation goals that are applicable for the project. The documents and reports are collected through publicly available information online, or by retrieving them from stakeholders i.e. while performing interviews. This information can be an addition to interviews and the empirical data collected (Verschuren & Doorewaard, 2010). An overview of the documents that were used can be found in table 3.

Table 3: Documents and Reports in Rotterdam, Umeå, and Glasgow.

	Documents and Reports
Rotterdam	- Programma Duurzaam (Sustainability Program) (Municipality of Rotterdam, 2015) - Smart City Rotterdam (PBLQ, 2015) - Stadsvisie Rotterdam (City Vision) (Municipality of Rotterdam, 2007) - Roadmap Next Economy (MRDH, 2016)
Umeå	- EGCA 2018, Umeå, Sweden (2015a,b)
Glasgow	- Climate Change Strategy & Action Plan (GCC, 2010) - Energy & Carbon Master Plan (GCC, 2014)
All Cities	Ruggedised project proposal (TNO, personal communication, October 5th, 2016).

Data collection method 2: Online Questionnaires

The second step included collecting qualitative and quantitative data from an online questionnaire with both open and closed questions that were sent to all the relevant stakeholders of the three city projects (see Appendix 8.3). This questionnaire can be seen as a basis/basic structure, where data from documents and reports, and interviews will be added to, to gain more in-depth information. The questionnaire was divided into three parts, namely: 1) Stakeholder information, 2) Presence of smart city governance elements; and 3) Smart city governance challenges. The second and third part of the questionnaire align with the second and third sub question of this research whereas the first part gathers background information about the respondent and the initiatives they are involved in. The structure of the questionnaire is elaborated upon in detail in Appendix 8.4. The questionnaires allowed for an extended access to participants that could otherwise not be reached or contacted for conducting interviews. To avoid that respondents forget to fill in the questionnaire, a reminder is sent every week to the stakeholders for six consecutive weeks (Opdenakker, 2006). A total of 30 online questionnaires were sent of which 16 were filled in (table 4).

Table 4: Filled in questionnaires per city and stakeholder group.

	Government	Private Company	Researcher	Total
Rotterdam	2	6	3	11
Umeå	2	2	0	4
Glasgow	1	0	0	1
Total	**5**	**8**	**3**	**16**

To obtain enough respondents, first an email was sent to ask the project leader of each city in order to obtain a contact list of stakeholders that could be approached for the questionnaire. Afterwards, each stakeholder was sent an e-mail, asking them to fill in the questionnaire, and to make an appointment for a telephone/skype/face-to-face interview. The website 'Qualtrics' was used in order to create and spread the questionnaire among stakeholders. This website allowed the researcher to create a professional looking questionnaire, and offered the options to create the different type of questions that were needed in order to collect relevant data for this research. The questionnaires provide results about the experience stakeholders have with the governance in the project regarding the smart initiatives they are involved in, and CO_2 mitigation. This will provide more in-depth information for identification of problems and strengths in the governance of the project and/or

initiative(s). By using this questionnaire, the researcher is able to steer towards the information required for answering the research questions (Verschuren & Doorewaard, 2010).

Data Collection Method 3: Interviews
The third method and third step of data collection include performing interviews with relevant stakeholders involved in the project. Before the researcher performs these interviews with the stakeholders, they first were asked to fill in the online questionnaires. Some exceptions were made with stakeholders who requested to fill in the questionnaire while being interviewed. Based on the answers the stakeholders have given in the questionnaire, questions in the interview are asked to elaborate on the answers the stakeholders have given. Questions are asked when respondents have not filled in an answer, were unclear in answering a question, or when the researcher wanted to know the reasons behind a given answer. By only discussing several questions, and not all, this allows the stakeholder to have time to respond to the questions asked and be able to retrieve more in-depth information. These interviews usually took longer as the questions in the questionnaire needed to be answered and at the same time additional comments of the respondent had to be made. In Appendix 8.5 an overview can be found per city of the performed interviews.

The interviews were mostly being conducted through telephone, with three being performed through Skype and face-to-face in formal settings. Skype and telephone interviews were deemed useful as sometimes only several questions were asked about the questionnaire, and also because a portion of the stakeholders live abroad. This method saves a lot of time and financial resources and still provides the information deemed necessary to obtain. The phone interviews took between 30-70 minutes, as the author is aware that most stakeholders do not have or want to invest more time in it, and a sufficient amount of data can be collected within this time period. The Skype and face-to-face interviews usually took longer as the questionnaire was also filled in together with the respondent. Respondents were being contacted via e-mail. All interviews were recorded and notes were taken during the interviews and used for the analysis of the empirical research.

3.4 Operationalization and Data Analysis Methods
The previous section discussed three methods of data collection, namely collecting information from documents and reports, creating an online questionnaire, and performing interviews. In this section, the operationalization and analysis methods of each of these three methods are explained.

Three groups of stakeholders
As there are three different types of stakeholders, namely: city government, researchers, and private companies, the analysis is categorized per these three groups. Grouping them also allows comparing differences in perspectives and relevant challenges. Each element will be split into the three different stakeholder groups, and the same will be done for the smart city governance challenges part. Within these groups, the results of the empirical research are shown and the data is compared and analyzed.

Analyzing the data
In order to be able to analyze data, the abstract smart city governance concept needs to be translated into indicators. The defining elements and challenges in the conceptual model that have been discussed in chapter 2 are used as indicators for this concept. Additionally, the elements and

challenges themselves also consist of several indicators to test whether the elements individually are present in the projects and/or initiative(s) and to find out which challenges and improvements to the projects and/or initiative(s) can be made. These indicators are the questionnaire questions and are based on the literature research (table 5). In Appendix 8.6 it is explained in detail how this connection between the literature and creating of questionnaire questions is made. By breaking the smart city governance concept up into the different elements, the analysis' reliability and validity were enhanced as analyzing one large concept is more difficult to interpret and analyze (Matthes & Kohring, 2008).

Table 5: Criteria of smart city governance elements and challenges.

Elements	Criteria
Integrated Vision	1. Presence of a plan/document with a long term integrated vision including CO_2 mitigation goals. 2. Presence of a shared vision between stakeholders.
Use of ICTs	The degree that ICTs helps to increase helps to: 1. Increase citizen participation. 2. Simplify interactions between stakeholders. 3. Improve internal administrative operations. 4. Improve urban services.
Legislation and Policies	1. Helping and hampering policies and legislations that can influence CO_2 mitigation goals.
Innovation Capacity	1. Degree of how innovative capacity is being ensured/stimulated. 2. Amount of potential to keep innovating.
Collaboration and Participation	1. Presence of synergies. 2. Synergies that have not yet been fulfilled. 3. Presence of a dominating stakeholder. 4. Level of citizen engagement.
Internal Coordination	1. Degree of communication between different departments, people, and agencies within an organization.
Decision-making process	1. Presence of a decision-making structure that is deliberately designed beforehand. 2. Clearly defined and communicated stakeholder roles. 3. Transparent decision-making. 4. Degree of help from ICT to make better decisions.
E-administration	1. Activities that are undertaken to improve the transparency of stakeholders' actions.
Challenges	The degree of: 1. Financial Challenges 2. Technical Challenges 3. Environmental Challenges 4. Privacy 5. Lack of Leadership 6. Digital Divide 7. Collaboration 8. Legal and Policy Challenges 9. Discussion of challenges with other consortia

As has been mentioned before the structure of the analysis is based on the questionnaire and sub-questions of this research. First, background information is given about the city projects, secondly the presence of smart city governance elements is analyzed (sub-question 2), followed by an analysis of the governance challenges (sub-question 3). Finally, based on these analyses, an analysis is made in how smart city governance and its challenges are expected to influence CO_2 mitigation goals in the city projects (main research question). After the analysis of each city, the cities are briefly compared with each other and a final conclusion is made.

Analyzing the Presence of Smart City Governance

To measure the presence of the smart city governance elements a five point scale is used to score the cities on the presence of smart city governance (table 6). Based on the indicators and the data retrieved from the three collection methods, this gives an indication to what extent an element is present. The different criteria weigh the same and there is no strict boundary between the scores which can make the outcome subjective and normative. However, this method is the best to give a clear overview of the presence of smart city governance based on the different criteria.

Table 6: Explanation of the five point scale.

Score	Degree of Presence
--	Not Present
-	Slightly Present
+/-	Moderately Present
+	Mostly Present
++	Completely Present

Analyzing the Governance Challenges

The governance challenges were measured based on indicators collected from literature which have been translated into questionnaire questions, and by using different analysis methods which will be further elaborated upon below. Here, it is described how the three different data collection methods are operationalized and the retrieved data is analyzed in order to be able to assess the presence of smart city governance and identify the governance challenges.

Documents and Reports

Documents were analyzed to gain background information about the city projects. This background information consists of the 1) brief background of the cities regarding smart city governance and environmental sustainability, and 2) the background of the projects, including a description of the initiatives and stakeholders. Data retrieved from documents and reports is also used when it is deemed relevant for the elements and indicators of smart city governance discussed in the previous section.

Questionnaires

The first questions of the questionnaire allow the researcher to categorize and identify the stakeholders that fill in the questionnaire, and which initiative(s) they are in involved in. This is important in order to compare the different groups of stakeholders and initiatives with each other when analyzing the other questions. Additionally, the questionnaire contains different types of questions to analyze, namely closed 'Yes/No' questions, 'If Yes/If No' questions with the option to elaborate when the respondent has chosen yes or no, open questions, and questions that can be answered with the use of a Likert scale. Below is for each of these types of questions explained how they are analyzed.

Yes/No Questions (Q6, Q13, Q14, Q15, Q22)

Closed yes or no questions are asked when the researcher wants to know the presence of smart city governance elements or perspective of the respondent about certain elements but when it is deemed not necessary to go in-depth as the answer itself already gives enough information about the relevant element. These questions can be seen as additional criteria for determining to what extent the elements are present in the initiative/project according to the stakeholder and are analyzed quantitatively.

If Yes/If No Questions (Q5, Q9, Q12, Q19, Q23)

A combination of open and closed yes or no questions is also used. These questions are first structured as a closed yes or no question, followed by a question why yes or no has been chosen. The Yes/No questions are analyzed quantitatively as described above, while the open answers given when chosen yes or no are categorized. This is elaborated upon below.

Open Questions (Q3, Q4, Q7, Q8, Q11, Q16, Q18, Q21, Q25)

Open questions are asked when deemed necessary by the researcher to go more in-depth in the topic. The content analysis method is used to analyze data retrieved from the open questions from the questionnaires and interviews. This is deemed the most appropriate method as data from the questionnaires and interviews can be categorized in open categories that guide the coding process (Verschuren & Doorewaard, 2010). Another benefit, which is relevant for this research, is that other concepts and categories that were previously not taken into account can arise from this data, such as problems or undiscussed elements of smart city governance which stakeholders think can be improved in governance to reach CO_2 mitigation goals. Categories are made based on the data retrieved from questionnaires and literature. Each open question has been categorized to give a clear overview of the answers that the respondents have given to each open question. Categories were made based on the found literature, and later based on the results of the empirical research. These categories per question can be found in Appendix 8.7. The answers given on the open questions are then analyzed and an overview can be made of the categories based on how many times respondents have chosen this category as an answer.

Likert Scale Questions (Q10, Q17, Q20, Q24)

There are in total four different Likert scale type of questions. A 5-point Likert scale is used in order to indicate to what extent for example elements or factors are present. The measures of this scale are easy to administer, quantify, and code and the acquired results are recognized as reliable and valid (Li, 2013; Bolívar & Meijer, 2016). The results are summarized by mean, median, and standard deviation of the responses which helps to analyze the data obtained, which are also used for the comparison between the stakeholder groups (Bertram, 2007). Ultimately, for factual questions the 'don't know' option is added in the questionnaire when there is a reasonable likelihood that not all respondents may be able to give an answer.

Interviews

After the questionnaires are filled in, respondents who have opted to be available for a telephone, skype, or face-to-face interview will be asked questions about the project and the questionnaire they have filled in. This means that each interview is different with different questions and answers. To analyze this, content analysis is used to categorize the answers. Each question in the interview is

related to a question in the questionnaire, and the answers given in the interview are then added to the results and analysis of the questionnaire. For example, in the questionnaire a question is asked about the hampering and helping legislations and policies. Categories have been made for this based on literature research and given answers in the questionnaires. The answers that have been given in the interviews are added to these categories or new categories are created if the answer does not fit in a category that was created in the questionnaire. The recordings of the interviews are transcribed and only the relevant information from the interviews is coded, while the other less relevant and repetitive parts are synthesized. All interviews are separately summarized from the recordings and the notes taken by the researcher are added to this summary.

3.5 Causality, Validity and Reliability

This section discusses the causality, validity, and reliability of this research. Mentioning them is important for the repeatability, and credibility of this and further research.

Causality is needed to determine whether smart city governance can cause CO_2 mitigation. Determining the causal relationship between smart city governance and the CO_2 mitigation outcome is difficult due to many other factors also being able to affect CO_2 mitigation. In order for this research to be valid, it has been designed in order that the smart city governance precedes the CO_2 mitigation outcome (asymmetry), and focuses as much as possible on the CO_2 mitigation outcome (covariance), by asking several questions on how smart city governance can affect CO_2 mitigation goals. Because this relationship is difficult to make, also for respondents, only some questions were made where explicitly was asked to answer in context of CO_2 mitigation. If this would not have been done, it would have resulted into answers that were not in the context of this research. For example, the first question about legislation and policies was asked to answer in the context of policies and legislations connected to CO_2 mitigation. If this was not done, respondents could have answered any policy or legislation they thought was effective or hampering the project/initiative(s). For the other questions, general questions were asked about the smart governance elements. The answers given, are then coded and analyzed, and a link is made to CO_2 mitigation goals based on the literature and other data retrieved from the questionnaire and interviews.

Subsequently other external variables affecting smart city governance and CO_2 mitigation are accounted for as much as possible (non-spuriousness) through a literature study, having similar smart initiatives within three cities of the same project and them all having CO_2 reduction goals. In the context of this research however, full non-spuriousness is impossible to achieve due to the changing circumstances and the many other variables that can cause CO_2 mitigation. Although this can affect the validity of this research, it must be noted that a compromise must be made between validity and feasibility of the research (Verschuren & Doorewaard, 2010). As has been mentioned before, validity is further strengthened through using multiple methods and sources, and by having multiple comparable cases (Verschuren & Doorewaard, 2010).

Finally, in order to increase the reliability of this research, the smart city governance model, the relevant literature and its operationalization, data collection methods, and data analysis methods have been made as clear and detailed as possible in order for other researchers to repeat this study in other contexts. Additional detailed information was added in the appendices which makes this research transparent.

4. Results and Analysis

4.1 Introduction

This chapter presents the results and analysis of the three selected city projects and their initiatives, based on the filled in questionnaires, interviews with different stakeholders, and document analysis. First, some background information is given about Ruggedised and the selected city projects, followed by an analysis of the results per city project. This is done in the structure of the conceptual model and research questions. First, the presence of smart city governance is assessed based on the conceptual model and studied literature, followed by identifying the governance challenges. Based on these analyses, a connection between the presence of smart city governance, the challenges, and the influence these can have on the CO_2 mitigation goals of the three city projects will be discussed. Finally, the city projects will be compared to each other.

4.2 Background Information of the Ruggedised project

The Ruggedised project officially started in November 2016 for the duration of five years, and is a part of the European Commission's Horizon2020 program. The project has the three overall aims to 1) Improve the quality of life of citizens, 2) Reduce the environmental impacts of activities, and 3) Create a stimulating environment for sustainable economic development. These aims are supported by smart ICT solutions for energy and mobility, to the benefit of the citizens (TNO, personal communication, October 5th, 2016).

The main participating cities in the Ruggedised project are Rotterdam, Umeå, and Glasgow. In total, they are involved in 32 initiatives of which thirteen are in Rotterdam, ten in Umeå, and nine in Glasgow (figure 4). These initiatives are identified as 'smart', since they are innovative initiatives that involve ICTs in order to improve the urban environment in the smart city. Besides this, the aims of Ruggedised and the initiatives perfectly align with the three main objectives of the smart city as described by Castelnovo et al. (2016). The initiatives are divided in three categories: 1) Smart Thermal Grid, 2) Smart Electricity Grid & E-mobility, and 3) Energy Management and ICT. Currently, the initiatives of all city projects are at various stages of implementation. Some are being installed while others are at the planning stage. The three consortia of the different cities interact with each other to share knowledge and insights about the projects (Ruggedised, 2017a). The municipality of Rotterdam has been assigned as the coordinator of the whole Ruggedised project (TNO, personal communication, October 5th, 2016).

The Ruggedised project is an addition to already existing city projects in the three cities. This is important as this is different than a project starting from scratch, which will be elaborated upon later. By including Ruggedised in their city projects, the three cities are able to improve or expand the already existing initiatives in the city projects. The main goal of the project is not the development of the initiatives itself. Sharing information, finding a way to find the right incentives and creating validated business cases to allow large scale deployment and replication of the smart initiatives are considered more essential (TNO, personal communication, October 5th, 2016). In this regard, there are three more 'follower' cities involved in the project to closely follow the cities and to prepare for implementation in the nearby future, namely Brno (Czech Republic), Parma (Italy), and Gdansk (Poland). These cities are however left out of the study as these cities are currently not yet fully engaged in Ruggedised.

Smart City Governance in Ruggedised

The Ruggedised project acknowledges the need for smart governance and specifically states that collaboration between different stakeholders is of high importance in order to meet the climate change goals (TNO, personal communication, October 5th, 2016). Smart governance is recognized as a vital ingredient for smart city development yet this is not yet fully developed in the three cities to an extent that this is usable for all stakeholders. Therefore it is deemed important to perform research about this.

CO_2 mitigation goals in Ruggedised

As could be derived from the project's aims, CO_2 mitigation is one of the main goals of Ruggedised. Every city project and smart initiative has CO_2 mitigation goals that have to be reached by the end of the project. It is expected that the three city projects in total have a reduced energy consumption of 4.5 GWh per year, and reduce 3.7 Mton CO_2 per year (TNO, personal communication, October 5th, 2016). Additionally, the aim is to improve air quality and implement sustainable mobility initiatives, such as green bus lines and charging hubs for electric vehicles. Despite CO_2 mitigation and energy reduction being addressed as one of the most important objectives of the project, it was remarkable that there was no clear overview given in the project proposal of Ruggedised which displayed the expected energy reduction and CO_2 mitigation goals per city project and per initiative. This would have helped to get a perspective of how much energy reduction and CO_2 mitigation every city project and initiative would have to reach. The rest of this chapter will give background information and present the analysis of each city project in Ruggedised.
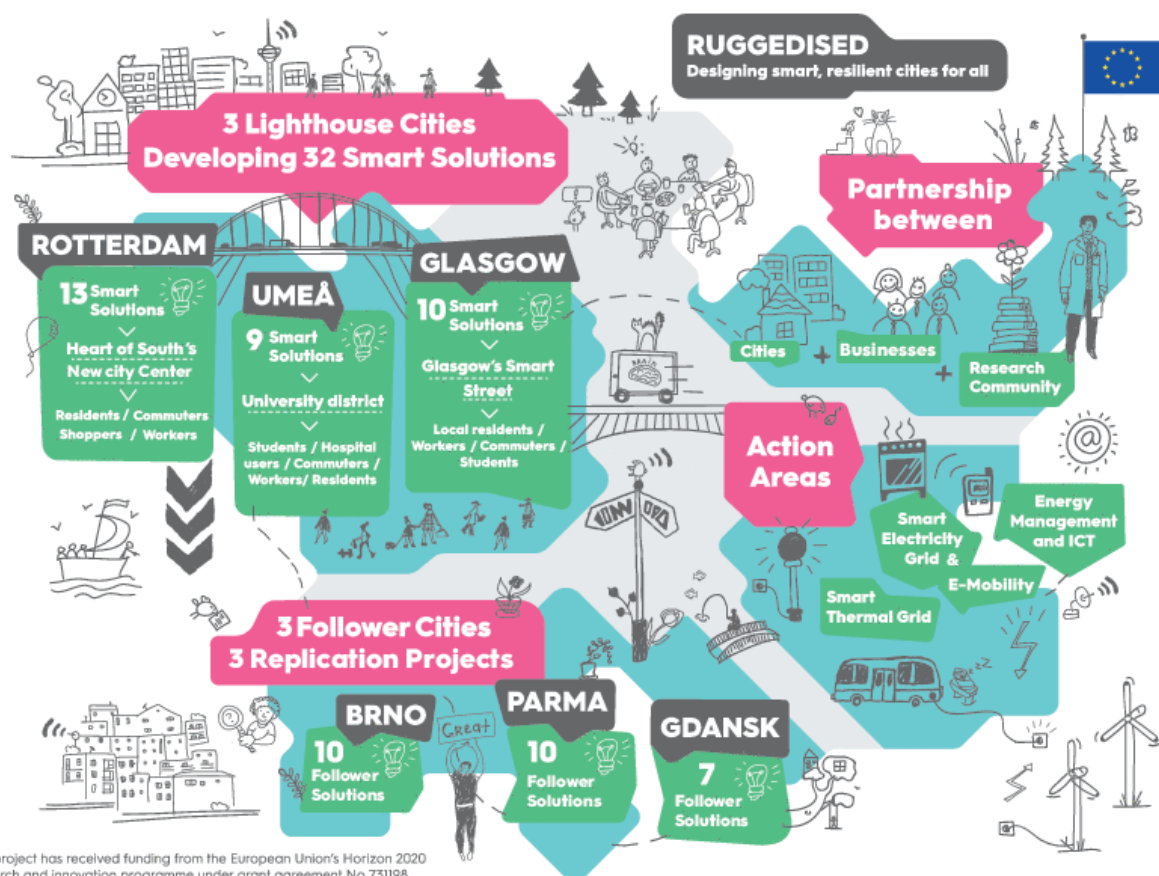
Figure 4: A summary of the Ruggedised project (Ruggedised, 2017c).

4.3 Rotterdam

4.3.1 City Background information

The city of Rotterdam is located in the south-west of the Netherlands on the river 'de Nieuwe Maas', is the second-largest city in the Netherlands with approximately 630.000 inhabitants, and has one of the largest ports in the world. The city is well-known for its famous and innovative architecture, its port, and has a long history in trading and logistics (Deltacities, 2017). Rotterdam is one of the many cities that considers mitigating CO_2 emissions and adapting to climate change as one of its future challenges, because the city is, as part of the Rhine-Maas delta, extremely vulnerable for uncontrolled impacts of climate change and has climatologic challenges as high importance (Rotterdam Climate Initiative, 2013). This is also visible in the city's plans and visions such as the Rotterdam Climate Initiative and Sustainability Program 2015-2018 (Municipality of Rotterdam, 2015; Rotterdam Climate Initiative, 2013). The city plans to organize a transition from a mainly fossil fuel driven economy to an economy based on the use of sustainable energy sources within the next decades, providing opportunities to significantly stimulate a circular economy. Specifically, the reduction of CO_2 emissions and energy use play an important role in this. These developments are strongly boosted by the dynamic and rapidly growing ICT-sector (Rotterdam Climate Initiative, 2013). It is crucial to understand how the city should respond to these changes to be competitive and ready for the future. Rotterdam and its goals are a perfect example of the challenges smart cities can face, especially regarding environmental sustainability challenges, and is therefore a representative example for a smart city. The following section gives more information about the project, its stakeholders, and the challenges that occur in the Rotterdam city project.

4.3.2 City Project Background information

For the Ruggedised project, Rotterdam has chosen the 'Hearth of South' district to redevelop (figure 5). The 'Hearth of South' project is a project that has been started before the start of the Ruggedised project. It is a (re)development project consisting of the sustainable renovation of an outdated shopping center, the renovation of the public transport hub both, as well as various large-scale multifunctional buildings (such as a swimming pool, arts building, exhibition halls, and a congress center). Additionally, the public space in the area will also be drastically redeveloped. The development of the area was tendered together with a twenty-year maintenance of the area in 2013 by the municipality of Rotterdam. A coalition led by construction company Ballast Nedam won the tender in 2013 resulting in a single public-private partnership between the municipality of Rotterdam and Ballast Nedam. In 2016, construction company Heijmans joined Ballast Nedam in the project (TNO, personal communication, October 5th, 2016).

For Ruggedised, the challenge is to connect buildings, mobility, and energy sources by using ICT-systems in a 'smart' way (TNO, personal communication, October 5th, 2016)**.** Renewable energy sources such as solar panels, urban wind turbines, cold-heat storage, and energy recovery from the sewer and the pavement are being used to increase energy efficiency and lower CO_2 emissions (Municipality of Rotterdam, 2016). In total thirteen 'smart solutions' are being implemented which can help the city of Rotterdam to aim to achieve maximum energy efficiency and CO_2 reduction by using smart ICT solutions to reach their climate goals (table 7). A total of seven partners are directly involved in the implementation of the smart initiatives, namely 1) the municipality of Rotterdam (ROT); 2) Ballast Nedam/Heijmans (BNH); 3) Eneco; 4) RET; 5) Erasmus University Rotterdam (EUR);

6) KPN; and 7) Future Insight (FI). Additionally, TNO assists the project through advising and helping with the implementation of the initiatives with their knowledge and expertise. A brief description and overview of all the initiatives, the role of the stakeholders, and the CO_2 and/or energy targets can be found in Appendix 8.8.
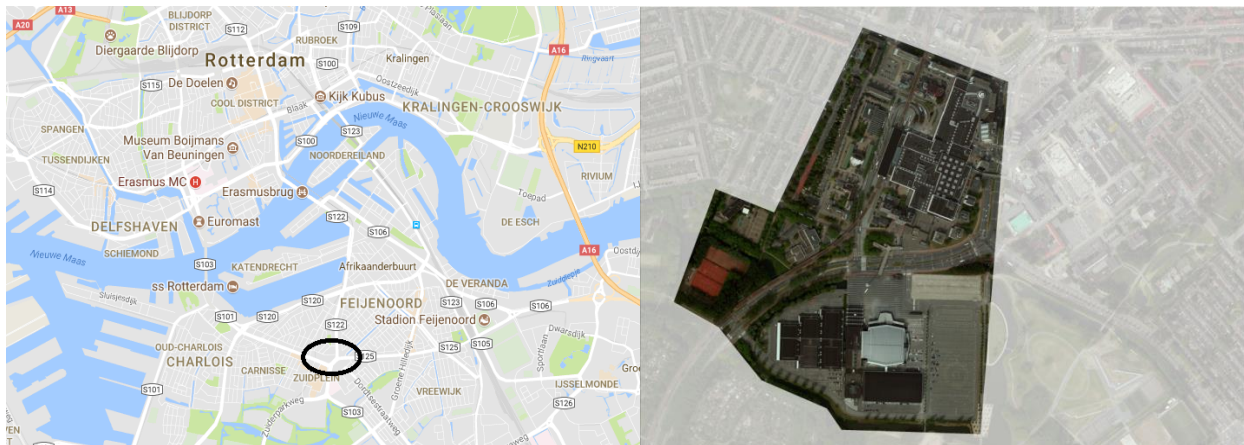
Figure 5: Geographical location of Rotterdam Hearth of South District (Google Maps, 2017a; Hart van Zuid, 2017).

Table 7: Analyzed Rotterdam Smart Initiatives.

Code	Smart Initiative	Stakeholders	Expected CO_2 Savings (tCO_2/yr)
Smart Thermal Grid			
R1	Geothermal heat-cold storage and heat pumps	BNH, ENECO	N/D
R2	Thermal energy from waste water	BNH, ENECO, ROT	N/D
R3	Surface water heat-cold collection	BNH, ENECO	N/D
R4	Pavement heat-cold collector	BNH, ENECO, ROT	N/D
Smart Electricity Grid & E-mobility			
R5	RES generation and storage for mobility	RET, BNH, ENECO	N/D
R6	Smart charging parking lots	BNH, ENECO	N/D
R7	Optimizing the E-bus fleet of RET	RET, EUR	N/D
Energy Management and ICT			
R8	Energy Management	BNH, ENECO, EUR	N/D
R9	3-D City operations model	FI, ROT, EUR, KPN, BNH	N/D
R10	LoRa-network	KPN	N/D
R11	Efficient and intelligent street lighting	BNH, ROT	N/D
R12	eRadiator	ENECO	N/D
R13	Smart Waste Management	ROT	N/D
Total			5630

Sources: TNO (personal communication, October 5th, 2016), Ruggedised (2017d), Ruggedised (2017e), and Ruggedised (2017f).

4.3.3 Results and Analysis

In this section, the results of the city project in Rotterdam will be analyzed. In total, eleven questionnaires out of the fourteen questionnaires sent were filled in, and ten interviews were performed with all involved partners of the city project (table 8). This amount of respondents allowed gaining a representable perspective of the presence of the smart city governance elements and challenges in the project. In Appendix 8.11.1, the categorization and quantitative data of the retrieved data can be found. This section analyzes these results.

Table 8: Questionnaires and interviews per stakeholder group in Rotterdam.

	Government	Private Companies	Researchers	Total
Questionnaires	2	6	3	11
Interviews	1	6	3	10

First of all, an analysis of the presence of smart city governance will be performed based on the smart city governance elements and their criteria derived from questionnaires and interviews. Subsequently the governance challenges in the project and initiatives are debated, and finally a connection between the presence of smart city governance, the challenges, and the influence these can have on the CO_2 mitigation goals of the Rotterdam city project, will be discussed.

Presence of Smart City Governance Elements

Element 1: Integrated Vision   **Presence: -**

Criterion: Presence of a plan/document with a long term integrated vision including CO_2 mitigation goals

All stakeholders are indifferent whether there is a plan or document that includes a long term integrated vision for the project/smart initiatives. Overall, it was concluded that there are documents or plans with a vision, however not specifically made for the Ruggedised part of the project. A project plan of the Hearth of South area exists, although the smart initiatives have not been fully integrated in this plan as it was made before the Ruggedised project started. Besides this, this project plan mentions environmental sustainability as one of the objectives, however this is left out when discussing the project's main vision which focuses more on the social and economic development of the area. Additionally, it was mentioned that there are other documents and plans with visions such as the City Vision document, Rotterdam Climate Initiative, and Roadmap Next Economy (see table 3). However these documents are applied on a city and region wide level and it was argued that their visions do not completely come back in the initiatives. Besides this, a program called 'Programma Duurzaam' (Sustainability Program), contains an integrated vision of city projects where social, environmental, and economic objectives are combined. However, this is on a city level and is on a short term (2015-2018) and it has not been described clearly how this integrated vision will be realized in practice. There is however a document that contains the CO_2 mitigation and energy reduction goals per initiative that briefly states what the expected impact will be of the initiatives. Despite this not being a vision, it gives a proper overview of all initiatives and contributes to reaching the environmental goals of the project. Finally, all but one private stakeholder argued that they thought an integrated vision would possibly not contribute to reaching the goals of the initiatives as the implementation of the smart initiatives are already mentioned very specifically in the Horizon2020 bid and there could be no deviation from this. This can describe the lack of flexibility regarding the set plans in the project which will be elaborated upon later.

Criterion: Presence of a shared vision between stakeholders

According to all but one private stakeholder, there is no shared vision in the project. It was stressed that this is the consequence of having private stakeholders who are more focused on the financial gains, while governmental stakeholders do not have this goal. This could also be derived from the answers regarding the ultimate goal of the project and initiatives. The most mentioned ultimate goal was the aim to make sure the development and implementation of the initiatives would be successful. Followed by the goal to improve the sustainability performance and decrease CO_2 emissions. A difference between the stakeholders groups here is that the private stakeholders were the only stakeholder group that argued that developing the initiatives was the most important objective. Both government and research stakeholders stated that the ultimate objective was to improve sustainability, decrease CO_2 emissions and optimize energy efficiency. The lack of a shared vision is also in line with a report written by the consultancy company PBLQ about the potential and strategy of smart city Rotterdam. They concluded a shared vision and structure are missing in smart city projects to create a cohesive smart city (PBLQ, 2015).

"There are fundamental differences between private stakeholders who want to make profit, and a municipality who doesn't (Government Stakeholder)".

Overall, there is no clear integrated vision specifically for the smart initiatives, however there is a short-term integrated vision on a city level that also includes environmental sustainability as objective. Despite this, there is no clear method as in how to realize this vision for the project. Additionally, the vision of all stakeholders is not shared, therefore this element is considered being slightly present.

Element 2: The use of ICTs   **Presence: +/-**

Criterion: The degree that ICTs helps to increase helps to: 1) Increase citizen participation, 2) Simplify interactions between stakeholders, 3) Improve internal administrative operations, and 4) Improve urban services.

Overall, the stakeholders indicated that ICT in the project and smart initiatives helps to increase citizen participation, simplify interactions between stakeholders, improve internal administrative operations, and improve urban services moderately well. There was however a difference in results between the government and private stakeholders, and the researchers. The researchers argued that ICT only helps the four factors slightly well. Especially ICTs would not help to increase citizen participation at all, while it was argued there is great potential. It was mentioned that with the availability of current techniques, the governmental and private stakeholders should engage citizens a lot more with ICTs so they can participate in certain parts of the project. All stakeholders overall agreed that ICT helped to improve urban services the most. For example the LoRa network can significantly contribute to improved urban services as public lightning and waste management systems could be improved. Based on these results, this element is being considered moderately present.

Element 3: Legislation and Policies   **Presence: -**

Criterion: Helping and hampering policies and legislations that can influence CO$_2$ mitigation goals

Helpful

It was indicated that there were several helpful policies and legislations supporting the initiatives, and some major hampering factors that influence the smart initiatives in the project. A helpful policy document according to the governmental stakeholders is the aforementioned Sustainability Program. This program stimulates integration and innovation of city projects and therefore connects to this smart city project. Another positive factor that was mentioned by the other stakeholders is that the municipality of Rotterdam strives to create public-private partnership projects. This creates collaboration between private and government stakeholders, to realize projects and initiatives that otherwise would not be possible if implemented alone. A final positive factor mentioned was a granted subsidy, for implementing solar panels in specific initiatives. This was necessary according to the private stakeholders, as solar panels are still not currently financially profitable.

"A positive side is that the municipality of Rotterdam has policy focused on public-private partnerships and is able to realize this here. I think they are doing a very good job on that (Private Stakeholder)".

Hampering

Regarding the hampering legislations and policies, there were several hampering factors mentioned by the private companies and researchers:

Firstly, the hampering factor mentioned most often, included the old and existing agreements and contracts with other stakeholders that hamper the implementation of certain initiatives. As was mentioned before, the Ruggedised project with the thirteen smart initiatives was added to the already existing Hearth of South project. This Hearth of South project contains a model where certain agreements and contracts were set up by the government and different companies. However, if they want to implement the thirteen smart initiatives successfully, older contracts need to be changed, which can often be met with objection, as the changes may be less profitable for the stakeholders involved. There is a major challenge regarding how to change these old contracts, make sure the initiatives will be implemented, and keep all stakeholders satisfied. It was suggested there should be more flexibility in these models and contracts in order to intervene when circumstances change or when these models and contracts can be improved.

Second, there are double energy taxes on the battery storage initiatives, which make the business case hard to develop and realize. It was indicated that you pay taxes for the generation of renewable energy, and on top of that, taxes also need to be paid for the storage of this energy. This brings the implementation of initiatives that involve battery storage in danger, as it would make this very unprofitable.

Thirdly, another hampering factor is the procurement law, which can hinder innovation and collaboration. Currently, the municipality of Rotterdam has to tender, and must give every company an opportunity to participate in the project. This process costs a significant amount of time, and is risky for private stakeholders who come to the government with a specific idea or plan, in the hopes of developing it. To fix this, it was suggested that the government should discuss plans with private

stakeholders, and if successful, the private stakeholder should be able to develop and implement this plan with the government, instead of the government having to cultivate it with other stakeholders. Because it is likely that all the time and resources that the private stakeholder put into this discussion about the development of the plan could be for nothing, and it demotivates private stakeholders to present innovative ideas.

Fourth, regarding the heat and cold storage initiatives, there only exists a national Heat law and no 'Cold' law, with regulations about supplying and storing cold. It was indicated that this is seen as a hampering factor as it is unclear which regulations apply for the storage and collection of cold.

Finally, there are hampering regulations about the heat/cold storage initiative that makes it difficult to reach the CO_2 mitigation goals. Currently, the district heating gets their heat from leftover heat from waste incineration. There are regulations about the way this is calculated that currently makes this already sustainable to an extent. The smart initiative of heat/cold exchange is more sustainable and emits less CO_2 than the current district heating, however the net reduction of CO_2 emissions of this smart initiative in comparison to the already existing district heating is limited. This fixed calculation makes that it is difficult to reach the CO_2 goals for this initiative. To reach the CO_2 mitigation goals of this initiative, it was argued that investments need to be made in renewable energy sources, which costs extra financial resources that are often unavailable. This could endanger reaching this initiative's CO_2 goals.

Overall, there are some policies and legislation that help to develop and implement the smart initiatives in this project such as the Sustainability Program document and subsidies for solar panels. However, there are some major hampering legislations, regulations, and policies that could endanger the implementation of the initiatives. Due to the large impact this can have on the project, this element is considered slightly present.

Element 4: Innovation Capacity   **Presence: +**

Criterion: Degree of how innovative capacity is being ensured/stimulated
More than half of all stakeholders stated that innovation capacity is being ensured through communication and collaboration between all partners. Constant communication between government, knowledge institutes and private companies creates shared knowledge, financial resources, and innovation resources such as technologies and methodologies that would otherwise not be created without collaboration. In addition, it was also mentioned that transparency between stakeholders and sharing data helped to increase innovation as other stakeholders have an idea of how and what other stakeholders are doing.

Criterion: Amount of potential to keep innovating
Eight out of eleven stakeholders believed that there is currently enough potential to keep innovating in the project. Three private stakeholders argued that innovation is currently limited. It was mentioned that this project is not very flexible regarding collaboration with different third parties in the project to enhance the innovation capacity as it is currently confirmed for the duration of the project which stakeholders are allowed to participate. Third parties can propose new ideas or make recommendations which can create opportunities that could help the development of the project. Excluding third parties can limit innovation as they cannot easily contribute to the project.

"There has to be some sort of flexibility in a project. I do not know if this project is flexible enough to jump in, not only when things go wrong, but also to seize opportunities and change things." (Research Stakeholder)

Despite these arguments, innovation capacity is considered mostly present as most stakeholders indicated there is enough potential to keep innovating in the project, and it was stressed that collaboration strengthens the innovation capacity significantly through the exchange of knowledge, financial resources, and innovation resources.

Element 5: Collaboration and Participation   Presence: +/-
Criterion: Presence of synergies

Regarding the collaboration and participation in the project, several examples of synergies were mentioned. Most of the private stakeholders stressed that there is a close collaboration between stakeholders which helps to share knowledge and pick up challenges. It was also mentioned by several stakeholders that this project makes visions come together in the sense that through collaboration, stakeholders get to know each other better, and influence each other which can help to develop a more coherent and supported vision (textbox 1). This can also increase the chance for future collaboration if collaboration was successful. Additionally, it was mentioned that meetings with all stakeholders in the project are held every month where the process and content of initiatives and the project is being discussed.

> An example was given about the synergy between RET and EUR, where RET lacks knowledge to develop the logistics of the E-bus fleet. EUR supports them by doing research and using students that can support in this research. Their findings are being given to RET which gives them the possibility to develop the logistics of the E-bus fleet. While this benefits RET, it benefits EUR as well because they have developed knowledge and put students to work. Besides this, the government is also satisfied as this helps the development and implementation of the E-bus fleet initiative which can lead to for example reaching the CO_2 mitigation goals.

Textbox 1: The synergy between RET and EUR.

Criterion: Synergies that have not yet been fulfilled

However, there were also expected synergies that currently not have been fulfilled. For many stakeholders this was too early to indicate as the project is still in the starting phase, but some indicated that the current process of collaboration is going very slow which they had expected to go faster. They mentioned that different priorities of stakeholders and insecurities such as the old contract agreements discussed before hampers an efficient collaboration. Additionally, one stakeholder also mentioned that it was expected there would already be a clear division of stakeholder roles in the initiatives to understand what everyone is doing and to enhance collaboration.

Criterion: Presence of a dominating stakeholder

All stakeholder groups were indifferent regarding whether a party was dominating the partnership. The government stakeholders stressed that this was not the case and collaboration was horizontal.

This perspective was also shared by four private stakeholders and researchers which indicated that this horizontal collaboration was not always deemed as the desired situation. However, most private stakeholders argued that both BNH and the municipality of Rotterdam were leading and dominating. They mentioned that BNH is leading whereas the municipality facilitates and steers the process when necessary. There were however different opinions as where some stakeholders mentioned that BNH was visibly dominating, whereas others mentioned they were more in the background of the project. Based on this it does not seem clear to everyone what each of these stakeholders' role is. Although these parties may be considered dominating, it should be noted that most stakeholders indicated that the term 'dominating' should not be interpreted as something negative as sometimes a steering or leading party is necessary in order to make collaboration necessary.

Criterion: Level of citizen engagement

Regarding citizen participation, all stakeholders indicated that citizens are only being slightly engaged during the project and pointed out that this would slightly progress during the project. The private stakeholders stated that citizens were almost not engaged at all in the initiatives of the project. Several stakeholders, including the government stakeholders, indicated that this would not always be necessary in the initiatives they were involved in such as the smart thermal grid, whereas others would like to see more citizen engagement. It was argued that some initiatives require citizen engagement to be developed efficiently such as the 3-D city operations model or the eRadiator initiatives. All private stakeholders and researchers indicated that they have barely seen any plans regarding citizen engagement and most of them stated that they would have liked to see this engagement already for several initiatives. The government stakeholder indicated however that for certain not started initiatives they would look at different ways to engage citizens such as performing online questionnaires.

I don't think any form of citizen participation has been put in the objectives of this project. I was surprised by this because in other projects citizen participation was one of the main goals (Private Stakeholder)".

Overall, it was indicated there are synergies and successful collaborations, however the lack of citizen participation and indistinctness of who is dominating the project, including some struggles regarding collaboration, makes this element being considered moderately present. This conclusion is in line with the results of the aforementioned PBLQ (2015) report that stated that it is an important challenge to create more cohesion and collaboration between different smart initiatives and their stakeholders.

Element 6: Internal Coordination   Presence: +

Criterion: Degree of communication between different departments, people, and agencies within an organization

To improve the communication and collaboration within their organizations, almost all stakeholder groups mentioned that regular meetings about content and process of the project/initiatives were held, and they work together with other departments in their organization with people that often have different backgrounds to increase the overall knowledge. Almost all stakeholders indicated that there were clear roles within their organization which helped to increase the efficiency within the organization. However one stakeholder indicated that within the municipality of Rotterdam several

opinions were heard about the project. It was stated that whereas one department supports the Ruggedised project and its initiatives and wants to stimulate innovation, another department only has the interest in completing the Hearth of South project, which was started before the Ruggedised project. It was argued that they would want to implement the project with as few risks as possible and extra factors that would increase this risk would have to be eliminated. This shows that despite the government stakeholders indicated departments work together, departments can have different interests and can work in silos. Despite this, no problems were mentioned in any of the other stakeholders' organizations. Therefore this element is being considered mostly present.

Element 7: Decision-making Process   **Presence: -**
Criterion: Presence of a decision-making structure that is deliberately designed beforehand
There was a clear difference between the responses of the private stakeholders and government, and research stakeholders regarding whether the decision-making structure of the project/smart initiatives is deliberately designed beforehand. Whereas the government and two out of three research stakeholders stated that this was the case, all private stakeholders indicated the opposite. They mentioned that this has not been formally agreed on yet and the organizational structure and decision-making structure is currently unclear and being discussed. A government stakeholder mentioned however there is a clear decision-making structure that has been designed beforehand and that every stakeholder in the project signed and agreed with as this was a necessity to apply for this Horizon2020 project. It was indicated however that there are sometimes several problems with the public-private partnership of the projects such as clarifying the aim or goals. Besides that it is sometimes unclear what each stakeholders' role is and how mutual expectations can be dealt with. It was mentioned that former relationships with actors helped to make decisions, as they trusted each other. The latter are important aspects that are already meaningful in the phase before the development of initiatives and/or business models start. The research stakeholders were also indifferent about whether there was an organizational or decision-making structure and concluded it is currently unclear who decides what in the project. They stated the decision-making structure is horizontal, but non-binding which can explain the delay of some initiatives since there is no decisiveness. Overall, based on the above, this indicates that it is currently unclear whether a decision-making structure is currently present for the smart initiatives in this project.

"The process is transparent, however the decision-making is less transparent (Private Stakeholder)."

Criterion: Clearly defined and communicated stakeholder roles
There was also indifference about whether roles of all stakeholders were clearly defined and communicated. While there were no clear differences of answers between the stakeholder groups, a small majority stated this was the case. However some stakeholders mentioned multiple times that it is still unclear what the role of some stakeholders in the project is. It could be that this was not communicated to them clearly.

Criterion: Transparent decision-making
A small majority of the stakeholders stated that decision-making is transparent in the project/initiatives. Whereas the government and two out of three research stakeholders stated that this was the case, all private stakeholders indicated the opposite. This could be related to their perspective of the lack of an organizational and decision-making structure.

"Who are all the decision makers? Who is the steering committee in Rotterdam? And what is the formal process? I haven't seen it, and I think that is an omission (Private Stakeholder)".

Criterion: Degree of help from ICTs to make better decisions
Despite the indifferences described above, all stakeholders unanimously agreed that data retrieved from ICTs does not help yet to make better decisions. One of the reasons for this is that many stakeholders many stakeholders indicated that it is currently too early in the project to say something about this as many initiatives are still in their starting phase. In the future of the project, it was argued that certain initiatives such as the smart thermal grid and energy management initiatives should be able to give data that could help in making better decisions.

Overall, there are many differences between the stakeholder groups regarding the decision-making process. The private stakeholders indicated that a clear decision-making structure is lacking, there is no transparency, and some argued that the roles of all stakeholders are not clearly defined or communicated which have led to a delay of initiatives. Although the government and research stakeholders were more positive, it can be concluded that these indifferences are not contributing to decisions that are being made as the organizational and decision-making structure should be clear to all stakeholders. Therefore, this element is considered slightly present.

Element 8: E-administration   Presence: +
Criterion: Activities that are undertaken to improve the transparency of stakeholders' actions
According to most stakeholders, transparency is being improved by constant tuning with partners, presenting all activities, visions and strategy to partners and by keeping up a document about the process of the project. For example, after each monthly meeting between the stakeholders, a report is made about the content of the meeting. This is spread to all stakeholders to give insight what has been discussed. The research stakeholders also mentioned that a wiki webpage and a project place have been developed where all process and activities of initiatives are being documented. The government stakeholders argued that they try to be transparent as possible and they share all information and progress with all stakeholders.

However, it was noticed that although there is a document that describes all CO_2 mitigation goals per initiative, several stakeholders were not aware that such a document exists. They stated they would like to see this as CO_2 mitigation is one of the main objectives of the project, although they did not know where to find this. Despite this, in general a lot is being done in order to keep the project and initiatives as transparent as possible. Therefore, this element is considered mostly present.

Overall: Smart City Governance   Presence: +/-
Overall, smart city governance is considered moderately present in the Rotterdam city project. There are some hampering issues, mostly indicated by the private stakeholders, which have delayed initiatives such as the lack of a clear integrated vision, helping policies and legislations, and decision-making structure. Although there were also helping factors to develop and implement the initiatives such as the creation of synergies, transparency, and internally coordinated organizations.
The stakeholders themselves also scored smart city governance as being moderately present. As could be derived from above, the private stakeholders scored the presence of all elements lower

(slightly to moderately present) than the government stakeholders (mostly present). They scored every element around moderately present without any significant outliers. This indicates that generally the stakeholders in the project have a proper indication of how present smart city governance actually is in the project. While they are aware, this can help them to look for solutions and address the issues they are currently facing.

Governance Challenges

When describing the presence of smart city governance, several specific challenges were already discussed (table 9). This section describes what stakeholders think are the most important challenges in the project, based on the criteria that were given in the questionnaire. Subsequently, it also elaborates on the other challenges which are present that have not yet been discussed. As many challenges are interconnected, no overview per criteria has been given as has been done in the previous section.

Table 9: Governance challenges and issues in Rotterdam

Developing an integrated vision for the Project	Addressing issues derived from old and existing contracts
Ensuring a shared vision for the project	Calculation of heat/cold storage initiative
Realizing a more effective use of ICTs	No flexibility and excluding third parties
Increasing citizen engagement	Lack of a clear overview of stakeholder roles
Lack of a 'Cold' law	Lack decisive project leader or stakeholder
Double Energy taxes	Having the same priorities within government departments
Procurement law	Lack of a decision-making structure

The stakeholders argued that the challenges regarding collaboration were the most important (textbox 2). This could also be derived from the former section as collaboration is currently not always going as efficiently as it could be. The financial challenges were considered the second most important challenge. Mainly because it is sometimes difficult to receive enough funding in order to implement initiatives successfully. Besides this, old contracts and agreements, and different visions make a successful implementation of the initiatives difficult. Several stakeholders argued that these two challenges are the most important due to successful collaboration being an important factor in the creation of business cases, which is important in a successful implementation of an initiative. Without solving the financial challenges, it would be impossible to implement an initiative. When the financial challenges are solved and business cases are made, the environmental challenges would also be solved as a successful implementation of an initiative would automatically lead to reaching the CO_2 mitigation goal of that initiative. This is the reason why most stakeholders scored the environmental challenges as moderately important. Factors

1. Collaboration
2. Financial Challenges
3. Lack of Leadership
3. Political Support
5. Legal/Policy Challenges
6. Technical Challenges
6. Privacy
8. Environmental Challenges
9. Digital Divide

Textbox 2: Importance of challenges according to stakeholders in Rotterdam.

such as addressing and solving the challenges of smart city governance and receiving political support and having proper leadership can also help to be able to implement an initiative successfully.

"Financial and organizational aspect are among the most challenging issues to deal with in the transition towards sustainable cities (Research Stakeholder)".

Technical challenges were considered moderately important as most techniques that are required when implementing the initiatives are already available, however the way to implement and finance this efficiently was still defined as a challenge. Privacy was considered moderately important by private companies and researchers, while the government scored this as very to extremely important. This difference can be explained by the difference between the initiatives. Several initiatives that involve consumer generated data such as the eRadiator and energy management system can violate privacy as some citizens might mistrust data and systems under development. It is therefore necessary to inform citizens in time in order to create awareness and knowledge about the smart initiatives. Finally, the digital divide was considered the least important challenge as all stakeholders argued this would not become an issue in the project and initiatives as they stated that citizens would not be able to participate on most initiatives anyway.

Another challenge mentioned was to create a visible and tangible result on short term. As the project's duration is five years, this can be considered as short in order to implement and monitor all the initiatives successfully. As could be seen, there are currently still many challenges that already have delayed several initiatives. It was therefore considered a challenge to be able to realize all initiatives within this time period. Finally, most stakeholders argued that challenges are being openly discussed with the cities of Umeå and Glasgow. This helps them to exchange information and gain ideas in order how to solve their own challenges. It was mentioned however that the challenges within the consortium of Rotterdam were not sufficiently discussed which can make it difficult solve them. This can have consequences for the development of the project as unsolved challenges can cause problems and result in delay of the project or not being able to implement initiatives. This also has its effect on being able to reach the CO_2 mitigation goals. The next section elaborates on what for influence the challenges and the presence of smart city governance can have on the CO_2 mitigation goals of Rotterdam.

Influence of smart city governance and the challenges on the CO_2 mitigation goals

Now the presence of smart city governance and the challenges have been analyzed, it must be explained what influence this can have on the CO_2 mitigation goals of the project. Smart city governance was considered moderately present in Rotterdam with several challenges identified that affected the development of the initiatives and the CO_2 mitigation goals. Innovation capacity was ensured through collaboration and communication between all partners which creates shared knowledge, financial resources and innovation resources which has resulted in being able to finance and implement the initiatives. Without this, it would not have been possible to implement the initiatives and set the mitigation goals. Regarding the E-administration and internal coordination in Rotterdam, it is difficult to assess a connection to their influence on CO_2 emissions. It can be said that these elements indirectly influence CO_2 mitigation goals as a full presence of both elements can result in a more efficient organization and process of the project, which can help to develop and reach the goals of the initiatives faster. This is the similar for the use of ICTs element. While this was considered moderately present, it was argued that it was too early in the project stage to make statements about whether ICT has made an impact so far as most initiatives are still being developed.

Regarding aspects that could negatively influence reaching the CO_2 mitigation goals, the lack of a clear integrated vision that includes environmental sustainability as one of the main objectives can result in isolated initiatives, whereas an integrated vision could enhance the initiatives, resulting in reaching the CO_2 mitigation goals more efficiently. Subsequently, the lack of a shared vision has already delivered several issues in collaboration and financing the initiatives. Whereas private stakeholders are more focused on the financial aspects of the development of the initiatives, the research and government stakeholders focus more on the environmental and social aspects. The different visions conflict with each other and have resulted in difficulties creating business models to be able to implement the initiatives. The lack of sufficient policies and legislations in order to implement the initiatives flawlessly, also have impacted the initiatives and CO_2 mitigation goals. Although there are subsidies to implement solar panels, hampering factors such as the double energy taxes and hampering regulations about the heat/cold storage initiative can hinder the implementation of initiatives and reaching the CO_2 mitigation goals significantly. The exclusion of third parties can also indirectly affect reducing CO_2 emissions in several cases. When better or more efficient ideas or solutions arise during the project that allow reaching the CO_2 mitigation goals more efficiently or are even able to mitigate more than anticipated, it should be possible for third parties to step in to be able to implement their ideas. Another factor that was considered as an influence on the CO_2 mitigation goals was that not every stakeholder was aware of the CO_2 mitigation goals of the initiative(s) they were working on. Awareness of these goals may give an indication during the development and implementation of the initiative, whether the initiative is on the right way to reach these goals. Without knowing what the CO_2 mitigation goals are, it makes it difficult to reach them. Finally, the lack of a decision-making and organizational structure has already led to a delay of the initiatives. The division of roles is unclear and there is no stakeholder or person that is leading and being decisive which speeds up the decision-making process. Due to a delay, the initiatives may be implemented too late which can result in reaching the initiatives' objectives not in time.

Overall, this shows that there are not many smart city governance elements that contribute to reaching the CO_2 mitigation goals of the project and initiatives in Rotterdam, while the challenges and governance elements that were lacking have already had some influence in reaching these goals. The stakeholders in Rotterdam are also aware of this as six out of eleven stakeholders think that the project/initiatives will not reach the CO_2 mitigation goals. The main reason for this is because they argued that the goals were set as too ambitious. However, they stated this was partly done to be able to receive the European Horizon2020 funding for the project as in theory the CO_2 mitigation goals could be reached. Other given reasons were that the project is already experiencing issues and could therefore not reach the ultimate goals, the previously discussed financial challenges, and the limitations of existing cities which makes it hard to implement new technologies and adapt to already existing infrastructure. The other five stakeholders argued that they believe that the CO_2 mitigation goals will be reached. Despite the issues the project is already experiencing, they have faith in each other that the given issues will be solved and it will still be in time for the project and initiatives to reach their goals.

In conclusion, there are still many challenges to be solved in Rotterdam in order to reach the set CO_2 mitigation goals of the project and initiatives. It is difficult to state the exact influence of smart city governance on this, but it can be argued that several elements bring challenges and can influence whether an initiative will be successfully implemented and reach the CO_2 mitigation goals.

4.4 Umeå

4.4.1 City Background information

Umeå is the fastest growing city in Sweden north of the Stockholm region. The city is located on the Ume River, and has a subarctic climate with short and reasonably warm summers. Umeå is the biggest city in the province of Norrland, the capital of Västerbotten County and the 11th biggest city in Sweden. The Umeå University was established in 1965 and this sped up population growth significantly. Over the last 40 years, the population increased over 60% to approximately 120.000 inhabitants in 2016. The establishment of the university has affected the city with a young population of which most are born outside the municipality and of which around 10% is born outside Sweden. At this moment there are two universities with over 39.000 students and 700 to 800 new apartments are constructed every year. The city has been nominated for the Green Capital award in 2016 and 2017 showing that environmental sustainability is an important topic on the agenda (TNO, personal communication, October 5th, 2016).

This is also visible in the overall vision of Umeå which stresses continued social, economic, and environmental sustainable growth. This outlined by the City Council, as well as in the six development strategies adopted in the city-wide master plan. Development strategies such as more efficient land use, less care use, promoting public transport, cycling and walking, smarter energy systems solutions with lower climate impacts can help to reach the objective of reaching a climate neutral energy system by 2018 and reducing CO_2 emissions by 50% by 2025 (compared to 1990). Access to open data and active involvement of monitoring, evaluating, and research in projects can open up opportunities for knowledge sharing and benefit all involved stakeholders (TNO, personal communication, October 5th, 2016).

There are various plans impacting Umeå's smart city context and ambition such as the SEAP, which is a city master plan, and an in-depth master plan for the campus area. The objective is to sustainably grow to 200.000 inhabitants by 2050. Sustainability plays here an important role and comes back in nearly all the strategies that are developed by the City Council. Overall, Umeå is actively involved in tackling urban problems, and developing the city in a smart and sustainable way (TNO, personal communication, October 5th, 2016).

4.4.2 City Project Background information

The Ruggedised city project of Umeå is the Innovation District that is located in the University area to the east of the Umeå city center (figure 6). This area includes a mix of residential, academic, and research facilities from two universities, a regional hospital, and community, recreational, and commercial buildings. The object of Ruggedised here is to facilitate a unified 'smart district' that focuses on (environmental) sustainability and new technologies, which is supported by planned regeneration and new developments in the area, and investment of public and the private sector by around 600 million euros between 2016 and 2025 (TNO, personal communication, October 5th, 2016).

The university area that has been studied is the largest workplace hub in northern Sweden and has local, regional, national, and international relevance. This area uses new technologies and ICTs in an integrated and 'smart' manner in order to improve the urban environment. Isolated from each other,

each smart initiative holds a high degree of complexity, however it will be the connection between them that will make them truly smart. The area includes over 12.000 employees and about 40.000 daily visitors. It must be noted that although the area is a large workplace hub, only 3000 people live here which is a small amount related to other city districts. However, during the Ruggedised project, it is expected this amount will triple due to the construction of many new apartments. The district includes seven neighborhoods, each with its own characteristics, and they all have a separate development agenda that is part of the whole area master plan. Despite the area being located close to the city center, the Innovation District has historically not always been perceived as an integrated part of the city. The district is characterized by its young, student-influenced population. It is one of the least car-dependent neighborhoods in Umeå and has a relatively high share of bikes compared to the rest of the city (TNO, personal communication, October 5th, 2016). For the Ruggedised project, there are a total of nine smart initiatives with seven different stakeholders involved, namely 1) the municipality of Umeå (UK); 2) Akademiska Hus (AH); 3) Västerbotten County Council (VCC); 4) Umeå Energi (UE); 5) UPAB; 6) Umeå University (UU); and 7) SP/RISE (table 10). A brief description and overview of all the studied initiatives, the role of the stakeholders, and the known CO_2 and/or energy targets can be found in Appendix 8.9.
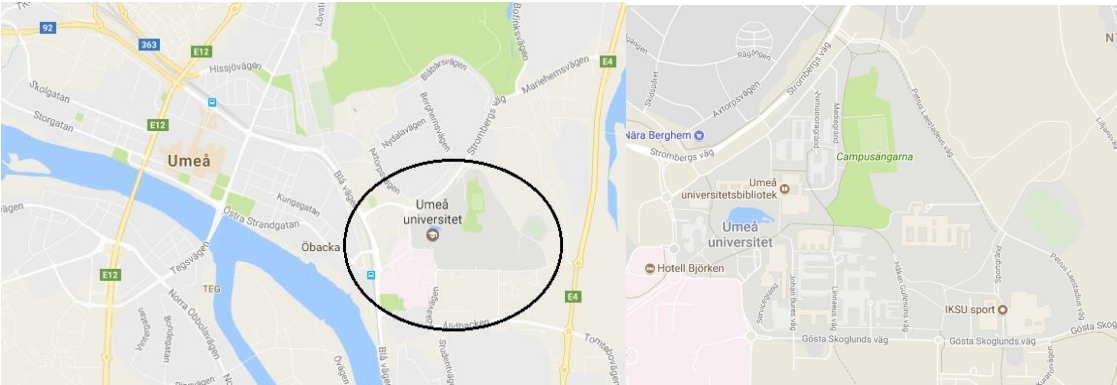
Figure 6: Geographical location of Umeå Smart Campus Innovation District (Google Maps, 2017b).

Table 10: Analyzed Umeå Smart Initiatives.

Code	Smart Initiative	Stakeholders	Expected CO_2 Savings
Smart Thermal Grid			
U1	Smart City connection to 100% renewable Energy	UE, AH, VCC	100% climate neutral
U2	Peak load variation management and power control	UE, AH, VCC, SP, UU	Reduce energy use 15%
U3	Geothermal heating/cooling storage and exchange	VCC, AH, UE	N/D
U4	Energy optimized Electric BRT-station	UK, UPAB, AH	N/D
Smart Electricity Grid & E-mobility			
U5	EV-charging hub. Storage and exchange, and optimization of the integration of RES in the grid	UE, AH, VCC, UPAB, UK	100% fossil free by 2020
U6	Energy-efficient land use through flexible green parking pay off	UPAB, UK, AH	N/D
U7	Intelligent building control and end user involvement	UE, AH, UU, VCC, SP	N/D

Energy Management and ICT			
U8	Smart Open Data city Decision platform	UK, UU, AH, UE, UPAB, VCC, SP	N/D
U9	Demand-side management	AH, UU, UK	Energy consumption lowered 15% by 2020
Total			N/D

Sources: TNO (personal communication, October 5th, 2016), Ruggedised (2017d), Ruggedised (2017e), and Ruggedised (2017f).

4.4.3 Results and Analysis

In this section, the results of the research will be analyzed. In total, four questionnaires out of the nine questionnaires sent were filled in and one interview was performed with the project leader of the Umeå project from the municipality of Umeå (table 11). Although not all stakeholders responded, the retrieved data from the filled in questionnaires and the interview still allowed getting a perspective of the presence of smart city governance elements, and challenges in the project. In Appendix 8.11.2, the categorization and quantitative data of the retrieved data can be found. This section analyzes these results.

Table 11: Questionnaires and interviews per stakeholder group in Umeå.

	Government	Private Companies	Researchers	Total
Questionnaires	2	2	0	4
Interviews	1	0	0	1

First of all an analysis of the presence of smart city governance will be performed based on the smart city governance elements and their criteria derived from questionnaires and interviews. Subsequently the governance challenges in the project and initiatives are discussed, and finally a connection between the presence of smart city governance, the challenges, and the influence these can have on the CO_2 mitigation goals of the Umeå city project, will be discussed.

Presence of Smart City Governance
Element 1: Integrated Vision   Presence: +
Criterion: Presence of a plan/document with a long term integrated vision including CO_2 mitigation goals

There are various plans in Umeå impacting the city's smart city context and ambition such as the Sustainable Energy Action Plan, City Master plan, and an in-depth Master plan for the campus area that can be applied on the city project. According to the government, these plans have a long term integrated vision together with CO_2 mitigation goals. However they are often not clearly described and could be more concrete. Everything that is being developed needs to have a sustainability factor in it. An example is given for the project area in Umeå. The amount of people living there will increase significantly in the future which means the energy use will also increase. However due to an integrated vision, a goal has been made that despite the development of the area and increasing amount of people living there, the energy use and footprint of the area should lower or stay the same. Such an integrated vision can have a positive effect on lowering energy use and reducing CO_2 emissions. However this perspective is not shared with the private companies. According to them,

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there is no plan or document that includes an integrated vision. Nonetheless, they state having an integrated vision is important and this has to be discussed in the near future. The difference between the answers of the stakeholder groups can be due to not knowing that this comprehensive plan exists or not has been communicated to the private stakeholders by the government.

Criterion: Presence of a shared vision between stakeholders
The stakeholders agree there is a shared vision in the project which can avoid conflicts, and help the development of the initiatives. This could also be seen when was asked for the ultimate goal of the project and initiatives. There was an overall agreement what the ultimate goal of the project and initiatives is between the private stakeholders and government. Both mention that the ultimate goal is to develop the initiatives and to reduce climate impact. Additionally the government sees the creation of a sustainable part of the city one of the main goals. This is on an environmental, financially, as well as social level. The aim is to build towards a sustainable city, and not a smart city per se. The smart city is seen as a means towards becoming sustainable. Finally, an additional goal that was mentioned was the creation of business models which is needed in order to implement the initiatives.

"We have to build sustainable cities. We are not allowed to build a city that is not sustainable in the future (Government Stakeholder)".

In conclusion, the presence of several plans which include an integrated vision and the presence of a shared vision between stakeholders makes that the integrated vision in this project is mostly present. Due to private stakeholders not knowing about integrated visions in the different plans, and indicating that the integrated visions could be described more clearly, a full score was not given.

Element 2: The use of ICTs   Presence: +/-
Criterion: The degree that ICTs helps to increase helps to: 1) Increase citizen participation, 2) Simplify interactions between stakeholders, 3) Improve internal administrative operations, and 4) Improve urban services.
The governmental actors indicate that ICT in the project only slightly helps to increase citizen participation, simplify interaction between stakeholders, improve internal administrative operations, and improve urban services. However, it was mentioned that this is due to the project being still in the starting phase and the implementation of this has not started yet. In the future of the project, the goal is to make sure ICTs help to increase specifically citizen participation and urban services extremely well in order to have successful initiatives. On the contrary, the private companies agree with each other that ICT helps the four different aspects very well. This could also be due to them predicting this for the future as it is too early to indicate in the Umeå project if this is currently the case. Therefore, due to differences between the governmental and private stakeholders, this element is considered moderately present.

Element 3: Legislation and Policies   Presence: +
Criterion: Helping and hampering policies and legislations that can influence CO_2 mitigation goals
Helping
Mostly helping policies and legislations were mentioned such as the presence of an energy policy, air quality policy, and sustainability policies and legislations, that help to implement the initiatives.

Hampering

Almost no hampering policies or legislations were mentioned that obstruct the implementation of the initiatives. The only hampering factor that is mentioned, are the business structures that are based on linear value chains. This can be seen as an 'old' way of thinking. Linear business structures are not designed to, for example, take into account initiatives that store energy and can deliver this back to households. Therefore it is difficult to adapt these linear business structures to several smart initiatives in the Umeå city project.

Due to only one hampering factor being mentioned, legislation and policies in Umeå seem to support the initiatives more than to hamper them. Therefore this element is considered mostly present.

Element 4: Innovation Capacity   Presence: ++
Criterion: Degree of how innovative capacity is being ensured/stimulated

Innovation is being ensured through close collaboration with all the involved stakeholders in the project by exchanging knowledge and expertise. Besides this, a private company has indicated that they specifically invest in innovation and development. However the largest factor that can stimulate innovation will be the development of an innovation platform where different (external) stakeholders can exchange ideas and find solutions to achieve goals. Besides this, an institute will be created by the government and university for sustainable city development and smart city development. It was indicated that this is however an idea and this process has not started yet.

Criterion: Amount of potential to keep innovating

All stakeholders agreed there is currently enough potential to keep innovating in the project. They pay close attention to innovation as could be derived from the criterion above.

As all stakeholders agreed there is enough potential to keep innovating and many examples were given of how innovative capacity is, and will be ensured, it is concluded this element is fully present.

Element 5: Collaboration and Participation   Presence: +
Criterion: Presence of synergies

All stakeholders agree that collaboration and participation is one of the most important elements of a smart city. The government indicated that current collaboration will help future collaboration with partners. In Umeå, collaboration between different stakeholders in the project has already led to integration and up scaling of initiatives. Both stakeholder groups indicated that the synergy has lifted the initiatives to a new level and all expected synergies were fulfilled. An example of this was given about the collaboration within the EV hub initiative (textbox 3). Synergies were also created with small companies or other semi-public companies that have a connection with the area. They are invited to dialog meetings where they have the possibility participate in city projects such as this one which indicates Umeå is open for participation and collaboration with third parties.

> Through collaboration, the EV Hub has been expanded to a block of buildings instead of one building originally. This was due to stakeholders indicating that close collaboration with each other during the development of the area would help to make the area more environmentally sustainable, and would later also be profitable financially. This has led to an up scaling of this initiative which can eventually lead to more energy reduction and CO_2 mitigation than was anticipated.

Textbox 3: Collaboration within the EV hub initiative.

Criterion: Synergies that have not yet been fulfilled

None of the respondents mentioned any unfulfilled synergies in the project.

Criterion: Presence of a dominating stakeholder

As regards to dominating stakeholders in the project, various answers were given. The governmental stakeholders disagreed with each other. One governmental stakeholder described that there is no stakeholder dominating and collaboration has a horizontal structure, whereas the other governmental stakeholder indicated that the government itself has a dominating structure due to having the role of facilitator, as well as the land owners who are dominating because the other companies depend on them in terms of their decisions in the project. This disagreement was also seen between the two private companies where one indicated the presence of horizontal collaboration, where the other company indicated a private party dominating due to the amount of knowledge and power they have within the project. This shows that, even when some stakeholders think collaboration is horizontal, other stakeholders can think the opposite.

Criterion: Level of citizen engagement

Regarding the participation and collaboration with citizens, both government and private companies agree with each other that currently citizens were only slightly to moderately engaged in the project. Both groups indicated that this is going to slightly improve in the future. Up until now, (paper) questionnaires were made and more citizen-involvement through (online) questionnaires and the open-data platform will be included in the future.

Overall, collaboration and participation is mostly present despite the lack of citizen participation and the different opinions of which stakeholder is dominating the project. Collaboration between stakeholders has resulted in integration and even up scaling of initiatives which indicates current collaboration is successful, whereas citizen participation could improve.

Element 6: Internal Coordination   Presence: ++

Criterion: Degree of communication between different departments, people, and agencies within an organization

Both governments and private companies have indicated that they each have a project coordinator, involve different departments, and have different coordination meetings and project group meetings within their organization. One governmental stakeholder indicated they held a project presentation within the organization to inform everyone about the city project. None of the stakeholders have indicated that there were any problems regarding internal coordination, resulting in this element being completely present.

Element 7: Decision-making Process   **Presence: +**

Criterion: Presence of a decision-making structure that is deliberately designed beforehand

There is a difference between the government and private companies whether the decision-making structure is deliberately designed beforehand. The private companies are divided whether the decision-making structure was designed beforehand or not. The government stated that it was designed before the project started, however also mentioned that this decision-making structure is currently flexible and is based on discussions and collaboration between the stakeholders. This could explain the division of the private companies. So far, monthly meetings between the stakeholders take place where nothing has come to a point where everyone disagreed with each other on how to move on. Because most companies are semi-public owned, it makes it easier to make decisions because their visions are similar. This can have a positive impact on the development of the initiatives and reaching their goals.

"They don't have the main goal to make money, but to make the area great. Because if the area is great, they are going to make money of it (Government Stakeholder)".

Criterion: Clearly defined and communicated stakeholder roles

According to three out of four stakeholders (whereas the fourth one did not know) all roles of all stakeholders are clearly defined and communicated. This makes it easier for example to know what to expect from each other during the project.

Criterion: Transparent decision-making

The decision-making process was considered transparent, whereas one private stakeholder disagreed. It was indicated that decisions were made in collaboration with all relevant stakeholders of which transparency was an important factor.

Criterion: Degree of help from ICT to make better decisions

Finally, none of the stakeholders knew whether data retrieved from ICT has helped to make better decisions. One of the governmental stakeholders stated that this is probably due to the early stage the project currently is in and this would change in the future.

Overall, although there are some minor disagreements and it is unknown whether data from ICT helps to make better decisions, the successful decision-making process between stakeholders and running in no major problems in the decision-making process results in this element being considered mostly present.

Element 8: E-administration   **Presence: ++**

Criterion: Activities that are undertaken to improve the transparency of stakeholders' actions.

Regarding E-administration, all stakeholders had three activities to improve the transparency of their own actions within the project. First of all, all meetings are documented and accessible for everyone involved in the project. Secondly, information is given about the project and process in newsletters, webpages and demos. For example, the government of Umeå is for example building a Swedish version of the Ruggedised project website. Thirdly, meetings with internal and external people allow being transparent to them, and gives them information about the project. Additionally it was mentioned that ICTs are, and will be used to interconnect and integrate information, processes and

physical infrastructure in order to improve the urban environment. Based on this information E-administration is considered completely present in the project.

Overall: Smart city governance   **Presence: +**

Overall, smart city governance is considered mostly present in Umeå. The different stakeholders have indicated that they do not experience many major issues in the project. Additionally the plans with an integrated vision, having a shared vision and successful collaboration between stakeholders may for example reduce issues and lower challenges in the project.

The stakeholders themselves pointed out that they thought most elements were moderately to very present. However the government stakeholder indicated that the integrated vision and decision-making process was slightly present whereas the private stakeholders indicated this was mostly present. The scoring of the governmental stakeholder is therefore also considerably different than based on the indicators and rating of presence of elements described above. Another difference between the stakeholder groups are the government stakeholder rating E-administration, and collaboration and participation as completely present, whereas the private stakeholders rated this as moderately present. Reasons for this could be the feeling that a private stakeholder is unwillingly being dominated or there are still certain issues between stakeholders that could still be improved.

Governance Challenges

When describing the presence of smart city governance, several specific challenges were already discussed (table 12). This section describes what stakeholders think are the most important challenges in the project, based on the criteria that were given in the questionnaire. Subsequently, it also elaborates on the other challenges which are present that have not yet been discussed. As many challenges are interconnected, no overview per criteria has been given as has been done in the previous section.

Table 12: Governance challenges and issues in Umeå.

Realizing a more effective use of ICTs
Developing an integrated vision for the project
Moving away from business structures that have a linear value chain
Increasing citizen engagement

There are not many differences between the two stakeholder groups regarding the challenges they consider important (textbox 4). One outlier is the legal and policy challenges. The governmental stakeholders rated this as slightly important while the private stakeholders rated this as very important. This is most likely due to one private stakeholder mentioning a hampering policy as was mentioned in the section above. This could also be due to the private stakeholders not having as much knowledge about policies and legislation as the governmental stakeholders and they could therefore see it as most challenging. Subsequently, both groups indicated that the privacy challenges are the least important and the challenges regarding collaboration are the most important. It was stressed in the questionnaires and interview multiple times by the stakeholders that collaboration was considered the most important challenge. This is likely due to when collaboration is going well, it is less difficult to solve the other challenges as together there is more knowledge, expertise, and financial resources available. Additionally, based on the presence of elements, the use of ICTs can

also be considered as an important challenge. The stakeholders indicated that the use of ICTs only slightly helps to increase citizen participation, simplify interaction between stakeholders, improve internal administrative operations, and improve urban services. It was indicated that this should improve in the future, however it is unknown when and how this will happen. Another challenge that was mentioned was the timespan of the project. It was argued that these kinds of development projects with a lot of innovation and ambitious goals would need more time to be able to reach the goals of the project. Finally, a private stakeholder indicated that the coordination and collaboration between different cities would be a challenge. This is most likely due to Rotterdam and Glasgow being different cities with a different project and setting making it for example hard to replicate initiatives. Despite this, all stakeholders indicated that challenges are being openly discussed with the other consortia from Rotterdam and Glasgow and within the consortium of Umeå. The next section elaborates on what for influence these challenges and the presence of smart city governance can have on the CO_2 mitigation goals of Umeå.

1. Collaboration
2. Environmental Challenges
2. Political Support
4. Financial Challenges
4. Technical Challenges
4. Lack of Leadership
7. Legal/Policy Challenges
7. Digital Divide
9. Privacy

Textbox 4: Importance of challenges according to stakeholders in Umeå.

Influence of smart city governance and the challenges on the CO_2 mitigation goals

Based on the retrieved information from the previous sections, it will be discussed what influence Umeå's governance has on the CO_2 mitigation goals in the city project. Smart city governance was considered mostly present in Umeå, and only several minor challenges were mentioned by the stakeholders. Due to putting sustainability as the most important priority in their plans, and having everything to be integrated with sustainability, this has a positive effect on the CO_2 mitigation goals. Having sustainability and energy policies also contributes to this. Additionally, the shared vision of stakeholders and the expansion of initiatives through collaboration such as the EV hub also have a positive impact on the CO_2 mitigation goals. By expanding certain initiatives, the impact of the initiatives will also grow, which in this case means more energy efficiency and lower CO_2 emissions. Noteworthy to mention however, is that the government stakeholder indicated that CO_2 goals of the project most likely would not be reached. A stakeholder indicated that this is most likely due to the lack of financial resources to develop the initiatives on the larger scale the goals are set for. An example was given where an initiative could be developed for a small part of a building, but not for the whole building, while this was necessary to reach the CO_2 mitigation goals. This means that other stakeholders have to invest more in the initiatives and they are not always willing to do that. This can influence the CO_2 mitigation goals when this leads to initiatives that are not being developed completely. This could be an explanation for why collaboration has been stressed as most important element, as through collaboration such issues could be prevented or solutions could be found, which can result in developing the initiatives completely and reaching the set goals.

The complete presence of innovation capacity can also have a positive impact in the future in Umeå. Besides the already done investment of innovation, the future development of an innovation platform that is accessible for different (external) stakeholders can help to increase innovation which can lead to a for example more efficient EV Hub or improved renewable energy sources which will then lead to lower CO_2 reductions. This is especially important for the long term of the project.

Regarding the E-administration and internal coordination in Umeå, it is difficult to assess a connection to their influence on CO_2 emissions. It can be said that these elements indirectly influence CO_2 mitigation goals as a full presence of both elements can result in a more efficient organization and process of the project, which can help to develop and reach the goals of the initiatives. This is the similar for the use of ICTs element. Although this was considered moderately present, it was argued that it was too early in the project stage to make statements about whether ICT has made an impact so far as most initiatives are still being developed. However, for the future, the use of ICTs is expected to significantly contribute to the CO_2 goals as data and information can be gathered and spread more easily and insight on for example data on the energy usage of a building can be retrieved which would otherwise not be accessible.

Regarding aspects that could negatively influence reaching the CO_2 mitigation goals, it was mentioned that the CO_2 goals are very ambitious and it is hard to reach them in the time period of the project. Even though smart city governance in Umeå is considered mostly present, the development of the initiatives would need more time and it was considered difficult to measure the goals on a short term, while they are developed for a long time period. Citizen participation, in which Umeå is relatively lacking in comparison to the other elements, can also help the development of the initiatives. As has been said before, when there are not enough resources to develop initiatives completely, citizen engagement might offer solutions for the problems. Citizens can invest their time and use their knowledge for the initiatives, which can result in ideas which can be used to develop the initiatives. It is better to have citizens engage at the start of the project as changes to initiatives can still be made.

In conclusion, it is difficult to state the exact influence of smart city governance on the CO_2 mitigation goals in Umeå as the project is still in an early stage, however it can already be seen that some elements already have, and will have a positive impact on the CO_2 mitigation goals. By also addressing and redressing the challenges, these can be worked on in the future to be able to develop the initiatives successfully and can help to reach the CO_2 mitigation goals.

4.5 Glasgow

4.5.1 City Background information

Glasgow is a densely populated, post-industrial city located on the west coast of Scotland with almost 600.000 inhabitants. It is the biggest city of Scotland and is the main commercial hub and economic center of the region and Scotland. Over the last two centuries, Glasgow has developed from a carbon-intensive manufacturing city to a modern city which aims to become low-carbon in the future. There is a large contradiction among citizens across the city in terms of income, wealth, and opportunity. Almost half of the city's citizens live in 20% of the most deprived areas in Scotland. Air quality is a big issue in Glasgow, with the city center being designated as an Air Quality Management Area due to high levels of NO_2. This is most likely caused by the high amount of motorways that are running through the city center. Glasgow aims to achieve 30% CO_2 reduction by 2020 (compared to 1990) for which it currently is on goal due to the many smart initiatives the city is involved in (TNO, personal communication, October 5th, 2016).

Glasgow aims to become a sustainable, connected, and healthy city through innovative smart initiatives. It aims to be one of the most sustainable cities in Europe over the next 20 years. Therefore it created several policies and plans such as the Energy and Carbon Master plan, which focuses on Glasgow's carbon reduction target of 30% in 2020 compared to 2006 (GCC, 2014), and the Digital Glasgow Program, which aims to make Glasgow a leading digital city by 2020. These are several examples to show Glasgow is actively engaged in becoming a smart and sustainable city (TNO, personal communication, October 5th, 2016).

4.5.2 City Project Background information

For the Ruggedised project, Glasgow will create a 'Smart Corridor District' that is located along George Street and Duke Street in the city center (figure 7). This district has a mix of residential, community, academic, retail and industrial facilities. The University of Strathclyde is located in the area and contains different university buildings and student accommodations. Challenges in this district are the ageing infrastructure, air pollution, and the many citizens facing fuel poverty due to high fuel costs and electrically heated housing.
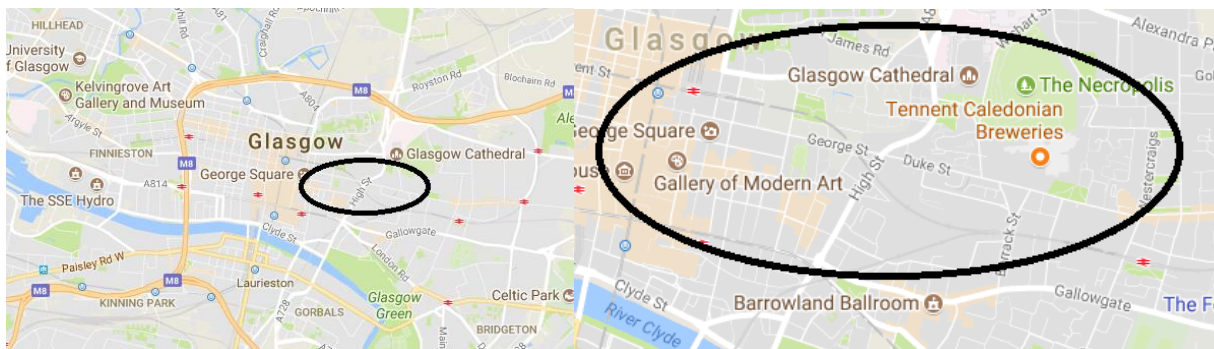
Figure 7: Geographical location of Glasgow Smart Corridor District (Google Maps, 2017c).

The initiatives in the district aim to combine the many challenges and opportunities the district has to offer. So can the improving of air quality be combined with the electric vehicle charging infrastructure, and this can be tied with other challenges such as infrastructural decay. A total of ten smart initiatives and seven partners must help the area to become more energy efficient and

decrease the CO_2 emissions (table 13) (TNO, personal communication, October 5th, 2016). The partners involved are 1) Glasgow City Council (GCC); 2) Tennent Caledonian Brewery (TCB); 3) Wheatley Group (WG); 4) SP Energy Networks (SP); 5) University of Strathclyde (US); 6) Siemens (SIE); and 7) Transport Scotland (TS). A brief description and overview of all the initiatives, the role of the stakeholders, and the CO_2 and/or energy targets can be found in Appendix 8.10.

Table 13: Analyzed Glasgow Smart Initiatives.

Code	Smart Initiative	Stakeholders	Expected CO_2 Savings
Thermal Smart Grid			
G1	Heat and Cold exchange - Connection of buildings to district heating network	GCC, TCB, WG, US	N/D
Smart Electricity Grid and E-mobility			
G2	Battery storage technology as grid balancing mechanism & Supply of RES to EV charging and battery infrastructure/ Innovative connection to renewables and storage	GCC, TS	N/D
G3	Surplus power storage in EV Charging hub	TCB, SIE, SP, GCC	N/D
G4	Optimization of the integration of near site RES, potentially liked into battery storage	GCC, US, SP	N/D
G5	EV Charging hub in city center car park	GCC, SIE, TS	N/D
G6	Intelligent LED street lights with integrated EV charging functionality, wireless communications network, and air pollution monitors	GCC, TS	N/D
Energy Management and ICT			
G7	Smart open data Decision platform/central management system	GCC	N/D
G8	Implementation of demand-side management technology in street lighting	SIE, GCC	N/D
G9	Implementation of demand-side management technology in domestic properties	SIE, WG, GCC	N/D
G10	Implementation of demand-side management technology in nondomestic properties	SIE, GCC	N/D
Total			N/D

Sources: TNO (personal communication, October 5th, 2016), Ruggedised (2017d), Ruggedised (2017e), and Ruggedised (2017f).

4.5.3 Results and Analysis

In this section, the results of the research will be analyzed. In total, one questionnaire out of the five sent were filled in and no interviews were performed due to a lack of contact information and stakeholders that were unwilling or unable to respond (table 14). The only stakeholder that filled in the questionnaire was the project coordinator of the municipality of Glasgow. Due to this project coordinator leading the project in Glasgow, this still allowed to gain a perspective of the presence of smart city governance elements and challenges in the city project, however no comparison could be made between the stakeholder groups. This should be kept in mind while reading the analysis below. In Appendix 8.11.3, the categorization and quantitative data of the retrieved data can be found. This section analyzes these results.

Table 14: Questionnaires and interviews per stakeholder group in Glasgow.

	Government	Private Companies	Researchers	Total
Questionnaires	1	0	0	1
Interviews	0	0	0	0

First of all an analysis of the presence of smart city governance will be performed based on the smart city governance elements and their criteria derived from questionnaires and interviews. Subsequently the governance challenges in the project and initiatives are discussed, and finally a connection between the presence of smart city governance, the challenges, and the influence these can have on the CO_2 mitigation goals of the Glasgow city project, will be discussed.

Presence of Smart City Governance

Element 1: Integrated Vision   Presence: +/-

Criterion: Presence of a plan/document with a long term integrated vision including CO_2 mitigation goals

The government indicated that there is currently no plan or document of this project that includes an integrated vision specifically for this project. However, it was mentioned that there are several smart integrated projects in the city that enhance the benefits of them delivered to the city whilst meeting multiple objectives. Additionally, the city's Energy and Carbon Master Plan also stresses the integration of policies and projects to have beneficial social, economic, and environmental outcomes to promote sustainable development and lower CO_2 emissions (GCC, 2014). This integrated vision on a city level is also being applied on individual projects such as the Glasgow Smart Corridor District. The government stated that an integrated vision specifically for this project would be beneficial and one will be developed in the near future.

Criterion: Presence of a shared vision between stakeholders

The government argued that all stakeholders in the project shared the same vision. This would be that the goal of this project is to progress the city further towards becoming a smart, sustainable, and connected city. This is done through maximizing the interconnectedness between the initiatives and to utilize data to create new decision-making models. With this, the initiatives and corresponding methods should be able to be replicable in different projects and different cities.

Overall, due to the lack of an integrated vision specifically for this project, but having an integrated vision on a city level, and because of the existence of a shared vision, an integrated vision is considered moderately present.

Element 2: The use of ICTs   Presence: +/-

Criterion: The degree that ICTs helps to increase helps to: 1) Increase citizen participation, 2) Simplify interactions between stakeholders, 3) Improve internal administrative operations, and 4) Improve urban services.

The government has rated that the use of ICTs helps to increase citizen participation, simplify interactions between stakeholders, improve internal administrative operations and improve urban services moderately well. As no other additional data could be collected regarding this element, the presence of this element is considered moderately present.

Element 3: Legislation and Policies   **Presence: +**

Criterion: Helping and hampering policies and legislations that can influence CO$_2$ mitigation goals

Helping

It was mentioned there are several policies in the form of plans on a city level such as the Energy and Carbon Master Plan, Resilience Plan, Climate Change Adaptation and City Mitigation Plan, and the City Development Plan that help to support the smart initiatives in the city project and address the reduction of CO$_2$ emissions. These are supported by national policies such as the Climate Change Strategy, the Energy Strategy, building regulations and developing District Heating Regulations. The local policies and plans strive towards promoting more integration of initiatives and creating an integrated approach towards the development and planning of a sustainable Glasgow (GCC, 2010; GCC, 2014).

Hampering

According to the government, a hampering factor that hinders the development of the district heating initiatives in the project is the lack of district heating regulations and national policy on business rates applying to district heating. This makes it difficult to create a profitable business case for all involved stakeholders. Due to this being the only hampering factor that was mentioned, the presence of this element is considered mostly present.

Element 4: Innovation Capacity   **Presence: ++**

Criterion: Degree of how innovative capacity is being ensured/stimulated

According to the government, the innovation capacity in the project is being ensured through the development of a start-up incubation hub to be able to provide the right environment for innovation to flourish and develop into sustainable business models. This provides a platform for stakeholders that are also currently not involved in the project to innovate, keep developing better initiatives, and help to meet challenges of urban governance.

Criterion: Amount of potential to keep innovating

The government stakeholder indicated that there is enough potential to innovate in the project. It was indicated this is due to the above mentioned measurements.

Because innovation capacity is being ensured and there is enough potential to innovate, the presence of this element is considered completely present.

Element 5: Collaboration and Participation   **Presence: +**

Criterion: Presence of synergies

The government stresses that there is synergy in the project, however states that this is not created automatically. Although on paper synergy is apparent in the ultimate objectives, this does not necessarily have to be the same in the delivery of the objective. Private stakeholders sometimes have a very specific and self-motivated agenda that can cause tension with the wider local government agenda. The government stakeholder stresses synergy in the project is only met when the benefits of the objective are many and varied. However, this can be hard to achieve and can sometimes cause difficult situations of collaboration between private stakeholder and government. The government for example argued that gaining sufficient financial resources and knowing where to exactly invest it

in when developing business models can form can form a problem. Nonetheless, synergies in the project are created such as in the battery storage initiative (textbox 5).

> The synergy between stakeholders that was created during the design of the battery storage has helped to develop further understanding of the storage market and the local government objectives in relation to this, while also providing the government the means by which to design the required system. This synergy has led to increased knowledge about this which also could be used for the design of other initiatives.

Textbox 5: Synergy during the design of the battery storage.

Criterion: Synergies that have not yet been fulfilled

The government stakeholder did not mention any unfulfilled synergies in the project.

Criterion: Presence of a dominating stakeholder

The government stakeholder specified that there is currently no party dominating the partnership, however also mentioned that this is not the desired situation. This can mean that there is a lack of leadership or a strive for a coordinating party or person that takes the lead in order to take responsibilities and manage the implementation of smart initiatives, city infrastructures, human assets and other immaterial capitals.

Criterion: Level of citizen engagement

For the city project, there has been no citizen engagement in the preparation phase of the project, while in the starting phase of the project citizens are mostly engaged. For the rest of the project, the government indicated that citizens will be moderately engaged. The government mentioned that a framework will be set up in order to engage citizens in the decision-making, including the development of a bottom-up approach in the city project. The sudden increase of citizen engagement from the preparation phase to the starting phase of the project can indicate that the government has first developed ideas regarding the initiatives where no citizen engagement was deemed necessary, and is currently engaging citizens in order to collect their perspectives, criticisms, and suggestions in order to enhance the initiatives. This allows the stakeholders in the project to make choices that fulfill the needs of the population better and can result in more insight or improvements of the initiatives. Besides the focus on citizen participation, the government has an active engagement strategy in place where people within the government such as politicians, senior officials, and other employees in the government are engaged, but also stimulates engagement of stakeholders outside the government organization such as academics, experts, and interested parties in the project.

Overall it is difficult to assess the presence of this element as only one perspective could be given, while for collaboration and participation a multiple perspective assessment should be made in order to assess it effectively. However based on the provided information, the element is considered mostly present as synergies are created and citizens are increasingly being engaged in the project, which are important criteria for successful collaboration and participation in smart city governance.

Element 6: Internal Coordination   **Presence: ++**

Criterion: Degree of communication between different departments, people, and agencies within an organization

A coordinator has been appointed in the government organization who coordinates different people from different departments. This has led to a more effective collaboration within the government. As no issues were mentioned by the government stakeholder within the government organization, and effective coordination was stressed within the government organization, this element is therefore deemed completely present.

Element 7: Decision-making Process   **Presence: +**

Criterion: Presence of a decision-making structure that is deliberately designed beforehand

The government indicated that the decision-making structure of the project and smart initiatives was deliberately designed beforehand in a collaborative way. It was argued that this helps to make decisions that are ultimately most beneficial for all involved stakeholders' objectives.

Criterion: Clearly defined and communicated stakeholder roles

The government stakeholder stated that the roles of all stakeholders in the project are clearly defined and communicated. It was not indicated there were any problems regarding this.

Criterion: Transparent decision-making

The government stakeholder did not know whether decision-making is transparent.

Criterion: Degree of help from ICT to make better decisions

Data retrieved from ICT has helped to make better decisions such as in the smart open data decision platform initiative and intelligent LED street lights initiative. It was argued that data retrieved from ICTs has helped significantly during the development of the initiatives.

Overall, as the transparent decision-making indicator is lacking, but all other indicators are present, this element is considered mostly present.

Element 8: E-administration   **Presence: -**

Criterion: Activities that are undertaken to improve the transparency of stakeholders' actions

The government indicated that the public administration's transparency still needs to be improved in the project. This is relevant for stakeholders involved within the project but also stakeholders outside of the project such as citizens or companies that want insight of what is happening in the project. There is for example no information on the city website about the project or the activities that are happening in the project. There is however very limited information on the Ruggedised project website about the activities and process of the project in Glasgow. Due to the very limited amount of transparency, and due to own indication of the government that this needs to be improved, this element is considered slightly present.

Overall: Smart City Governance   **Presence: +**

Despite E-administration being slightly present and the integrated vision and use of ICTs moderately present, the overall presence of smart city governance in the Glasgow Smart Corridor District can still be considered mostly present. The other five mostly to completely present elements are of major

importance in realizing the initiatives and give an indication that they fulfill most requirements of the smart city governance concept. There were almost no major issues mentioned and despite some hick-ups, the overall smart city governance process seems to go well. Besides this, the government has also indicated there are future plans to improve the lower scored elements in the project.

The government scored the presence of elements themselves as moderately to mostly present in the project. However it should be noted that this conclusion of smart city governance being mostly present in the project is a sole government perspective. As could be seen in Glasgow and Rotterdam, the government stakeholders generally also scored the elements more positive than the other stakeholder groups.

Governance Challenges

When describing the presence of smart city governance, several specific challenges were already discussed (table 15). This section describes what the government stakeholder thinks are the most important challenges in the project, based on the criteria that were given in the questionnaire. Subsequently, it also elaborates on the other challenges which are present that have not yet been discussed. As many challenges are interconnected, no overview per criteria has been given as has been done in the previous section.

Table 15: Governance challenges and issues in Glasgow.

Developing an integrated vision for the project
Increasing transparency
Realizing a more effective use of ICTs
Hampering policies and regulations on district heating
Different agendas of government and private stakeholders
Increasing citizen engagement

Although smart city governance has been scored as mostly present, and the challenges derived from the elements are limited, according to the government there are still many challenges that are deemed very important. The government indicated that all challenges but one as proposed in the questionnaire were extremely important with the lack of leadership challenge scored as very important (textbox 6). This indicates that the government is aware that there are still challenges and improvements to be made. Most of these challenges can be faced by improving the smart city governance. For example the high amount of citizen engagement in Glasgow can help to identify privacy related challenges of the initiatives which can then be discussed and solved, and through successful collaboration most differences between stakeholders were solved which has led to developed initiatives that are profitable for all involved stakeholders. The next section elaborates on what for influence these challenges and the presence of smart city governance can have on the CO_2 mitigation goals of Glasgow.

1. Financial Challenges
1. Technical Challenges
1. Environmental Challenges
1. Privacy
1. Political Support
1. Digital Divide
1. Collaboration
1. Legal/Policy Challenges
9. Lack of Leadership

Textbox 6: Importance of challenges according to the government stakeholder in Glasgow.

Influence of smart city governance and the challenges on the CO_2 mitigation goals

Smart city governance has been considered mostly present in Glasgow with several challenges identified that can affect the development of the initiatives and the CO_2 mitigation goals. The lack of an integrated vision specifically designed for the project can for example hamper the integration between the initiatives, which can result in isolated initiatives that will not be able to cooperate and enhance each other. However, there are policies and legislations on a city level that focus on sustainability and have an integrated vision. For example the objective of the city to reduce CO_2 emissions by 30% in 2020 from 2006 levels, and integrating energy planning into their sustainable city planning helps the city project significantly. Also the complete presence of the innovation capacity element with the development of a start-up incubation hub that is accessible for different stakeholders can help to increase innovation. This can lead to improved efficiency of initiatives in the future, such as a more efficient energy use of initiatives i.e. the EV charging hub. Subsequently, data retrieved from ICT helps to make better decisions such as in the smart open data decision platform where collected data will be analyzed to enhance energy planning in the city.

So far, some elements have had an indirect positive influence on the CO_2 goals depending on whether an initiative was successfully implemented. The thus far successful collaboration and decision-making between stakeholders has resulted in the development of initiatives with different objectives. When the collaboration and/or decision-making process would have been unsuccessful, initiatives could have failed which has a direct negative impact on reaching the CO_2 emission goals. Similar to Rotterdam and Umeå, it is difficult to assess the influence of the internal coordination element on the CO_2 mitigation goals. However it can be argued that the complete presence of this element can result in a more efficient organization and process of the project, which can help to develop and reach the goals of the initiatives.

Regarding aspects that could negatively influence reaching the CO_2 mitigation goals, the lack of transparency of the government makes them closed off to other stakeholders. If it is not visible to other stakeholders what and how well the government is doing in the project, they cannot offer their services in order to help. For example, if the government made clear that they are falling behind on schedule and CO_2 mitigation goals would possibly not be reached, other stakeholders such as citizens or companies can offer solutions, knowledge or financial resources in order to help the government reach their goals. Therefore it can be argued that this element being slightly present can negatively affect CO_2 mitigation.

Finally, despite the smart city governance elements being mostly present and a limited amount of challenges mentioned, the government has stated that they think the project and solutions will not reach the CO_2 mitigation goals in isolation, but only when replicated. This replication of the initiatives in the project needs more time to take place as possibly other stakeholders require being involved and new plans and decisions must be made in order to realize this replication. This can result in not reaching the CO_2 mitigation goals of the project in time.

However, as can be concluded from the above analysis, this replication can be successful when all stakeholders in the project are aware of the challenges they face and when aspects of the governance elements that were scored lower on will be improved. This way, CO_2 mitigation goals can still be met although it was indicated this will most likely not be in time for the project duration.

4.6 Comparison between the cities

After an analysis of each city explaining the presence of smart city governance, identifying their challenges, and making the connection to its influence on the CO_2 mitigation goals, in this section a brief comparison between the cities will be made explaining the main differences and similarities between the cities. In table 16 an overview is given of the presence of smart city governance. The Rotterdam city project scored the lowest of all three cities regarding the presence of smart city governance. Although Umeå and Glasgow received the same overall score, Umeå scored better than Glasgow per individual smart city governance element. When looking at the main challenges in the city projects (table 17), Rotterdam had the most challenges identified in their city project, whereas Umeå had the least identified challenges. Glasgow was in between these two city projects and had several challenges they were struggling with such as with transparency, and the lack of an integrated vision. However, note that these results may be influenced by the limited amount of respondents in Umeå and Glasgow.

Table 16: Presence of Smart City Governance in the three cities.

	Rotterdam	Umeå	Glasgow
Integrated Vision	-	+	+/-
Use of ICTs	+/-	+/-	+/-
Policies and Legislations	-	+	+
Innovation Capacity	+	++	++
Collaboration and Participation	+/-	+	+
Internal Coordination	+	++	++
Decision-making	-	+	+
E-administration	+	++	-
Total: Smart City Governance	+/-	+	+

Differences

There are a couple main differences between the city projects. One of the most important ones is the different stakeholders that are involved in the city projects. Whereas Umeå is only working together with semi-public companies, Glasgow and Rotterdam are collaborating with private stakeholders. The analysis has shown that that this can influence collaboration and decision-making. For example, the shared vision between stakeholders in Umeå and efficient collaboration has already lead to unexpected up scaling of certain initiatives whereas for example in Rotterdam initiatives have been delayed due to a difference in visions and several struggles regarding collaboration.

Another difference between the three city projects were the lack of policies and legislations in Rotterdam regarding smart cities and sustainability, and having a clear integrated vision regarding this, whereas for Umeå and Glasgow, documents could easily be found regarding future plans for sustainability and smart cities. Besides this, these plans contained an integrated vision whereas for Rotterdam this was not the case. Additionally, there were also many hampering policies and legislations identified by the private stakeholders in Rotterdam that could endanger a successful implementation of the initiatives. In Umeå and Glasgow only one hampering factor was mentioned. This difference might be explained by the presence of many policy documents regarding smart cities and sustainability in Umeå and Glasgow compared to Rotterdam. The policies of those two cities can prevent or identify possible hampering factors that may play a role in the city project.

Table 17: Identified challenges in the three city projects.

	Rotterdam	Umeå	Glasgow
Integrated Vision	- Developing an Integrated Vision for the Project - Ensuring a shared vision for the project	- Developing an Integrated Vision for the Project	- Developing an Integrated Vision for the Project
Use of ICTs	- Realizing a more effective use of ICTs	- Realizing a more effective use of ICTs	- Realizing a more effective use of ICTs
Legislation and Policies	- Addressing hampering policies and legislations - Addressing issues derived from old and existing contracts	- Moving away from business structures that have a linear value chain	- Addressing hampering policies and regulations on district heating
Innovation Capacity	- Increasing flexibility and participation of third parties		
Collaboration and Participation	- Increasing citizen engagement - Lack of a clear overview of stakeholder roles	- Increasing citizen engagement	- Different agendas of government and private stakeholders - Increasing Citizen Engagement
Internal Coordination	- Having the same priorities within government departments		
Decision-making	- Lack of a decisive project leader or stakeholder - Lack of a decision-making structure		
E-administration			- Increasing Transparency
Other Challenges	- Creating a visible and tangible result on short term	- Creating a visible and tangible result on short term	- Creating a visible and tangible result on short term

Concerning innovation, although all three city projects had a positive score, there was a clear difference regarding the allowance and involvement of third parties that are being engaged in the city projects to participate or share their ideas about the project. In Umeå and Glasgow this was realized through an innovation platform and meetings whereas the stakeholders in Rotterdam argued that Rotterdam is not very open to this and leaves these parties out of the project which could hinder innovation. This difference can be explained due to the creation of closed contracts in Rotterdam where it is determined in advance which stakeholders participate in the city project.

Rotterdam also scored lower than Umeå and Glasgow regarding citizen participation in the project. Although this also could be improved in both of these cities, Glasgow and Umeå stated that citizens are currently increasingly being engaged through for example (online) questionnaires and the (future) implementation of open data platforms. They are further advanced with this than Rotterdam as they indicated that citizens only slightly have been engaged in the city project and they still have to make plans about how, if, and when they are going to engage more citizens in the project.

There was also a difference regarding the decision-making element in all cities. Whereas in Glasgow and Umeå the roles of each stakeholder were clearly defined and there was a decision-making structure that was clear to all stakeholders, this was not the case in Rotterdam. There was often no clarity about who is responsible regarding certain aspects of the project/initiatives and it was indicated this is one of the reasons this has resulted in a delay of some initiatives. Most stakeholders in Rotterdam stated however that this was one of the top priorities that were going to be discussed in the near future, and several indicated that this should have already been clear at the start of the project.

Finally, regarding the E-administration element, the government stakeholder in Glasgow indicated that improvement was necessary regarding their transparency in the project as this was currently very limited. Rotterdam and Umeå had a positive score where they indicated to be transparent regarding their administration and documentation in the project. An explanation for this difference could be that Glasgow simply not thought about being transparent in the project, or discussing confidential information could be a reason why Glasgow has not been very transparent yet.

Similarities
Regarding similarities between the three cities, the use of ICTs was scored as moderately present in all city projects. It was indicated that the projects are currently in a too early stage to make statements about this. When the initiatives have been implemented, most stakeholders indicated ICTs would be able to increase citizen participation, simplify interactions between stakeholders, improve internal administrative operations and improve urban services.

Every city project had a positive score on the innovation capacity as most stakeholders could give examples of how to make sure innovation capacity was being ensured and argued that there was enough potential to keep innovating in the projects. This could be explained by the high importance innovation has on the agendas of the stakeholders.

The internal coordination element also retrieved a positive score as based on the retrieved data. All stakeholders stated they worked together with different departments or people with different backgrounds and mentioned no problems within their organization, with the exception of Rotterdam, where a private stakeholder mentioned that different departments within the municipality of Rotterdam had different views regarding the amount of risks that should be taken in the city project.

A final challenge that was mentioned in all the cities was the short time frame of the project in which they have to develop and implement the initiatives. Most initiatives are innovative and require new methods and techniques to realize. This costs time and can bring unexpected and new challenges, as could be seen in this section. Being unable to implement the initiatives and overcome challenges in time can result in not reaching the goals before the end of the project.

Overall, it can be seen that there are several differences in the city projects regarding the challenges and smart city governance elements. Now the main similarities and differences between the city projects have been identified, it will be indicated what this means regarding the influence on CO_2 mitigation goals. This will be discussed in the conclusion.

5. Conclusion

This research had two objectives: 1) To develop a model that clearly describes the smart city governance concept, and 2) To test this model in a practical application and lay the focus on one smart city governance outcome (CO_2 mitigation). The research question central to this study was:

How can smart city governance contribute to CO_2 mitigation goals of smart city projects?

In order to help answer the research question, the following sub questions have been formulated:
1. How can smart city governance be conceptualized?
2. Which and to what extent are smart city governance elements present in smart city projects?
3. Which smart city governance challenges occur when smart city projects want to reach their CO_2 mitigation goals?

This chapter will answer each of the sub questions, followed by answering the main research question.

How can smart city governance be conceptualized?
The small amount of literature on smart city governance and the unclear concepts and definitions derived from this literature led to the creation of a new comprehensive definition and conceptualization. This research defines smart city governance as governance that involves using ICTs, allowing city governments and other stakeholders to function more effectively and efficiently, addressing and redressing the possible outcomes of technologies, while actively involving and collaborating with all relevant stakeholders. Based on the smart city governance model of Bolívar and Meijer (2016), an improved and more detailed smart city governance model was created that can be applied in practice. This model consists of the defining elements of smart city governance which are: 1) An integrated vision, 2) Use of ICTs, 3) Legislation and Policies, 4) Innovation Capacity, 5) Collaboration and Participation, 6) Internal Coordination, 7) Decision-making, and 8) E-administration, and the governance challenges. The elements are interconnected and influence each other, and the challenges play an important role in smart city governance as mapping them are of great importance for successful governance. The different elements create various challenges for smart city governance. Vice versa, it must be noted that most, if not all of these challenges affect or can be solved by smart city governance and are therefore mutually related. The defining elements and challenges are influenced by the different contextual factors per city, as every city has different stakeholders, policies, legislations, culture, and an urban environment, which can influence the governance of a city. This all can influence the aspired outcome of smart city governance which, in this research, is CO_2 mitigation.

Which and to what extent are smart city governance elements present in smart city projects?
This research involved three different smart city projects in Rotterdam, Umeå and Glasgow which consisted of 32 smart initiatives in total. To assess the influence of smart city governance on CO_2 mitigation, first an analysis had to be made on whether smart city governance was present in these smart city project and initiatives. The smart city governance elements were used as criteria to assess the presence of smart city governance, and these elements consisted of other criteria to assess the presence of these elements. The analysis was split in three groups, namely government stakeholders, private companies, and researchers to compare different perspectives. Overall, it is concluded that

smart city governance is mostly present in Umeå and Glasgow, whereas in Rotterdam it is moderately present. The 'innovation capacity' and 'internal coordination' elements were mostly to completely present in the three cities, whereas the 'use of ICTs' element was moderately present. Differences could be found in the presence of an integrated vision, policies and legislations, collaboration and participation, and decision-making. These elements were less apparent in Rotterdam (slightly to moderately present) than in Umeå and Glasgow (mostly to completely present). It could also be concluded that the government stakeholders generally scored the presence of smart city governance higher and were more positive about the project than the other stakeholder groups.

Which smart city governance challenges occur when smart initiatives/smart city projects want to reach their CO_2 mitigation goals?

The three city projects had a different number of challenges that were identified (table 17). The most challenges were identified in Rotterdam, where several issues have already caused a delay of some initiatives. In Glasgow only several challenges were identified, however they did not have a significant impact on the implementation of the initiatives compared to Rotterdam. Finally, Umeå had the least amount of challenges where almost no issues were identified. Challenges for all three cities are to develop an integrated vision specifically for the city project, realize a more effective use of ICTs, increase citizen engagement, and address the hampering policies and legislations that can hinder the development of initiatives. Finally, one of the major challenges mentioned in all of the city projects, was the creation of business cases that are profitable on the long-term for all involved stakeholders. It was indicated that this is one of the major factors determining whether an initiative will succeed. For this reason many stakeholders argued that collaboration was the most important challenge to be addressed, as successful collaboration can significantly help with overcoming financial challenges. It was argued that if these challenges could be solved, the environmental challenges would also be solved. Ultimately, based on the analysis, it is argued that most challenges derive from elements that are not completely present. It could be seen that a complete presence of smart city governance could address these challenges and make sure initiatives can succeed.

How can smart city governance contribute to CO_2 mitigation goals of smart city projects?

It is difficult to assess the exact influence of smart city governance on reaching CO_2 mitigation goals, however this research did provide results that when smart city governance is present, this can positively contribute to reaching CO_2 mitigation goals. It is argued that smart city governance generally has an indirect effect on CO_2 mitigation, as smart city governance plays an important role in influencing whether smart initiatives and smart city projects will succeed. The degree of success has influence on the amount of CO_2 emissions that will be reduced. It should be noted that this degree of success of the initiatives can also influence other objectives (figure 8).

It could also be seen that some elements have more influence on reaching the CO_2 mitigation goals than others. This was not expected from theoretical literature. It was argued that for the 'E-administration' and 'internal coordination' elements it was difficult to assess their influence on CO_2 emissions. It is argued that these elements indirectly influence CO_2 mitigation goals as a full presence of both elements can result in a more efficient organization and process of the project, which can help to develop and reach the goals of the initiatives. For the use of ICTs element, it is unclear how and to what extent ICTs exactly influence the CO_2 mitigation goals, as the city projects and initiatives

were too early in their stages of development to be able to analyze this accurately. However, it could be seen that the degree of presence of these elements was less decisive than the other elements. Based on the results, the smart city governance elements that were considered to have the most influence were the integrated vision, policies and legislation, collaboration and participation, innovation capacity, and decision-making, as they played a major role in the development of the initiatives. One of the most striking examples regarding this was that in Umeå, an integrative vision and successful collaboration between stakeholders led to unexpected up scaling of initiatives, which could result in mitigating more CO_2 emissions than anticipated, whereas in Rotterdam issues regarding collaboration, decision-making and policies and legislation has delayed and hampered the development of several initiatives, possibly resulting in not reaching the CO_2 mitigation goals.

It should be noted however that there are other external factors that also can influence the degree of successful implementation of initiatives as was stated in the smart city governance model. The most striking example was the difference regarding the type of private companies. In Umeå, all companies that participated in the project were semi-public whereas in Rotterdam and Glasgow they were private. This influenced the process of the city project. For example, this has resulted in a shared vision in Umeå, where in Glasgow and Rotterdam the private companies were more focused on the financial aspect which was sometimes indicated as hampering.
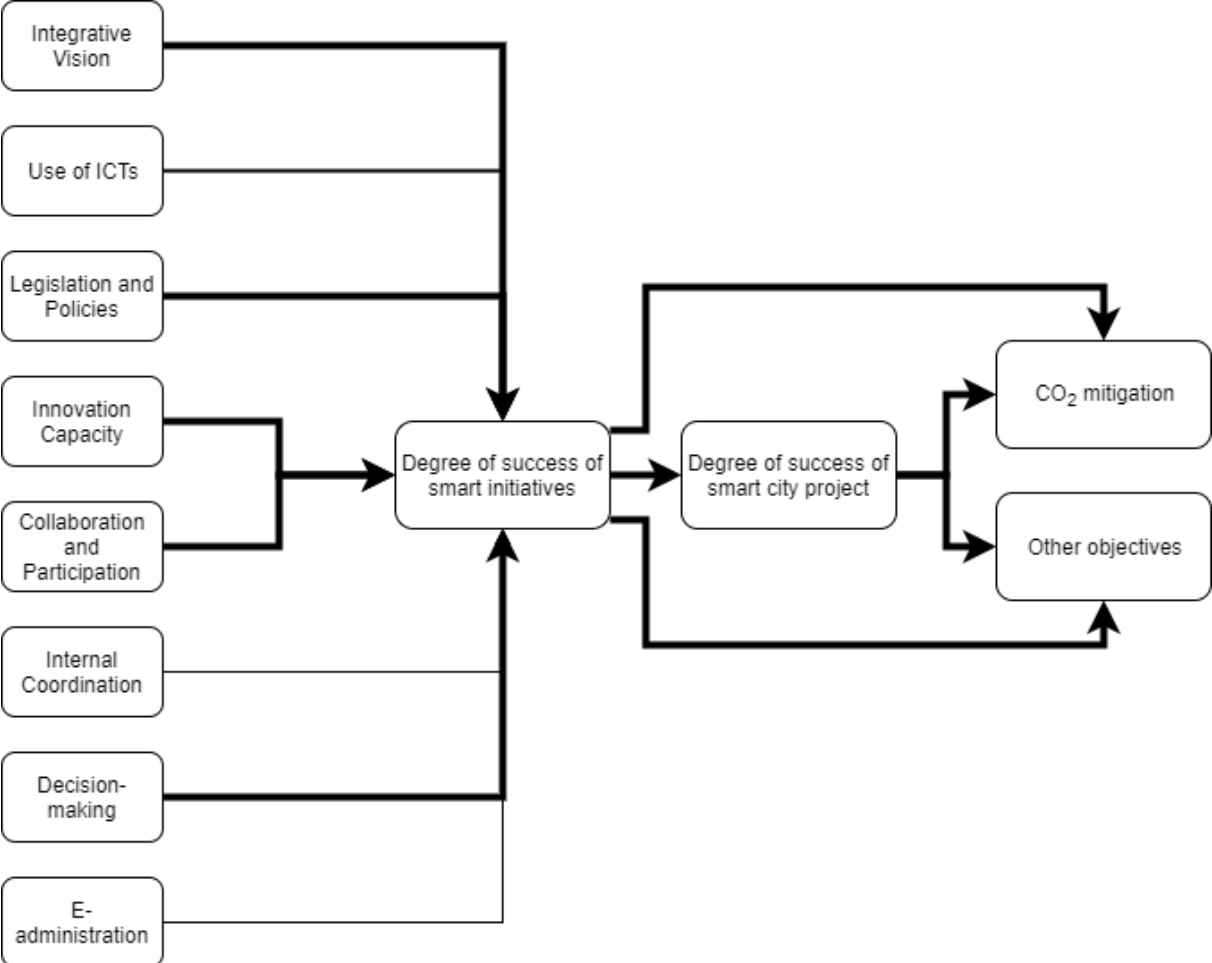
Figure 8: Influence of smart city governance on CO₂ mitigation. A thicker line means more influence.

Overall, a trend could be seen where Umeå has the highest presence of smart city governance and the least amount of challenges, Glasgow scoring on certain elements lower and having several challenges, whereas Rotterdam has scored the lowest and has the most challenges and issues that can endanger a successful implementation of smart initiatives, and therefore endanger reaching the CO_2 mitigation goals. It is argued that the more present smart city governance is, the smaller the amount of challenges are, and the more positive influence this has on reducing CO_2 emissions and reaching the CO_2 mitigation goals, as smart initiatives are more likely to succeed.

Ultimately, it can be said that smart city governance contributes to reducing CO_2 emissions and reaching CO_2 mitigation goals of smart initiatives and smart city projects as it can play an important role in to which extent an initiative will succeed. Different smart city governance elements can have a different amount of influence on this. Subsequently, smart city governance can help to address and redress the challenges and help to increase the chance of a successful implementation of smart initiatives and reach the CO_2 mitigation goals.

6. Discussion, Limitations, and Recommendations

6.1 Limitations of the Research Project

Even though the choices in this research are carefully made, it still contains some limitations.

The lack of respondents from Umeå and Glasgow has affected the external validity of this research. Despite contacting stakeholders in these cities many times, only several filled in the questionnaire. Whereas in Umeå four out of seven stakeholders responded, in Glasgow this was only one stakeholder. This made it difficult to get a complete overview of smart city governance, identify the challenges and make a comparison between the city projects as there was a limited amount of data. In Glasgow, only the government stakeholder filled in the questionnaire. Therefore, different perspectives from different stakeholder groups could not be retrieved which has led to a one-sided perspective of the city project. As could be seen in the other two city projects, the government stakeholders were generally more positive about the city project than the other stakeholder groups. The results in Glasgow could therefore have been more positive than would have been the case when other stakeholder groups would have participated.

Another limitation to this research is the inability to get a complete and detailed overview of all smart city governance elements. Although this study has gone into detail in some cases, it would cost too much time to get a complete and detailed understanding of every element. Therefore, the most important factors for every element were discussed to still be able to give a representative overview of the presence of the elements. Additionally, through having so many elements that need to be discussed, only shorter and broad answers were given as there was no time in the interviews and questionnaires to discuss every aspect of every element in detail. For example, regarding internal coordination it must be noted that the researcher did not gain full insight into the organizational coordination and structure of the stakeholders. It was asked whether the organizations were coordinated efficiently, however to get a complete picture of this element, more detailed information is necessary and more questions need to be asked about every aspect of this element as was described in the literature.

Regarding the policies and legislations, cities sometimes only have limited influence on solving the challenges they face. It was indicated that sometimes national and European policies can hamper city projects such as the national law on district heating and the European procurement law. Changes on national and European levels need to be made in order to solve these challenges.

It should be noted that most smart city projects are developed on a small scale. Lafferty (2006) argued that these smart initiatives can succeed on a small scale, however when up scaling these projects, different challenges can arise. For example E-administration can play a more important role in the up scaling of projects as more data and more information from ICTs will be available, which should be processed efficiently through the administration of organizations. Smart city governance can help in the up scaling of projects and initiatives to avoid issues that would have appeared in 'traditional' governance. However, no comparison could be made with a project without smart city governance. It could not be researched what effect this would have on CO_2 mitigation, and if a lack of smart city governance would influence initiatives and CO_2 mitigation differently, in comparison to when smart city governance would be present.

Regarding the reliability, it should be noted that a certain amount of bias in the results can be found due to a certain interpretation of the researcher of indicators or elements. Besides this, as this study is heavily dependent on interviews and questionnaires with stakeholders, stakeholders can give different answers when repeating this study. This can for example be due to stakeholders having more knowledge of the topic, speaking to other representatives of the stakeholders, the interpretation of the researcher, or the possibility that stakeholders can give strategic answers to questions. Data and information from documents can partly make up for this bias (Verschuren & Doorewaard, 2010). When data and information from interviews is lacking, the available information and interpretation of the researcher can also steer towards bias. However it is mentioned explicitly when there is a lack of data or information.

Another limitation is that the multiple embedded case study method pressurizes the external validity of this research because the results of the few cases studied are more difficult to apply to other cases outside the Ruggedised project. These other cases are most likely different projects with different goals and aims. Studying the effects of smart city governance is a complex matter where the use of ICTs, stakeholders, and effects on the urban environment are contextual. There is a possibility that an approach that is successful in one city, may fail in another (Meijer, 2016). However, as this is an in-depth study, and little to no research has been carried out on this level, results might be of interest for practitioners and scientists alike, as many smart initiatives are faced with the same or similar elements of smart city governance in any city. Subsequently, this research also operationalized the smart city governance concept which has rarely been done so far.

6.2 Theoretical Implications

This research has contributed to the theoretical body of literature in several ways. A knowledge gap was identified in chapter one, described as 1) the lack of a clear and detailed overview of the smart city governance concept and application of this in a practical setting, and 2) the lack of research analyzing the influence of smart city governance on a specific environmental sustainability factor, namely CO_2 mitigation.

First of all, several authors such as Bolívar and Meijer (2016), Aylett (2015), and Nam and Pardo (2011) identified the need for more research regarding smart city governance. Only a small amount of research has been done about this concept and a clear and detailed overview was lacking. The smart city governance model of Bolívar and Meijer (2016) was used as a basis to explain this concept, and this model has been improved in multiple ways through performing an extensive literature review of existing theories on smart city governance. Therefore, this research has provided an improved and more detailed understanding of the smart city governance concept than currently available. Additionally, Bolívar and Meijer (2016), and Bolívar (2016a) indicated the lack of empirical research regarding smart city governance. This research showed how to apply the smart city governance concept in a practical setting, which has rarely been done so far. This has resulted in a better understanding of the smart city governance concept by showing that the presence of most theoretically explained elements and challenges of smart city governance, were confirmed in practice. Additionally, also more concrete challenges and issues could be identified than were found in the literature. Subsequently, it could also be concluded that the different elements each had different influences on a successful implementation of the initiatives, whereas in literature it was understood all elements would have the same influence on the aspired outcome. However it was

difficult to assess the exact influence of the different elements as described in theory as more in-depth information was necessary to gain a complete understanding of the elements. Besides this, it was unclear what influence the 'use of ICTs' element had as the initiatives were in a too early stage to determine the influence.

Secondly, Ahvenniemi et al. (2017) argued that cities play a very important role in the fight against climate change and smart city governance is seen as a key factor in decreasing CO_2 emissions and improving energy efficiency of cities. However it was stated that it was unclear how smart city governance can contribute to this decrease in CO_2 emissions. Gollagher & Hartz-Karp, (2013), Gunningham (2009), and Kim (2010) indicated only a small amount of research has been done about the contribution of smart city governance and to environmental sustainability goals, and a clear formulation of this relationship was lacking. This research has given several insights in this relationship. It was argued that smart city governance can influence CO_2 mitigation goals through whether a smart initiative will succeed. A requirement is that the smart initiatives must have CO_2 mitigation goals as was the case in this research. The level of presence of smart city governance can influence to which extent an initiative will succeed. Additionally, an integrated and shared vision, and policies that stimulate CO_2 mitigation, can significantly contribute to setting and working towards CO_2 mitigation goals.

Finally, regarding the stressed need for smart city governance in relation to 'traditional' governance as was stated by Bolívar (2016a) and Walters (2011), it could be seen that for smart city projects and smart initiatives addressing for example the use of ICTs and technologies, and the innovation capacity were deemed important. ICTs and technologies can gather data that can help to make better decisions as was the case in several smart initiatives. Regarding innovation capacity, it was the constant collaboration between stakeholders, and engaging third parties that could be seen as important factors to ensure innovation capacity. Addressing these elements can help to keep developing better initiatives in the future and help cities to overcome the challenges they currently face.

6.3 Recommendations for Further Scientific Research

Based on the theoretical implications, several recommendations for further scientific research can be made. Further research is necessary to find further evidence in how smart city governance can contribute to CO_2 mitigation goals, especially in other city projects than Rotterdam, Umeå, and Glasgow. Recommendations for this are elaborated upon below.

Since this research was performed during the starting phase of the project, not all elements and challenges of smart city governance could be completely addressed. Therefore it is recommended that research can be performed when a project has ended (ex-ante), as smart initiatives have already been developed and implemented. This would also allow analyzing the influence this has on CO_2 mitigation goals, as could be seen how much CO_2 was mitigated per initiative. This can help in getting closer to being able to assess the actual impact of smart city governance on CO_2 mitigation. Even more interesting would be to perform a longitudinal study of smart city projects where the same research would be performed in different stages of the project. From this it can be concluded which challenges and elements play an important role when wanting to reach CO_2 mitigation goals.

Researching the influence and participation of citizens would also be of interest for further research. This could provide more detailed results and gain the perspective of the citizen in how much they are being engaged in the project, and what influence this can have on the smart initiatives and project.

It would also be recommended to use the smart city governance model for other aspired outcomes from initiatives and projects as was mentioned in table 2. This way, the model gets tested on different topics besides CO_2 mitigation. However, the elements and their criteria as explained in this research should also be changed as some of them are specifically focused on the CO_2 mitigation outcome.

Finally, as was mentioned before, every smart city governance element can be analyzed more into detail. Each element could be studied separately in order to find concrete and robust information about how present an element is. This provides more time to assess the actual presence and influence of an element as more factors could be researched and could provide more in-depth results.

6.3 Recommendations for Practice

It is recommended for practitioners to use the smart city governance model in order to analyze and identify successes, issues and challenges in smart city projects. This can be any smart city project all over the world that includes CO_2 mitigation goals. The model helps to create an overview which can help to solve issues and challenges more easily, while successes can be shared with other stakeholder in other cities or projects. It must be communicated between stakeholders within a project who is going to execute the model, and that constant and open communication between stakeholders is necessary to be able to execute the model as efficiently as possible. A research stakeholder might be the most suitable for this as they are often already have an advising role in the project. Subsequently, it is recommended that before the development of an initiative or project starts, stakeholders should see if they fulfill the criteria of the smart city governance model in order to implement the initiatives successfully, and reach the desired goals. This way, issues and challenges can be identified and/or solved before the project starts. Subsequently, the model can be executed every year during the project to be able to see if criteria are still met, or if factors have changed. At the end of the project, an ex-ante research could be performed by one of the stakeholders to learn lessons for other similar projects.

Chapter 4 already discussed several recommendations per city and element in detail based on the identified successes and issues. Here, brief recommendations for stakeholders in smart city projects are made for each element of smart city governance:

Integrated vision: Develop an integrated vision for the project where it is made clear how initiatives can enhance each other, and where clear CO_2 mitigation goals are set. Create this vision together with all relevant stakeholders, and ensure that everyone knows and shares this vision.

Use of ICTs: Make sure that ICTs are used to the fullest extent. Use ICTs to engage citizens through open data platforms or online questionnaires, and analyze to what extent ICTs help to improve urban services, improve internal administrations, and simplify interactions between stakeholders.

Policies and legislations: Analyze which policies and legislations can hamper the implementation of the initiatives or the CO_2 mitigation goal, if possible, before the project starts. This can prevent unexpected policies and legislations to delay the implementation of initiatives and the project. Map the hampering policies and legislations and discuss with the other stakeholders how to address them. Additionally, analyze which policies and legislations can help to develop the initiatives and reach the CO_2 mitigation goal. This can possibly provide information that can be used to help the project.

Innovation Capacity: Ensure innovation through constant collaboration with different stakeholders and exchange knowledge and expertise, and be open to the involvement of third parties. This can help to keep innovating and improve initiatives. For example, an innovation platform can be developed where different (external) stakeholders can exchange ideas and help to find solutions to overcome challenges.

Collaboration and Participation: While collaborating with other stakeholders, try to understand each other's vision and aims in the project. This can make collaboration more efficient and avoid possible conflicts. Also, engage and inform citizens, through social media, online questionnaires, and/or open data platforms, as their opinions and knowledge can be used in improving the initiatives and project and this helps to make choices that fulfill the needs of the population better.

Internal Coordination: Within an organization, there should be a project coordinator or person that represents all standpoints in an organization to avoid conflicts. It is recommended that different departments and people with different backgrounds work together to increase overall knowledge.

Decision-making: There should be a transparent decision-making structure before the start of the project. It should be possible to make adaptations to this structure during the project when necessary. The roles of all stakeholders should be clearly defined and communicated before the start of the project.

E-administration: Improve transparency by constant tuning with partners, presenting all activities, visions and strategy to partners and by keeping up a document about updates in the project. Be transparent as possible in your actions, and try to share all information and progress with all relevant stakeholders in the project. This also includes being transparent with citizens by informing them and by sharing information with them about the process of the project online through a website or social media.

These recommendations should be able to help stakeholders during the development of smart city projects. This will increase the chance of a successful implementation of smart initiatives and raise the chance of reaching the CO_2 mitigation goals of a project. However, as Lafferty (2006) has argued, these smart initiatives can succeed on a small scale, but can they also on a larger scale? Cities have to look into this as a smart approach of governance can become even more important in the future.

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8. Appendices

Appendix 8.1: Explanation of Key Concepts

Smart city

Over the last decade, an increasing amount of attention among academics, urban politicians and professionals around the world has been given to the concept of 'Smart Cities' where the use of Information and Communication Technologies (ICT) can help to effectively address social, economic, and sustainability challenges cities face (Bolívar & Meijer, 2016). It is generally agreed that Smart Cities are distinguished through their use of ICT which can help city officials and other stakeholders to, for example, interact directly with citizens through the creation of an open data platform, monitor city infrastructure, and collect data i.e. through the use of sensors integrated with real-time monitoring systems (Ahvenniemi et al., 2017; Batty et al., 2012; Neirotti et al., 2014). An example to reduce CO_2 emissions and energy use in a smart city is through the use of ICT systems that can enhance logistics and transportation by gaining information about traffic conditions and energy consumption (Neirotti et al., 2014). Users can use this information to save time and improve commuting efficiency, save costs, and reduce CO_2 emissions. Besides this, transport managers and users can communicate with each other in a network to give each other feedback which leads to an improvement of services and a higher environmental efficiency (EP, 2014).

The smart city consists of three elements: technology, human resources, and governance with the objectives of sustainable development, economic growth, and better quality of life for citizens (Castelnovo et al., 2016; Bolívar & Meijer, 2016). Meijer & Bolívar (2016) argue that "the smartness of a city refers to its ability to attract human capital and to mobilize this human capital in collaborations between the various (organized and individual) actors through the use of information and communication technologies" (p. 398).

Information and Communication Technologies (ICT)

It is difficult to find consensus with regard to the definition of ICT (Zuppo, 2012). Nonetheless, information and communications technology (ICT) generally refers to utilizing digital technologies and all equipment, applications, and services that involve communication such as computers and cellphones (Zuppo, 2012). It includes the process of transferring or exchanging data from one machine to another, using computers, modems, routers, and other digital technologies. This makes it different from information technologies (IT) such as scanners, printers, CD-ROM etc., as this excludes communications technology such as the internet, wireless networks, cell phones, and other means of communication (Lee, 2017; Zuppo, 2012).

Smart city governance

In the context of a smart city, a new, innovative and ICT-based form of governance has been conceptualized as smart city governance and is deemed necessary by practitioners and academics to govern the smart city. Smart city governance can be seen as one of the ways to effectively manage the smart city. Smart city governance involves using ICTs, allowing city governments and other stakeholders to function more effectively and efficiently, addressing and redressing the possible outcomes of technologies, while actively involving and collaborating with all relevant stakeholders. It can help governments to design new governance instruments that enable an effective management of smart city initiatives, and of a city's complexity and the challenges it faces, and is seen as an

important factor in the development and the transition from a city, to a smart city (Belissent, 2011; Chourabi et al., 2012; Giffinger et al., 2007). To get a better overview and perception, eight key elements of smart city governance are highlighted based on a literature review and model of the smart city governance concept made by Bolívar and Meijer (2016), namely: 1) Integrated vision, 2) The use of ICTs, 3) Legislation and Policies, 4) Innovation Capacity, 5) Collaboration and Participation, 6) Internal Coordination, 7) Decision-making processes, and 8) E-administration.

Smart initiatives

Smart initiatives are innovative initiatives that involve ICT in order to improve the urban environment in the smart city. Smart initiatives are often part of a bigger project in a smart city where multiple initiatives are involved. An example of a smart initiative is implementing ICT systems such as traffic monitoring systems with cameras and sensors that can provide city governments with detailed information about traffic streams and congestions which can be used for traffic management (Hoh et al., 2008).

Appendix 8.2: Aspired Outcomes of Smart City Governance

First-order outcomes (changes to government)

1) Efficient government

One of the most important ambitions of smart city governance is to make better use of the available resources (Batty et al., 2012). ICTs for example positively affect the administration of the government and smart city governance helps to organize, coordinate and deliver services in an efficient way. Interaction with citizens and private companies can help governments to be more efficient in overcoming the challenges in the urban area as other stakeholders might have knowledge, skills, financial power, and technology that governments do not have.

2) Readiness for disaster management

According to Alkandari, Alnasheet & Alshekhly (2012), cities need quick responses to emergency situations. This can range from small car accidents to natural disasters such as floods or storms. Smart city governance can help to provide smart systems that deliver services anywhere and anytime. It can also help to develop better risk management through better interaction with stakeholders and the increased amount of data available.

Second-order outcomes (changes in position of government related to other urban actors)

3) Improve citizen-centric services

Several authors state that improving citizen-centric services is one of the main goals of smart city governance (e.g. Batagan, 2011; Giffinger et al., 2007). Citizen-centric services are for example designing websites to make it easier for citizens to find information, or filling out online applications, online complaints, online surveys, online registration, or paying taxes etc. (Wang, Bretschneider & Gant, 2005).

4) Interact with the public

Smart city governance allows government to better interact with the public through the use of ICTs. Hereby, citizens can participate in the decision-making process and can influence their own urban environment by providing knowledge and opinions. Castelnovo et al. (2016) argue that it is important

for governments to be transparent in their actions so they can gain trust from citizens in order to prove that what they are doing is the best for the city and its citizens.

5) City branding

Several authors argue that one of the outcomes of smart city governance is city branding (Bolívar & Meijer, 2016). Batty et al. (2012) states that smart city governance could only be seen as a label of a city when the city itself categorizes itself as smart. Giffinger and Gufrun (2010) go even further by saying that some city governments label their governmental management as smart to attain a better position in city rankings. They hereby ignore the original purpose of smart city governance. Therefore, improving the city's image is another aspired outcome of smart city governance.

Third-order outcomes (improvements to the city)

6) Improve economic growth performance

Many authors indicate the effect smart city governance has on the economic growth performance of cities. Bolívar (2016a) argues that sustainable economic growth is one of the main objectives of smart city governance. Kourtit et al. (2012) and Batagan (2011) argue that smart city governance helps to promote the economic growth performance of cities because public sector services are expected to improve. Besides this, the implementation of smart initiatives also generates economic growth for, for example, private companies.

7) Social inclusion

Social exclusion is a severe problem in urban areas where citizens and organizations are denied full access to numerous rights, opportunities, and resources that are generally available to other groups. Governments are under pressure to develop policies that allow equitable urban growth (Caragliu et al., 2011; Deakin, 2012). Smart city governance aims to achieve social inclusion, and in order for this to happen, citizens and/or organizations have to be able to participate in the decision-making and planning processes (Angelidou, 2015; Marsal-Llacuna, Colomer-Llinàs, & Meléndez-Frigola, 2015). Caragliu et al. (2011) argues it is important whether all social classes benefit from implementing ICTs in urban areas.

8) Improve ecological performance

Ecological performance is deemed a very important outcome of smart city governance. Many cities aim for example to mitigate CO_2, reduce energy use, and reduce air pollution in order to improve the urban environment (Kourtit et al., 2012). Cities are also being pressurized through ambitious climate goals set by the European Union (EC, 2014) and United Nations (2016). Smart city governance can be seen as an effective approach in order to reach these climate goals. This is elaborated upon in section 2.4.

9) Boost the number of highly educated citizens

The previously mentioned human resources element of a smart city discussed the term 'smart citizens' as being an important part of the growth of a smart city. Cities would want to have these smart citizens as their knowledge, creativity, and engagement can generate smart solutions that improve the smart city (Kourtit et al., 2012; De Wijs et al., 2016; Nam & Pardo, 2011). Winters (2011) states that smart cities aim to become centers of higher education and smart city governance aims to strengthen this process.

Appendix 8.3: Questionnaire

Link to questionnaire: https://qtrial2017q2az1.az1.qualtrics.com/jfe/form/SV_a5UFXrP1foJQW8Z

Dear Ruggedised partner,

Over the last decade, an increasing amount of attention among academics and practitioners around the world has been given to the concept of Smart Cities. The Ruggedised project can be described as a smart city project since it involves the use of ICTs and aims to effectively address social, economic, and sustainability challenges cities face. One of the aspects of smart cities is smart city governance. This is a new, innovative and ICT-based form of governance and can be seen as one of the ways to effectively manage the smart city. This smart city governance concept is also considered important in the Ruggedised project. It is defined as follows:

"Smart city governance involves using ICTs allowing city governments to function more effectively and efficiently, addresses and redresses the possible outcomes of technologies, and strengthens urban governance while actively involving and collaborating with stakeholders".

The concept can be divided into eight elements:

Policies and Legislation	Integrated Vision	Use of ICTs	Innovation Capacity
Collaboration and Participation	Internal Coordination	Decision-making	E-administration

Additionally, one of the most important targets of Ruggedised is CO_2 mitigation. The smart city governance elements described above can play an important role in reaching these CO_2 mitigation targets. Therefore, this survey is about the concept of smart city governance and to research to which extent these elements are present in the Ruggedised project, and how it can contribute to reaching the CO_2 targets of Ruggedised.

The questions in this survey are about either the city project, or the 'smart solutions' of the city project depending on where you, or your organization, is currently involved in. If you are involved in multiple 'smart solutions', please state which solution you are talking about when answering questions. This survey is handed out to all Ruggedised partners of Rotterdam, Umeå, and Glasgow.

If you have any questions, feel free to contact Nick Schasfoort (TNO) at nick.schasfoort@tno.nl

Q1. In which Ruggedised city are you involved as a stakeholder?

- Rotterdam
- Umeå
- Glasgow

Q2. What type of stakeholder are you?

- ○ Government, City name: [   ]
- ○ Researcher, Organization name: [   ]
- ○ Private Company, Organization name: [   ]

What smart solution(s) are you involved in in the city of Rotterdam? This can also be the whole city project.

- ☐ Whole city project
- ☐ R1: Geothermal heat-cold storage and heat pumps
- ☐ R2: Thermal energy from waste streams
- ☐ R3: Surface water heat-cold collection
- ☐ R4: Pavement heat-cold collector
- ☐ R5: DC grid, PV and storage for mobility
- ☐ R6: Smart charging parking lots
- ☐ R7: Optimising the E-bus fleet of RET
- ☐ R8: Energy Management
- ☐ R9: 3-D City operations model
- ☐ R10: LoRa-network
- ☐ R11: Efficient and intelligent street lighting
- ☐ R12: Nerdalize eRadiator
- ☐ R13: Smart Waste Management

What smart solution(s) are you involved in in the city of Umeå? This can also be the whole city project.

- ☐ Whole city project

- ☐ U1: Smart City connection to 100% renewable energy

- ☐ U2: Peak load variation management and power control

- ☐ U3: Geothermal heating/cooling storage and exchange

- ☐ U4: Intelligent building control and end user involvement

- ☐ U5: Energy optimised electric BRT-station

- ☐ U6: E-charging hub/charging infrastructure (e-bike, private car, taxi, car-share), storage and exchange, and optimisation of the integration of RES in the grid

- ☐ U7: Energy-efficient land use through flexible green parking pay off

- ☐ U8: Smart Open Data city Decision platform

- ☐ U9: Demand-side management

What smart solution(s) are you involved in in the city of Glasgow? This can also be the whole city project.

- ☐ Whole city project

- ☐ G1: Heat and Cold exchange - Connection of buildings to district heating network

- ☐ G2: Battery Storage technology as grid balancing mechanism & supply of RES to EV charging and battery infrastructure

- ☐ G3: TCB CHP surplus power storage in EV charging hub battery storage

- ☐ G4: Optimisation of the integration of near-site RES, potentially liked into battery storage

- ☐ G5: EV Charging hub in city centre car park

- ☐ G6: Intelligent LED street lights with integrated EV charging functionality, wireless communications network, and air pollution monitors

- ☐ G7: Smart open data decision platform/central management system

- ☐ G8: Implementation of demand-side management technology in street lighting

- ☐ G9: Implementation of demand-side management technology in domestic properties

- ☐ G10: Implementation of demand-side management technology in non-domestic properties

Q3. What is the ultimate goal of this project/smart solution(s)?

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The following questions are about the eight different elements of smart city governance.

Element 1: Legislation and Policies
In smart cities, legislation and policies can help or hinder the implementation of smart initiatives.

Q4. Please state the legislation and/or policy that is the most helping, and the most hampering to successfully realize CO_2 mitigation goals of the project/smart solution(s). **If you do not know the answer to this question, please fill in 'Don't know.**

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Element 2: Integrated Vision
Different visions can conflict with each other; however modern cities must be able to combine multiple visions. Smart cities distinguish themselves through having plans that contain integrated visions. An integrated vision can help to integrate and coordinate the various domains in a smart city from different stakeholders.

Example: An objective to increase accessibility of transportation and the objective to improve air quality contradict each other but through an integrated vision, policies can be made that addresses both objectives.

Q5. Is there a plan/document that includes a long term integrated vision in the project/smart solution(s) and has CO_2 mitigation targets been included in this plan/document?

- ○ If Yes: Can you name an example? Please indicate whether the plan is about the whole city project, or a specific smart solution(s), and how many years this integrated vision is for.

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- ○ If No: Do you think an integrated vision is necessary to reach the goals of the project/smart solution(s) and why?

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- ○ Don't know

Q6. Do all stakeholders share the same vision in the project/smart solution(s)?
- ○ Yes
- ○ No
- ○ Don't know

Element 3: Collaboration and Participation

The participation and collaboration between different public and private actors helps to manage relations and make use of their intelligence and knowledge. Within the Ruggedised lighthouse cities, you work together with other partners.

Q7. Can you give an example of the synergy this creates between you and the other partner(s)?

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Q8. What kind of synergy did you expect with partner(s) that currently has not yet been fulfilled?

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Q9. Is any party dominating the partnership?

- ○ If Yes: public or private, and why?

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| |

- ○ If No: is this the desired situation?

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| |

- **Q10.**

In which phase and to what extent are/will citizens be engaged in the project/smart solution(s)?

	Not Engaged	Slightly Engaged	Moderately Engaged	Mostly Engaged	Completely Engaged	Don't know
Preparation Phase	○	○	○	○	○	○
Starting Phase (Year 1-2)	○	○	○	○	○	○
Middle Phase (Year 3-4)	○	○	○	○	○	○
End Phase (Year 5-6)	○	○	○	○	○	○

Element 4: Internal Coordination

Internal coordination is present when there is collaboration among departments, agencies, and people, and when there is a person, department, or agency supervising and coordinating the project or initiative. Coordination is expected to be better when different department, people, and agencies are interconnected and aim to achieve the same goals.

Q11. What is being done to improve the communication and coordination between different departments, people, and agencies to realize the smart solution(s)/project?

Element 5: Decision-making process

Smart city governance engages different stakeholders in the decision-making process in order to make the best decisions. ICTs can play an important role in the decision-making process as there is more complete, readily available, and accessible information for stakeholders to use in decision-making processes. Collaborative projects ask for a vision and distribution of roles in the decision-making process.

Q12. Is the decision-making structure of the project/smart solution(s) deliberately designed beforehand? Please specify this decision-making structure, is this horizontal (collaborative) or vertical (one coordinating body)?

- ○ Yes

- ○ No

- ○ Don't know

Q13. Are the roles of all stakeholders in the project/solution(s) clearly defined and communicated?
- ○ Yes
- ○ No
- ○ Don't know

Q14. Is decision-making transparent?
- ○ Yes
- ○ No
- ○ Don't know

Q15. Does data retrieved from ICT help to make better decisions?

- ○ Yes
- ○ No
- ○ Don't know

Element 6: E-administration

E-administration uses ICTs to interconnect and integrate information, processes, institutions, and physical infrastructure in order to improve the urban environment. Administrations need to be innovative in order to cope with the requirements of different policies, and in order to improve productivity and performance. Transparency plays an important role here. Administrations of organizations should be as transparent as possible in what they are doing as this can for example eliminate corruption and improve the degree of credibility in an organization.

Q16. What activities do you undertake to improve transparency of your own actions within the project/solution(s)?

Element 7: Use of ICTs

ICTs can play an important role in developing policies by collecting information from, for example, sensors or smart grids. This information can help to gain a better view of situations in which policies can be changed or new policies can be developed.

Q17. To what extent helps ICT in the project/smart solution(s) to:

	Not well at all	Slightly well	Moderately well	Very well	Extremely well	Don't know
Increase citizen-participation?	○	○	○	○	○	○
Simplify interactions between stakeholders?	○	○	○	○	○	○
Improve internal administrative operations?	○	○	○	○	○	○
Improve urban services?	○	○	○	○	○	○

Element 8: Innovation Capacity

Smart cities are cities that are continuously innovating. There is sometimes not enough capacity for stakeholders to innovate. This could be for example due to a lack of knowledge and expertise, finances, or hindering regulations.

Q18. How is innovative capacity being ensured/stimulated?

Q19. Do you think there is currently enough potential to keep innovating in this project?

- ○ Yes
- ○ If No, what should be improved?

Q 20. Governance challenges in the project/smart solution(s)

There are many challenges in smart city projects. Below, several challenges are mentioned. Please indicate for each challenge how important this is in the project/smart solution(s).

	Not at all important	Slightly important	Moderately important	Very important	Extremely important
Financial challenges	○	○	○	○	○
Technical challenges	○	○	○	○	○
Environmental challenges	○	○	○	○	○
Privacy	○	○	○	○	○
Lack of leadership	○	○	○	○	○
Political support	○	○	○	○	○
Digital Divide	○	○	○	○	○
Collaboration	○	○	○	○	○
Legal/policy challenges	○	○	○	○	○

Q21. Are there any other challenges that are of importance in the project/smart solution(s)?

[   ]

Q22. Are challenges being openly discussed with other consortia?

- ○ Yes
- ○ No
- ○ Don't know

Q23. Do you think the project/solution(s) will reach the CO_2 mitigation targets?

- ○ Yes
- ○ If No, why?

[   ]

Q24.
On a scale of 1-5 (1 being not at all, 5 being completely present) how much are the following elements present in the current project/smart solution(s)? Please note this is related to the CO_2 mitigation goals and the elements below are in the context of Smart City Governance.

	Not present	Slightly present	Moderately present	Mostly present	Completely present
Smart Policies and Legislation	○	○	○	○	○
Integrated Vision	○	○	○	○	○
Collaboration and Participation	○	○	○	○	○
Internal Coordination	○	○	○	○	○
Decision-making	○	○	○	○	○
E-administration	○	○	○	○	○
Use of ICTs	○	○	○	○	○
Innovation Capacity	○	○	○	○	○

Q25. Are there any other elements/aspects that are missing, or that have not been covered of what you think is important in the project/smart solution(s)?

```
[                                    ]
```

End of Survey. Thank you for filling out this survey. If you want to be notified about the results, please enter your e-mail address below.

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[                                    ]
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Appendix 8.4: Online Questionnaire Structure

The questionnaire is divided in three parts. First, an introduction to the questionnaire is given and stakeholders are asked which city and organization they are from, which initiatives they are involved in, and what the goal is of the project and/or initiatives they are involved in. The latter is asked because smart city projects/initiatives often have different goals as described in the literature. This way, the researcher can find out where the first priorities of the stakeholders are. Noteworthy to mention is that in the questionnaire the word 'solutions' is used instead of 'initiatives'. This is due to the Ruggedised project consistently using this word instead of 'initiatives'. By using 'solutions' instead, it is easier for stakeholders to understand what is meant by using this word. Additionally, it can be helpful to know about which initiatives stakeholders are involved in as it can become clear which part of the project they are talking about and from which perspective they are answering. The second part contains questions about the presence of the smart city governance elements in the project or initiatives. These questions are based on the literature study of this research and can be described as criteria to which extent an element is present in the project and/or initiative(s). A short introduction text is given to help to make the stakeholders understand the different elements. The final part consists of how important the challenges are that they come across in the project and/or initiatives, what challenges they encounter and whether respondents think the CO_2 mitigation targets will be met. Additionally, stakeholders are asked about to which extent the smart city governance elements are present in the project and/or initiative(s) they are involved in. This has been put last, as during the interview the elements are explained and elaborated upon which might give the interviewee a better idea and understanding of what the elements are. This question has been added to be able to find out whether respondents think the smart city governance elements are present in the project/initiatives. This will be compared to the second part of the questionnaire where is being tested if there is an actual presence of the smart city governance elements. Comparing this with each other may for example have the result that stakeholders think smart city governance is present while in reality there is actually little presence of the smart city governance concept.

Appendix 8.5: List of Interview Respondents

These were made anonymous on request.

Date	Stakeholder Group	Role	Type	Duration
Umeå				
29-05-2017	Government	Project Coordinator	Skype	80 mins
Rotterdam				
31-05-2017	Private Company	Program Manager	Phone	30 mins
08-06-2017	Research	ICT expert	Face-to-Face	75 mins
09-06-2017	Research	Research Expert	Phone	35 mins
12-06-2017	Private Company	Organization Coordinator	Phone	50 mins
14-06-2017	Private Company	Organization Coordinator	Phone	30 mins
16-06-2017	Private Company	Technical Coordinator	Phone	40 mins
20-06-2017	Private Company	Organization Coordinator	Phone	60 mins
21-06-2017	Government	Project Coordinator	Phone	65 mins
04-07-2017	Private Company	Organization Coordinator	Phone	30 mins
04-07-2017	Research	Research Expert	Face-to-Face	30 mins

Appendix 8.6: Connection between literature and questionnaire questions

Below a description is given of the questionnaire questions and the connection with literature. The questionnaire questions are based on the literature study and indicate whether an element is present in a project or in initiative(s). Due to the large size of the smart city governance concept, only one or several questions per element were asked in order to collect as much data as possible and to keep the questionnaire not as long, increasing the chance respondents will fill in the questionnaire.

Legislation and Policies

A focus is laid specifically on legislation and policies regarding smart city governance and CO_2 mitigation, as this is the aspired outcome of this research. Literature states that legislation or policies can for example help or hinder the implementation of smart initiatives (Batty et al., 2012; Bolívar & Meijer, 2016; Leydesdorff & Deakin, 2011; Nam & Pardo, 2011). It is therefore important to know if there are policies or legislations that affect the smart initiatives in city projects in a specific way.

Integrated Vision

The integrated vision of the projects and initiatives are identified through whether there is a plan or document that includes a long-term integrated vision that matches the needs for the cities, and whether CO_2 mitigation targets have been included in this plan or document. It should be noted that 'long-term' is subjective and can be interpreted differently per stakeholder. Therefore a minimum of ten years is taken to be characterized as long term, while in the interviews it is also asked what is meant with 'long-term'. Additionally, it is asked whether all stakeholders in the project/initiative(s)

share the same vision as literature stated that this is important to coordinate the various components in a smart city (Goh, 2015; Nam & Pardo, 2011; Shelton et al., 2015).

Collaboration and participation

The collaboration and participation are of major importance in smart city governance. Therefore, there are multiple indicators analyzing the collaboration and participation. Interviewees are asked about the synergy between different stakeholders in the project to identify the collaboration between stakeholders. Additionally, a question is asked about the expectations of synergy between stakeholders can give information about the issues or challenges that exist. Subsequently, indicating if a party is dominating the partnership can give information about whether this is desired and why. Dominating parties can pressure smaller parties which can affect the collaboration and relationship between parties. Finally, a question is asked about when citizens are or will be engaged in the project/initiative(s) as this engagement is deemed of vital importance in the scientific literature.

Internal coordination

Internal coordination is present when there is collaboration among departments, agencies, and people, and when there is a person, department, or agency supervising and coordinating the project or initiative. Coordination is expected to be better when different department, people, and agencies are interconnected and aim to achieve the same goals. Interviewees are asked about what is being done to improve the communication and coordination between different departments, people, and agencies to realize the project/initiative(s). This gives a proper indication to which extent internal coordination is present.

Decision-making process

Giffinger et al. (2007) argued that participation of different stakeholders in the decision-making process helps to make decisions that are ultimately most beneficial for the urban environment. Smart city governance engages different stakeholders in the decision-making process in order to make the best decisions. Therefore, interviewees are asked about whether the decision-making structure of the project/initiative(s) is deliberately designed beforehand, and is specifically vertical or horizontal. This gives an indication how decisions are made. Additionally, three closed questions must indicate whether the decision-making processes are all clearly defined and communicated, if decision-making is transparent to all stakeholders, and if data retrieved from ICTs helps to make better decisions.

E-administration

E-administration uses ICTs to interconnect and integrate information, processes, institutions, and physical infrastructure in order to improve the urban environment. Transparency plays an important role here. Administrations of organizations should be as transparent as possible in what they are doing as this can for example eliminate corruption and improve the degree of credibility of an organization. Transparency can for example be achieved by using ICTs such as putting reports or documents online. Therefore, interviewees are asked about what activities are undertaken to improve the transparency of their own actions within the project/initiative(s). As transparency is considered the most important factor for E-administration, this has been chosen as only indicator to be measured.

Use of ICTs

ICT in the context of governance can play multiple roles in a smart city. It can help for example in developing policies by collecting information from for example, sensors or smart grids and let more citizens participate in the decision-making process of a city, and let their voice be heard through online surveys or platforms. Castelnovo et al. (2016) stated that ICTs can help cities to, for example, simplify and improve interaction between government and other stakeholders, improve the internal administrative operations of government and can be used to improve the quality, efficiency, and interactivity of urban services. Therefore, it is asked to what extent ICT in the project/initiative(s) help to improve these factors. This gives an indication of what role ICTs play in the project/initiative(s).

Innovation capacity

The innovation capacity is important for the future development of a city. Innovation is important in order to keep developing better solutions and help city governments to meet challenges of urban governance and to improve urban environments (Meijer, 2016). Interviewees are asked about how innovative capacity is ensured or stimulated and if they think there is currently enough potential to keep innovating.

Smart City Governance Challenges

For the smart city governance challenges, it is asked how important the different challenges are that are derived from literature and chapter 2.4. This is done to indicate what stakeholders find specific challenges important, or not important. All of these challenges are deemed important in smart city governance literature and this question could give an idea where the preferences of challenges/topics lie of stakeholders. Additionally, it is asked whether other challenges are of importance in the project/initiative(s). This is done to let the respondents be able to elaborate on the different challenges they come across. Besides this, it is important that the challenges that stakeholders come across are being openly discussed with other consortia, which are in this case the other city projects in order to let other stakeholders know, or retrieve help or information in how to tackle the challenges stakeholders come across. Finally it is asked whether the respondents think the project or initiatives they are involved in will reach the CO_2 mitigation targets, and it is asked why if they think they will not be reached. This is done in order to identify issues or challenges in the project or initiatives specifically regarding CO_2 mitigation targets.

Appendix 8.7: Categorization of Open Survey Answers

For several questions it was difficult to base categories on literature, as there was no known literature about these topics yet. Therefore several questions have only categories based on the empirical results.

L = Literature, E = Empirical.

Question	Type	Categories
Q3: What is the ultimate goal of this project/smart solution(s)?	Open	Develop the initiatives (E) Improve sustainability performance (L) Decrease CO_2 emissions (L) To meet the objectives of the project and how (E) Optimize energy efficiency (E) Increase livability of the city (L) Creation of a business model (E) Becoming a smart, sustainable, and connected city (E) Maximize interconnectedness between initiatives (E) Replication (E)
Q4: Please state the legislation and/or policy that is the most helping, and the most hampering to successfully realize CO2 mitigation goals of the project/smart solution(s).	Open	**Hampering:** Old and existing Regulations/Contracts (E) City heating regulations (E) Only heat law, no heat/cold law (E) Energy taxes (E) Business structures based on linear value chains (E) Lack of district regulations (E) Lack of national policy on business rates applying to district heating (E) **Helping:** SDE Subsidies (E) Striving of municipality to PPP (E) Programma Duurzaam (Sustainability Program) (E) Sustainability Policies and Legislations (L) Energy Policy (E) Air Quality Policy (E) Energy & Carbon Masterplan (E) Resilience Plan (E) Climate change Adaptation & Mitigation plan (E) National Policies: Climate Change Strategy, Energy Strategy, Building & District heating regulations (E)
Q5: Is there a plan/document that includes a long term integrated vision in the project/smart solution(s) and have CO2 mitigation targets been included in the plan/document?	If Yes/No	**Yes:** Project plan PPS Hearth of South (E) Document with CO_2 reduction per initiative (E) City Vision Document (E) Document of impact when initiatives fail (E) Only sub plans, no total plan (E) Documents with main visions (E) Increasing inhabitants -> increasing energy -> but

		plans for more sustainable (E)
		No:
		No, not part of Ruggedised project (E)
		Yes, is needed, only not available for Ruggedised (E)
		Yes, will look in future (E)
		Yes, integration between stakeholders is important (E)
		Yes, it enhances the benefits of the initiatives (E)
Q7: Can you give an example of the synergy this creates between you and the other partner(s)?	Open	Close collaboration between partners to pick up challenges (L)
		Project makes visions come together (L)
		Collaboration RET and EUR (E)
		Future collaboration with partners (L)
		Lift solutions to new level (E)
		Creates mutual ambitions between partners (E)
		Helps future understanding of storage market and local authorities' objectives in relation to this (E)
Q8: What kind of synergy did you expect with partner(s) that currently has not yet been fulfilled?	Open	Too early to indicate (E)
		Division of roles of initiatives (E)
		None (E)
		Don't know (E)
Q9: Is any party dominating the partnership?	If Yes/No	**Yes:**
		Public (L)
		Private (E)
		Public, Rotterdam is leading (E)
		Private, BNH won the tender and therefore makes decisions (E)
		Private, A lot of knowledge(E)
		Public, Role of facilitator (E)
		Private, land owners are also dominating. Other companies dependent on them (E)
		No:
		Yes (L)
		Yes, horizontal collaboration (L)
		No (L)
		Currently working on the right balance (E)
Q11: What is being done to improve the communication and coordination between different departments, people, and agencies to realize the smart solution(s)/project?	Open	Regular meetings about content and process (E)
		Working together with different departments (L)
		Project presentation within organization (E)
		Hiring consultant (E)
		Engagement Strategy (E)
Q12: Is the decision-making structure of the project/smart solution(s) deliberately designed beforehand? Please specify this decision-making structure, is this	If Yes/No	**Yes:**
		Horizontal (L)
		Vertical (L)

horizontal (collaborative) or vertical (one coordinating body)?		**No:** Not yet (E) Not thought through (E) Horizontal (L)
Q16: What activities do you undertake to improve transparency of your own actions within the project/solution(s)?	Open	Constant tuning with partners (L) Present all activities, vision and strategy to partners (E) Development of a wiki (E) Spreadsheet of process (E) Documentation of meetings, accessible for everyone involved (E) Dissemination by demos, newsletters, webpage (E) Meetings with internal and external people (E) Needs improvement (E)
Q18: How is innovative capacity being ensured/stimulated?	Open	Communication and collaboration between all partners (L) Transparency (E) Invest in innovation and development (E) Innovation platforms (E) Development of Start-up incubation hub (E)
Q19: Do you think there is currently enough potential to keep innovating in this project?	If No	Limited time, increase timeslot (E) More flexibility (E) More collaboration and co-creation (E)
Q21: Are there any other challenges that are of importance in the project/smart solution(s)?	Open	Creating a visible and tangible result on short term (E) Coordination and collaboration between different cities (E)
Q23: Do you think the project/solution(s) will reach the CO2 mitigation targets?	If No	Too ambitious (E) Existing cities have limitations (E) Financial Challenges (E) Already experiencing issues (E) Not in isolation, but only when replicated (E)
Q25: Are there any other elements/aspects that are missing, or that have not been covered of what you think is important in the project/smart solution(s)?	Open	-

Appendix 8.8: Rotterdam Smart Initiatives and Stakeholders

Stakeholders

Municipality of Rotterdam (ROT)

The municipality of Rotterdam is the coordinator of the city project, and the Ruggedised project. It is their responsibility that every partner in the project executes the tasks they have been given. They are ultimately responsible for the city project, and must give updates to the European Commission in Brussel about the project and development of the initiatives. The municipality is almost directly involved in every initiative.

Ballast Nedam/Heijmans (BNH)

Ballast Nedam/Heijmans is a development and construction company. Heijmans has joined Ballast Nedam in 2016 to work together on the Hearth of South District. Ballast Nedam/Heijmans is responsible for the design, construction, financing and maintenance of both the property and the public space. They are actively involved in the heat cold storage related initiatives while they oversee the other initiatives (personal communication). During the development of the zoning plan of the Hearth of South District, BNH has involved citizens in urban development plans to reduce the amount of complaints and so that maximum support is created among the population. Besides this they involved all relevant stakeholders in the area in an interactive planning process so that support is increased for the smart initiatives (TNO, personal communication, October 5th, 2016).

Eneco

Eneco is a Dutch natural gas, electricity, and heat supplier. They focus on sustainability and innovation while investing in smart products and services to increase energy efficiency and lower greenhouse gas emissions (Eneco Groep, 2017). They want to be the operator of sustainable generating assets, and they want to achieve new forms of innovation. However, their core business is exploitation of the initiatives they are involved in.

KPN

KPN is a Dutch landline and mobile telecommunications company. It is one of the leading suppliers of ICT services in the Netherlands (KPN, 2017). In the Ruggedised project, KPN provides a digital infrastructure network (LoRa) and is able to deliver data storage and services. Besides this, they believe in bringing together companies, governments, and knowledge institutes to create new innovations together (KPN Innovatie, 2017).

RET

RET is a tram company in Rotterdam and has been a household name in the city and Rotterdam region for over a century. RET is a semi-privatized company with the municipality of Rotterdam and the Metropole Region Rotterdam The Hague as the sole shareholders (RET, 2017). RET is preparing for a new bus concession that starts in 2019, where around 100 new electric buses will be implemented in the city. The bus and metro station Zuidplein plays an important role in this. Additionally, they are involved in the realization of finding ways to effectively charge and store energy that is used for the buses.

Erasmus University Rotterdam (EUR)

The Erasmus University Rotterdam is one of the knowledge institutes that is involved in the Ruggedised Hearth of South District. Specifically the Rotterdam School of Management (RSM) is involved in the different initiatives of the project. EUR perform scientific research to help the development of several initiatives. They also include master students in this research, and a PhD student. They work together with RET in finding methods how the electric buses can be planned and fit into the bus schedule, how these buses can be charged efficiently, and calculate the reach of the buses. Additionally, they also look into the creation of new business models in the energy management, and 3D city operations model initiatives.

Future Insight (FI)

Future Insight is a small data warehouse developer in the Netherlands. They are specialized in the spatial impact projects such as city development and civil construction projects. They are only involved in one smart initiative in the project, namely the 3-D city operations model. For this, they use 'Clearly' which is a platform that can help to, for example, allow equal insight of projects on past, present, and future processes (Future Insight, 2017). In the Hearth of South District, FI is helping the municipality of Rotterdam in building the 3D infrastructure for the 3D city operations model.

TNO

TNO is the knowledge partner in the project supporting the different stakeholders during the development of the initiatives. They try to help the cities, and try to look for input, best practices, and perform scientific research in order to find solutions for the problems that occur during the city project. In the Ruggedised project, they also have the role of helping the city projects to learn from each other.

Rotterdam Smart Initiatives

Code	Smart Initiative	Stakeholders	Description	Expected CO$_2$ Savings
Smart Thermal Grid				
R1	Geothermal heat-cold storage and heat pumps	BNH, ENECO	An extensive heat and cold storage and exchange system based on a low-temperature thermal grid is developed that will be used to connect all the existing buildings and some new parts of the area with each other, such as the exhibition center Ahoy, the congress center, arts building, and swimming pool. This maximizes the uses of waste heat/cold storage through geothermal storage and lowers the total cost of ownership (TCO). The energy is re-used and stored instead of wasted. The lower TCO will benefit the citizens and owners of most buildings with a public function.	N/D
R2	Thermal energy from waste water	BNH, ENECO, ROT	Thermal energy from waste water will be extracted and connected to the geothermal grid for heating and cooling in the project area. Waste water of showers in the swimming pool is used to directly heat tap water, while heat and cold from sewage water from household will be used in the geothermal smart grid. This will benefit specifically the swimming pool and the households in the area.	N/D
R3	Surface water heat-cold collection	BNH, ENECO	The buildings which are connected to the smart geothermal grid use more heat than cold. By adding heat to the storage system, a balance should be created. Surface water around the Hoornbeeck College and Ahoy complex will be used provide this depending on the demand in the buildings connected to the network.	N/D
R4	Pavement heat-cold collector	BNH, ENECO, ROT	A heat exchanger installed under the surface in the pavement/road, heat and cold can be extracted from the surface and stored in the heat-cold storage system. This will make bus lanes and pedestrian walkways free from snow and ice in the winter, and cool in the summer thereby extending the pavement lifetime.	N/D
Smart Electricity Grid & E-mobility				
R5	RES generation and storage for mobility	RET, BNH, ENECO	New renewable energy sources (RES) will be developed to improve the electricity grid and to cope with the energy demand of the growing electric-bus fleet in Rotterdam. Solar panels will be installed on roofs close to the bus station to deliver energy to battery storage at the bus station, and wind turbines will be installed at the Ahoy exhibition centre. This way, electric buses can be quickly charged in a sustainable way.	N/D
R6	Smart charging parking lots	BNH, ENECO	Because the area electricity grid is almost at its maximum capacity, 25 smart charging points for electric vehicles will be installed in parking lots in the area that can cope with a two way energy flow (grid to vehicle and vehicle to grid) to minimize peak loads. This efficient use of energy can lead to lower energy bills of citizens and building owners.	N/D
R7	Optimising the E-bus	RET, EUR	The goal is to introduce zero emission e-buses successfully on a large scale, starting with six, and aiming at 40 in the	N/D

	fleet of RET		next decade. At the same time the reliability of the timetables of the public transport in all situations and at all times has to be assured. Real-time planning software will be developed and tested to experience the effects on the logistic operations. Simulation models by the EUR will be used for this. This prepares Rotterdam for a modern and well equipped transport company, ready for the future.	
Energy Management and ICT				
R8	Energy Management	BNH, ENECO, EUR	To make good energy management possible, it is important to measure and monitor the supply and demand side. This is done by using smart meters that will also be connected to a building management system to optimize energy use and promote energy efficient behavior. The information is open source, so that all building users can see how their building is functioning compared to other buildings.	N/D
R9	3-D City operations model	FI, ROT, EUR, KPN, BNH	The data that is retrieved from the use of energy of the buildings in the other solutions will be matched and transferred to a 3-D city operations model. This model can show and visualize the actual use of energy as well as the use over a period of time of the individual buildings and the whole area. Data in this 3-D model will be open to other users which can stimulate further innovation. The city of Rotterdam as well as private parties will use this model for new applications.	N/D
R10	LoRa-network	KPN	The Long Range (LoRa) network operated by KPN allows transferring data more efficiently. Sensors in the Hearth of South District will use this network for communication at low costs. Public lightning and waste management systems can for example use this network.	N/D
R11	Efficient and intelligent street lighting	BNH, ROT	Street lightning will be fitted with LED lights and modern sensor technology to lower the energy demand. This allows lighting intensities to be adjusted to the real time needs of citizens that are passing by. The LoRa-network is used to manage this remotely. If up scaled citywide, energy use can reduce by 30%.	N/D
R12	eRadiator	ENECO	The Eneco eRadiator is a server that will be installed as a heater in households in the project area. Installing these servers in households instead of in large data centers allows the heat that is generated by the computer servers in houses to be used to heat citizens' homes. This will reduce their heating demand significantly.	N/D
R13	Smart Waste Management	ROT	The energy use of vehicles for waste collection is lowered by monitoring the degree of filling and optimizing the route of the collection trucks. Besides this, sensors will be installed at waste facilities to measure the filling percentage and to indicate when the container has reached its maximum fill level or when it has been emptied. The LoRa network will (possibly) be used to communicate the data to a centralized management system. It is estimated that 20% less kilometers will be driven in the city.	N/D
Total				5630

Sources: TNO (personal communication, October 5th, 2016), Ruggedised (2017d), Ruggedised (2017e), and Ruggedised (2017f).

Appendix 8.9: Umeå Smart Initiatives and Stakeholders

Stakeholders

Umeå Kommun (UK)

The municipality of Umeå plays an important role in the university district. It facilitates the other stakeholders in the district by closely collaborating with them. The municipality owns no land in the district, but only the roads. They are directly involved in most of the Smart Electricity Grid and E-mobility, and Energy Management and ICT solutions of the Ruggedised project.

Umeå Energi (UE)

Umeå Energi is an energy company that is located in the city of Umeå and owned by the municipality of Umeå. They have sustainability as one of their focus points in providing energy to their customers and aim to be climate neutral in 2018, which is also one of the smart initiatives in the University District (Umeå Energi, 2017). Umeå Energi is the system owner of the peak load variation management and power control initiative, owner of the business model of the Geothermal heating/cooling storage and exchange initiative, owner of the electricity grid, and owner and user of the planning tool in the smart open data city decision platform initiative.

Akademiska Hus AB (AH)

Akademiska Hus is one of Sweden's largest real estate businesses and is the property owner of the university and housing area. They closely work together with universities to strengthen Sweden as a knowledge country by building, developing, and maintaining different environments for education, research, and innovation (Akademiska Hus, 2017).

SP/RISE

SP/RISE/Acrea is a Swedisch research institute focused on electronics, optics, and communication technologies. They are the technical specialist, aim to find new ICT-solutions, and create sustainable growth in industry and society (RISE, 2017).

Umeå University (UU)

The Umeå University is one of the main stakeholders in the area. They are mostly involved in the smart electricity grid and e-mobility initiatives in the area. They closely work together with all the other Ruggedised stakeholders to ensure that the University District area is being developed sustainably.

UPAB

UPAB is an organization that is owned by the municipality and is responsible for the parking and the parking lots in the city of Umeå (UPAB, 2017). They are involved in the smart initiatives that involve parking, or are closely related to parking lots, such as charging points for electric cars when you park. UPAB and AH will set the framework of the business model of the flexible green parking initiative and UPAB will monitor and measure the traffic.

Västerbotten County Council (VCC)

The Västerbotten County Council is a political organization which is responsible for the regional development of Västerbotten County and its fifteen municipalities. They are the property owner of

the hospital buildings and flat tenants. Its main goal is to focus on the county's growth and development. Examples of the county's responsibilities include the monitoring and influencing of the processes and decision at EU and national level that have an impact on the region, and the management of the county's growth strategies and development priorities. It also has the task to coordinate the regional development plan and the regional growth program for the county. In these plans, several of their strategies include sustainable development goals such as promoting environmental-driven businesses and stimulate environmentally driven development (Region Västerbotten, 2017).

Umea Smart Initiatives

Code	Smart Initiative	Stakeholders	Description	Expected CO$_2$ Savings
			Smart Thermal Grid	
U1	Smart City connection to 100% renewable Energy	UE, AH, VCC,	A business model will be developed to optimize renewable energy production and storage, and to improve monitoring, power quality, amount of disruptions etc. This business model at district level will be applied to the whole city that can help to achieve the overall goal of UE to make Umeå 100% climate neutral by 2018.	100% climate neutral in 2018
U2	Peak load variation management and power control	UE, AH, VCC, SP, UU	By using buildings as thermal energy storage, it is possible to even out peak load variations of the buildings. An automated peak load management system will be developed and tested to assess and exploit heat differences in the various buildings such as offices and teaching facilities together with more energy-intensive laboratories and computer rooms. This can potentially reduce energy use on the campus by 15%.	Reduce energy use 15% in 2021
U3	Geothermal heating/cooling storage and exchange	VCC, AH, UE	A business model will be developed for sharing of a geothermal heating/cooling storage. This geothermal heat/cold storage unit will connect and map different buildings with different energy needs to distribute energy more efficiently during the day, but also during the year. The goal is to secure the delivery of heat and cold during the extreme weather variations Umeå can have in the summer and winter, but also when one operation may have an excess of heat or cold when the other is in need of it.	N/D
U4	Energy optimized Electric BRT-station	UK, UPAB, AH	An electric-bus-rapid-transit-station (BRT-station) will be developed within the project area to tackle the problem of the heat and energy loss during boarding procedures of the buses which limits the range of e-buses during the winter. In order to minimize the heat and energy loss, a new BRT-station must help to provide shelter, heating systems, an intelligent ticked identification system using smartphones before boarding, and an insulation structure to	N/D

		minimize energy loss from the boarding procedures.		
Smart Electricity Grid & E-mobility				
U5	EV-charging hub. Storage and exchange, and optimization of the integration of RES in the grid	UE, AH, VCC, UPAB, UK	Up to eight EV-charging facilities using solar energy will be installed to ensure the roll out of electric vehicles in the project area. Different batteries and storage solutions will be tested and a smart power control management-system, including a payment system for the charging will be tested.	100% fossil free by 2020
U6	Energy-efficient land use through flexible green parking pay off	UPAB, UK, AH	A new business model will be developed to enable a reduction of car parking spaces and to direct developer investment from parking towards sustainable mobility solutions which reduces the climate impact and energy use. The business model will be an extended version of a currently existing 'Green Parking Pay-Off model that has been developed for commercial buildings in Umeå.	N/D
U7	Intelligent building control and end user involvement	UE, AH, UU, VCC ,SP	An intelligent and integrated control system for the internal climate will be installed in new apartment buildings in the district to enable continuous monitoring and analysis of each building's internal energy performance. This is tested in new apartment buildings and 130 offices owned by AH in the project area.	N/D
Energy Management and ICT				
U8	Smart Open Data city Decision platform	UK, UU, AH, UE, UPAB, VCC, SP	A smart open data city platform will be developed to provide open source data on for example Umeå's energy consumption and production, buildings and technologies, travel patterns, business models and support processes. Everyone will be allowed to access the data provided on this platform.	N/D
U9	Demand-side management	AH, UU, UK,	An energy demand management system is planned to be installed in the project area by using multivariate analysis tools to track usage by for example the amount of logins to the wireless network so that facility services e.g. cleaning floors and waste management can be coordinated and managed. Based on predictions of the services to actual behaviors, energy consumption can be lowered during the hours when facilities are off-peak.	Energy consumption lowered 15% by 2020
Total				N/D

Sources: TNO (personal communication, October 5th, 2016), Ruggedised (2017d), Ruggedised (2017e), and Ruggedised (2017f).

Appendix 8.10: Glasgow Smart Initiatives and Stakeholders

Glasgow City Council (GCC)

The ultimate goal of the Glasgow City Council is to progress the city further towards becoming a smart, sustainable, and connected city. They aim to maximize the inter-connectedness of energy infrastructure with smart controls, utilizing data to drive new decision making models (personal communication). The City Council is directly involved in eight out of the ten smart initiatives in the city project.

Tennent Caledonian Brewery (TCB)

The Tennent Caledonian Brewery is a known beer brewery in Scotland. They export their beers across the world. The Wellpark brewery building is located in the city project area (Tennent Caledonian, 2017). They are involved in two smart initiatives in the area mostly concerning heat and energy exchange between different buildings in the area.

Wheatley Group (WG)

The Wheatley Group is a housing, care and property-management group in Scotland which provides homes and services to over 200.000 people across central Scotland (Wheatley Group, 2017). They are involved in the two smart initiatives that include residential properties.

SP Energy Networks (SP)

SP is an energy company located in the United Kingdom that transmits, distributes and connects electricity to and from homes and businesses over their own network (SP Energy Networks, 2017). They are involved in two smart initiatives in the district involving energy battery storage.

University of Strathclyde (US)

The University of Strathclyde is a Scottish public research university and is the third largest in Scotland. They are involved in two smart initiatives involving heat and cold exchange and renewable energy sources.

Siemens (SIE)

Siemens is one of the largest industrial manufacturing companies in Europe. Its main activities are industry, energy, healthcare, and infrastructure and cities. Siemen's technologies can help Glasgow to combat challenges with innovative solutions and expertise in the areas of electrification, automation, and digitalization (Siemens, 2017).

Transport Scotland (TS)

Transport Scotland is the national transport agency in Scotland. They aim to deliver a 'safe, efficient, cost-effective and sustainable transport-system' to help achieve sustainable economic growth and to benefit the people of Scotland (Transport Scotland, 2017).

Glasgow Smart Initiatives

Code	Smart Initiative	Stakeholders	Description	Expected CO$_2$ Savings
Thermal Smart Grid				
G1	Heat and Cold exchange - Connection of buildings to district heating network	GCC, TCB, WG, US	The development of a business model must enable public sector buildings in the area to sell surplus heat from/to one another and for private industry to sell heat to local housing, either directly or via an intermediary.	N/D
Smart Electricity Grid and E-mobility				
G2	Battery storage technology as grid balancing mechanism & Supply of RES to EV charging and battery infrastructure/ Innovative connection to renewables and storage :	GCC, TS	Battery storage technology will be developed to support the integration of electricity generated by PV and wind turbines, and will act as a grid balancing mechanism. There will be a technological and business case challenge to understand how energy is purchased from local generators, provided to the battery and sold by the storage provider either for consumption or to provide grid balancing services.	N/D
G3	Surplus power storage in EV Charging hub	TCB, SIE, SP, GCC	A surplus of electricity from the TCB energy center will be stored for later use in city systems such as EV charging. A business model will be developed which deliberates how energy can be (re)sold from batteries to other local organizations.	N/D
G4	Optimization of the integration of near site RES, potentially liked into battery storage	GCC, US, SP	Renewable energy sources such as wind turbines and solar panels will be installed on the roof of a multi-story car park on Duke Street. Energy generation against consumption will be monitored and an overload of generated energy can be netted off to other users.	N/D
G5	EV Charging hub in city centre car park	GCC, SIE, TS	A business case will be developed for an EV charging hub that will be installed in the Duke Street multi-story car park. When there is a low demand for charging electric vehicles, the energy that is generated will be stored for later use. The aim is however to minimize the amount of energy being fed back into the local electricity grid, and to make sure energy is consumed immediately or stored locally for consumption when demand is high or generation is low.	N/D
G6	Intelligent LED street lights with integrated EV charging functionality, wireless communications network, and air pollution monitors	GCC, TS	An EV-charging point will be integrated into a street lighting column in the district. The data generated from these columns will be used to examine the demand-side management potential of connected EV assets and street lights themselves.	N/D
Energy Management and ICT				
G7	Smart open data Decision platform/central	GCC	A Smart open data Decision platform will be build upon the existing open data platform and energy application that will collect data related to city	N/D

			management (e.g. energy, air quality, traffic flow, etc.) and will provide an analysis of data sets to enhance energy planning in the city. Users of this platform such as local authority practitioners, businesses, and academics can use this to gain information which can be used for research and making better decisions through having more knowledge.	122
G8	Implementation of demand-side management technology in street lighting	SIE, GCC	LED street lights that are connected to a smart grid will be linked up to a central energy demand management system which can control lighting such as reducing the brightness of street lights. This can save up energy or make energy available to other areas where demand is peaking. It will also be explored to connect EV to the grid.	N/D
G9	Implementation of demand-side management technology in domestic properties	SIE, WG, GCC	Similar to G8, residential properties in the district will be linked up to a smart grid and central energy demand management system to gain an overview of the local energy scenario. This allows delivering cheaper tariffs for energy to residents when renewable generation exceeds demand. The impact of local storage will also be analyzed.	N/D
G10	Implementation of demand-side management technology in nondomestic properties	SIE, GCC	Similar to G9, however this involved non-residential municipal buildings in the area that will be linked up to a smart grid and central energy demand management system to gain an overview, and to optimize the energy use.	N/D
Total				N/D

Sources: TNO (personal communication, October 5th, 2016), Ruggedised (2017d), Ruggedised (2017e), and Ruggedised (2017f).

Appendix 8.11: Results from Questionnaires and Interviews
8.11.1 Rotterdam
Filled in Questionnaires: 11 (2 government, 6 private companies, 3 researchers).
Interviews: 10 (1 government, 6 private companies, 3 researchers).

Q3. What is the ultimate goal of this project/smart solutions? (N=11)

	Categories (Amount)
Government	Increase livability of the city (1x) Improve sustainability performance (1x) Decrease CO_2 emissions (1x)
Private Company	Develop the initiatives (4x) Optimize energy efficiency (2x) Decrease CO_2 emissions (1x)
Researcher	To meet the objectives of the project and how (2x) Improve sustainability performance (2x) Decrease CO_2 emissions (1x)
Total	**Develop the initiatives (4x)** **Improve sustainability performance (3x)** **Decrease CO_2 emissions (3x)** **To meet the objectives of the project and how (2x)** **Optimize energy efficiency (2x)** **Increase livability of the city (1x)**

Element 1: Integrated Vision
Q5. Is there a plan/document that includes a long term integrated vision in the project/smart solution(s) and has CO_2 mitigation targets been included in this plan/document? If Yes, can you name an example? If No, Do you think an integrated vision is necessary to reach the goal of the project/smart solution(s)? (N=11)

	Yes	Categories (Amount)	No	Categories (Amount)	DK	Total
Government	2	City Vision Document (1x) Project plan PPS Hearth of South (1x)	0		0	2
Private Company	4	Document with CO_2 reduction per initiative (1x) Document of impact when initiatives fail (1x) Only sub plans, no total plan (1x) Project plan PPS Hearth of South (1x) Roadmap Next Economy (1x)	1	No, not part of Ruggedised project (1x)	1	6
Researcher	1	Documents with main visions (1x) Project plan PPS Hearth of South (1x)	1	Yes, is needed, only not available for Ruggedised (1x)	1	3
Total	6	**Project plan PPS Hearth of South (3x)** **Document with CO_2 reduction per initiative (1x)**	3	**No, not part of Ruggedised project (2x)** **Yes, is needed, only not available for Ruggedised**	2	11

	City Vision Document (1x) Document of impact when initiatives fail (1x) Only sub plans, no total plan (1x) Documents with main visions (1x)	(1x)		

Q6. Do all stakeholders share the same vision in the project/smart solution(s)?

	Yes	No	Don't Know	Total
Government	0	1	1	2
Private Company	1	2	3	6
Researcher	0	2	1	3
Total	1	5	5	11

Element 2: The use of ICTs

Q17. To what extent helps ICT in the project/smart solution(s) to:

A = Increase Citizen Participation?; B = Simplify Interactions between stakeholders?; C = Improve internal administrative operations?; D = Improve urban services? (N=11)

Scale of 1 to 5. Where 1= Not well at all, and 5 = Extremely well.

	Government			Private Companies			Researchers			Total		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A	3	3	1,41	2,67	2,5	1,63	1,67	2	0,58	2,45	2	1,37
B	4	4	0	3,5	4	1,64	2,67	3	0,58	3,36	4	1,29
C	4	4	0	3,83	4	1,17	2,33	2	0,58	3,45	4	1,13
D	4	4	0	4	4,5	1,26	3	3	0	3,73	4	1,01
Total	3,75	4	0,71	3,5	4	1,44	2,42	2,5	0,67	3,25	3	1,26

Element 3: Legislation and Policies

Q4. Please state the legislation and/or policy that is the most helping, and the most hampering to successfully realize CO_2 mitigation goals of the project/smart solution(s). (N=11)

	Hampering Categories	Helping Categories
Government		SDE Subsidies (1x) Programma Duurzaam (1x)
Private Company	Only heat law, no heat/cold law (1x) Energy taxes (1x) City heating regulations (1x)	SDE Subsidies (1x) Striving of municipality to PPP (2x)
Researcher	Old and existing Regulations/Contracts (3x) City heating regulations (1x)	
Total	**Old and existing Regulations/Contracts (3x)** **City heating regulations (2x)** **Only heat law, no heat/cold law (1x)** **Energy taxes (1x)**	**SDE Subsidies (2x)** **Striving of municipality to PPP (2x)** **Programma Duurzaam (1x)**

Element 4: Innovation Capacity

Q18. How is innovative capacity being ensured/stimulated? (N=11)

	Categories (Amount)
Government	Communication and collaboration between all partners (2x)
Private Company	Communication and collaboration between all partners (3x) Transparency (1x)
Researcher	Communication and collaboration between all partners (2x)
Total	**Communication and collaboration between all partners (7x)** **Transparency (1x)**

Q19. Do you think there is currently enough potential to keep innovating in this project? If No, What should be improved? (N=11)

	Yes	No	If No: Categories (Amount)	DK	Total
Government	2	0		0	2
Private Company	3	3	Limited time, increase timeslot (2x) More flexibility (2x) More collaboration and co-creation (2x)	0	6
Researcher	3	0		0	3
Total	**8**	**3**	**See Private Company**	**0**	**11**

Element 5: Collaboration and Participation

Q7. Can you give an example of the synergy this creates between you and the other partner(s)? (N=11)

	Categories (Amount)
Government	Collaboration RET and EUR (1x)
Private Company	Close collaboration between partners to pick up challenges (4x) Future collaboration with partners (1x) Project makes visions come together (1x)
Researcher	Project makes visions come together (1x)
Total	**Close collaboration between partners to pick up challenges (4x)** **Project makes visions come together (2x)** **Collaboration RET and EUR (1x)** **Future collaboration with partners (1x)**

Q8. What kind of synergy did you expect with partner(s) that currently has not yet been fulfilled? (N=11)

	Categories (Amount)
Government	Too early to indicate (1x)
Private Company	Too early to indicate (1x) Division of roles of initiatives (1x)
Researcher	Too early to indicate (1x)
Total	**Too early to indicate (3x)** **Division of roles of initiatives (1x)**

Q9. Is any party dominating the partnership? If Yes, public or private and why? If No: Is this the desired situation? (N=11)

	Yes	Categories (Amount)	No	Categories (Amount)	DK	Total
Government	0		2	Yes (2x)	0	2
Private Company	4	Private, BNH won the tender and therefore makes decisions (2x) Public, Rotterdam is leading (4x)	2	Currently working on the right balance (1x) No (1x)	0	6
Researcher	1	Private, BNH won the tender and therefore makes decisions (1x) Public, Rotterdam is leading (1x)	2	Yes (1x) No (1x)	0	3
Total	5	**Public, Rotterdam is leading (5x) Private, BNH won the tender and therefore makes decisions (3x)**	6	**Yes (3x) No (2x) Currently working on the right balance (1x)**	0	11

Q10. In which phase and to what extent are/will citizens be engaged in the project/smart solution(s)? (N=11)
A = Preparation Phase; B = Starting Phase (Year 1-2); C = Middle Phase (Year 3-4); D = End Phase (Year 5-6).
Scale of 1 to 5, where Not Engaged = 1, and Completely Engaged = 5.

	Government			Private Companies			Researchers			Total		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A	2	2	0	1,2	1	0,45	2	2	0	1,56	2	0,53
B	2	2	0	1,25	1	0,5	2,33	2	0,58	1,75	2	0,71
C	3	3	0	1,33	1	0,58	2,67	3	0,58	2,14	2	0,90
D	3	3	0	2	2	1	3	3	1	2,57	3	0,98
Total	**2,5**	**2,5**	**0,58**	**1,4**	**1**	**0,63**	**2,5**	**2**	**0,67**	**1,97**	**2**	**0,84**

Element 6: Internal Coordination

Q11. What is being done to improve the communication and coordination between different departments, people, and agencies to realize the smart solution(s)/project? (N=11)

	Categories (Amount)
Government	Regular meetings about content and process (2x) Working together with different departments (1x)
Private Company	Regular meetings about content and process (4x) Working together with different departments (3x)
Researcher	Regular meetings about content and process (3x) Working together with different departments (2x)
Total	**Regular meetings about content and process (9x) Working together with different departments (6x)**

Element 7: Decision-making Process

Q12. Is the decision-making structure of the project/smart solution(s) deliberately designed beforehand? Please specify this decision-making structure, is this horizontal (collaborative) or vertical (one coordinating body)? (N=11)

	Yes	Categories (Amount)	No	Categories (Amount)	DK	Total
Government	2	Horizontal (2x)	0		0	2
Private Company	0		5	Not yet (5x)	1	6
Researcher	2	Horizontal (2x)	1	Not thought through (1x)	0	3
Total	**4**	**Horizontal (4x)**	**6**	**Not yet (5x)** **Not thought through (1x)**	**1**	**11**

Q13. Are the roles of all stakeholders in the project/solution(s) clearly defined and communicated? (N=11)

	Yes	No	Don't Know	Total
Government	2	0	0	2
Private Company	2	3	1	6
Researcher	2	1	0	3
Total	**6**	**4**	**1**	**11**

Q14. Is decision-making transparent? (N=11)

	Yes	No	Don't Know	Total
Government	2	0	0	2
Private Company	0	5	1	6
Researcher	2	1	0	3
Total	**4**	**6**	**1**	**11**

Q15. Does data retrieved from ICT help to make better decisions? (N=11)

	Yes	No	Don't Know	Total
Government	0	2	0	2
Private Company	0	3	3	6
Researcher	0	3	0	3
Total	**0**	**8**	**3**	**11**

Element 8: E-administration

Q16. What activities do you undertake to improve transparency of your own actions within the project/solution(s)? (N=11)

	Categories (Amount)
Government	Constant tuning with partners (2x) Present all activities, vision and strategy to partners (1x)
Private Company	Constant tuning with partners (3x) Present all activities, vision and strategy to partners (1x)
Researcher	Development of a wiki (2x) Spreadsheet of process (1x)
Total	**Constant tuning with partners (5x)** **Present all activities, vision and strategy to partners (2x)** **Development of a wiki (2x)** **Spreadsheet of process (1x)**

Governance Challenges

Q20. Please indicate for each challenge how important this is in the project/smart solution(s). (N=11). A = Financial Challenges; B = Technical Challenges; C = Environmental Challenges; D = Privacy; E = Lack of Leadership; F = Political Support; G = Digital Divide; H = Collaboration; I = Legal/Policy Challenges. Scale from 1 to 5, 1 = Not at all important, and 5= Extremely important.

	Government			Private Companies			Researchers			Total		
	Mean	**Median**	**SD**	**Mean**	**Median**	**SD**	**Mean**	**Median**	**SD**	**Mean**	**Median**	**SD**
A	4	4	0	4,5	4,5	0,55	4,67	5	0,58	4,45	4	0,52
B	2,5	2,5	0,71	3,67	3,5	0,82	3,67	3	1,15	3,45	3	0,93
C	4	4	1,41	3,17	3,5	0,98	3	3	1	3,27	3	1,01
D	4,5	4,5	0,71	3,33	3	1,03	3	3	0	3,45	3	0,93
E	4	4	0	4,17	4	0,75	4,33	4	0,58	4,18	4	0,60
F	4,5	4,5	0,71	3,83	4	0,75	4,67	5	0,58	4,18	4	0,75
G	2,5	2,5	0,71	3	3	0,63	2	2	1	2,64	3	0,81
H	4,5	4,5	0,71	4,83	5	0,41	4	4	1	4,55	5	0,69
I	4,5	4,5	0,71	3,67	4	0,52	3,67	3	1,15	3,81	4	0,75
Total	**3,89**	**4**	**0,96**	**3,80**	**4**	**0,90**	**3,67**	**4**	**1,11**	**3,78**	**4**	**0,96**

Q21. Are there any other challenges that are of importance in the project/smart solution(s)? (N=11)

	Categories (Amount)
Government	Creating a visible and tangible result on short term (1x)
Private Company	
Researcher	
Total	**Creating a visible and tangible result on short term (1x)**

Q22. Are challenges being openly discussed with other consortia? (N=11)

	Yes	No	Don't Know	Total
Government	2	0	0	2
Private Company	3	2	1	6
Researcher	2	1	0	3
Total	**7**	**3**	**1**	**11**

Q23. Do you think the project/solution(s) will reach the CO_2 mitigation targets? If No, why not? (N=11)

	Yes	No	If No: Categories (Amount)	Total
Government	1	1	Existing cities have limitations (1x)	2
Private Company	3	3	Too ambitious (3x) Financial Challenges (1x) Already experiencing issues (1x)	6
Researcher	2	1	Too ambitious (1x)	3
Total	**5**	**6**	**Too ambitious (4x)** **Existing cities have limitations (1x)** **Financial Challenges (1x)** **Already experiencing issues (1x)**	**11**

Presence of elements according to stakeholders

Q24. On a scale of 1-5 (1 being not at all, 5 being completely present) how much are the following elements present in the current project/smart solution(s)? (N=11). A = Integrated Vision; B = The use of ICTs; C = Legislation and Policies; D = Innovation Capacity; E = Collaboration and Participation; F = Internal Coordination; G = Decision-making Process; H = E-administration.

	Government			Private Companies			Researchers			Total		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A	4	4	0	2,67	3	0,82	2,33	2	0,58	2,81	3	0,87
B	4	4	0	2,83	2,5	0,98	3,33	3	0,58	3,18	3	0,87
C	4,5	4,5	0,71	2,83	3	0,75	3	3	0	3,18	3	0,87
D	3,5	3,5	0,71	2,83	3	0,75	3,33	4	1,15	3,09	3	0,83
E	3,5	3,5	0,71	2,5	2,5	0,55	3	3	1	2,82	3	0,75
F	4,5	4,5	0,71	2,33	2	1,03	3,33	4	1,15	3	3	1,26
G	4	4	0	2,5	2,5	1,05	2,67	2	1,15	2,82	3	1,08
H	4	4	0	3	3	0,89	3,67	4	0,58	3,36	4	0,81
Total	**4**	**4**	**0,52**	**2,69**	**3**	**0,83**	**3,08**	**3**	**0,83**	**3,03**	**3**	**0,92**

Q25. Are there any other elements/aspects that are missing, or that have not been covered of what you think is important in the project/smart solution(s)? (N=11)

	Categories (Amount)
Government	-
Private Company	-
Researcher	-
Total	-

8.11.2 Umeå

Filled in Questionnaires: <u>4</u> (2 government, 2 private companies, 0 researchers)
Interviews: 1 (1 government)

Q3. What is the ultimate goal of this project/smart solutions? (N=4)

	Categories (Amount)
Government	Create a business model (1x) Develop the initiatives (1x) Decrease CO_2 emissions (1x) Improve sustainability performance (1x)
Private Company	Develop the initiatives (1x) Decrease CO_2 emissions (1x)
Researcher	N/D
Total	**Develop the initiatives (2x)** **Decrease CO_2 emissions (2x)** **Create a business model (1x)** **Improve sustainability performance (1x)**

Element 1: Integrated Vision

Q5. Is there a plan/document that includes a long term integrated vision in the project/smart solution(s) and has CO$_2$ mitigation targets been included in this plan/document? If Yes, can you name an example? If No, Do you think an integrated vision is necessary to reach the goal of the project/smart solution(s)? (N=3).

	Yes	Categories (Amount)	No	Categories (Amount)	DK	Total
Government	1	Increasing inhabitants -> increasing energy -> but plans for more sustainable (1x)	0		0	1
Private Company	0		2	Yes, will look in future (1x) Yes, integration between stakeholders is important (1x)	0	2
Researcher	N/D	N/D	N/D	N/D	N/D	N/D
Total	**1**	**Increasing inhabitants -> increasing energy -> but plans for more sustainable (1x)**	**2**	**Yes, will look in future (1x) Yes, integration between stakeholders is important (1x)**	**0**	**3**

Q6. Do all stakeholders share the same vision in the project/smart solution(s)? (N=4)

	Yes	No	Don't Know	Total
Government	1	0	1	2
Private Company	1	0	1	2
Researcher	N/D	N/D	N/D	N/D
Total	**2**	**0**	**2**	**4**

Element 2: The use of ICTs

Q17. To what extent helps ICT in the project/smart solution(s) to:

A = Increase Citizen Participation?; B = Simplify Interactions between stakeholders?; C = Improve internal administrative operations?; D = Improve urban services? Scale of 1 to 5. Where 1= Not well at all, and 5 = Extremely well. (N=4)

	Government			Private Companies			Researchers			Total		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A	3	3	2,83	4	4	0	N/D	N/D	N/D	3,5	4	1,73
B	1,5	1,5	0,71	4	3	0	N/D	N/D	N/D	2,75	3	1,5
C	2,5	2,5	2,12	3	3	0	N/D	N/D	N/D	2,75	3	1,26
D	2,5	2,5	2,12	4	4	0	N/D	N/D	N/D	3,25	4	1,5
Total	**2,38**	**1,5**	**1,69**	**3,75**	**4**	**0,46**	**N/D**	**N/D**	**N/D**	**3,06**	**4**	**1,39**

Element 3: Legislation and Policies

Q4. Please state the legislation and/or policy that is the most helping, and the most hampering to successfully realize CO_2 mitigation goals of the project/smart solution(s). (N=4).

	Hampering Categories	Helping Categories
Government	-	Energy Policy (1x) Air Quality Policy (1x) Sustainability Policies and Legislation (1x)
Private Company	Business structures based on linear value chains (1x)	Sustainability Policies and Legislation (1x)
Researcher	N/D	N/D
Total	**Business structures based on linear value chains (1x)**	**Sustainability Policies and Legislation (2x)** **Energy Policy (1x)** **Air Quality Policy (1x)**

Element 4: Innovation Capacity

Q18. How is innovative capacity being ensured/stimulated? (N=4)

	Categories (Amount)
Government	Innovation platforms (1x)
Private Company	Communication and collaboration between all partners (1x) Invest in innovation and development (1x)
Researcher	N/D
Total	**Communication and collaboration between all partners (1x)** **Invest in innovation and development (1x)** **Innovation platforms (1x)**

Q19. Do you think there is currently enough potential to keep innovating in this project? (N=4).

	Yes	No	If No: Categories (Amount)	DK	Total
Government	2	0		0	2
Private Company	2	0		0	2
Researcher	N/D	N/D	N/D	N/D	N/D
Total	4	0		0	4

Element 5: Collaboration and Participation

Q7. Can you give an example of the synergy this creates between you and the other partner(s)? (N=4).

	Categories (Amount)
Government	Future collaboration with partners (2x) Lift solutions to new level (1x)
Private Company	Lift solutions to new level (1x) Creates mutual ambitions between partners (1x)
Researcher	N/D
Total	**Future collaboration with partners (2x)** **Lift solutions to new level (2x)** **Creates mutual ambitions between partners (1x)**

Q8. What kind of synergy did you expect with partner(s) that currently has not yet been fulfilled? (N=4)

	Categories (Amount)
Government	None (2x)
Private Company	None (2x)
Researcher	N/D
Total	**None (4x)**

Q9. Is any party dominating the partnership? If Yes, public or private and why? If No: Is this the desired situation? (N=4)

	Yes	Categories (Amount)	No	Categories (Amount)	DK	Total
Government	1	Public, Role of facilitator (1x). Private, land owners are also dominating. Other companies dependent on them (1x).	1	Yes, horizontal collaboration (1x)	0	2
Private Company	1	Private, A lot of Knowledge (1x)	1	Yes, horizontal collaboration (1x)	0	2
Researcher	N/D	N/D	N/D	N/D	N/D	N/D
Total	**2**	**Private, A lot of Knowledge (1x) Public, Role of facilitator (1x). Private, land owners are also dominating. Other companies dependent on them (1x).**	**2**	**Yes, horizontal collaboration (2x)**	**0**	**4**

Q10. In which phase and to what extent are/will citizens be engaged in the project/smart solution(s)? (N=4).
A = Preparation Phase; B = Starting Phase (Year 1-2); C = Middle Phase (Year 3-4); D = End Phase (Year 5-6).
Scale of 1 to 5, where Not Engaged = 1, and Completely Engaged = 5.

	Government			Private Companies			Researchers			Total		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A	2	2	1,41	2	2	1,41	N/D	N/D	N/D	2	2	1,15
B	2,5	2,5	2,12	3	3	1,41	N/D	N/D	N/D	2,75	3	1,5
C	3	3	1,41	4	4	1,41	N/D	N/D	N/D	3,5	4	1
D	3	3	1,41	3	3	1,41	N/D	N/D	N/D	3	3	1,15
Total	**2,63**	**2,5**	**1,3**	**3**	**3,5**	**1,12**	**N/D**	**N/D**	**N/D**	**2,81**	**3**	**1,22**

Element 6: Internal Coordination

Q11. What is being done to improve the communication and coordination between different departments, people, and agencies to realize the smart solution(s)/project? (N=4)

	Categories (Amount)
Government	Hiring consultant (1x) Regular meetings about content and process (1x) Project presentation within organization (1x) Working together with different departments (1x)
Private Company	Regular meetings about content and process (2x) Working together with different departments (2x)
Researcher	N/D
Total	**Regular meetings about content and process (3x)** **Working together with different departments (3x)** **Project presentation within organization (1x)** **Hiring consultant (1x)**

Element 7: Decision-making Process

Q12. Is the decision-making structure of the project/smart solution(s) deliberately designed beforehand? Please specify this decision-making structure, is this horizontal (collaborative) or vertical (one coordinating body)? (N=4)

	Yes	Categories (Amount)	No	Categories (Amount)	DK	Total
Government	1	Horizontal (1x)	0		1	2
Private Company	1	Vertical (1x)	1	Horizontal (1x)	0	2
Researcher	N/D	N/D	N/D	N/D	N/D	N/D
Total	**2**	**Horizontal (1x)** **Vertical (1x)**	**1**	**Horizontal (1x)**	**1**	**4**

Q13. Are the roles of all stakeholders in the project/solution(s) clearly defined and communicated? (N=4)

	Yes	No	Don't Know	Total
Government	2	0	0	2
Private Company	1	0	1	2
Researcher	N/D	N/D	N/D	N/D
Total	**3**	**0**	**1**	**4**

Q14. Is decision-making transparent? (N=4)

	Yes	No	Don't Know	Total
Government	2	0	0	2
Private Company	1	1	0	2
Researcher	N/D	N/D	N/D	N/D
Total	**3**	**1**	**0**	**4**

Q15. Does data retrieved from ICT help to make better decisions? (N=4)

	Yes	No	Don't Know	Total
Government	0	0	2	2
Private Company	0	0	2	2
Researcher	N/D	N/D	N/D	N/D
Total	**0**	**0**	**4**	**4**

Element 8: E-administration

Q16. What activities do you undertake to improve transparency of your own actions within the project/solution(s)? (N=4)

	Categories (Amount)
Government	Dissemination by demos, newsletters, webpage (1x) Meetings with internal and external people (1x) Documentation of meetings, accessible for everyone involved (1x)
Private Company	Meetings with internal and external people (1x) Documentation of meetings, accessible for everyone involved (2x) Dissemination by demos, newsletters, webpage (1x)
Researcher	N/D
Total	**Documentation of meetings, accessible for everyone involved (3x)** **Dissemination by demos, newsletters, webpage (2x)** **Meetings with internal and external people (2x)**

Governance Challenges

Q20. Please indicate for each challenge how important this is in the project/smart solution(s). (N=4). A = Financial Challenges; B = Technical Challenges; C = Environmental Challenges; D = Privacy; E = Lack of Leadership; F = Political Support; G = Digital Divide; H = Collaboration; I = Legal/Policy Challenges. Scale from 1 to 5, 1 = Not at all important, and 5= Extremely important.

	Government			Private Companies			Researchers			Total		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A	4	4	0	3	3	0	N/D	N/D	N/D	3,5	3,5	0,58
B	3	3	1,41	4	4	0	N/D	N/D	N/D	3,5	4	1
C	4	4	0	4	4	0	N/D	N/D	N/D	4	4	0
D	2	2	0	2,5	2,5	0,71	N/D	N/D	N/D	2,25	2	0,5
E	3	3	0	4	4	0	N/D	N/D	N/D	3,5	3,5	0,58
F	4	4	0	4	4	1,41	N/D	N/D	N/D	4	4	0,82
G	3,5	3,5	0,71	3	3	0	N/D	N/D	N/D	3,25	3	0,5
H	4,5	4,5	0,71	4,5	4,5	0,71	N/D	N/D	N/D	4,5	4,5	0,58
I	2,5	2,5	0,71	4	4	0	N/D	N/D	N/D	3,25	3,5	0,96
Total	**3,39**	**4**	**0,92**	**3,67**	**4**	**0,77**	**N/D**	**N/D**	**N/D**	**3,53**	**4**	**0,84**

Q21. Are there any other challenges that are of importance in the project/smart solution(s)? (N=4)

	Categories (Amount)
Government	Creating a visible and tangible result on short term (1x)
Private Company	No (1x) Coordination and collaboration between different cities (1x)
Researcher	N/D
Total	**Coordination and collaboration between different cities (1x)** **Creating a visible and tangible result on short term (1x)**

Q22. Are challenges being openly discussed with other consortia? (N=4)

	Yes	No	Don't Know	Total
Government	2	0	0	2
Private Company	2	0	0	2
Researcher	N/D	N/D	N/D	N/D
Total	**4**	**0**	**0**	**4**

Q23. Do you think the project/solution(s) will reach the CO_2 mitigation targets? (N=3)

	Yes	No	If No: Categories (Amount)	DK	Total
Government	0	1	Too ambitious (1x)	0	1
Private Company	2	0		0	2
Researcher	N/D	N/D	N/D	N/D	N/D
Total	**2**	**1**	**Too ambitious (1x)**	**0**	**3**

Presence of elements according to stakeholders

Q24. On a scale of 1-5 (1 being not at all, 5 being completely present) how much are the following elements present in the current project/smart solution(s)? (N=3). A = Integrated Vision; B = The use of ICTs; C = Legislation and Policies; D = Innovation Capacity; E = Collaboration and Participation; F = Internal Coordination; G = Decision-making Process; H = E-administration.

	Government			Private Companies			Researchers			Total		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A	2	2	0	3,5	3,5	0,71	N/D	N/D	N/D	3	3	1
B	5	5	0	3,5	3,5	0,71	N/D	N/D	N/D	4	4	1
C	5	5	0	4,5	4,5	0,71	N/D	N/D	N/D	4,67	5	0,58
D	4	4	0	3,5	3,5	0,71	N/D	N/D	N/D	3,67	4	0,58
E	5	5	0	3,5	3,5	0,71	N/D	N/D	N/D	4	4	1
F	3	3	0	3	3	0	N/D	N/D	N/D	3	3	0
G	2	2	0	3,5	3,5	0,71	N/D	N/D	N/D	3	3	1
H	5	5	0	3,5	3,5	0,71	N/D	N/D	N/D	4	4	1
Total	**3,88**	**4,5**	**1,36**	**3,56**	**3,5**	**0,63**	**N/D**	**N/D**	**N/D**	**3,67**	**4**	**0,92**

Q25. Are there any other elements/aspects that are missing, or that have not been covered of what you think is important in the project/smart solution(s)? (N=4)

	Categories (Amount)
Government	-
Private Company	-
Researcher	N/D
Total	-

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Filled in Questionnaires: 1 (1 government, 0 private companies, 0 researchers)

Interviews: 0

Q3. What is the ultimate goal of this project/smart solutions? (N=1).

	Categories (Amount)
Government	Becoming a smart sustainable and connected city (1x)
	Maximize interconnectedness between initiatives (1x)
	Replication (1x)
Private Company	N/D
Researcher	N/D
Total	See Government

Element 1: Integrated Vision

Q5. Is there a plan/document that includes a long term integrated vision in the project/smart solution(s) and has CO$_2$ mitigation targets been included in this plan/document? If Yes, can you name an example? If No, Do you think an integrated vision is necessary to reach the goal of the project/smart solution(s)? (N=1).

	Yes	Categories (Amount)	No	Categories (Amount)	DK	Total
Government	0	-	1	Yes, it enhances the benefits of the initiatives. (1x)	0	1
Private Company	N/D	N/D	N/D	N/D	N/D	N/D
Researcher	N/D	N/D	N/D	N/D	N/D	N/D
Total	0	See Government	1	See Government	0	1

Q6. Do all stakeholders share the same vision in the project/smart solution(s)? (N=1).

	Yes	No	Don't Know	Total
Government	1	0	0	1
Private Company	N/D	N/D	N/D	N/D
Researcher	N/D	N/D	N/D	N/D
Total	1	0	0	1

Element 2: The use of ICTs

Q17. To what extent helps ICT in the project/smart solution(s) to: A = Increase Citizen Participation?; B = Simplify Interactions between stakeholders?; C = Improve internal administrative operations?; D = Improve urban services? Scale of 1 to 5. Where 1= Not well at all, and 5 = Extremely well. (N=1).

	Government			Private Companies			Researchers			Total		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A	3	3	0	N/D	N/D	N/D	N/D	N/D	N/D	3	3	0
B	3	3	0	N/D	N/D	N/D	N/D	N/D	N/D	3	3	0
C	3	3	0	N/D	N/D	N/D	N/D	N/D	N/D	3	3	0
D	3	3	0	N/D	N/D	N/D	N/D	N/D	N/D	3	3	0
Total	3	3	0	N/D	N/D	N/D	N/D	N/D	N/D	3	3	0

Element 3: Legislation and Policies

Q4. Please state the legislation and/or policy that is the most helping, and the most hampering to successfully realize CO$_2$ mitigation goals of the project/smart solution(s). (N=1).

	Hampering Categories	Helping Categories
Government	Lack of district regulations. (1x) Lack of national policy on business rates applying to district heating. (1x)	Energy & Carbon Masterplan (1x) Resilience Plan (1x) Climate change Adaptation & Mitigation plan (1x) National Policies: Climate Change Strategy, Energy Strategy, Building & District heating regulations (1x)
Private Company	N/D	N/D
Researcher	N/D	N/D
Total	**See Government**	**See Government**

Element 4: Innovation Capacity

Q18. How is innovative capacity being ensured/stimulated? (N=1).

	Categories (Amount)
Government	Development of Start-up incubation hub (1x)
Private Company	N/D
Researcher	N/D
Total	**See Government**

Q19. Do you think there is currently enough potential to keep innovating in this project? (N=1).

	Yes	No	If No: Categories (Amount)	DK	Total
Government	1	0	-	0	1
Private Company	N/D	N/D	N/D	N/D	N/D
Researcher	N/D	N/D	N/D	N/D	N/D
Total	**1**	**0**	**-**	**0**	**1**

Element 5: Collaboration and Participation

Q7. Can you give an example of the synergy this creates between you and the other partner(s)? (N=1).

	Categories (Amount)
Government	Helps future understanding of storage market and local authorities' objectives in relation to this. (1x)
Private Company	N/D
Researcher	N/D
Total	**See Government**

Q8. What kind of synergy did you expect with partner(s) that currently has not yet been fulfilled? (N=1).

	Categories (Amount)
Government	Don't know (1x)
Private Company	
Researcher	
Total	**See Government**

Q9. Is any party dominating the partnership? If Yes, public or private and why? If No: Is this the desired situation? (N=1).

	Yes	Categories (Amount)	No	Categories (Amount)	DK	Total
Government	0		1	No	0	1
Private Company	N/D	N/D	N/D	N/D	N/D	N/D
Researcher	N/D	N/D	N/D	N/D	N/D	N/D
Total	**0**		**1**		**0**	**1**

Q10. In which phase and to what extent are/will citizens be engaged in the project/smart solution(s)? A = Preparation Phase; B = Starting Phase (Year 1-2); C = Middle Phase (Year 3-4); D = End Phase (Year 5-6). Scale of 1 to 5, where Not Engaged = 1, and Completely Engaged = 5. (N=1).

	Government			Private Companies			Researchers			Total		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A	1	1	0	N/D	N/D	N/D	N/D	N/D	N/D	1	1	0
B	4	4	0	N/D	N/D	N/D	N/D	N/D	N/D	4	4	0
C	3	3	0	N/D	N/D	N/D	N/D	N/D	N/D	3	3	0
D	3	3	0	N/D	N/D	N/D	N/D	N/D	N/D	3	3	0
Total	**2,75**	**3**	**1,26**	**N/D**	**N/D**	**N/D**	**N/D**	**N/D**	**N/D**	**2,75**	**3**	**1,26**

Element 6: Internal Coordination

Q11. What is being done to improve the communication and coordination between different departments, people, and agencies to realize the smart solution(s)/project? (N=1).

	Categories (Amount)
Government	Engagement Strategy
Private Company	N/D
Researcher	N/D
Total	**See Government**

Element 7: Decision-making Process

Q12. Is the decision-making structure of the project/smart solution(s) deliberately designed beforehand? Please specify this decision-making structure, is this horizontal (collaborative) or vertical (one coordinating body)? (N=1).

	Yes	Categories (Amount)	No	Categories (Amount)	DK	Total
Government	1	Horizontal	0		0	1
Private Company	N/D	N/D	N/D	N/D	N/D	N/D
Researcher	N/D	N/D	N/D	N/D	N/D	N/D
Total	**1**	**See Government**	**0**		**0**	**1**

Q13. Are the roles of all stakeholders in the project/solution(s) clearly defined and communicated? (N=1).

	Yes	No	Don't Know	Total
Government	1	0	0	1
Private Company	N/D	N/D	N/D	N/D
Researcher	N/D	N/D	N/D	N/D
Total	**1**	**0**	**0**	**1**

Q14. Is decision-making transparent? (N=1).

	Yes	No	Don't Know	Total
Government	0	0	1	1
Private Company	N/D	N/D	N/D	N/D
Researcher	N/D	N/D	N/D	N/D
Total	**0**	**0**	**1**	**1**

Q15. Does data retrieved from ICT help to make better decisions? (N=1).

	Yes	No	Don't Know	Total
Government	1	0	0	1
Private Company	N/D	N/D	N/D	N/D
Researcher	N/D	N/D	N/D	N/D
Total	**1**	**0**	**0**	**1**

Element 8: E-administration

Q16. What activities do you undertake to improve transparency of your own actions within the project/solution(s)? (N=1).

	Categories (Amount)
Government	Need improvement
Private Company	N/D
Researcher	N/D
Total	See Government

Governance Challenges

Q20. Please indicate for each challenge how important this is in the project/smart solution(s). (N=1). A = Financial Challenges; B = Technical Challenges; C = Environmental Challenges; D = Privacy; E = Lack of Leadership; F = Political Support; G = Digital Divide; H = Collaboration; I = Legal/Policy Challenges. Scale from 1 to 5, 1 = Not at all important, and 5= Extremely important.

	Government			Private Companies			Researchers			Total		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A	5	5	0	N/D	N/D	N/D	N/D	N/D	N/D	5	5	0
B	5	5	0	N/D	N/D	N/D	N/D	N/D	N/D	5	5	0
C	5	5	0	N/D	N/D	N/D	N/D	N/D	N/D	5	5	0
D	5	5	0	N/D	N/D	N/D	N/D	N/D	N/D	5	5	0
E	4	4	0	N/D	N/D	N/D	N/D	N/D	N/D	4	4	0
F	5	5	0	N/D	N/D	N/D	N/D	N/D	N/D	5	5	0
G	5	5	0	N/D	N/D	N/D	N/D	N/D	N/D	5	5	0
H	5	5	0	N/D	N/D	N/D	N/D	N/D	N/D	5	5	0
I	5	5	0	N/D	N/D	N/D	N/D	N/D	N/D	5	5	0
Total	**4,89**	**5**	**0,33**	**N/D**	**N/D**	**N/D**	**N/D**	**N/D**	**N/D**	**4,89**	**5**	**0,33**

Q21. Are there any other challenges that are of importance in the project/smart solution(s)? (N=1).

	Categories (Amount)
Government	-
Private Company	N/D
Researcher	N/D
Total	-

Q22. Are challenges being openly discussed with other consortia? (N=1).

	Yes	No	Don't Know	Total
Government	1	0	0	1
Private Company	N/D	N/D	N/D	N/D
Researcher	N/D	N/D	N/D	N/D
Total	**1**	**0**	**0**	**1**

Q23. Do you think the project/solution(s) will reach the CO_2 mitigation targets? (N=1).

	Yes	No	If No: Categories (Amount)	DK	Total
Government	0	1	Not in isolation, but only when replicated	0	1
Private Company	N/D	N/D	N/D	N/D	N/D
Researcher	N/D	N/D	N/D	N/D	N/D
Total	0	1	**See Government**	0	1

Presence of elements according to stakeholders

Q24. On a scale of 1-5 (1 being not at all, 5 being completely present) how much are the following elements present in the current project/smart solution(s)? (N=1). A = Integrated Vision; B = The use of ICTs; C = Legislation and Policies; D = Innovation Capacity; E = Collaboration and Participation; F = Internal Coordination; G = Decision-making Process; H = E-administration.

	Government			Private Companies			Researchers			Total		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
A	3	3	0	N/D	N/D	N/D	N/D	N/D	N/D	3	3	0
B	3	3	0	N/D	N/D	N/D	N/D	N/D	N/D	3	3	0
C	4	4	0	N/D	N/D	N/D	N/D	N/D	N/D	4	4	0
D	3	3	0	N/D	N/D	N/D	N/D	N/D	N/D	3	3	0
E	4	4	0	N/D	N/D	N/D	N/D	N/D	N/D	4	4	0
F	4	4	0	N/D	N/D	N/D	N/D	N/D	N/D	4	4	0
G	4	4	0	N/D	N/D	N/D	N/D	N/D	N/D	4	4	0
H	3	3	0	N/D	N/D	N/D	N/D	N/D	N/D	3	3	0
Total	**3,5**	**3,5**	**0,53**	**N/D**	**N/D**	**N/D**	**N/D**	**N/D**	**N/D**	**3,5**	**3,5**	**0,53**

Q25. Are there any other elements/aspects that are missing, or that have not been covered of what you think is important in the project/smart solution(s)? (N=1).

	Categories (Amount)
Government	-
Private Company	N/D
Researcher	N/D
Total	-