Western Norway University of Applied Sciences

MASTER'S THESIS

Co-creation for the adoption of smart technologies in the public sector

For energy efficiency in a Norwegian county municipality

By

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Studieobjekt: Vestland fylkeskommunes videregående skoler lokalisert i Bergen kommune

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Sammendrag:

Vi står i disse dager ovenfor en klimakrise som har resultert i at viktige verdensorganisasjoner har brukt enorme ressurser for å tilrettelegge for en global energiomstilling. Dette skaper ringvirkninger for bærekraft og energieffektivisering, også lokalt. I en rask og voksende teknologisk utvikling, byr enorme muligheter seg for virksomheter på tvers av sektorer. Uavhengig av dette eksisterer det et adopsjonsproblem i offentlig sektor av smart-teknologi, forårsaket av visse barrierer som hindrer offentlig sektor å innovere og adoptere smarte teknologiske løsninger for energieffektivisering.

Formålet med studien er å undersøke disse barrierene med fokus på offentlige bygninger i Vestland fylkeskommune, og hvordan disse kan overkommes ved bruk av samskaping (co-creation). Den gjeldende klimaplanen fremhever at det største potensialet for energieffektivisering ligger i eksisterende bygningsmasse. Det er også i eksisterende bygningsmasse at de største utfordringene for energieffektivisering befinner seg. Siden videregående skoler i Vestland fylke utgjør 95% av bygningsmassen som ligger under fylkeskommunens eierskap, har vi rettet fokuset mot fylkets videregående skoler i Bergen. Vi har utført en kvalitativ singel case-studie hvor vi har samlet inn datamateriale fra aktører både i privat og offentlig sektor, samt akademia. I tillegg komplementerer vi masteroppgaven med en pilotstudie fra høsten 2019 med intensjon om å skape kunnskap før arbeidet med masteroppgaven startet. Vi har i tillegg gjort observasjoner ved å delta på seminarer om pågående utfordringer rundt energieffektivisering i bygninger. Kombinert med sekundærdata avdekkes det således kunnskap som har gitt oss innsikt om barrierer for adopsjon av smart-teknologi, og hvordan disse kan overkommes ved hjelp av samskaping.

Gjennom en omfattende analyseprosess finner vi at totalt 20 barrierer er fremtredende under kategoriene: *prioritering, organisasjon, økonomi, kompetanse, teknologi og regelverk*. Videre redegjør vi for anbefalinger til co-creation prosessen, samt forutsetninger som må være til stede for at co-creation skal kunne benyttes effektivt for å løse barrierene. Resultatene fra analysen tyder på at co-creation kan løse 16 av 20 barrierer i sin helhet, og dermed kunne bidra sterkt til å overkomme de hindringene som henspiller seg for adopsjon av smart-teknologi i offentlig sektor. Vi har beriket vårt teoretiske rammeverket med empiriske funn gjennom sammenligning av de to rammeverkene, og konkluderer med at manglende prioritering er studiens største bidrag til etablert kunnskap om barrierer for innovasjon i offentlig sektor.

Summary:

Facing an ongoing climate crisis has resulted in world organizations' having devotedly allocated enormous resources to facilitate a global energy transition. This creates a dispersion for sustainability and energy efficiency, on local and regional levels as well. Rapid growing technological development lead to great opportunities for businesses across sectors. However, it exists a deployment failure of smart technologies in the public sector, whereof it is suggested that certain barriers are preventing the public sector to innovate and to adopt smart-technologies to exploit the technological benefits towards energy efficiency.

Focusing on public buildings in Vestland county municipality, the purpose of this study is to explore the barriers preventing the public sector adopting smart-technologies for energy efficiency, and how the barriers can be solved by utilizing co-creation. The current climate plan highlights that the greatest potential, as well as challenges, for energy efficiency lies within the existing building mass. Since upper secondary schools are under the ownership of Vestland county municipality, and makes up 95% of the building mass that, we have focused our case towards these buildings. We have limited our research geographically by addressing upper secondary schools located in Bergen municipality. By conducting a qualitative single case study, framing public buildings (upper secondary schools) in Bergen, we have collected data material from actors from the private and public sectors, as well as academia. In addition, we completed a pilot study through the fall semester in 2019, with the intention to create knowledge before the actual research started. We also participated relevant seminars and observed speakers presenting ongoing challenges and opportunities related to energy efficiency in buildings. Combined with secondary data, we have uncovered knowledge that has given us insights on barriers relating to the adoption of smart technology, and how these can be solved utilizing co-creation.

Through a comprehensive analysis process, we a total of 20 barriers are prominent in the following categories: *prioritization, organization, economy, expertise, technology and regulations.* We also describe recommendations for the co-creation process, as well as conditions that must be in place for co-creation to effectively solve the barriers. The results of the analysis suggest that co-creation can solve 16 of 20 barriers, and thus could greatly contribute for overcoming the barriers that are preventing the adoption of smart technology in the public sector.

We have enriched the theoretical framework with empirical findings through comparison of the two frameworks. The study concludes with *lack of priority* as the strongest contribution to established knowledge about barriers to innovation in the public sector.

Stikkord for bibliotek:

Samskaping, offentlig innovasjon, smarte byer, smarte strømnett, tingenes internett, store data, energieffektivisering og bærekraft.

Co-creation for the adoption of smart technologies in the public sector - For energy efficiency in a Norwegian county municipality

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Preface

The submission of our master thesis marks the end of our studies in the master's program in Innovation and Management at Western Norway University of Applied Sciences in Bergen and is an important milestone for further accomplishments. The study explores the spectrum of barriers that are preventing the adoption of smart technological solutions in the Norwegian public sector. Global climate challenges are increasing, and there is broad agreement on the importance of introducing solutions that positively impacts the environment. Smart technological solutions have not been satisfactorily adopted in public buildings, and the new technologies provides opportunities to achieve important climate targets to reduce climate emissions. Our study explores how a Norwegian county municipality's energy goals can be achieved in public educational buildings within a municipality. Reduction of energy consumption in public educational buildings will, due to large building mass, contribute greatly to achieve energy targets. A strategic goal to achieve the county's goals is energy efficiency. We aim to explore the barriers for adopting smart technologies in public educational buildings to achieve the goal of energy efficiency, and whether the practice of co-creation among different actors may help to overcome the barriers that prevents adoption of smart technology solutions.

We want to pay our respect and tribute to our supervisor, Paul Benneworth, for the good support, for all the input and feedback, expertise and professionalism in his role as supervisor of our master's thesis. We would also like to thank him for his ability to motivate us to constantly search for ways to make this study even better, and for being given the opportunity to work with him. We would also like to thank all our informants who have supported and provided us with important data. The commitment to find innovative and good solutions in the public sector is high, and we are grateful that we have been given the opportunity to explore different actors present challenges and seen how they devotedly work to optimize the Norwegian public sector's buildings. Furthermore, we want to thank our families and friends for good support and feedback, especially during the ongoing pandemic of the coronavirus, Covid-19, which has resulted in significantly more work from home than planned. We would also like to thank the entire institution for two great and educational years. Finally, we thank each other for good collaboration throughout the period we have been working on our master's thesis.

David Sjåstad & Sindre René Frydstad - The 29th of May 2020

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Chapter 1 - Introduction

In this study our intention is to explore how certain barriers seem to be preventing for the public sector to adopt smart technologies for becoming energy efficient, and whether co-creation practises may be utilized to resolve the barriers. The political agreement on the importance of finding solutions that slow down or stop greenhouse gas emissions are broad. United Nation's (UN) 17 Sustainable Development Goals (SDG) lays down guidelines for sustainable measures within countries. The work towards fulfilment of climate goals are extensive. Counties and municipalities in Norway have developed local climate plans including specific areas in which the aim is to reduce greenhouse gas emissions. Among the Norwegian regions several ongoing sustainability projects regards reducing emissions, and to some extent co-creation methodology has played an important role for realization. An unexploited potential exists for reducing energy consumption in buildings through the utilization of smart-technology in the public sector. Knowledge about potential barriers has been a key part in public sector innovation research (De Vries, Bekkers & Tummers, 2016). An adoption problem for implementing smart-technology towards energy efficiency objectives in public buildings exists. In this paper we aim to understand the nature of technological and environmental complexity, the barriers that creates the adoption problem in the public sector, the composition of them, and whether or not co-creation can be used to overcome them. The barriers responsible for the adoption problem makes it challenging to adopt smart technologies but have characteristics that makes co-creation a possible solution to them in the public sector.

1.1 Relevance

UN's Brundtland Commission report explain sustainability as: "*a development that meets today's needs without destroying the ability of future generations to meet theirs*" (Brundtland & Dahl, 1987 cited in Carson & Skauge 2019, p. 127). Sustainability has become increasingly important since then, and today the UN's 17 SDG are central and embedded in a broad spectrum of political and organizational levels all around the world. The goals intention is to result in a sustainable development that addresses a variety of challenges, concerning the needs of people living today as well as for future generations by 2030 (Carson & Skauge 2019, p. 128). Sustainability is central in municipalities' strategies and innovation efforts. KS's (Municipal Central Organization) identifies the municipal sector's work on sustainable development, and signals the UN's 17 sustainability goals as important, and thus contributes to stimulate towards achievement of the goals addressed in Norwegian municipal climate plans (KS, n.d.). In order to create changes that contributes to the achievement of public objectives regarding sustainability in Norwegian municipalities, possibilities of using technology to drive the changes are accounted for.

An opportunity to meet the global climate challenges we face today might be through the use of modern and rapid developing smart technologies (Hordaland fylkeskommune, 2014, p. 32). Big data and machine learning are two technologies that are closely linked to IoT (Rolstadås, Krokan, & Dyrhaug, 2017). IoT components generate large amounts of data, and machine learning can be used to analyse it, extracting insights that can be used i.e. for decision support around energy efficiency in buildings. These insights would not be obvious to humans, due to the complexity of these datasets (Rolstadås et al, 2017). As mentioned initially, the public sector is not utilizing the potential of today's smart technology to achieve energy efficiency in buildings. To find out why this are not satisfyingly happening, this study does an exploration of barriers preventing municipalities adopting smart technologies for energy efficiency in buildings. The model predicts that there will be different actors with different orientations and experiences which in turn raises the question of whether those differences can be resolved, and whether co-creation specifically would help bridging and resolving those issues.

1.2 Research question and limitations

In today's comprehensive climate focus the potential for reducing greenhouse gas emissions from public commercial buildings exists to a large extent. Our main research question deals with exploring the barriers for adopting smart technologies in the public sector, by addressing public upper secondary schools. As mentioned, the construction industry is one of the sectors with the biggest potential for reducing greenhouse gas emissions, and the technology for achieving this already exists. However, adopting smart technologies for energy efficiency in the public sector are not easily achieved, which gives reason to explore the range of the most prominent barriers for implementation of smart technology. Our main research problem is:

Which barriers prevents public upper secondary schools adopting smart technologies to reduce energy consumption during the operational phase?

1.2.1 Sub research question

The barriers that are preventing public upper secondary schools adopting smart technologies in the operational phase can most likely be addressed by utilizing appropriate practices to solve them. By focusing on the methodology of co-creation, our intention is to explore how this methodology can resolve the barriers for implementing smart technology in the public sector. Resource scarcity and an increased focus on quality when producing products and services have led to increased attention to co-creation in the public sector. The essence of co-creation refers to getting public and private actors to work together to create quality outcome without adding cost (Torfing, Røiseland & Sørensen, 2016; 11). Purchases in the Norwegian public sector is regulated by law and regulation on public procurement, with the purpose of securing a healthy competition and prevent corruption (Direktorat for forvaltning og IKT, 2019). However, this is an example that creates boundaries for the public sector when looking to procure and implement new solutions, because of extensive purchasing processes and detailed demands to the delivery. By addressing the barriers for adopting smart technologies in the public sector, we are exploring whether co-creation specifically can contribute to resolving them. Our sub research question is:

Can the co-creation methodology be utilized to close the gap for implementing smart technologies in public upper secondary schools?

1.3 Previous research and the contribution of the study

This study aims to add a contribution in two research fields relative to energy efficiency. One related to smart technology, and the latter on co-creation and public sector innovation in Norway. The two fields are complex, which breed some implications for engaging further research. As a result of this, our study's interests regard technologies merely on the fact that they are not easily implemented in the public sector.

In the municipal context, innovation is explained to be a relatively new as a field of research (Holmen & Ringholm, 2019). That is conceivable given the relatively inconsiderable amount of research related to the field. In research combining smart technologies with co-creation, there are even less amount of contributions. Around 3,500 results appeared on Oria by searching for "*IoT*" + "*co-creation*". A majority of the research examines co-creation with technologies as IoT for commercial matters, for example in retail industries (Balaji & Roy, 2017). However, this contribution was challenging to relate our research' aim towards, due to the contrasts in topics. Therefore, we searched for "*co-creation*" + "*smart technologies*" to widen the search, were we identified contributions related to artificial intelligence in the public sector (Mikalef, Fjørtoft & Torvatn, 2019), smart cities for energy savings (Böckle & Kwaku, 2019), as well as co-creation in a digital platform for customer engagement reasons (Cornelissen & Effing, 2019) and co-creation of E-government services (Khan & Krishnan, 2019). We also identified projects, for instance "*OrganiCity*", where citizens, researchers and other actors were linked in the development of smart city services (Gutiérrez, Amaxilatis, Mylonas & Muñoz, 2018). However, our impression is that there is far less contributions of research that explore smart technologies and public sector innovation in an isolated manner, which creates the presented gap between them. The gap, which concerns the adoption of smart technologies in a municipal context in the public sector, treats investments as facility management and not innovation. Our research' contribution aim to strengthen the research field of smart technologies and public sector innovation, by exploring the possibility of practising co-creation to resolve the barriers for adoption of the technologies.

1.4 Our study's structure

The former sections have presented an introductory view of our study, argued the reasoning behind the research questions and discussed this study's aim for contribution to already established research. Chapter 2 sets out smart-technologies and their potential for energy efficiency in upper secondary schools. The characteristics of these technologies helps us understand the nature of complexity, and why they are difficult to deploy in practice. We have also included theory involving public sector innovation and how co-creation between different actors might solve the adoption of smart technologies. The chapter summarize the theoretical content by a theory synthesis and a conceptual framework *(Figure 4: Conceptual Research Model)*. This will function as basis for analysis of the data material. Chapter 3 presents our methodological framework and the foundation of why we have chosen our research design. Furthermore, we explain our strategy as to how the data collection has been conducted, processed and analysed. We finalize chapter 3 with a presentation of our case, introducing the case unit and the reasoning behind it. In chapter 4 we process our gathered data. We coded the interviews to a set of high-level codes based on our theoretical framework, which were placed in a codebook. Then we explain how we went through our macro codes and made new sets of sub-codes, which was the basis for the new codebook. We then re-coded all of the interviews based on our set of sub-codes, which represents empirical findings on barriers for adopting smart technologies in the public sector. The sub-codes relating to the barriers were taken further into cluster analysis which led to our empirical framework, where we present findings related to the barriers. We illustrate an empirical model of the barriers that emerged, which are the foundation for our exploration of whether co-creation can be used as a methodology to overcome the barriers. Further, we explain the characteristics of each barrier. Chapter 6 presents co-creation as a possible solution to overcome the barriers, and present whether co-creation can solve them. We debate several important viewpoints that needs to be taken into account, introducing indications of the co-creation process and important conditions for practising the methodology. Chapter 7 introduces our empirical framework for comparison with the theoretical framework. We explain the differences and how the empirical framework (*figure 6*) emerged from our data. Further, we discuss whether co-creation can be used to solve the barriers. Co-creation are found to be suitable for solving 16 of 20 barriers, making a strong contribution for overcoming them. The chapter are finalized by a discussion of to what extent the public are already aware of the barriers. We answer our research questions in Chapter 8 along with final comments on what seem to be necessary to consider. I.e., lack of prioritization seems to be the study's biggest contribution to already existing knowledge. This is complemented with recommendations for beneficial practices for using co-creation. We then reflect on the studies limitations, what we have learned and what we would have done differently in another similar study and is finalized with suggestions for further research.

Chapter 2 - Theoretical framework

The chapter presents our theoretical framework in which we will base our analysis on to answer our research questions. The theoretical components deal with the exploration of potential barriers that are preventing the public sector to adopt smart technologies, and whether or not co-creation can function as a bridging mechanism for resolving them. Intentionally, the adaptation of the smart technologies is fundamentally argued to comprehend with policy - and energy goals by applying more efficient ways to consume energy within buildings. The theories derive from two comprehensive fields of research consisting of smart technologies and public sector innovation, as well as co-creation as a suggested bridging mechanism connecting the two fields. In the following chapters on smart cities, smart-grids and technologies we describe the potential of smart-technology for reaching energy efficiency goals in their theoretical contexts. The nature of the technologies complexity is extensive and serves as an obstructing factor for deployment in the public sector. We aim to understand this complexity through our discussion in chapter 2.1 and 2.2. Thereafter, we present chapter 2.3, "*The deployment failure - public sector not effectively adopting smart technologies*" to address the deployment failure and potential to adopt smart technologies. Within chapter 2.3 we present theory about public sector innovation (2.3.1), as well as what prevents the public sector to use smart technologies and governance principles impact on co-creation (2.3.2). We then structure our study with 2.4 "*The Diagnosis - a mismatch between production and deployment of smart technologies*" as a way to respond on those constraints on public sector innovation, as well as further considerations on co-creation (2.4.1). In chapter 2.5 we have conducted a conceptual framework based on the theory to summarize and visualize our conceptual approach. Before moving into chapter 3.0, we present the study's conceptual research model, which sets the foundation for exploring the barriers causing the deployment failure.

2.1 Smart cities and the use of technologies to build better services

To understand the nature of complexity we consider the concept of smart cities to illustrate a sufficient example of large technological structures working to improve the environment. The Norwegian Ministry of Local Government and Modernisation defines cities that utilize digital technologies to be smart cities. With the subjective to "*improve public services and the quality of life of its citizens, optimize the utilization of common resources, (...) and reduce climate and environmental problems in cities*" (Kommunal- og moderniseringsdepartementet, 2016, p. 110). The number of Norwegian municipalities that are developing projects with smart solutions are increasing (Junker, 2019), and several factors indicates that the number of smart city initiatives will increase in the future too (Stenstadvold & Lanestedt, 2019, p. 13). In the development of smart cities, it has been argued that the Internet of Things (IoT) can be seen as one of the key drivers (Evertzen, Effing & Constantinides, 2019).

Information and communication technology (ICT) will play an important role in modernizing and developing smart cities and will facilitate and simplify cooperation (Gutiérrez et al, 2018, p. 668). ICT solutions are part of and are an imperative for everything called "*smart*". Smartness involves assessing potential opportunities and consequences before grasping decisions (Junker, 2019). Large amounts of data are sent and received from various sources in cities, for instance from digital sensors placed in the infrastructure (Kommunal- og moderniseringsdepartementet, 2016, p. 110). The transactions of the vast amounts of data (big data) gets stored in databases with the aim of extracting insights for decision support through analysis of these large datasets (Koseleva & Ropaite, 2017). The concept of big data was first introduced as a framework (Laney, 2001) to extract dimensions that point to the challenges associated with data analysis and management. Big Data is a broad term and the nature of complexity are extensive. The value lies not in the data itself, but the ability to make sense of it (Koseleva & Ropaite, 2017). Therefore, big data governance for sustainable processes and development in smart cities becomes an important measure. The concept of smart-city governance is much debated, and it has been implied that governance capacity (i.e. human capacity and ability to engage to form trustworthy relationships and shared commitment) and organizational capacity (coordination, communication and integration), is what makes such governance work (Paskaleva et al, 2017 p. 4). The potential of data governance however, is an under-researched theme. In this context, the literature underpins some important aspects when working with data governance. These are issues regarding collecting and applying data, data relevancy and quality of data. A range of barriers related to the collection of data in a smart city projects includes: a lack of historic data; challenges managing the large volume of the data generated; lack of interoperability between devices and technologies; lack of standardisation of data formats; and, technical challenges ensuring data security and integrity (Paskaleva et al, 2017 p. 12). However, there are approximate consensus in the agreement that the data collected contains value in the form of once made open accessed, it raises public awareness. Personal data leads to positive behaviour change, especially regarding energy consumption (Paskaleva et al, 2017 p. 13). To better understand data governance, it is important not to neglect the complexity of big data itself, and understand the main characteristics of the concept, both in general terms and how it makes itself applicable in regard to energy efficiency.

The nature of complexity of smart technologies has been debated and encouraged to widen the understanding of the key aspects of what needs to be considered when working with Big Data (Wamba, Akter, Edwards, Chopin & Gnanzou, 2015). Especially four dimensions are considered to be relevant. 1) *Volume*, which refers to the amount and extent of data generated from the various sources. 2) *Velocity* takes into account the speed requirements for collecting, processing, and use insights from big data. 3) *Variety* deals with the complexity of the data, as well as 4) *Value,* which is considered as the value of the data, meaning when information has been extracted from analyses and acted on, in the form of decision-making that the value of them emerges (Zhou et al, 2016; Gandomi & Haider, 2015). These four dimensions are particularly important for the cause of energy efficiency through data analysis and are imbedded into what is called Energy Data. This refers to energy being saved through analysis of big data, which is exchanged and integrated from other sources to realize the value of the analysis basis most effectively (Zhou et al, 2016). Through analysis of the energy data, i.e. using machine learning, it is suggested opportunities to provide decision support for energy-optimizing measures in buildings. This is interesting for energy efficiency in several ways (Rathore et al, 2018), for instance due to the irregularities in outside temperatures, machine learning can predict outside temperatures and weather based on forecast data, and adapt the inside climate based on real time events. In this way, energy is being saved through more efficient processes utilizing technology.

The "*Datalake*" in Bergen is one example of a technological solution based on the big data technology. In the present, the data lake is used in the water and drainage system in the city. Sensors are placed throughout the system. This enables a much higher level of monitoring and detection of errors such as leakages (Bouvet, 2019). The sensors immediately detect when and where there are potential leaks in the system, thus, the municipality can initiate measures to rectify errors. The municipality's measures with the data lake create opportunities for smarter handling of big data, by extracting important insights out of it through analysis, which again leads to better decision support in regard to public service development based on the citizens best interests. Physical smart-components are essential for generating the data in projects such as the "*Datalake*", which also might serve efficiency in buildings. The smart-components needed for generating the data might partly uphold some of the barriers that are preventing the public sector to adopt the technologies. One smart city approach introduces a solution based on IoT sensor, which consists of such components. IoT relates to connected physical components which communicates through the internet, which are able to rapidly generate large amounts of data (Rolstadås et al, 2017; Rathore, Ahmad, Paul & Rho, 2016). It is estimated that 100 billion IoT components will be connected to the internet by 2030, which are indicating rapidly an increase in future developments (Al-Mashari & Del Giudice, 2016). More specifically it is known as a network infrastructure for cyber-physical systems (CFS), which refers to systems with built-in sensors, processors and actuators designed to interact with the users and generate data for analytical measures (Yunchuan, Houbing, Jara, & Bie, 2016; Madakam, Ramaswamy & Tripathi, 2015). It is *"an open and extensive network of intelligent objects that have the ability to automatically organize and share information, data and resources, and act and respond to situations and environmental changes"* (Madakam et al, 2015, p. 165). In this way, IoT enables efficiency in gathering, sharing and communicating data, which creates a bigger picture and clarity with the help of the technology.

Even though the technological opportunities within IoT are promising, it is debated if IoT adequately safeguards privacy, and if it contributes in increasing the potential of illegal surveillance and digital attacks (Bang, 2019). In this regard, several measures are implemented for continual management of privacy and security, among them through the Norwegian emergency regulation, which sets clear demands to the security of such systems. In addition, there exist several research and development projects which aims to protect *Advanced Metering Systems* (AMS) and cloud-based solutions. For instance, an ICT-notification initiative group within the Norwegian Ministry of Petroleum and Energy (KraftCERT) has the capacity to manage unwanted ICT-events related to domestic energy industries (Olje- og energidepartementet, 2016). Specific smart-technologies such as *"Smart power grids"* and *AMS* has been developed for the concern of energy efficiency in buildings. They create the foundation that other smart-components relies on in order to communicate information about building's energy consumption. Current smart meters can be classified under the term IoT, because they are connected to the internet and can communicate with other components based on power consumption data (Olje- og energidepartementet, 2016).

In the next section we aim to understand the characteristics of smart power grids and AMS, to develop a holistic understanding of the nature of complexity relating to the technologies relevant in the context of energy efficiency in buildings.

2.2 Smart Grids and smart readers - improving energy management

In the field of energy efficiency in buildings, the power grid plays a significant role. The smart grid is a prerequisite to effectively manage, monitor and coordinate energy use in all buildings. There are several definitions of smart power grids based on the field of study and perspective used. We have in this thesis chosen to use the EU's definition of smart grids: *"A smart power grid is an electricity network that can intelligently integrate the actions all users connected to* *it (...) for the purpose of providing sustainable, economical and secure electricity supply"* (Shabanzadeh & Moghaddam, 2013, p. 2). The term smart grid is used to refer to a power grid that has changed from analog to become a digital powergrid, enabling better communication and increased control. It is more stable, since one can predict problems, outage and errors much more effectively than before. Furthermore, the smart grid helps to mitigate emissions and enables integration of new large-scale technologies. It has been discussed that smart power grids and the opportunities it gives us, are an essential component to reduce emissions. The innovation has the potential to revolutionize transmission, energy distribution and conservation (Shabanzadeh & Moghaddam, 2013). Smart power grids make it possible to integrate information flow and energy flow, and thus enable data collection and energy transfer simultaneously (Zhou et al, 2016). In Norway, the power grid is now being modernized, which is the largest modernization in more than 100 years (Søviknes, 2017). This includes a comprehensive implementation of AMS which makes a necessary contribution to the modernization of the norwegian power grid (Olje - og Energidepartementet, 2016, p. 146).

AMS are connected to the power grid and record the electricity consumption hour-by-hour, which allows the utilities to provide users with much better information to control energy consumption (Søviknes, 2017). The meters reports consumption data and other relevant information about consumption and location, automatically to the utility (Søviknes, 2017). When questions around AMS's impact on sustainable change are being raised, it is rather the technological opportunities that comes from the development of the smart-grid where AMS are implemented as a component that contributes to what in Norway has been called "*Det Grønne Skiftet*" (Sjursen, 2016, p. 61). The development of the smart-grid are about reducing energy consumption and what is happening around the implementation of AMS has been foreseen to impact necessary behavioral change among the end-users. Environmental benefits can be achieved through additional functions facilitated by AMS, making it easier for the end-user to make smart decisions leading to lower energy consumption, or local production of energy through solutions such as i.e. solar panels (Sjursen, 2016, p. 66).

2.3 The deployment failure - public sector not effectively adopting smart technologies

The deployment failure of smart technologies in the public sector is a technology adoption problem. Possibilities for adopting smart technologies for energy efficiency in building exists but are being exploited too slowly in the public sector. This suggests rigid processes, which might be suboptimal for public sector innovation, and reflects the complexity of deployment, both in regard to technology and measures for utilizing them. The following chapter presents public sector innovation (2.3.1) and barriers and principles impacting the public sector that are preventing them from adoption of smart technology for energy efficiency (2.3.2).

2.3.1 Public sector innovation

Smart technologies described in the upper sections have proven themselves difficult to implement in the public sector. Because of this, public innovation becomes important to address to provide the necessary suggestions to why the public sector not effectively adopts smart technologies. In a municipal context, innovation is as a relatively new initiative (Holmen & Ringholm, 2019). There has been a growing interest in studying public sector innovation in the recent years, and it is considered to be a key factor for efficiency and improvement of public services (Moore & Hartley, 2008). The Innovation Report, "*Et nyskapende og bærekraftig Norge*" was the first parliamentary report to include innovation in Norway, with the intention of putting the term on the agenda (Nærings- og handelsdepartementet, 2008). The concept of innovation can be regarded as a contentious concept without a clear definition. However, this makes it possible to define the phenomenon in different ways (Holmen & Ringholm, 2019; Trott, 2017). Innovation may be new in one context, and existing in another. Such a perspective complements Schumpeter's (1934) contextualized understanding of innovation, which is based on the fact that innovation must be understood from the context in which it is formed.

The public sector is familiar with major change processes, despite the concept of innovation being relatively new (Abelsen, Isaksen & Jacobsen, 2013; Sørensen & Torfing, 2011; Holmen & Ringholm, 2019). However, there are examples of major (innovative) changing processes, such as the transfer of responsibility for the Norwegian specialist health care service from the county municipalities to regional health authorities (Abelsen et al, 2013, p. 116). This despite assumptions that the public sector serves the private sector exclusively as a facilitator (Holmen & Ringholm, 2019, p. 14; Mazzucato, 2015). However, the public sector innovates by improving public goods and services. At the same time, there is also a focus on solutions that address societal challenges (Moore & Hartley, 2008, p. 3; De Vries, Bekkers & Tummers, 2016, p. 153). Innovation in municipalities can open up ways for how technology can be used in collaboration between several actors in the public and private sectors, to create changes that contribute to the goal of achieving energy efficiency. It exists several barriers to public sector innovation which are slowing down the innovation process, or preventing innovation from happening, e.g. adoption of new technologies. In the next chapter 2.3.2, we present various barriers and principles which seem to be impacting public sector to innovate.

2.3.2 Barriers and principles impacting public sector innovation

Knowledge about barriers to innovation has been a key part of the theme in research on innovation in the public sector (De Vries, Bekkers & Tummers, 2016; Cinar, Trott & Simms, 2019). Many actors are involved in public innovation processes, including public actors, political entities, private contractors and organizations. In the following we will discuss each barrier included in our theoretical framework, which covers; political, organizational, economical, communication, competence, regulation and technological barriers. There are different kinds of governance principles used in the public sector, which impacts how knowledge can emerge and be incorporated. This is central because it can provide better understanding of why modern technology is not used or implemented to the same extent as in the private sector. Our intention here is that what limits the capacity of public sector organisations to innovate is their governance approaches, which result in a mismatch with the needs and interests of innovative businesses. The three governance paradigms described as dominant in the public sector (Tortzen, 2019) are: Traditional Public Administration (TPA), New Public Management (NPM) and New Public Governance (NPG). We have listed some key comparative points which illustrate the main differences (*figure 1*).

	TPA	**NPM**	**NPG**
Public sector	Authority	Service producer	Arena for co-creation
Overall principle	Hierarchy	Market	Network
Citizen's role	Passive recipient	Customer/client	Co-creator
Co-creation	Excluded	An opportunity	Central mechanism of governing

Figure 1: Comparative points of governance approaches

They consist of different features and perceptions, which impact the relationship between the public sector, citizens and civil society, and could influence different innovation processes in the public sector (Hartley, 2005; Holmen & Ringholm, 2019). The paradigms (*figure 1*) are considered to be segueing, meaning that they do not replace each other. However, some fundamental differences exist and separate them. The governance approach of TPA consider the role of e.g. municipalities as an authority, with hierarchical structures based on laws and regulations and bureaucratic processes. The production of public services is developed in public institutional settings with a bare minimum of external involvement, referring to the citizens as passive recipients of public services (Moore & Hartley, 2008, p. 6; Røiseland & Vabo, 2012, p. 19). Since the 1980s, there have been a number of reforms and measures to professionalize the governance in the public sector. For instance, as a result of TPA being too bureaucratic (Holmen & Ringholm, 2019, p. 137). Further, it can be linked to the former British Prime Minister, Margaret Thatcher's administration, with a policy that reduced public control of social development in a time when public governance was needed (Røiseland & Vabo, 2012, p. 17). The former strategy of centralizing public sector production is replaced by a market approach with NPM (Hartley, 2005, p. 28).

NPM is a collective term for such reforms and governance measures which aims to make management more effective by introducing private sector practices into public matters (Tortzen, 2019; Holmen & Ringholm 2019). The municipality's role is described as a service provider with the market as the guiding principle, and the citizen's referred to as clients to achieve better quality and efficiency through involvement with the society (Torfing, Røiseland & Sørensen, 2016, p. 13). However, recent research (Tortzen 2019; Christensen & Lægreid 2007) shows that NPM has led to fragmentation of the public sector, due to the shared production of public services between public and private actors. There is also the problem related to the possibility of getting market failures, which tends to undermine innovative capacity, because services are chasing short term target measures to ensure their long-term survival and not spending enough time focusing on long term innovation and change. Additionally, by replicating a market mode, it leads to that it is not possible to do worse than the market (Williamson, 1995, p. 339), and therefore preventing them to experiment, innovate and change. Competition as a result of an increasing degree of privatization in the public sector is starting to reach a threshold on public savings, that it will become increasingly difficult to harvest savings disputes for the future (Torfing et al, 2016; 10). In response to NPM, a more holistic approach has been adopted which facilitates co-creation and opens up for better horizontal coordination and cooperation between multiple actors (Christensen & Lægreid, 2007, p. 1060).

NPG distinguishes from hierarchical and centralized social governance (Tortzen, 2019; Hartley, 2005). In the literature, decentralized forms of governance are also partly known as co-management (Tortzen 2019; Røiseland & Vabo, 2012; Holmen & Ringholm 2019). This coincides with Kooiman's (2003) definition of co-creation that understands the phenomenon as: "*The totality of interactions, in which the public as well as private actors participate, aimed at solving societal problems or creating societal opportunities; attending to the institutions as* *contexts for these governing interactions (..)"* (Kooiman 2003, p. 4). The definition includes private actors in the development but does not specifically mention who. The ideal of NPG is that relevant actors work together to identify and define problems and challenges in an open system. The general interaction between government and the society is regarded as central to public policy and administration, which are considered in a comprehensive systematic review of barriers for public sector innovation (Cinar et al, 2019, p. 274).

Additionally, politics are mentioned as one of the most reported factors that are preventing the public sector to innovate (Kirsner, 2018). A broad spectrum of barriers is included, presented as four main categories: organizational barriers, interaction specific barriers between innovation partners, barriers related to perceived characteristics of innovation and contextual barriers. The categories cover barriers related to politics, economy and funding, administration, lack of focus on ambidexterity, interactive communication. This demonstrates that public innovation is complex and difficult to implement effortlessly. The next paragraphs present some key indicators, which are functioning as obstructive for public innovation.

A survey among 270 corporate leaders in large organizations, reveals the respondent's opinions on which factors that are preventing them from being innovative (Kirsner, 2018). This is considered organizational barriers and reflects the internal circumstances in which the innovation takes place. It exists cultural differences within the organizations which impacts the attitudes towards experimental learning for new initiatives, explained as fear of disrupting established business (Kirsner, 2018). This is especially relevant for public sector innovation due to the circumstances and nature of the public taking care of multiple interests in the society.

Governance and leadership can be seen as both drivers and barriers to innovation in the public sector, to promote innovation, but also appear to be a potential obstacle if management lacks leverage to exercise innovation activities or is not adapted to the organizational innovation climate internally (Holmen & Ringholm, 2019, p. 19). Furthermore, it is important to look at the conditions for new and creative thinking and development processes. As part of the framework conditions within organizations in the public sector for innovation, new and creative thinking can be hampered by normative expectations for intolerance for mistakes and multi-stakeholder development processes limited by lack of traditions for user-centered development or cooperation (Bason, 2007, p. 15).

Rigid organizational structures within public organizations functions as a facilitator for slow decision-making processes, which makes it time consuming to move an innovation project forward. These kinds of inappropriate structures are often also associated with slow bureaucracy, risk averse and inefficient learning culture, which are in reality hindering innovation processes (Cinar et. al, 2019, p. 272). Barriers such as different competencies and cultures in public organizations (Termeer, 2009) and lack of trust between public organizations (Pietroburgo, 2012) may be the reason for a lack of tradition for bringing actors together for development in the public sector. Cultural differences within large organizations, as well as fear of harming established business are treated as competence barriers. Exploitation of established business might prevent development of new knowledge and competency that can harm the existing activities (Kirsner, 2018). This can lead to reactions or fear, which are the potential reasons for not having an openness to new opportunities that leads to increase of competence and knowledge because it might compromise established business.

The economical budgets are considered more conservative and limited in the public sector, which can have a potential impact on new ventures, such as adoption of smart technologies. Lack of budgets for R&D and limited resources are reported as a significant obstacle for public sector innovation (Kirsner, 2018). In addition, lack of national and state funding is reported as a major barrier which inhibits public innovation, along with interrupted or unreliable funding if the source of the funding is another public organization (Cinar et. al, 2019). One of the most prominent barriers related to resources for public sector innovation were the lack of human resources (Raipa & Giedraityte, 2014). Governments are furthemore dependent on justifying high investments. Investments in new technology are often expensive, and energy efficiency in buildings through the use of smart-technology is an extensive task. It involves risk and uncertainty regarding return on investment (ROI) (Luthra, Kumar, Kharb, Ansari & Shimmi, 2014). These are clear barriers for public sector innovation, which we are treating as economical barriers from a theoretical context.

Relative to adoption of smart technologies in the public sector, communication might play a role. Barriers are formed during the interaction between the parties involved in public innovation processes and may be affected by both sides of an interaction. Lack of shared understanding is an example of a barrier that may arise during interaction between stakeholders. This was also one of the most prominent barriers when public actors come together to innovate (Cinar et. al, 2019, p. 273). Lack of shared understanding emerges as a result of absent communication activities that are crucial for avoiding this type of barrier from emerging. Examples of these communication activities are agreeing on common goals, visions and missions, which are shown to be a difficult task because of the fact that public organizations and citizens are often negotiating based on their own interests (Ansell & Gash, 2008; Van

Buuren & Loorbach, 2009). Another challenge is resistance or lack of support from one or several actors involved in the innovation process (Cinar et. al, 2019). This hinders important communication that would otherwise build a healthy innovation culture. From a theoretical perspective, we are considering these as communicative barriers.

Lack of knowledge and technical skills in organizations has been a decisive factor to postpone or even cancel adoption of smart-technologies (Luthra et al, 2014). Strong foundation of competency and willingness to explore and create new knowledge has been shown to play a role when innovating in the public sector. The inability of being aware of changing environments makes it difficult to keep track, which impacts the opportunities of creating new knowledge. Inability to act on signals crucial to the future has been shown to be an obstacle to innovate, as well as for maintaining satisfying organizational learning culture (Kirsner, 2018; Marsden, Frick, May & Deakin, 2011).

Current laws, regulations and policies has shown to be dominant as a contextual barrier, which innovators face during the process (Cinar et al, 2019, p. 277). The regulations and laws can make it challenging for actors to develop new innovative initiatives, for example when developing within the EU due to their innovation regulatory framework (Susha & Gronlund, 2014). As a consequence of the rapid development of technology many regulative has become obsolete, which discourages investments in new, innovative technological solutions (Luthra et al, 2014). Procurement practices, which sets out rules for developing ways of buying, operating and managing, e.g. buildings in the public sector plays a role as well (Cinar et al, 2019, p. 275). Challenges with procurements refers to the pressure of maintaining cost-based contracts, which results to overall price orientated procurement systems (Hansson, Ovretveit & Brommels, 2012).

Barriers such as lack of infrastructure, immature technology and lack of open standards has seen to be prominent in adoption of smart-grid technology (Luthra et al, 2014). Energy efficiency in buildings demands implementation of new technologies, and an efficient integration with the smart-grid. Therefore, we consider these barriers to also apply to this study. End-use devices such as sensors and intelligent user interfaces to form an efficient communication architecture are examples of necessary infrastructure (Ramaswamy, Stifter, Deconinck, 2012). Technologies are still being developed, however lack of open standards continues to represent challenges (Luthra et al, 2014). Open standards and guidelines would make it possible for suppliers of technological solutions to customize much more efficiently within the IT-infrastructure of the customer (the public actor), unlike the lack of possibilities that exists in many of today's proprietary standards (Luthra et al, 2014).

In this section we have presented our theoretical framework relative to smart technologies, as well as public sector innovation, which lays the foundation for comparison with gathered data, so that we can answer our research question, "*Which barriers prevents public upper secondary schools adopting smart technologies to reduce energy consumption during the operational phase?* ". Seven specific categories of barriers from a theoretical context are presented in figure 2 below:

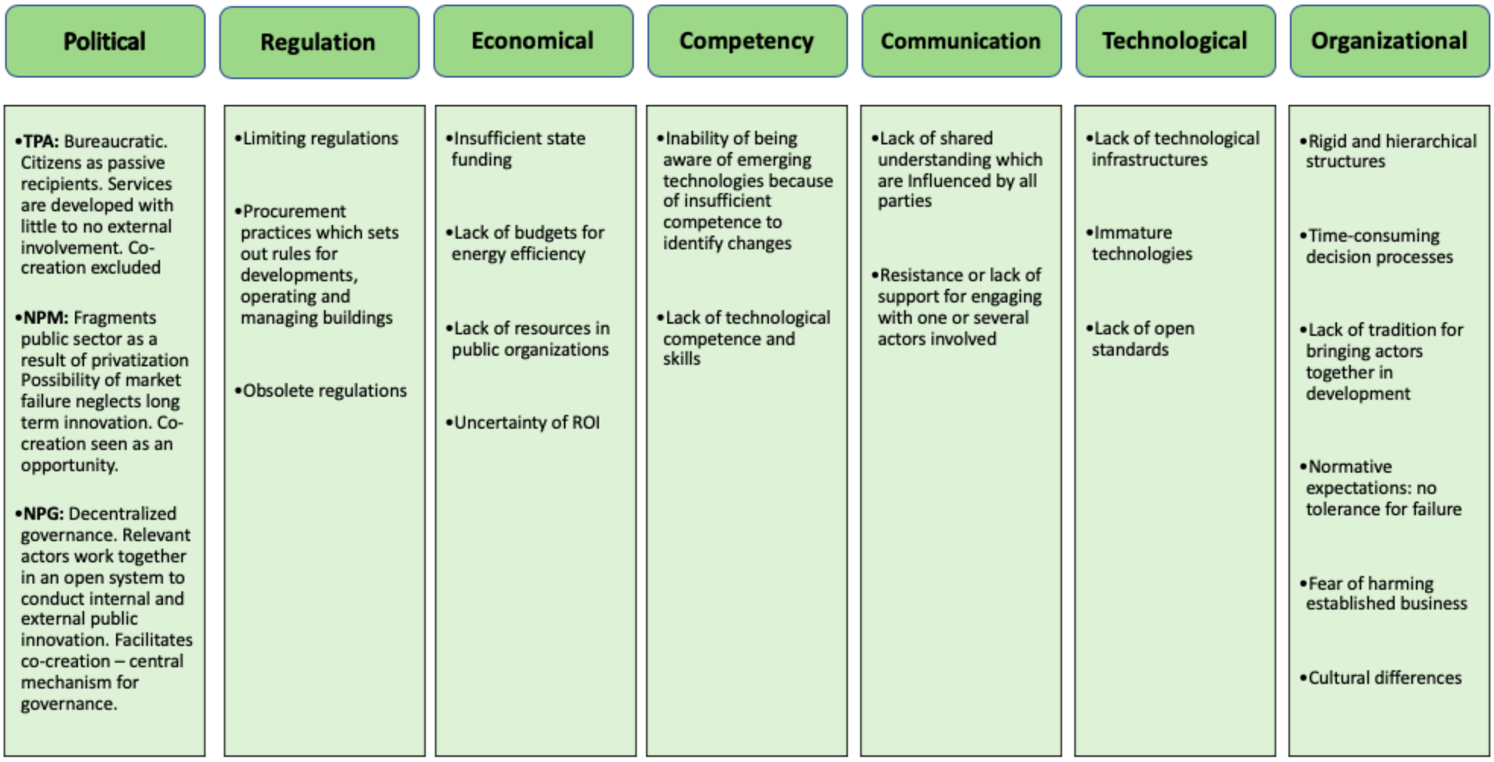

Figure 2: Barriers for public sector innovation

2.4 The Diagnosis - a mismatch between the production and deployment of smart technologies?

Taking our main research question into consideration, a potential mismatch between current production and deployment is happening, moreover due to potential barriers preventing the public sector from adopting smart technologies. As a way of addressing the constraints on public sector innovation, further considerations get introduced. In chapter 2.3 we have comprehended these into seven specific areas as a result of our theoretical literature research to analyse upon. Treating the concept of co-creation as a bridge for this study, might provide solutions for achieving adoption of smart technology in the public sector. After our theoretical framework started off by presenting different smart technologies, smart grids and smart energy management proposals, we introduced the deployment failure. That is, the public sector not effectively adopting smart technologies due to a set of barriers preventing that of happening. In the following, we are presenting co-creation as a methodology for practise towards an answer to our sub-research question, "C*an the co-creation methodology be utilized to close the gap for implementing smart technologies in public upper secondary schools?",* with corresponding theory.

2.4.1 Co-creation in the Norwegian public sector

Co-creation origins from the private sector, involving consumers in the development of commercial products and services (Eimhjellen & Loga, 2017, p. 7; Brandsen, Steen & Verschuere, 2018, p. 9). Co-creation can be seen as a relatively new paradigm and an alternative form for governance in which the public cooperates with civil society (Tortzen, 2019, p. 10; Røiseland & Lo, 2019, p. 51). In the research literature, co-creation can be explained from two main directions with branches based on the different forms of governance (Tortzen, 2019). One major focus is more on social and political dimensions of co-creation and envisions co-creation as something that empowers citizens and civil society to change the distribution of power and roles (Tortzen, 2019). Co-creation is described as network-based collaboration between various public and private actors, working together to prioritize, plan or produce welfare (Tortzen, 2019, p. 55). The second direction is called efficiency co-creation, where resource scarcity is a driver for co-creation. The main goal and understanding are characterized by an economic rationale where there is an interest in the cooperative's return on government investments, and the more profitable aspects of what collaboration contributes financially (Tortzen, 2019).

Co-creation, as a way to interact and develop services among several actors, provides an opportunity to blend knowledges and competencies in the process, which can potentially be used as a transparent way to implement smart solutions based on technology (Gutiérrez et al, 2016; Khan & Krishnan, 2019). Relative to our study, figure 3 below illustrate the characteristics of co-creation. Resource scarcity and focus on production of quality products and services have led to increased focus on co-creation in the public sector, intentionally to create quality without additional cost (Torfing, Røiseland & Sørensen, 2016; 11) After adopting the term into the public sector, it has been treated in broader sense, and has included another term (co-production). Nevertheless, it is unclear how they differ from one another, much because the terms are used interchangeably (Voorberg, Bekkers & Trummers, 2015, p. 1340). Co-production refers to processes in which citizens are involved in the implementation of public services (Voorberg et al, 2015, p. 1347; Ewert & Evers, 2013, p. 18). However, co-creation is often distinguished based on whether or not the process or activities affect an organisation's core tasks (Brandsen, Steen & Verschuere, 2008, p. 15). One is about complementary tasks, e.g, that relatives propose entertainment for patients living in a care home, while the other is about core tasks, whereas the patients are being involved in the development of treatment solutions.

In this study, co-creation (*figure 3*) will be understood as a non-hierarchical process, where public and private actors and resources are being coordinated and given common direction and meaning. It is conceivable that the meaning of what co-creation is, are conditional and depending on the specific situation. Here we aim to ensure that the public sector have several core tasks, which impacts each co-creation process. Further, three aspects are included in our definition of co-creation in this study: (1) that the actors involved in the co-creation process are mutually dependent on each other, meaning that the actors can only achieve what they are trying to do in common with each other (Røiseland & Vabo, 2012: 22). (2) that decisions are made after negotiations with the actors involved. This is explained through the understanding were use of force will not work with co-creation, because there is a risk that the actors, who may possess important resources for the co-creation, might withdraw. (3) that co-creation is a goal-oriented and planned activity, meaning that the process of co-creation, nor the output are not accidently happening (Røiseland & Vabo, 2012: 23).

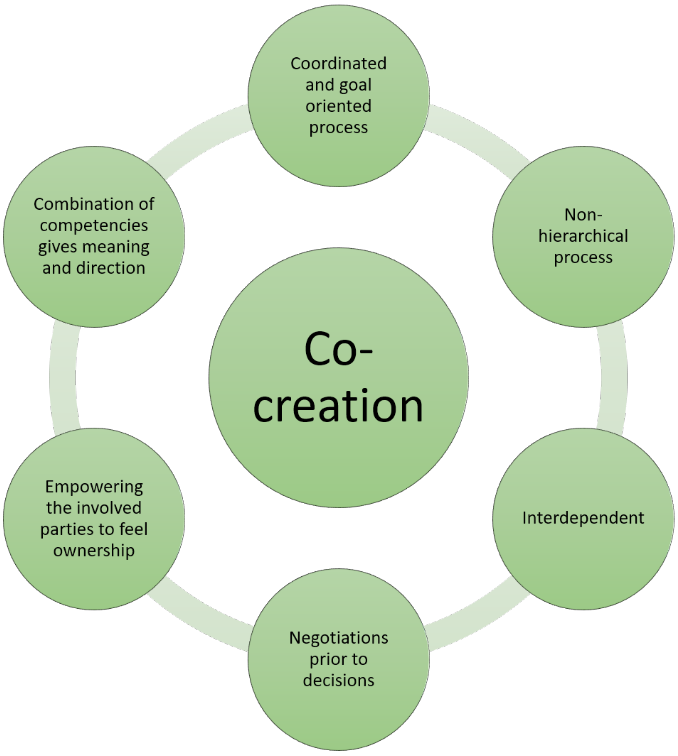

Figure 3: Characteristics of co-creation processes

2.5 Conceptual research model

Chapter 2 have presented relevant theory about barriers for public sector innovation, as well as theory about co-creation in the public sector (Cinar et al, 2019; Kirsner, 2018; Bason, 2007). Our theoretical framework enables us to explore relevant research empirically within two fields, which we intend to answer our main research question with: "*Which barriers prevents public upper secondary schools adopting smart technologies to reduce energy consumption during the operational phase?*". We aim to make a relevant contribution on how the barriers for adopting smart technologies in the public sector can be addressed, through the use of co-creation. Presented as: "*Can the co-creation methodology be utilized to close the gap for implementing smart technologies in public upper secondary schools?*"

Based on the relevant barriers, and the concept of co-creation as a possible bridging mechanism, we present our conceptual model, which illustrate presented barriers for adoption of smart technologies in the public sector. The model suggest that IT-companies hold the necessary technological competence relevant for implementation of smart technologies within buildings for better energy management. Furthermore, the model suggests that adopting smart technologies in public upper secondary schools might occur despite the identified barriers taking use of co-creation to overcome them. Below is our conceptual research model:

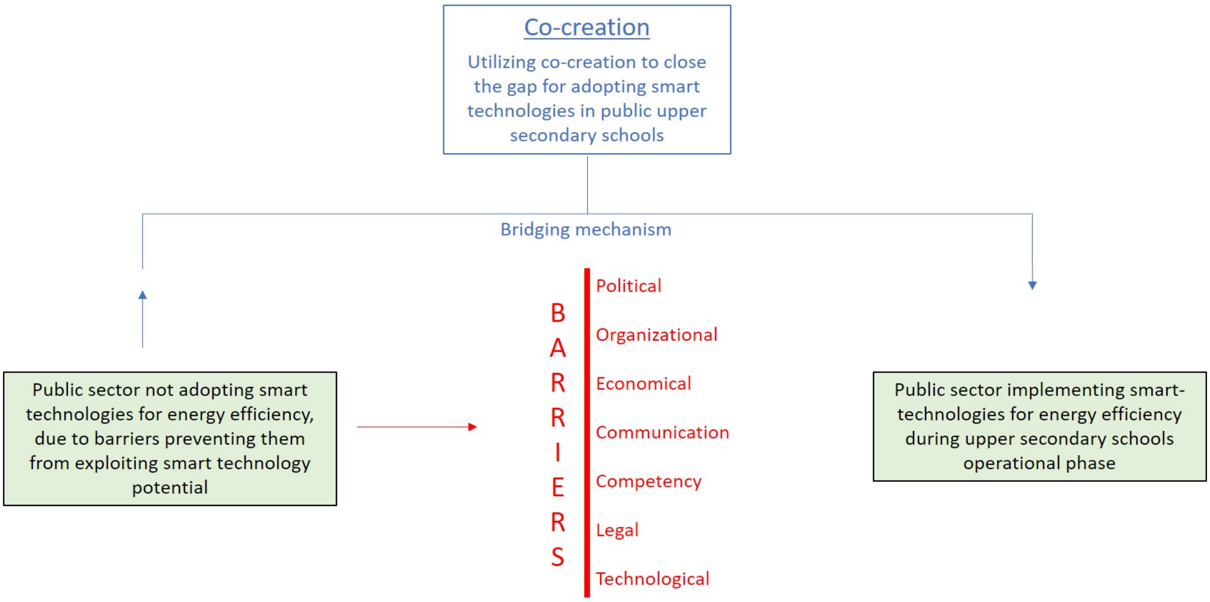

Figure 4: Conceptual research model

Chapter 3 - Research Design and Methodology

This study explores which barriers that are preventing smart technologies from being adopted in the public sector. Co-creation might contribute to making it easier to increase the implementation of technologies within public buildings. To answer our research questions, we will take an exploratory approach, by complementing our study with in-depth data derived from relevant actors related to energy efficiency, climate, as well as technological organizations from both public and private sectors. By conducting a single-case study of a county municipality, focusing on upper secondary schools within one municipality, gives us the ability to answer our research questions in the most comprehensive way. We are searching for reflections, experiences and deep knowledge from various stakeholders, which contributes to several opinions relative to what the barriers are and how they prevent the public sector adopting smart technologies in public buildings to reduce energy consumption. Explanations with the empirical literature and the actors within it, is that there is to a greater extent agreement that energy efficiency positively impacts the global climate, nevertheless it exists different opinions to how and where we need to be efficient. Adopting a critical realism (CR) approach suggest structured ways of thinking relative to social and organizational problems (Easterby-Smith et al, 2015, p. 59). This allows us to process our research instrumentally, as well recognizing differences of reflections, experiences and opinions about barriers for adopting smart technologies in the public sector.

Conducting a specific kind of research methodology relative to applying smart technologies for achieving energy efficiency in the public sector has been treated gently due to the uniqueness within county municipalities and the different municipalities. Consequently, the existence of different municipalities' digital infrastructures and systems results to arguments of creating local knowledge, which is explained to be significant important relative to the contextual conditions (Easterby-Smith et al, 2015, p. 99). Additionally, there might be different opinions about which combination of technologies and user interfaces that will be optimal. That being said, we expect a certain degree of agreement about which core technologies should be included in a solution, as well as regarding the objective relative to energy efficiency. Therefore, collecting this specific type of knowledge, we need to adopt a certain type of methodology, which again has consequences for how we carry out the design and how we gather the data. This chapter will present our research design and methodology that we have chosen for the study. We explain our choice of a qualitative single case study and why we took this approach. A discussion on our logic for the chosen analysis units and our recruitment strategy of informants are included. We also explain the data material, how we managed it and how we conducted a pilot study beforehand to create a knowledge foundation to be able to achieve more knowledge. Finally, we discuss and assess the study's data before a presentation of our case are given in section 3.5.

3.1 A qualitative single case study

A qualitative methodological approach emphasizes insights and seeks understanding (Tjora, 2017), and are suitable for questions that aims to find answers to what, why and how questions (Gripsrud, Silkoset, Olsson, 2010). The choice of an exploratory research methodology enables the development of in-depth knowledge of the theme, and thus provides suitable conditions to answer our research questions. Creating a specific framework with a single case study facilitates creation of in-depth knowledge in our case, as well as retaining a holistic perspective upon it (Yin, 2018, p. 5). However, statistical generalization from single case studies are rarely representative for its population (Yin, 2018, p. 20), and it is arguable that the variety and differences among the municipalities within the county prevent this from happening as well. We aim to understand the nature of technological and environmental complexity, the barriers that exists and the composition of these barriers, and whether co-creation can be used to overcome them. Studying such abstract processes reduces several concerns about generalising from it, as the study is reflective. However, the logic about the existence of municipalities' different digital infrastructures and systems explained in the upper section, strengthen our argument for conducting a qualitative single case study.

Even though we intentionally do not aim to generalize to other municipalities within the region, our goal is to enrich established theory (analytic generalization), which means that we generalize to theoretical proportions (Yin, 2018, p. 21) by connecting two fields of research. One related to barriers for implementing technology and the other related to whether the barriers can be solved by the use of co-creation, following public sector innovation. In this way, we aim to contribute to the county municipality' regional targets on energy efficiency in upper secondary schools, by enriching knowledge or suggest new knowledge to our theoretical framework of barriers to smart technologies in the public sector. The decision to focus merely on one municipality within a county municipality results from several arguments. To devote entirely to a single municipality gives an unique opportunity to gather in-depth knowledge about how they can contribute towards the county's energy goals. Further reasoning comes from the concentration of relevant, interdisciplinary actors inside the municipality, a spectre of business clusters for knowledge sharing and the geographical close distance from our research to our respondents. Besides this, another important consideration to argue is the differences between the municipalities IT-infrastructure, size and interests, which impacts how the barriers are seen by each municipality, which we assess as a potential obstruction to achieve in-depth knowledge due to the differences. Therefore, by conducting a single case study instead of choosing multiple cases or municipalities, we intend to explore deeply within one case.

Case studies research one or a few units of organizations, individuals or events (Easterby-Smith et al, 2015, p. 89). Further, it enables us to operationalize the research question and to collect in-depth data to create more knowledge about one municipality's opportunities to achieve regional, or county municipality climate and energy goals. By narrowing the scope and focus on county municipality owned upper secondary schools within a large municipality in Norway, our aim is to create knowledge around which barriers that prevents adoption of smart technologies in public county-owned buildings within a municipality, and whether or not co-creation can be used as a strategy to close the existing gap. Given that we did not have extensive knowledge of the theme prior to the research, it's important to emphasize satisfying understanding of the theme (Tjora, 2017). By maintaining a pragmatic and abductive approach based on what is observed, led us to generate questions about what we have seen (Jacobsen, 2015). The use of this approach prevents us from becoming too theory-driven (deductive) or too abstract and openly (inductive). The latter explains that the researcher goes from the empirical to the theoretical evidence (Easterby-Smith et al, 2018).

We started our research process by mapping already existing research and other established knowledge in the field, as well as conducting a pilot study prior to the data collection. The essence in the main research question have an exploratory view to identify which barriers that are preventing upper secondary schools to implement smart technologies for the cause of energy efficiency following one county municipality's energy goals. To address ways for the upper secondary schools to adopt the smart technologies, we have included co-creation as a potential bridging mechanism for the possibility of implementation in the schools. A combination of in-depth interviews, observations and document analysis have been conducted to secure a data material that contains several different viewpoints and considerations. These are necessary to take into account when identifying the barriers that do exist for upper secondary schools adopting smart-technology for energy efficiency, and when answering our main and assisting research question. Applying in-depth interviews can especially help by bringing insights to the participants perspectives (Yin, 2018, p. 118) related to how smart technology and co-creation applies for the achievement of the municipality's energy efficiency targets. In the next section we introduce how we have assessed sufficient approaches to recruit informants for in-depth interviews.

3.2 Selection strategy to recruit informants

Focusing on one municipality enable our study to gain deep knowledge about how the energy goals derived from the county municipality can be addressed, and since our study focus on one municipality as a single case, strategic selection (Ringdal, 2018) of our respondents will be relevant to answer our research question. We needed to be able to take an early stand with whom it will be interesting to get in touch with. This helped us to apply the snowball method and get tips on more relevant informants from the once we got in contact with early in the process, so that we will be able to collect data that leads us closer to answering our questions. The snowball method enables us to get suggestions from the respondents we speak with so that they can mention others who can also contribute information to the study (Easterby-Smith, Thorpe, Jackson & Jaspersen, 2018). In particular, there are two categories that we aimed to fill: a) municipal representatives working on development projects in public buildings, b) various IT companies that are known to have been involved in public projects in the past and c) informants from academia and research relative to energy efficiency and smart technologies.

3.2.1 Pilot study

As a preparation for our research and selection strategy, we completed a semester assignment (Frydstad & Sjåstad, 2019) at HVL last year. As a part of this, we intentionally aimed to create knowledge before the actual research begun, by conducting a pilot study to find the right focus for the main research. We did that by observe arrangements relevant for the study during the pilot phase last year. After visiting Bergen Innovation Lab October 2019, we got invited to join as guest students in a class at HVL a month later where a municipality representative of Bergen spoke about how the municipality work with its citizens and society with innovative ideas using the innovation lab, as well as informing us more about the project, "*Datasjø*". We participated and observed during the visits, asking relevant questions which enabled us to obtain more knowledge about ongoing projects and challenges, as well as getting in contact with the representative who spoke during the class at HVL. A natural hub and meeting place for various actors to get together are at cluster arrangements, where relevant actors with an interest in the same topic meet. With the use of open observation, we wanted to identify the ongoing discussions around energy during the launch of new the energy cluster, "*Energiomstilling Vest*". These early observation activities enabled us to hold background interviews later on during the pilot to gain even more knowledge. We also took part as audience for the launch of the new energy cluster. Due to the circumstances of this cluster's launch, our intention was to take a passive role to absorb the presentations during the event, without involving ourselves by participating, building a base of knowledge of the ongoing opportunities and barriers related to our topic.

The two open background interviews were with representatives from Bergen Municipality at their office and with Skype with an IT-company. Our intention for the early background interviews was to get clearer understanding about the digital infrastructures and relevant, ongoing projects related to technology. At the same time, we got the chance to test our knowledge about smart technologies, for instance IoT, machine learning and regulatory mechanisms regarding development projects. Additionally, the background interviews built a solid foundation for further contact and in-depth interviews, as well as getting recommendations of who we should contact. In this way the snowball methodology began taking form from last year's activities, starting with the background interviews, as well as three events where we observed, helped to assist with the selection of later in-depth interviews.

3.3 Data

Participatory observation and in-depth interviews are among the most widely used techniques for data collection in qualitative research (Ringdal, 2018, p. 227). However, we intend to use more sources of evidence as well. We have conducted 11 interviews to gain in-depth insights from the informant's perspectives related to the case study. Providing additional information about the municipality and the actors within it is conceivable to be supplemented for our in-depth interviews. During January 2020 we started to arrange specific dates for in-depth interviews, providing the respondents with declaration of consent for the study (Appendix 4) and semi-structured, interview guides before the actual interviews. We had this general approach where we created generic interview questions for the interviews and then had a selection of follow-up questions asked. The general semi-structured interview guide and the customized questions are shown in the appendix (Appendix 2 and 3). The selection of specific follow-up questions is presented this way for protecting the anonymity of the informants. Insights from the early in-depth interviews helped us identify other potential candidates to contact (Yin, 2018, p. 121), which we contacted by phone or e-mail to continue interviews with.

We attended one more event to observe local actors in the real estate and construction industries, were we attended as student guests at First Tuesday's event: "*Nye forretningsmuligheter i eiendomsbransjen*", which was an open arrangement where actors presented their ongoing initiatives, for instance to share innovative ways to deal with collaboration challenges in the industry. Additionally, by analysing 7 parliamentary reports and relevant energy - and climate plans we aimed to identify potential barriers for adopting smart technologies in the public sector. To analyse the documents, we explored openly the content without getting driven by predefined regularities, structures or searching for similarities with our theories (Ringdal, 2018, p. 270). We started roughly sorting out the irrelevant parts of the documents by searching for keywords such as, "*energy efficiency*", "*smart technology*", "*IoT*" and/-or "*co-creation*". After narrowing the content down, it was useful to openly search further for potential limitations and barriers for adoption of smart technology to get a clearer overview to which barriers that are preventing them for doing so. The findings on the barriers from the document analysis can be found in (Appendix 1). Our justification for attaching findings from the document analysis is to make sure our empirical findings from the in-depth interviews are not distorted by the documents.

We had arranged for a focus group to be held at Mohn Research Centre with some of our respondents from our in-depth interview's the 18th of March. However, due to the circumstances and the growing challenges related to the outbreak of the Covid-19 virus, we informed every party that it was necessary to cancel the event to safeguard both our respondents and us. When we had completed our last interviews, we recognized that our data, complemented with the other sources of evidence, to be sufficient to answer our research question. The table below presents our gathered data:

<table>
<tr><th colspan="2">Primary data</th><th>Secondary data</th></tr>
<tr><th>Interviews with informant (I)</th><th>Observations</th><th>Documents</th></tr>
<tr><td>Municipality of Bergen (Informant 1 and I9)
05.02.20: Semi structured in-depth interview completed with a representative from the municipality of Bergen.
06.03.20: Semi structured in-depth interview completed with a representative from the municipality of Bergen

Vestland county municipality (I2)
06.02.20: Semi structured in-depth interview completed with two representatives from the county municipality.

Tech companies (I4, I6 and I8)
07.02.20: Semi structured in-depth interview completed with a representative from an IT company.
20.02.20: Semi structured in-depth interview completed with an IT company
02.03.20: Telephone interview with an IT company

University of Bergen (I3, I7 and I11)
19.02.20: Semi structured in-depth interview completed with a representative from the university
03.03.20: Semi structured in-depth interview completed with a representative from the university
24.03.20: Skype interview completed with a representative from the university

Energy cluster (I5)
21.02.20: Semi structured in-depth interview completed with a representative from the cluster
Upper secondary school (I10)
18.03.20: Skype interview with a representative on the school</td><td>Seminar 04.02.20: at First Tuesday in Bergen, “Nye forretningsmuligheter i eiendomsbransjen”</td><td>St. Meld. nr. 7 (2008-2009) “Et nyskapende og bærekraftig Norge”

Meld. St. 22 (2018-2019) “Smartere innkjøp - effektive og profesjonelle offentlige anskaffelser”

Meld. St. 25 (2015-2016) “Kraft til endring - energipolitikken mot 2030”

Meld. St. 27 (2015-2016) “Digital agenda for Norge: IKT for en enklere hverdag og økt produktivitet”

Meld. St. 29 (2016-2017) “Perspektivmeldingen 2017”

Hordaland regional climate and energy plan 2014-2030

Bergen kommune (2016). Grønn strategi. Klima - og energihandlingsplan for Bergen. Med vedtak i Bystyret 21. sept 2016

BREEAM-NOR 2016 (Grønn byggallianse, 2019)</td></tr>
</table>

Table 1: Schematic table of gathered data

3.3.1 Selection of informants

Processing how to answer our research questions in single case study, this section will present our selection of informants and key informants. By referring to (3.2.1 pilot study), one of our intentions was to create contact with interesting and potential informants, as well as taking use of the snowball method to build our table (table 1). Reflecting upon the general sense of this case, it became clear after the pilot study that we needed to speak with municipality representatives and the county with technological, technical and project management backgrounds (*informant 1, 2, 9 and 11*). They provided inside on the different opportunities and ongoing projects that were of relevance for us to explore more broadly. For instance, technological infrastructures and integrations were something that we needed more insight on, which three technological companies provided *(informant 4, 6 and 8)*. Approaching smart technologies, we contacted key informants to ensure us of the ongoing status and opportunities with i.e. machine learning *(informant 3)*. Considering our sub-research question on whether co-creation can solve the barriers that are preventing them for adopting smart technologies, we especially wanted insight from three perspectives. 1) to explore the ongoing projects within an upper secondary school in the municipality *(informant 10)*. 2) to provide insights on how i.e. knowledge gets shared among academia and business actors relative to energy efficiency *(informant 7)*, and 3) speaking with relevant energy cluster representatives (*informant 5*) to explore how co-creation actually gets done.

3.4 Data management

We have followed recommended guidelines and suggestions from HVL, Norwegian Center for Research Data (NSD) and focusing on maintaining a satisfying research standard following specific ethical principles (Bell & Bryman, 2007) for our study. This enables us to ensure that our primary concern is the privacy of the human subjects, that they are participating after informed consent is handled, and that this study do not harm our informants in any way. We did the interviews and transcribed them parallelly, which resulted in a total of 155 transcribed pages. Before the actual collection of our data, we got our application for the research approved by NSD (Appendix 5). We sent interview guides for the interviews and informed consent with acceptance for recording the interviews in advance, as well as maintaining the collected data on private devices. In this way, safekeeping our informants' privacy by being as transparent and secure as possible during the research. We have respected every involved party during the research process.

3.4.1 The process of coding our data material

To answer our research question, we have analysed our data material comprehensively. Our strategy derives from our theoretical framework (Yin, 2018, p. 168), whereof we started with theory about barriers for public sector innovation (Cinar et al, 2019; Kirsner, 2018; Bason, 2007). We found inspiration from the instrumental process of grounded theory (Easterby-Smith et al, 2015, p. 192). Applying techniques from grounded theory (GT) methodology has been a success when doing critical realistic qualitative studies in the past, harnessing aspects from GT because of recent developments towards abduction (Hoddy, 2019). The methodical starting point of GT starts out with defining the researchers' own codes by reading the data material thoroughly, familiarize oneself with and reflecting upon the content (Easterby-Smith et al, 2015, p. 192). This provides a starting point for our own approach as a way of using the theoretical model whilst still looking broadly on our data material, as a way to arrange our data and search for findings. We have therefore used the GT technique as a starting point, in an instrumental way to guide the initial reading process, and for constructing our super-codes.

Our analytical process starts out with a set of high-level codes from the theory, seven relating to the barriers for adopting smart technologies into public sector and one to co-creation practices. We identified relevant content from the collected data from our in-depth interviews that corresponded with our listed barriers. We worked with each interview individually and separated them by labelling the interviews as informant 1 (I1), I2, I3 and so on. Thereafter we went through our macro data and generated - on the basis of the observed labels - sub-codes in a codebook. We went back to our transcribed data to recode and with the intention of working intensively and in-depth with our data material to develop new codes (super codes). The super codes related to the barriers was taken further into account, exploring through cluster analysis which led to our final empirical framework of the barriers, which was compared back to our literature framework to understand the dynamics of the identified barriers. In parallel with that, we also generated codes for co-creation practices already mentioned by interviewees, to generate a mode for the ways in which those practices would address the barriers. In this way we used the framework and the coding to empirically enrich the theory about barriers to adopt smart technologies in the public sector, and whether co-creation can be used to solve them. We present a visualization of the coding in a process chart below:

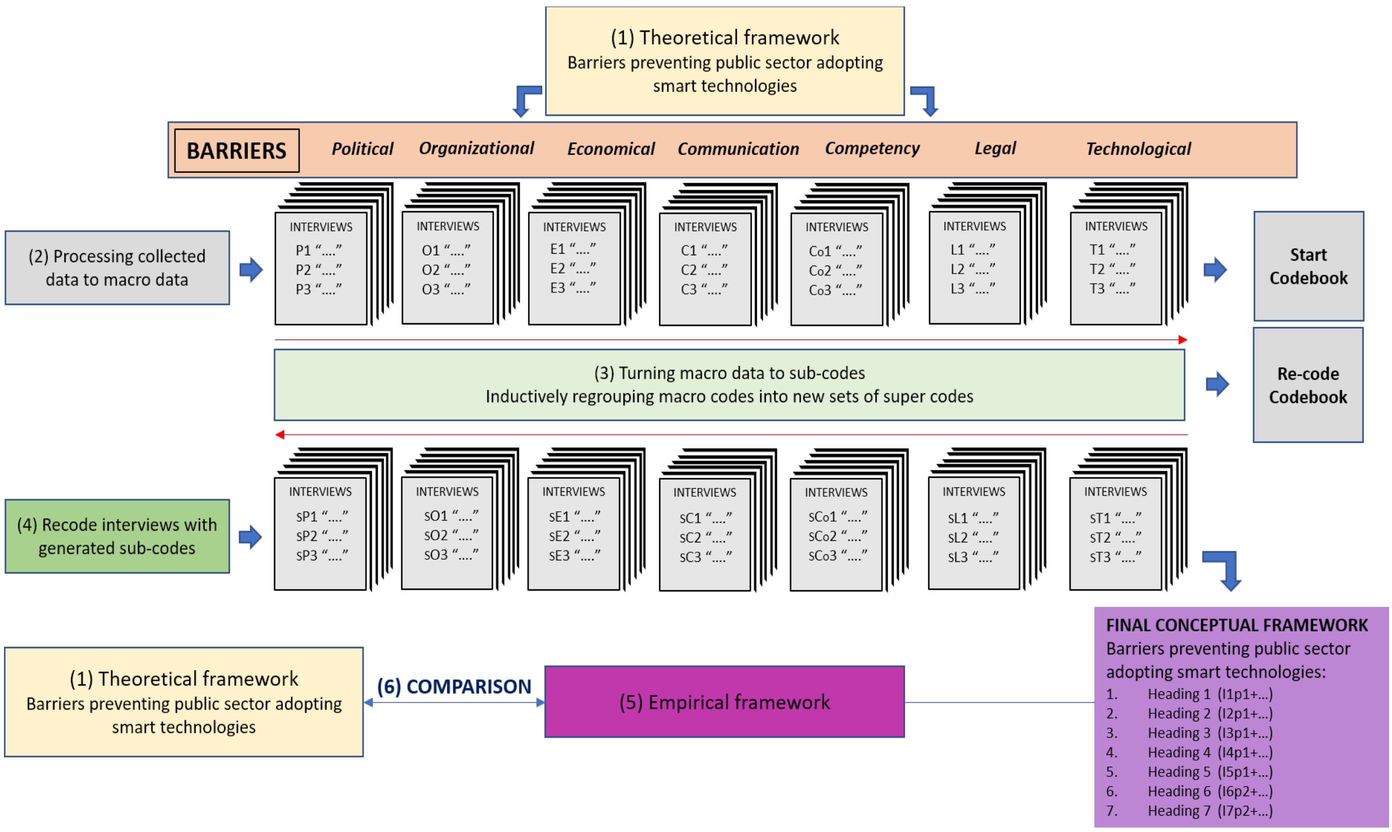

Figure 5: Coding process flow chart

In the transition of taking the super codes further into production of our final empirical framework, we adopted tools from cluster analysis. Cluster analysis is typically found in quantitative research and analysis; however, it exists opportunities to use clustering for qualitative research and analysis as well (Macia, 2015, p. 1083). Continuing on the coding process' last phases before the development of the empirical framework, our intention is to look even deeper for patterns of the developed super codes. Cluster analysis supports this exploration and maps patterns of similarities or dissimilarities that could be found in our qualitative data (Henry, Tolan & Gorman-Smith, 2005). Our intention is to identify patterns of what our informants said during the interviews to develop an empirical framework, which we are comparing the theoretical framework *(chapter 2.3.2, figure 2)*. Considering that we are conducting a single case study in this thesis, we have identified similar efforts in previous case studies. For instance, were clustering tools used in a study of China's grain production, where the researchers explored patterns of agricultural reforms through a case study of a Chinese province (Shui & Veeck, 2012). Therefore, we have found support to exploit the advantages of cluster analysis into our analytical process.

3.4.2 Critical assessment of the data material

Combining several sources of data can strengthen our study's research (Yin, 2018, p. 189). However, doing an exploratory single case study might impact how this research can accommodate certain logical tests: the study's construct validity, internal validity, external validity and reliability. Validity is a measure of whether the data material you have collected is valid, or accurate (Yin, 2018). Construct validity is possible to achieve by using multiple sources of evidence, as well as covering two defined steps (Yin, 2018, p. 89). We intent to do so by 1) defining the barriers for implementation of smart technology in upper secondary schools in a large municipality relevant for the specific concept of energy efficiency goals in the Norwegian public sector, coming from climate and energy plans for 2014-2030, and 2) identifying whether co-creation can bridge the gap regarding smart technology not being adopted in commercial buildings, focusing on upper secondary schools. We have collected data from several assessed informants to ensure that the results are verifiable, as well as complement different techniques for gathering the data. In addition, we have been critical to the selection of our data material to ensure that the data enables us to answer our research question.

Internal validity relates to factors that influences the research outcome, that certain conditions might lead to other ones (Yin, 2018, p. 91) for instance potential biases, e.g. misunderstandings during the interviews due to the conditions of our interview questions. However, it is mainly a concern for explanatory case studies where "*an investigator tries to explain "how" and "why" something x led to something else y*" (Yin, 2018, p. 91), therefore not a typical challenge for exploratory studies. External validity relates to the extent to which the conclusion of a study can be generalized across other contexts and studies (Yin, 2018; Easterby-smith et al., 2018). We aim to generalize to theoretical proportions "analytical generalization", where we generalize from the case-study, and not the case itself (Yin, 2018, p. 79). We will do so by following and analysing our gathered data upon our conceptual model, whereby our intention is to interpret the data and comparing it to the model to enrich established empirical theory. Reliability explains how trustworthy the study is (Ringdal, 2018, p. 247), and refers to whether this study's results can be identified and repeated in other researchers' studies (Yin, 2018 p. 93). However, reliability mainly concerns quantitative measurements (Ringdal, 2018, p. 247). We have assessed our data by ensuring that our formulated questions during the interviews were reformulated when the informants did not seem to understand them, to eliminate possible sources of errors related to misunderstandings of the questions. We have tried to facilitate this by providing accessibility to the transcripts of the interviews, produce clear interview guides and guidelines, and maintaining transparency in the research during the whole process.

3.5 Presentation of the case: county owned upper secondary schools located in Bergen municipality

This study narrows it down to focus merely on how different barriers might affect collaborative and deployment processes for the adoption of smart technologies to achieve the county's energy efficiency goals, addressing upper secondary schools in Bergen. Devoting entirely to a single municipality gives unique opportunities to gather in-depth knowledge about how they can contribute towards these goals. Even though the fact that the different barriers in any case are about abstract processes, our assessments of differences, i.e. in municipalities' IT-infrastructures, makes it reasonable to conduct a single case.

Throughout our study, emerging technologies and sustainability have been central. In particular, sustainability is very much debated within the world organizations because of the ongoing climate crisis. This case intends to combine these two important areas because they will continue to influence to a great extent in the future, as well as impacting constructing and operating buildings (Grønn Byggallianse, 2019). As mentioned, countries are conducting measures for contributing to reach the UN 17 SBG. KS are central to stimulate the Norwegian municipalities to adopt the UN's sustainability goals within their strategic and political plans (KS, n.d.). In this way the challenges are of high relevance both globally and on other levels. By January 1st, 2020, the counties of Hordaland and Sogn and Fjordane merged into what has been named, Vestland. We are conducting a single case study relative to Vestland county municipality's regional energy targets. The climate plan for the former Hordaland county 2014-2030 explains the county 's strategy for planning and targeting activities for stimulating reduction of greenhouse gas emissions from commercial buildings, among other emission sources. The plan, still active in Vestland, states that the energy use in buildings are greatest in the operational phase, and that energy consumption averages 150 kWh/m2 in buildings (Hordaland fylkeskommune, 2014, p. 32). In the absence of specific numbers for school buildings, it is expected that the energy use is slightly lower than in commercial buildings in general. Public upper secondary schools accounts for 95% of the total building mass in the former county (Hordaland fylkeskommune, 2014, p. 31), which has been an incentive for conducting this case.

In 2011 Hordaland was the county in Norway that consumed the most energy (Hordaland fylkeskommune, 2014, p. 17). Buildings in Bergen are targeted to produce their own energy by 2030, which means local production of electricity or heat in the building, for instance by utilizing solar cells, or various types of heat pumps (Bergen kommune, 2016, p. 50). The county's goal is to reduce energy consumption in public commercial buildings by 25% benchmarked against 2007 by 2030, is an important guideline for the choice of theme in this study. The county's investment in reducing emissions from buildings are strongly influenced by the EU's building energy directive, which requires all new buildings to be close to "*zero energy buildings*" by 2020 (Hordaland fylkeskommune, 2014). However, the municipality states that the need for investments for energy efficiency in older public buildings exists as well, and the greatest potential for energy efficiency in buildings lies within the existing building mass (Hordaland fylkeskommune, 2014, p. 31). The goal is to achieve more effective distribution of energy use throughout the day (Hordaland fylkeskommune, 2014).

In the present, several Building Management Systems (BMS) are being utilized. These are proprietary systems which limits the manoeuvrability to extract data and information for further development, or to integrate smart technologies to complement the systems. This is not effortlessly achieved because of several considerations that must be accounted for. One of the measures to achieve energy efficiency are through the use of technology, i.e. smart grids, smart readers (AMS) and other technologies which facilitates local energy production. Technologies such as the district cooling system in Bergen are extensively energy efficient. It is based on seawater obtained from "*Puddefjorden*" and are able to deliver 50-70 times more cooling energy than what is being put into the system to pump the water to the cooling destination. Today, the technology is used to cool the datacentre in the most innovative building in Bergen, "*Media City Bergen*" (MCB) (VVSForum, 2017). Regulations are also of great importance. The most effective means to reduce energy consumption in buildings are the building regulation (TEK) for planning and building projects (Hordaland fylkeskommune, 2014, p. 32). Departments researching environmentally friendly energy from NTNU and SINTEF, focuses on a holistic approach to building design with energy efficiency intentions. To achieve the anticipated goals for energy reduction, existing building mass within the public sector needs an ambitious upgrade (Sandberg, Brattebø & Gustavsen, 2019).

Chapter 4 - Towards an empirical framework

To be able to answer our main research question, "*Which barriers prevents public upper secondary schools adopting smart technologies to reduce energy consumption during the operational phase?*", this chapter will go through data, following the structure and the comprehensive coding process presented in chapter 3.4.1. This section presents the process of our gathered data, where we started off by deductively going through our gathered data material for our main research question, before we eventually in chapter 4.2 discussed our findings and inductively regrouped our produced macro codes into super codes. Chapter 4.3 presents a continuation of the coding process, where we explore even further by conducting cluster analysis of our generated super codes related to the barriers to better able to identify which barriers that are preventing adoption of smart technologies. Lastly, chapter 4.4 presents our analytical process for treating the codes related to our sub-research question and whether co-creation can solve the barriers preventing the adoption of smart technologies.

4.1 Producing macro codes: barriers

To start our analysis strategy, we printed out our collected data derived from the 11 interviews and went through them individually to discuss the content to search for meaning that reflected on the barriers from our theoretical framework (*figure 2*). In this part of the process, our goal was to develop macro codes from a set of high-level codes from the theory, which we later on discussed before we made our super codes. As mentioned in chapter 3.4.1, this starting point let us look broadly on the data whilst using the theoretical framework to start processing the informant's different reflections and meanings during the interviews. We assigned the barriers from the theoretical framework with numbers from 1 to 7, relating to the barriers for adopting smart technologies into the public sector. Our intention for doing so was to map out the areas in the transcribed interviews that correlated with the framework, and to easily copy that content into the codebook, which eventually resulted in a total of 253 macro codes, whereof. 213 macro codes corresponded with the barriers.

At this stage of the coding process we agreed upon to go through three transcribed interviews together to make sure that both of us used the same methodology for the last eight ones, which we divided into two groups. Once the data codes from the interviews, was placed in the codebook in the form of specific quotes from our informants, we started discussing them individually and collectively to create respective code names. As well as for control that we had followed up the same methodology for the last eight transcribed interviews. Before the actual creation of the macro names, we agreed upon a minimum expectation of at least two informants and data to justify the creation of the code names. For example, did informant 1 explain the lack of earmarked financial budgets to be an important concern which impacts their investment activities. Informant 8 did as well inform us about the issue with limited budgets, which had some similarity of what informant 1 told us. After we had discussed the findings, we labelled it as a macro code of *"Ingen øremerking av midler"* underneath the economical barrier. We did this for all of our material and barriers, and eventually after the first step of processing our collected data to macro codes was done, we discussed our input in the codebook and started inductively regrouping the macro codes for constructing a set of super-codes for further analysis and for recoding.

4.2 Inductively regrouping of macro codes into super codes

In this part of the coding process we took all of the 253 macro codes from the codebook onto a single working document to discuss what the interviewees was saying during the interviews more deeply. 213 macro codes related to the barriers. We highlighted the barriers and filled the matching macro codes that belonged to the specific barriers for every code. Thereafter, we went through each macro code and discussed the overall meaning behind the code so that we could isolate and map out the differences of themes underneath each barrier inductively. We colour marked the different super codes to make it easier to separate them. Eventually the macro codes were regrouped into 33 super codes for the barriers. This is visualized in table 2 below.

After the process of developing our 33 super codes corresponding with the barriers, we made considerations of two alternatives. 1) to go through the transcribed interviews as we did in the first stage of the coding process, or 2) to go through each interview together. Alternative 1 was reasonable to justify because we were to discuss them all over again in a recoded codebook, as well as continuing to the last stage of clustering them. We took the barriers and the super codes for each barrier onto a sheet of paper and started to go through the transcribed interviews to map out the data that related to the specific super code. As for the first stage of producing the macro codes, we used the same minimum expectation, were we had to have at least two informants to develop the codes. There was some inconsistency in how much data we could place under the different super codes due to the differences of our informant's background. For example, did representatives working from different IT companies provide more in-depth knowledge around technological aspects rather than commenting much around e.g. the political, which in turn resulted into some dissimilarities in value of number of informants for each super code. Additionally, we wanted to go through the density of our codes and try to reduce the least dense into the denser ones by simply counting codes and number of interviewees as well as corresponding quotes. The 33 super codes corresponding with the total of 213 data points relating to the barriers had an average number of codes per cluster of 4,71 codes and an average of 4,39 respondents per cluster. Even though the codes in table 2 started to take form, continuing our coding process might develop interconnections between some of the codes and create new sets of clusters. Some of the least dense ones, e.g. under the technological barrier, *"insufficient user interface"* consists only of two informants. This might be implying that the necessary technology is not intuitive enough to operate efficiently in the public sector.

Political	**Quotes**	**Informants**	**Competency**	**Quotes**	**Informants**
Political priority	9	5	Lack of digital expertise	9	8
Lack of incentive schemes and demands from politicians	9	5	Fragmented competence environments	11	4
Political signals	6	4	Lack of competence with buyers and advisors	8	3
Political decisions	6	2	Shortage of technological skills	5	3
			Inertia from learning to practice	3	2
Organizational			Lack of interdisciplinarity	8	5
Lack of priority	9	5	Lack of industry standard	5	4
Suboptimal delegation of tasks and respnsibility	11	5			
Rigidity	9	5			
Organizational cultural barriers	19	7			
			Legal		
Economical			Limited procurement schemes	10	6
High price focus	13	8	Standardization and regulatory deficiencies	15	6
Limited budget	6	5	Unflexible regulations	8	5
Expensive changes	7	3			
Usikkerhet rundt kostnadsfordeling	2	2			
Lack of labeled funds	3	3			
Communication			**Technological**		
Lack of awareness	11	5	Immature technology	11	3
Communicate requirements to suppliers	5	4	Challenges surrounding integrations and systems	15	6
Common multidisciplinary understanding	4	2	Insufficient user interface	2	2
Unclear contact points	8	4	Sensor-frequency inequalities	2	2
Sub-optimal conditions for communication	8	3	Outdated technology in existing buildings	6	5
Average codes per cluster	**4,71**		**Average informants per cluster**	**4,39**	

Table 2: Number of super codes from recoded codebook (barriers)

Reflecting upon the fact that some super codes made up little value in themselves due to the low number of informants that were representing those particular codes, we wanted to explore further with two different approaches of cluster analysis in an effort to create more insights on the barriers. Chapter 4.3 continue our process of gathered data related to the barriers for adopting smart technologies, with the intention to create a coherent model of our empirical findings.

4.3 A revised model of barriers facing energy efficiency in adoption of smart technologies in public buildings

We started discussing the data of the super codes related to the barriers individually with the intention to assess the strength between the particular data and super codes. We performed an instrumentally top-down approach, starting with the political barrier's super codes and worked our way down. Focusing on one barrier at a time, we analysed the sub-codes under each of the 33 super codes with the intention to group similar codes, move codes that seemed to fit better elsewhere and to remove the codes which ended up with too few codes for it to be representable. The 33 established super codes representing the barriers of adopting smart technologies into the public sector for energy efficiency, got reduced to 20 super codes *(table 3)*. Then we went through the 20 new super codes for identification of a better fitting description covering all the individual data points within the super code. The result is shown in the table below:

Political	**Quotes**	**Informants**	**Competency**	**Quotes**	**Informants**
Lack of consensus (lack of basic agreement)	9	4	Lack of expertise (technological and digital)	12	6
Lack of incentive schemes and terms from politicians	8	6	Lack of competence with buyers and advisors	15	6
			Lack of awareness of opportunities	4	3
Organizational					
Lack of energy efficiency priority	15	8	**Legal**		
Suboptimal delegation of tasks and respnsibility	15	6	Limited procurement schemes	8	4
Rigidity	10	5	Supoptimal regulatory requirements	19	8
Organizational cultural barriers	13	5			
Lack of standardization	5	3	**Technological**		
			Immature technology	13	4
Economical			Challenges surrounding integrations and systems	16	6
High price focus	16	8			
Limited budget	5	5			
Expensive changes	7	3			
Lack of labeled funds	4	3			
Communication					
Lack of common interdisciplinary understanding	7	6			
Sub-optimal conditions for communication	8	3			
Average codes per cluster	**2,9**		**Average informants per cluster**	**5,1**	

Table 3: Cluster model of barriers (Top-down)

The 20 super codes relating to the barriers had an average number of codes per cluster of 2,9 codes and an average of 5,1 informants per cluster. This made out a significant reduction of codes per cluster in average compared to table 2. By conducting a horizontal vertical (HV) cluster approach, we wanted to re-test to see whether the same barriers emerged.

By conducting the HV clustering approach, we removed all the titles of the barriers so that we had an unsorted set of data. We did this by sorting like with like, with the intention of grouping the codes and create new titles. We eventually developed 6 names representing the barriers for adopting smart technologies into the public sector. To create the sub-categories, we conducted further analysis individually, which we in turn discussed to identify similarities and differences, before we eventually developed a final version together. In this particular stage of the process we rejected 16 codes. The rejected codes, which to some extent indicate challenges related to different agendas, and social interaction difficulties when collaborating in projects did not fit the generated clusters, nor created any shared meaning related to barriers for adopting smart technologies.

In the former, we have explained the analysis of our gathered data comprehensively through multiple stages *(figure 5)*. The results were turned into one single coherent model (*figure 6*). As a result, if this, we finally developed our empirical framework in which we intend to use for comparison with the theoretical one. Figure 6 below presents our empirical findings of barriers to adopt smart technologies in the public sector, which are further explained in their entirety in chapter 5.

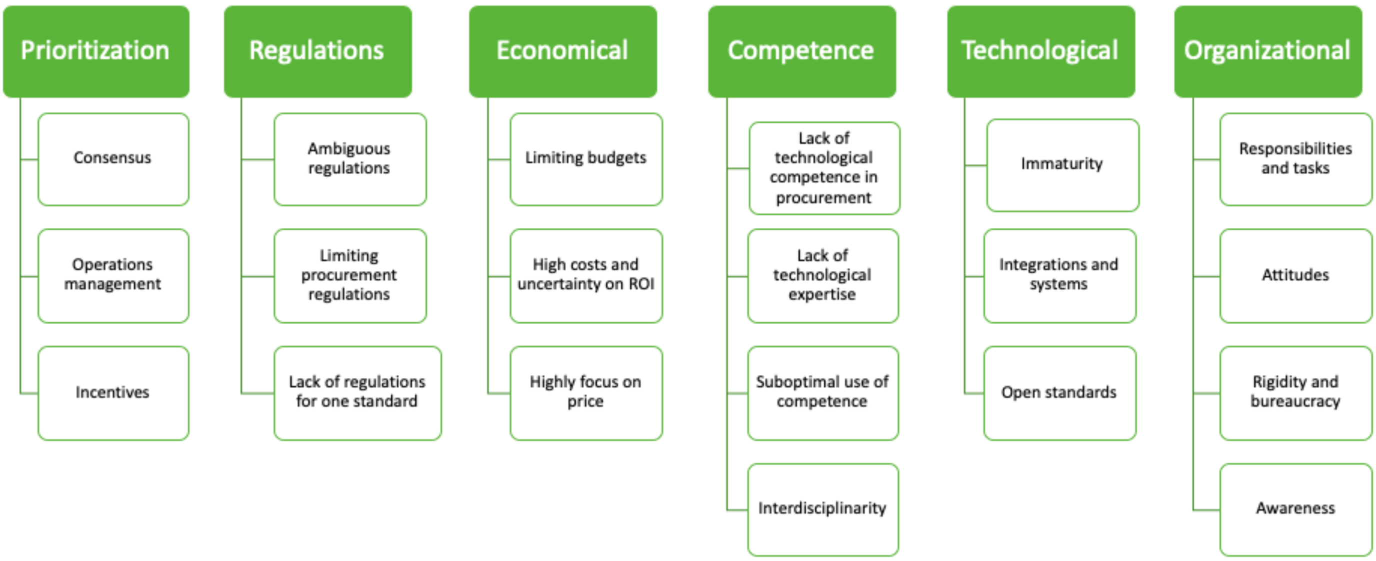

Figure 6: Coherent model, presentation of empirical findings of barriers to adopt smart technologies

4.4 Processing codes related to co-creation

In order to answer our sub-research question *"Can the co-creation methodology be utilized to close the gap for implementing smart technologies in public upper secondary schools?",* we coded and developed our macro codes from what our interviews were saying. After the coding process we found 40 macro codes corresponding and reflecting anything that had to do with co-creation. These codes were later regrouped inductively into 6 super codes, which represents effective co-creation practises represented by findings. These characteristics reflects important conditions when utilizing co-creation for solving the identified barriers and corresponds with theoretical considerations of co-creation *(Figure 3)*.

Chapter 5 - Barriers for adopting smart technologies in the public sector

In chapter 4 we explained how we conducted our empirical framework through based on our gathered data, which we comprehensively processed *(figure 5)*. Towards answering our research question *"Which barriers prevents public upper secondary schools adopting smart technologies to reduce energy consumption during the operational phase?"* this chapter will present the 20 sub categories making up the 6 barriers, which are preventing the public sector to adopt smart technologies for reduction of energy consumption in public buildings *(upper secondary schools*).

5.1 Prioritization

5.1.1 Lack of consensus for prioritizing energy efficiency

Missing consensus for prioritize energy efficiency in buildings exists *(informant 1, 2, 4, 5, 9 and 11)*. This relates to a certain degree of missing agreement both on a political and organizational level. Evidence suggests that different mindsets, agendas and professional starting points creates challenges within specific projects. On the political level, resources delegated to other measures than what is actually important, is an example of a consequence following from the missing consensus *(informant 2).* Deadlines from the politicians and grand openings of new buildings have such prestige that it would be suboptimal to report that the building is incomplete when the deadline date emerges *(informant 1 and 11)*. The missing consensus relating to the priority of deadlines rather than what's best for the building, leads to occupancy in unfinished buildings making them suboptimal in the operation phase *(informant 11)*. Departments responsible for managing energy consumption in buildings through the Building Management Systems (BMS) are experiencing being inhibited from higher instances in the organization as a result of the missing consensus of what should be prioritized *(informant 9)*. This gets further explained as a capacity problem, because decision makers do not prioritize suggestions from BMS-operators appropriately.

5.1.2 Lack of priorities in operations management

A lack of specific demands to the county municipalities for energy efficiency leads to confusion of which energy efficiency measures should be prioritized *(informant 1).* These demands relate to political leadership *(informant 1 and 4)*. Combined with building authorities unclarity around objectives for energy consumption, it becomes even harder to identify where prioritization should be. This leads to an unclear perception of what should be minimum requirements of which technological infrastructure that would make the building energy efficient *(informant*

8). With no earmarked budgets relating to energy efficiency it is difficult to prioritize it in the county. These funds are delegated from the state but are earmarked in a more general label as "*Rehabilitation*" in the budgets, which also covers several other prioritizations. As a result, the funds are to a great extent used otherwise *(informant 1).* This makes it harder for the daily management of the buildings, which has to consider multiple challenges, e.g. cleaning, replace broken technical components or changing light bulbs. A conflict in priorities between operations and facility management exists as a result of failure to bridge two different perspectives, meaning it is difficult to understand the indoor climate needs from off-site management, from the same perspective as the users which are located in the actual facility *(informant 11)*.

5.1.3 Uncertainty in the incentives to prioritize energy efficiency

The conflict between on-site and off-site management in chapter 5.1.2, seem to some extent to be connected to uncertainty in incentives to prioritize energy efficiency. It is unclear what the incentives are, which impacts how energy efficiency gets prioritized *(informant 8, 9 and 11)*. This gets supported by informants stating that investments that results in something visible within the building, are easier to pay for because they can see the changes. As soon as technical adjustments for i.e. room temperature are suggested, it gets less likely to pay additional costs *(informant 11)*. It can be interpreted as uncertainty around what the outcomes of adopting smart technologies are, which in turn reduces the motivation for considering and prioritizing energy efficient choices for operating public buildings.

5.2 Regulations

5.2.1 Ambiguous regulations

Unclear regulations lead to ambiguity among partners who are to conduct innovative procurement practices *(informant 1, 4, 6 and 10)*. The consequences of that seems to be inactions towards increasing the use of smart technologies in the public sector, which could contribute towards energy efficiency. The industries are not satisfyingly being involved through the public' use of innovative procurement, *(informant 4)* which leads to a cumulative effect of people achieving the learning of how it's necessary to use innovative procurement. This does not give people enough certainty to use innovative practices. The unclear regulations have an impact on the amount of conflicts that occurs *(informant 10),* and the data shows that the regulative ambiguities might also result in unnecessary resources being spent because of an increased conflict management *(informant 8)*.

5.2.2 Limiting procurement regulations

The public procurement system ensures safe procurement and fair competition in the public sector but has some restrictive implications for external collaboration and procurement *(informant 1, 2, 4, 8, 9, and 11)*. Data indicates that the procurement regulations are restrictive in the public sector because one can easily fall into "grey areas" *(informant 1)*. Based on examples from the data, building contractors and entrepreneurs with high professional competence sometimes gets involved before the actual project starts. The public sector cannot select these actors over others who have not gained early knowledge of the project, due to a professional reluctance around not keeping to the fair competition policy *(informant 1 and 2).* This inhibits sensemaking discussions that would build the necessary certainty among partners to implement innovative solutions. The procurement schemes are to a great extent price orientated, which discourages framing discussions and sensemaking before the tender process starts. This leads to many good solutions falling away *(informant 4, 8, 9 and 11).*

5.2.3 Lack of regulation for one standard

Several informants explain that there is lack of a single standard in the industry, which means that there are no uniform guidelines *(informant 1, 2, 4, 5, 8, 9, and 11).* This can be perceived as inhibiting the smart technology adoption. It is also pointed out that standards, for instance BREEAM are not applicable to existing and older buildings, but newer buildings and that the only choice is total renovation to meet this standard *(informant 9 and 11)*. Furthermore, deficiencies can occur in terms of disagreements about one uniform standard in the industry. Several possible solutions have been presented by the informants on this. It is highlighted that requirements are set for all public buildings to be energy-labelled based on the building's construction year and material for the tech-standard for that particular year *(informant 8)*. However, there is no requirement to show what they use per square meter, which is argued. Lack of uniform requirements enables different practices of using different models as desirable besides building technical regulations as minimum requirements *(informant 11)*. The specifications that are being made today appear to be inadequate for the adoption of new technology, according to several of our informants *(informant 2, 4, 8 and 11)* This is partly because the public sector does not upgrade the specifications in line with the development of the technologies *(informant 5)*, which in turn affects their ability to assess and select appropriate technologies in the buildings.

5.3 Economical

5.3.1 Limiting budgets

Limiting budgets sets out the possibilities of investments in energy efficiency technologies and measures. It provides guidelines for the size of, and where investments are directed. One informant reports possible disagreement around whom additional costs should be allocated to. The reason is that there does not exist any directives around the allocation of additional costs *(informant 2)* Limiting economical budgets, which are considered to be extensive within the public sector, creates challenges of buying and investing in new and innovative technological solutions *(informant 1, 2, 3, 9 and 11)*

5.3.2 High costs and uncertainty about return on investments

Incremental advances in existing buildings are associated with high costs, which are especially challenging working with limiting budgets in the public sector *(informant 2)*. Several energy efficiency measures in buildings requires a formation of new physical and technological infrastructure. Combined with uncertainty about the potential returns on investment makes decision makers more prominently sceptic around investments in energy efficiency *(informant 8)* Moreover, evidence suggest that uncertainty about return on investments concerns the lack of data to support the benefits of smart technologies to reduce energy consumption, and that actors are patient to assess the results of other, already existing smart buildings, before taking further action (*informant 4 and 6)*.

5.3.3 Highly focused on price

In context to the limited public budgets, suppliers are chosen based on favourable price, rather than adopting other, often newer technological solutions at higher prices *(informant 8, 9 and 11)*. The long-term benefits of installing sustainable technological solutions in a building are undermined because of a too high price focus relating to the costs of installations in the present *(informant 11)*. Framework agreements with technology suppliers are in some examples shelved when managed in price-fixated purchasing departments *(informant 4)* High price focus also applies to the construction and maintenance firms. Recommendations on energy efficient solutions are neglected by these firms because they strive to complete an order from the building manager as cost-efficient as possible *(informant 11).* This reinforces the inhibitions that emerges as a result of this barrier.

5.4 Competence

5.4.1 Lack of technological competence in procurement

The lack of relevant competence within the public sector to judge whether a technological opportunity is preferable is described as widespread by our informants *(informant 1, 4, 5 and 8).* This leads to the use of older specifications and requirements without considering the benefits of newer smart technologies or taking it into account in the requirements. At the same time, does the lack of competence also tend to lead to long-term consequences e.g. buildings not being technological adaptive for future innovations *(informant 4).* In some cases, buying organizations has ended up copying previously used specifications into new processes without considering the technological development *(informant 8)*

5.4.2 Lack of technological expertise

Technological expertise within the public sector in regards of assessing smart technological solutions is growing. However, it is explained that there is a lack of relevant competence in volume in the present, which also prevents the organizations internal knowledge and awareness for assessing technological solutions in decision-making processes *(informant 3, 4, 5, 8 and 11).* Due to the insufficient technological expertise in the public sector, promising and innovative technological opportunities might not be exploited or considered.

5.4.3 Suboptimal use of competence

Technological responsibilities should be allocated appropriately, due to the complexity of managing smart technologies. It is an increasing amount of people who undertake technological educations in the present, however because of the lack of technological competences in the public sector, employees with irrelevant professional backgrounds like carpenters and caretakers are given the day to day technological responsibility for operations inside the buildings, as well as taking care of other designated assignments related to their professions *(informant 5, 9, 10 and 11).*

5.4.4 Interdisciplinary challenges

In interdisciplinary cooperation's it is reported issues related to lack of mutual understanding among the actors because of different professional backgrounds. Evidence suggest that due to differences in perceptions of terminologies, people may be confused by information regarding unknown themes *(informant 2, 5 and 11)*. This may affect such interdisciplinary cooperation to be less effective. Lack of interdisciplinary agreement results in not having a mutual holistic view of the buildings best interests across of professions, as well as ineffective progress towards energy efficiency solutions.

5.5 Technological

5.5.1 Immature technology

The construction industry is among the least mature digital industries *(informant 4)*. Certain types of technology relevant for energy efficiency, e.g. transferring surplus energy from one building to another through the smart-grid, requires development of the infrastructure in order to be realized *(informant 2)* Furthermore, technology such as analogue sensors are often found in established buildings today for measuring energy efficiency. These sensors provides exact values, and are therefore favourable when managing ad-hoc energy efficiency measures *(informant 9 and 11)* Data indicates that IoT-components might be good for insights on e.g. air quality over a longer period of time, but are immature in regards to support the day-to-day energy efficiency management *(informant 11)* Another challenge with these components are battery capacity and the occasional need of changing them *(informant 9 and 11)*. The consequences of one component not working in a designed network that are dependent of every component, and when components have to be changed because of failure, it is argued that the solution is not mature to use in public buildings *(informant 11)*. Large public organizations seem to need reliable and mature technological actors to collaborate with. Data indicates that small, innovative start-ups are often let down by public organizations when they introduce technological solutions for energy efficiency in buildings, because of immaturity in technological solutions. Informants argue that unfinished products, lack of optimal user-interfaces and too little appliance to handle errors and defects efficiently to be reasons for rejections *(informant 9 and 11)*

5.5.2 Challenges around technological integrations and systems

Implemented Building Management Systems (BMS) are portrayed to be large and complex systems for managing energy usage in buildings, visualizing and reporting important energy efficiency values. New technology must be integrated in the BMS, which presents challenges if the new technology "speaks another language" than the technology already being used, which is quite likely *(informant 3).* Replacing sensors to updated models with different signals serves as an example. Another challenge is certain failures which leads to significant energy wastages might not be captured by the BMS. For example, in automatic heating systems based on water-borne heat, the valve motors become poor over time because of the wax which regulates the valves becomes rancid. Improper closing and opening of the valves occur, which again leads to unfortunate water leakages. A misperception of the regulation-need in the room occurs in the system, because heating takes place despite of the regulator in the room not asking for heat. The interpretation is that the heat is coming from somewhere else, and a cooling process starts to reduce the temperature to the level asked for by the users of the room. This leads to vast and unnecessary energy wastage as a result of simultaneous heating and cooling *(informant 8).* Furthermore, it is reported that too few important parameters for energy efficiency, from the existing building mass, are included in the BMS in order to manage energy efficiency well enough *(informant 9 and 11)*. In relation to this, descriptions related to both technological components and physical errors, are not integrated in the BMS *(informant 9).* This represents a tremendous manual plotting job which demands a certain amount of resources in order to be performed, which are challenging to put up with *(informant 9).*

5.5.3 Lack of open standards

Proprietary systems are widespread in the present, which makes it challenging to quickly integrate all systems together under one total system, according to our informants *(informant 2, 4, 8, and 9).* At the same time, it is desirable that suppliers use more resources to develop open standards interfaces and APIs against public building installation for development and adoption of smart technological solutions in public buildings. Proprietary systems face challenges in the same way as with "silo thinking", when one particular system fails, it does not happen at the same time as the other ones, which means that one and one component must be replaced *(informant 2)* Another issue relates to the amount of data that needs to be dealt with when turning the systems towards open systems. In example did one of our informants with expertise in smart technologies explain that due to massive amount of data and differences in frequencies in sensors inside educational buildings, it would take a lot of time to deal with the data to build open systems *(informant 9).* This is indicated as challenging to manage in a satisfying way if they do not consider developing more open standards for their systems.

5.6 Organizational

5.6.1 Suboptimal distribution of responsibilities and tasks

As a result of lack of sufficient technological competence, our data indicate that there may be suboptimal distribution of responsibilities and tasks in the public sector *(informant 1, 4, 5, 9 and 11)* In particular, it is emphasized that the responsibility for implementing digital infrastructures in building projects are currently absent *(informant 4)*. It would be desirable to gather analysis and decisions related to energy efficiency from OPS systems managed by staff with relevant engineering backgrounds *(informant 9).* Assigning tasks related to troubleshooting in the buildings are distributed to staff who have facility management tasks. At the same time, data indicates that several employees are not able to use relevant skills adequately during working hours and are also assigned more tasks that do not necessarily reflect the background of the specific employee *(informant 1, 4, 9 and 11).*

5.6.2 Internal attitudes

Internal attitudes as an inhibiting factor has been pointed out by several of our informants *(informant 4, 5, 8, and 10)*. Technology companies have the digital competence which are important for digitalisation processes within public organizations, and concerns among employees about being phased out or replaced are present *(informant 4).* Indications points out that the learning culture in the public sector need to be more offensive in gaining technological competence *(informant 5)*, and according to informants with technological backgrounds point out that it is important to keep up with the supplier market to not fall behind in the development *(informant 4)*. On the other hand, some of the internal attitudes that might prevent adoption of smart technology solutions in the public sector can be explained by beliefs that private actors get in dialogue with the public sector for the possibility of making profit *(informant 4)*. As a result, potential and important suppliers who can contribute with optimal energy efficiency solutions might not be considered as followed of misbeliefs.

5.6.3 Rigidity and bureaucratic processes

The organization structures of public organizations tend to be hierarchical, bureaucratic and rigid. Lack of adaptability and long decision processes are typically found and are to some extent preventing rapid decision-making processes for selecting and experimenting with smart technologies for energy efficiency in buildings *(informant 5, 6, 9)*. Difficulties in adapting quickly to changing environments might set out some of the arguments for slow adoption of smart technologies. Informants point out that because widespread development processes result in involvement of several people across different departments, change processes becomes slow *(informant 9)*. Informants explain that it is very circumstantial when activities outside the standards occurs, due to the multiple considerations that needs to be considered when operating outside the framework *(informant 9)*. The data indicates heavy bureaucratic processes for smaller projects too, as well as challenges with navigating through several public departments to get in contact before a decision can be made *(informant 6)*

5.6.4 Lack of awareness of energy efficiency

It has been reported that raised awareness on energy efficiency alone can significantly reduce energy consumption in buildings. This is one of the so called "low hanging fruits", which are referred to as simple steps that can be done in the present to make a reasonably big difference in reducing energy consumption *(informant 1 and 2)*. Managing behaviours and highlighting the actual energy consumption serves as an example. The potential of reduction is often higher than expected. Awareness of this potential leads to changing simple settings or add additional modules to the systems that helps reduce emissions *(informant 1 and 2)*. Awareness and maturity around energy efficiency in people are much of the reason why the small and easy steps that can be done immediately are not being fulfilled. Data indicates that a lack of standardization and detailed specifications of requirements for suppliers, in the form of plans and design manuals for energy efficiency, including technical solutions, are yet to be developed from public actors *(informant 8)*. This inhibiting factor is a result of lack of awareness.

Addressing the main research question *"Which barriers prevents public upper secondary schools adopting smart technologies to reduce energy consumption during the operational phase?"*, we have presented our empirical findings. We identify 20 sub categories relative to 6 categories of barriers: *prioritization, regulations, economical, competency, technological and organizational*. In the following, chapter 6 will address co-creation as a methodology to solve the barriers.

Chapter 6 - Co-creation as a bridging mechanism to solve the barriers

In chapter 5 we explained the 20 sub categories making up the 6 barriers which are preventing the public sector to innovate, more precisely to adopt smart technologies for reduction of energy consumption in public buildings. On the basis of previous chapter, we will here present the empirical indications related to co-creation methodology as a mechanism for closing the gap for utilization of smart technologies. Towards answering our sub-research question: "*Can the co-creation methodology be utilized to close the gap for implementing smart technologies in public upper secondary schools?",* our intention is to address whether co-creation is found to be an effective methodology to overcome the barriers, based on the 6 characteristics of effective co-creation processes *(Figure 3)*. Each paragraph is subject to a natural 4 step process which was conducted for this chapter specifically. We start by reiterating what the problem is shortly for each barrier. We then explain the co-creation activity, whether they can be solved and important conditions that must be present in order for co-creation to be an efficient solving mechanism. The structure of this chapter is similar to the previous chapter, which enables us to explore how extensive co-creation can be as a bridging mechanism for solving the barriers.

6.1 The use of co-creation to solve prioritization problems

6.1.1 Solving: Lack of consensus for prioritizing energy efficiency

Missing consensus for prioritization of energy efficiency in buildings exist both on a political and organizational level, resulting in resources being allocated to less important priorities. In organizations, departments are being thwarted by higher instances in the organization because of the lack of agreement around prioritizations. To some extent, data indicates that the global climate challenge brings people together and creates consensus around dealing with climate challenges. Further, data indicates that co-creation can be utilized to create a common understanding of the different professional point of views and clarify the incentives that creates the mindsets and arguments of the actors involved *(informant 2 and 7)*. During the process, a goal-oriented discussion between the parties leading to a common agreement of what should be prioritized would be beneficial to switch from projects being thwarted by missing consensus to more efficient projects based on the premises of agreement. Co-creation would work as an efficient mechanism to achieve this and can therefore be used to address the issues of missing consensus *(informant 7 and 5)*. However, certain conditions must be present. In particular, it will be important to take into account the individual contexts of the actors during the process, as well as making sure that the shared priority have meaning for each of the contexts the individuals are working in. In order to meet the energy targets by 2030, actors should be mutually dependent on each other to practice co-creation in order to reduce energy consumption in public buildings.

6.1.2 Solving: Lack of priorities in operations management

The problems relating to this barrier are three-folded. One relates to a lack of specific demands to the county municipalities from a political level, another to unclarity around energy efficiency objectives from the building authorities themselves, and lastly, a conflict between perspectives. Co-creation processes involving the actors who are running the day to day activities together with technological expertise would be a good composition for mapping the potential and produce clarity, which again leads to decisions on what should be prioritized. Design manuals and strategy notes for the building's energy use could be developed to clarify minimum demands for technological infrastructure for future energy efficiency and cost effectiveness both in operation and maintenance *(informant 4 and 8)*. Important conditions for achieving this relates to willingness among managers and politicians to allocate the necessary resources. A lack of earmarked budgets relating to energy efficiency makes it difficult to prioritize because funds are being spent in other prioritizations *(informant 1).* Co-creation processes with procurement specialists, politicians with fund delegating decision power and managers from the county municipality can bring forth reasons for why energy efficiency must be prioritized, and thereby earmark energy efficiency better. Transparency for change and investment among the actors would be important conditions for co-creation as a solution to this problem. The problem regarding priorities in operations management relates to indications that higher prioritization is given to the comfort of the users, rather than energy efficiency considerations. A conflict between perspectives makes energy efficiency neglected, as a result of the following mindset: "*If the users are cold, it's better to give too much heat than too little. Then they can just open a window if it gets too hot*" *(informant 11).* Co-creation can make a meaningful contribution to this barrier with a combination of the right knowledges about what affects the indoor climate in a room, as well as complementary knowledges to bridge the conflict between perspectives. Figuring out which regulatory responsibilities should be managed in offsite management, and which should be managed by the users of the building would be important objectives for a co-creation process. Transparency for restructuring responsibilities and trust are important conditions for a successful utilization of co-creation to solve this barrier.

6.1.3 Solving: Uncertainty in the incentives to prioritize energy efficiency

Unclear incentives for prioritization of energy efficiency impacts how energy efficiency gets prioritized. This can be dealt with utilizing co-creation practices by negotiating with several actors before making decisions to enrich the individual actors with knowledge about the long-term benefits, as well as consequences for not doing so. Uncertainty is an element that arguably will present itself in most processes that involves investing or developing new opportunities. However, uncertainty is something that can be reduced during the co-creation process. Through an intention-based dialogue highlighting valuable incentives for actors to prioritize energy efficiency, it would make it clearer and more motivating for the involved parties to focus on energy efficiency in public commercial buildings *(informant 6 and 7)*. Co-creation can be used to make the energy efficiency incentives clearer and bring forth a motivation to do so within the actors involved. Conditions for co-creation to solve this barrier, would be transparency for change and an implementation capacity, both in managers and employees, of necessary activities that follows with new prioritizations in the organization.

6.2 The use of co-creation to solve regulation challenges

6.2.1 Solving: Ambiguous regulations

Ambiguous regulations lead to an uncertainty on how to use innovative procurement practices. The problem relating to ambiguity in established relations is that there is a lack of confidence among actors to take innovative (potential risky) choices that they are unfamiliar with and are different from the traditional established practices *(informant 1 and 6)*. The evidence suggests that co-creating can assist in addressing this by building transparency *(informant 4 and 8)*. In the course of a co-creation process, partners would have the chance to create a common understanding of where the lack of clarity is and agree on a course of action of what should be done in a non-traditional way. By creating a targeted process concerning energy efficiency and explaining why the regulations seem unclear, it can contribute to clarify change necessities in the regulations. This could therefore potentially address ambiguity emerging from the interpretation of the regulations. Conditions for using co-creation as a solution for this barrier are transparency in bringing forth uncertainties in established regulations.

6.2.2 Solving: Limiting procurement regulations

Procurement regulations are restrictive because it sets out the rules for engaging and buying smart technologies, and to some extent lead to some reluctance because they can easily fall into “grey areas”. Practising co-creation can solve this particular problem by involving the right actors with the use of right procurement scheme, and through dialogue to utilize the regulations within its limitations in a more efficient way *(informant 10)*. Co-creation sessions involving discussions as a part of a sensemaking process, to i.e. co-design a tender, allows to proceed into an innovative procurement without feeling that the practice is not in line with the regulations, or in a so called "grey area" *(informant 1)*. Involving external actors early in public pre-commercial projects leads to important discussions and negotiations which contributes to common understanding that would address the negative effects of a too high price focus and make visible the long-term benefits of investing in good solutions *(informant 4)*. Therefore, the conditions that have to be met in order to use co-creation must be clarity in when and why innovative procurement schemes should and can be used for adoption of smart technological solutions in public buildings, as well as a mechanism to reward contractors spending their own resources to help the public sector better understand what they are doing. Another condition would be sensemaking and discussions before the tender process starts, despite the great extent of price orientation in the procurement processes. This would prevent good solutions from falling away.

6.2.3 Not solving: Lack of regulation for one standard

Currently, there are no common, uniform standard for the actors within the construction industry to follow, which makes it challenging to carry out optimal innovative procurement processes. Bringing forth a necessary certainty that all contractors are using the same definitions to describe important energy efficiency related matters are therefore challenging *(informant 6 and 8)*. Evidence show that efforts of creating uniform standards belongs on a higher national level through regulations, rather than through co-creation amongst actors on regional or lower levels *(informant 8)*. Therefore, we assess that it is not enough to apply co-creation practises to solve the barrier regarding lack of regulations for one standard.

6.3 The use of co-creation to solve economic problems

6.3.1 Solving: Limiting budgets

Limiting budgets inhibits the possibilities for the potential of investments that can be made in energy efficiency solutions and resources. Co-creation may help to create a common understanding of the importance of having enough funds for energy efficiency matters, as well as negotiating on fair allocation of costs among involved actors *(informant 4)*. Necessary competencies and knowledge can be obtained despite limited budgets with the use of co-creation with i.e. the private sector where the outcome would be a win-win solution *(informant 6 and 3)*. The knowledge gained might reduce unnecessary costs related to adoption of smart technologies in the present, and in the future. Data indicates that interaction processes have been done with limited user-involvement, in which experts tend to develop user-friendly solutions without involving users *(informant 3 and 9)*. This can lead to unnecessary waste of resources, since the solution has not been developed based on feedback or sufficient interaction with necessary groups of users or parties. A condition for efficient co-creation for reducing the effect of this barrier is user involvement from the start. This provides important input to be processed early, which in turn contributes to the avoidance of unnecessary changes afterwards. This is especially important when working under limited budgets where there is less room for economic loss or failure. Other conditions that must be present is a willingness from the state to delegate sufficient funds, and a transparency to make compromises among the actors in order to get to an agreement on cost distribution between them.

6.3.2 Solving: High costs and uncertainty about return on investments

High costs and uncertainty around return on investments makes decision makers sceptic in investing in energy efficiency more prominent. Co-creation can act as a mechanism for securing necessary competencies among the actors to highlight long-term benefits of energy investments. During the co-creation process, clarification of long-term profits of high investments, i.e. environmentally and as a result of less maintenance, would be necessary. Informants points out the importance of interacting with the suppliers of technical and energy efficiency solutions both in new and existing building structures *(informant 2 and 8)*. Informants also points out that if technology is the premise for a building, the return on investment would be higher in the long term, despite higher investments up-front *(informant 4 and 6)*. Building with technology as a premise does also make it easier to integrate new, inevitable emerging technologies later. Collaboration with private actors can help the public sector to become more informed about how and when investments in smart-technology that facilitates energy efficiency pays out. Conditions that has to be in place for co-creating towards a solution to this barrier, is a willingness to take risks and motivations to spend resources for the environment's best interests.

6.3.3 Solving: Highly focused on price

The problem with to high focus on price is that sustainable energy efficiency solutions are neglected for the benefit of price, without considering the long-term benefits, and/or the long-term costs of neglecting it. Also, actors such as consultants, engineers and others who have the responsibilities for energy efficiency recommendations and quality checks, should be employed by the actor who has the buildings best interests in mind, and not an actor who has saving costs as the number one priority *(informant 4)*. Increased awareness of return on investment will help to reduce the price focus when buying smart technologies into the public sector. This can be clarified through co-creation processes involving the right parties. In addition, making visible which professions should be employed by the energy efficiency authority to ensure starting points being the buildings best interests should be conducted in co-creation processes. It is pointed out that if the value of making energy efficiency investments gets signalled at political levels, it is obvious that more flexible budgets will be provided for energy efficiency matters *(informant 1)*. The high price focus can be dampened if the delegation of budgets were negotiated with a greater regard to energy efficiency before the funding decisions are made. Conditions for solving this barrier through co-creation would be to open dialogue with politicians who are close to decision-making power with the purpose of the delegation of higher, earmarked budgets for energy efficiency. Transparency to less risk-aversion and willingness to spend necessary resources for energy efficiency would be important conditions for solving the barrier of having high focus on prices.

6.4 The use of co-creation to solve competency problems

6.4.1 Solving: Lack of technological competence in procurement

The problem with insufficient technological competence in public procurements relates to issues of creating specifications which are not applicable for adopting newer technologies. Indications show that produced specifications in the procurements lack technological and digital considerations *(informant 8)*. Evidence does as well suggest that co-creation can solve this by engaging and practising more extensively innovative acquisitions, where relevant actors and the procurement staff sit down and discuss the ongoing technological supplements for building prospects *(informant 4 and 8)*. Conditions to be accommodated for utilization of co-creation are related to early decision-making around which actor should be involved in the co-creation process among the preparatory stages. Addressing this particular problem, technological competence can be built progressively in the public sector, by interact more with technological actors with innovative acquisitions in procurements.

6.4.2 Solving: Lack of technological expertise

Problems with lack of technological expertise and advisory are related to insufficient volume of competence. Indications leads to challenges in identifying and assessing new technologies because it exists too few experts to deal with the rapid technological developments and innovations *(informant 3 and 6)*. The problem is also connected to challenges in using the right set of competence, whereof technologies are often dealt with by employees with non-technological backgrounds because of insufficient knowledge about distribution of technology-related tasks *(informant 1).* Evidence point out that co-creation can strengthen public advisors' technological competences by engaging more frequently in negotiations with relevant technological actors, which leads to more experience dealing with smart-technologies *(informant 4)*. Our data indicates that the public sector is in contact with external suppliers of technological solutions, but at the same time, it will be relevant to consider whether public advisors are seeking to gather enough information about technological opportunities *(informant 3 and 5)*. During the co-creation process, actors would have the opportunity to learn by negotiating the technological opportunities, which would build up competence. Conditions for co-creation to solve this particular problem are related to openness in learning from external actors to increase technological expertise. A more extensive utilization of innovative procurement practises in the public sector, involving new technological solutions would strengthen the foundation for expertise and add value to future decisions in the public sector.

6.4.3 Not solving: Suboptimal use of competence

Suboptimal use of competence is problematic because staff with specialized competences are not working to their potential, but instead managing and working with tasks not suitable to their competence backgrounds. Evidence point out that it would be insufficient to process co-creation to solve suboptimal use of competence *(informant 3)*. However, involving current employees might be empowering to develop and learn necessary technological competences, making them even more valuable as employees *(informant 6)*. However, co-creation alone is not suitable to address this problem, because the process of change or applying established competence with sufficient technological competence are long term challenges. If they were to process a change in using their competences more optimal with co-creation, conditions to succeed would be to identify roles that tend to be responsible for high-tech solutions in public buildings today.

6.4.4 Solving: Interdisciplinary challenges

The problem with the interdisciplinary challenges is related to different professions point of views and use of terminology, leading to misunderstandings when working in interdisciplinary groups or projects. This may affect such interdisciplinary cooperation to be less effective. Lack of interdisciplinary agreement results in not having a mutual holistic view of the buildings best interests across of professions. The evidence shows that co-creation can serve to create a common, holistic understanding of energy consumption in buildings *(informant 4)*. By enlighten the importance of having the courage to ask when something is confusing or not understood initially of a co-creation process, may reduce the limiting factor regarding confusion as a result of the same terms meaning the same things in different professional disciplines *(informant 7)*. Being aware of the interdisciplinary challenges and communicate them to the involved parties in the co-creation process, could facilitate stronger decisions around energy efficiency, which in turn would be more resource friendly in the long term.

6.5 The use of co-creation to solve technological problems

6.5.1 Solving: Immature technology

The problem with immature technologies is related to the lack of considerations to the current way of managing energy in public buildings in the present, which to a wide extent involves public complex systems and analogue sensors. Immaturity in newer smart technologies, which are often relying on battery to function, are not sufficient to use due to the occasional need of changing drained or dysfunctional batteries *(informant 11)*. Evidence suggests that co-creation can assist in dealing with immature technologies. Through initiating collaboration where the parties involved are mutual dependent on each other to foreground smart technologies as an opportunity to deal with energy consumption can help the public sector to eliminate many of the risks related to the technological immatureness *(informant 4, 8 and 9)* With the correct composition of parties cooperating during the operational phase to solve ad-hoc problems and maintaining technological components, the possibilities becomes greater despite the immature technology. Co-creation practices can also be utilized for developing the immature technology itself, but this might be among the more challenging tasks, because of the technological readiness. Conditions that has to be met in order to solve this are represented by clarification of which actors that can be mature enough to function as a cooperation partner with public actors, and which risks that needs to be eliminated.

6.5.2 Solving: Challenges around technological integrations and systems

The problem with technological integrations and systems is that public actors rely on large and complex systems, which to a great extent are not ready to extract data from, nor are compatible enough to integrate efficiently as is. Several evidences point out that co-creation can help sort out the obstacles of the current systems used *(informant 3, 4, 6 and 8)*. Gathering necessary actors to coordinate sequential goals of extracting data over time and co-creating in making the systems open for integration, will in turn make it easier to take use of open standards and technological integrations for monitoring and reducing energy consumption in public buildings. During the co-creation process, the public and involved actors would have the chance to discuss steps towards integration-friendly systems and what needs to be done in specific order, which could facilitate a more comprehensive management of energy efficiency in existing building mass *(informant 4)*. Conditions that have to be in order for co-creation to solve this particular challenge are related to identifying which technological components that are necessary to integrate to uphold the current value of existing systems as well as applying value in the integrated system. Further, developing specific action plans and gather the right set of competencies among involved actors are important to address the matter.

6.5.3 Solving: Lack of open standards

The problem with the widely used proprietary systems makes it challenging to harvest insights, and in turn potential value from them. Creating open standards and APIs to public building installations can be dealt with the use of co-creation. Evidence suggest that co-creation might serve as a facilitator for developing open standards *(informant 3 and 4)*. By combining relevant competencies and actors in an open standard development project, the exchange of knowledge could lead to common understanding, and necessary consents arranged in order to turn them into open systems. In order for co-creation to be used as a way to overcome this challenge, it will be appropriate to extract historical data from previous systems and develop systems with open standards for energy efficiency purposes. Our data indicates that it is difficult to retrieve data, and that it takes time and effort to get all the data into one single interface *(informant 3 and 6)*. However, after the co-process of making the systems not proprietary, could facilitate continuous innovation of the solutions and systems through increased transparency in the systems.

6.6 The use of co-creation to solve organizational problems

6.6.1 Not solving: Suboptimal distribution of responsibilities and tasks

The problem regarding current distribution of responsibilities and tasks is related to employees that do not have the technological prerequisites to perform their tasks, nor to be responsible for technological considerations in public buildings. This runs into the absence of digital infrastructures in buildings, design manuals and specifications. Co-creation might not be sufficient or applicable to use for solving suboptimal distribution of responsibilities and tasks *(informant 3 and 6)*. However, evidence indicate that co-creation can assist in engaging in dialogues through coordinating interdisciplinary groups to assess whether digital infrastructures should be applied into future building design manuals and specifications *(informant 4 and 5)*, which can make it easier to adopt technologies into the specific public building. Co-creation can therefore to some extent make up for some of the results that comes from present suboptimal distribution of responsibilities and tasks. Conditions that have to be met for co-creation to solve the problem with applying digital infrastructures into future buildings projects are related to awareness of the technological opportunities of applying the digital infrastructure. For this, there is need for necessary technological competence among the involved actors during the co-creation process to assess and enlighten other actors about how to exploit smart technologies when the digital infrastructures are in place.

6.6.2 Solving: Internal attitudes

The problem with certain attitudes within the public sector is that there exists, to some extent, a feeling of being threatened by technological competence that the IT-companies offers. The lack of openness in exploring the range of opportunities that follows smart technologies, impacts how suppliers are treated. Indications show that private technological suppliers to some extent feel that the public sector have misbelieves regarding private actors getting involved only for exploiting ways to make profits *(informant 4 and 8)*. The evidence points out that co-creation can assist in enlighten the public actors about the technological opportunities and turn restrictive attitudes into attitudes that supports openness of technological development *(informant 4, 8 and 10)*. Instead of rejecting proposals that can change established framework conditions and agreements in construction projects, co-creation can address this problem by changing the organizational attitudes with open dialogue around improvements and adoption of technologies in buildings, while maintaining a coordinated and targeted process towards better energy management. Co-creation might also create motivation and empowering the involved people to feel ownership in such processes, which might impact the feeling of being threatened by technological actors. Conditions that has to be met for co-creation to solve this barrier is an open-minded attitude within the actors involved, manage motivation in employees and changing their beliefs of what is possible.

6.6.3 Not solving: Rigidity and bureaucratic processes

The problem with bureaucratic processes and rigidity is that it involves use of valuable time in processing before decision-making. It tends to be time consuming before the right public actors to get involved and accommodate inquiries and opportunities, because of the complex public organizational structures *(informant 6)*. The evidence suggest that co-creation might not be applicable for reducing bureaucracy immediately but might function as a facilitator for more efficient processes related to adoption of smart technologies by gathering relevant actors to develop procedures for efficient procurements that are crucial for increasing adaptability *(informant 8).* In the course of a co-creation process, actors should point out the opportunities of creating specific points of contact for suppliers to use for contacting the public sector. This eliminates waste of important resources by reducing the liabilities of hierarchy. By applying co-creation, you can drive projects forward more efficiently, and data supports and points to co-creation as “well planned and structured” *(informant 1, 6 and 10)*. This makes it easier to achieve goals, because those that are involved are held accountable for effective progress. Combined with specific contact points, this will reduce the disadvantages of bureaucratic and rigid organizational structures further. Conditions that has to be in place for using co-creation to overcome this barrier, are the awareness in public managers of the rigidity and bureaucratic structures within their own organization, increasing the focus on efficient decision making and experiment more extensively with co-creation processes to reduce some of the rigidity.

6.6.4 Solving: Lack of awareness of energy efficiency

The problem with lack of awareness of how to approach energy efficiency effectively is the lack of exploiting simple steps and adjustments, which immediately can increase efficiency within the organization. As a result of insufficient awareness on how to take immediate steps towards energy efficiency, important steps of applying suitable digital infrastructures does not happen, which prevent efficient adoption of smart technologies in public buildings. Evidence suggest that co-creation can raise the awareness in during the co-creative process through exchanging necessary knowledge from experts on technological opportunities for energy efficiency in buildings more frequently *(informant 5 and 7)*. During the co-creation process, involved actors would have the chance to combine competences to identify the low hanging fruits towards energy efficiency and at the same time, find immediate actions to exploit them *(informant 4 and 7)*. Co-creation can highlight such potential and put more effective energy management on the agenda as a priority in the organization through increasing the awareness of energy efficiency. A condition that has to be met so co-creation can solve this challenge is identification of the simple adjustments and steps and communicating the adjustments throughout the organization.

We have in this chapter presented how co-creation can be used to overcome the barriers, as well as referring to the table, which presents the value of co-creation (*Table 4*). After processing the co-creation methodology against the barriers, we identify that co-creation can be utilized to solve 16 out of the 20 challenges. We have provided ways for how co-creation could be used, as well the conditions for taking use of the methodology. A summary table of the contribution that co-creation can make towards solving the empirical barriers, and answering our sub-research question: "*Can the co-creation methodology be utilized to close the gap for implementing smart technologies in public upper secondary schools?"* are shown below:

Dimension	Sub-dimension	Value of co-creation	Conditions for using co-creation
Prioritization	Consensus	Create common understanding among the involved parties. Avoidance of departments being thwarted. Leads to projects based on premises of agreement.	Individual context of the actors, and that shared priority has meaning for all actors involved.
	Operations management	Mapping the potential. Decision making around prioritization.	Identification of reasons for neglect and transparency for change.
	Incentives	Enriching the individual actors' knowledge about the long-term benefits, and consequences of not doing so, leading to awareness and certainty. Makes incentives clearer which creates motivation.	Transparency for change. Implementation capacity of necessary activities.
Regulations	Ambiguous regulations	Building transparency and common understanding of where the lack of clarity is.	Transparency in bringing forth uncertainties in established regulations.
	Limiting procurement regulations	Utilization of the procurement regulations within its limitations in a more efficient way. Brings clarity around "grey areas". Common understanding of the long-term benefits of investing in good solutions.	Involving and rewarding external actors early in public pre-commercial projects. Clarity on relevant situations for innovative procurement. Sensemaking and discussions before the tender process starts.
	Lack of regulations. for one standard	Co-creation not a solution	Co-creation not a solution
Economical	Limiting budgets	Creating understanding of the importance in fund delegating instances. Negotiating a fair cost distribution among the involved actors.	Focus on user involvement. Willingness from the politicians to delegate sufficient funds. Willingness to make compromises among the actors.
	High costs and uncertainty on ROI	Clarification on long term profits and benefits.	A willingness to take risks and motivations to spend resources for the energy efficiency matter.
	Highly focused on price	Increased awareness of return on investment decreasing the high price focus. Clarification of professions that should be employed by the energy efficiency authority	Dialogue with politicians who are close to decision-making power with energy efficiency budget purposes. Transparency to less risk-aversion and willingness to spend necessary resources for energy efficiency among the actors.

Competence	Lack of technological competence in procurement	Navigate procurements with the right technological supplements for building prospects. Through involvement, to give meaning and direction in the decisions that are made regarding technologies.	Early decision-making around which actors should be involved.
	Lack of technological expertise	Strengthen advisors of technologies by engaging in negotiations and dialogue about technology opportunities.	Openness in interaction with external actors to learn about new technologies.
	Suboptimal use of competence	Co-creation not a solution. *Co-creation can partly contribute by bringing a probability to empowering employees to acquire necessary technological competence. Otherwise, not a solution	Co-creation not a solution. *Discipline to do what it takes to acquire the necessary competence.
	Interdisciplinarity	Creation of a holistic understanding of the goal of the process to solve interdisciplinary challenges.	Identifying individual actors and awareness through communication.
Technology	Immaturity	Clarification of large and heavy organizations. Mapping which risks needs to be eliminated. Project management. Enough resources. Relevant knowledge.	Easy access to expertise around new technology. Evolving immature technology.
	Integrations and systems	Make the systems fully integrated. Boost the BMS ability to uncover important, now hidden events. Uncover where challenges are to be met. Identify versions and types of components working together.	Identify which versions and types of technological components works together. Developing concrete action plans, and gather the right competencies for developing new technologies.
	Open standards	Realization of open standards. Facilitates innovation.	Extract historical data from previous systems. Combining the necessary expertise together.
Organizational	Responsibility and tasks	Co-creation not a solution. *Conditions for partly solving: Make it easier to adopt smart technology because professions without the right prerequisites do not have to decide on these things in a single project.	Co-creation not a solution. *Conditions for partly solving: Awareness of the technological opportunities of applying the digital infrastructure. Necessary technological competence among the involved actors during the co-creation process to assess and enlighten other actors
	Attitudes	Open dialogue about improvements and potential adoption of smart technologies to create motivation. Empowering the involved actors around energy efficiency.	Open minded attitude. Motivating leaders. Mindset shift towards private actors' motivation for involvement with the public sector.
	Rigidity and bureaucracy	Co-creation not a solution.	Co-creation not a solution. *Establishing specific points of contact for suppliers when reaching out to the

		*Co-creation can partly be used for reducing inhibitory effect from rigidity and bureaucracy, because of a more time effective progresses.	public actor
	Awareness	Increased awareness in decision-making processes. Exploit the opportunities of low hanging fruits. Highlight the potential of energy efficiency. Design manuals and specifications on energy efficiency.	Identification of easy accessed energy efficiency approached and communication throughout the organization to increase awareness.

Table 4 - Summary table of values and conditions of co-creation

Chapter 7 - Discussion and comparison

In this chapter we aim to take use of gathered data, which has been thoroughly processed in the latter chapters, to discuss our findings before answering our research questions. The general research question is: *"Which barriers prevents public upper secondary schools adopting smart technologies to reduce energy consumption during the operational phase?"*. We have explored the theoretical and the empirical indications that relates to different dimensions of barriers that are preventing the public sector to innovate and to adopt smart technologies for the purpose of energy efficiency in a Norwegian municipality. To complement this, we have explored how co-creation can be utilized in the following sub research question: *"Can the co-creation methodology be utilized to close the gap for implementing smart technologies in public upper secondary schools?"*. In the following, (*chapter 7.1*) we will present a comparison of the theoretical and empirical framework on the barriers for adopting smart technologies. Chapter 7.2 presents discussion upon whether co-creation can be used to solve the barriers, and lastly *(chapter 7.3)* to what extent the public sector is already aware of the barriers.

7.1 Comparison of theoretical framework and empirical findings

In the following, our intention is to introduce a revisited model and enrich the theoretical framework *(figure 2)* with empirical findings, which could potentially modify the framework. Evidence from this case study has focused single handed on activities in Bergen. So, to enrich the theoretical framework with our findings, figure 7 present a revisited model of barriers preventing the public sector to innovate and adopt smart technologies in public buildings. The theoretical framework derives from existing knowledge from existing documents and theories of innovation barriers in the public sector. Our findings in the empirical framework (*figure 7*) is slightly different from the theoretical one. This may be due to the fact that we have investigated barriers for adoption of smart technology, and not barriers to general innovation in the public sector. After processing our gathered data, the barriers got reduced from 7 to 6 barriers. Each section below presents our reflections and discussion around the most prominent findings for each barrier. In the following we present our revisited model and reflect and compare it to figure 2.

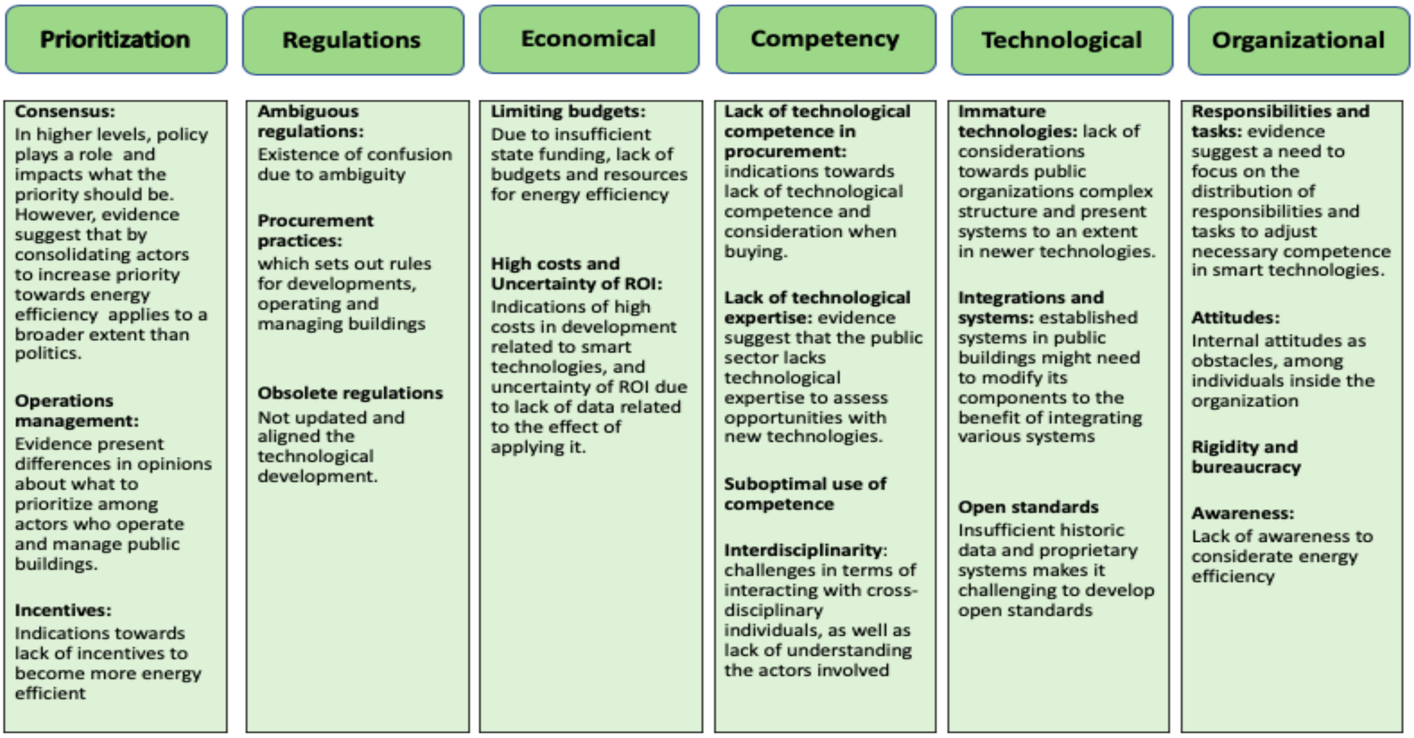

Figure 7: Revisited model of barriers

The barrier related to politics has been replaced with prioritization challenges, because we found that lack of priority was more prominent in several different contexts after the analysis. However, politics is still not irrelevant. Lack of priority applies in both political and organizational sense, as well as on higher county and national levels. We identify that politics impact how other barriers sets out and prevents the adoption, e.g. limiting public budgets and regulations under the economical and regulative barriers. For example, evidence show that with politics, it is important with common agreement around which areas that should be prioritized, delegation of funds and agreement around potential changes in regulations. This might affect the manoeuvrability that counties and municipalities get related to energy efficiency investments and procurement. During the analytical process of our gathered data, it became clearer that what our informants were saying did not have something to do with different governance approaches, but how they chose to prioritize energy efficiency. Further, we have presented how governance approaches, such as TPA, NPM and NPG could influence innovation processes in the public sector (Hartley 2005; Holmen & Ringholm, 2019). Nevertheless, after conducting our case study, we argue that politics naturally can be placed under the prioritization barrier. We introduced our study saying that the political agreement on the importance of finding solutions that slow down or stop greenhouse gas emissions are broad, and that the UN 17 SDG progressively lay down guidelines for sustainable measures.

Another point of reflection to argue our choice of treating politics under "*lack of prioritization*", relates to how politics seem to impact prioritization and 5.1.1 («*lack of consensus for prioritizing energy efficiency*»). Our findings indicate that focus on efficiency, in terms of deadlines and costs related to the building, get the better of energy efficiency. Reflecting on the NPM approach, we identify efficiency to correspond with the aim for effective public management (Tortzen, 2019; Holmen & Ringholm 2019). Focusing on short term measures, such as what some of our informants reflected upon, might compromise long term energy efficiency in buildings. This corresponds somewhat to the possibility of failures, where the innovation capacity tends to be undermined due to the chase of short-term targets in order to ensure long term survival, and not spending enough time focusing on long term innovation and change (Williamson, 1995, p. 339). The reflection from our informants clears this out - when the consideration of deadlines in terms of complying with set launch dates for building projects get prioritized over the assessment of necessary technical components in the building, it is hard to get energy efficient. Another point that we want to highlight is that the governance approaches seem to be segueing among the informants in this study. Our take away from our in-depth interviews, especially with representatives from the county and the municipality, is that regulations, bureaucratic processes and hierarchical structures are needed, which reflect upon the approach of TPA. For instance, when monitoring the BMS-systems related to the public buildings it is necessary to have experts monitoring them, and assessments of the beneficiary of the building tend to be isolated through the use of the right competence to adjust the buildings use of energy, and thereof having a passively relationship to the buildings users and other actors. When reflecting upon how this sets out the conditions for taking use of co-creation, it gets challenging to take use of co-creation. Considering the activities that finds place in Bergen's clusters, i.e. the new energy cluster, it looks like more of an approach of NPG, whereof creating an arena for co-creation, which stimulate and sets out the right conditions for practising co-creation. Evidence indicate that bringing different actors together for communicating knowledge and stimulating innovation is necessary for several energy related challenges. Since a lack of consensus for prioritizing energy efficiency exists, the role of the cluster to connect actors could stimulate to increased consensus. In general, politics has been described in chapter 2 to be one of the most reported factors that are preventing the public sector to innovate (Kirsner, 2018). However, reflecting upon our findings in this case study, our understanding is that politics complements into the barrier of prioritization as a higher-level factor that impacts both how actors prioritize, and their consensus related to energy efficiency.

The barrier related to regulations have empirical findings which correspond to the theoretical framework to some extent. However, "*Ambiguous regulations*" were found to be a regulatory barrier in our empirical model. Evidence suggest that ambiguity in regulations might indicate and explain, to some regard, why smart technologies are not adopted to the extent that align public sector more with the technological development. Continuing this reasoning, ambiguous regulations might reflect upon some of the evidence from our data, which points out early involvement of relevant actors in projects to be somewhat challenging in terms of knowing whether the engagement is within the regulatory procurement boundaries. This might lead to some restrictions towards including right actors to get involved in projects relating to the adoption of smart technologies. "*Limiting regulations*" and "*Procurement practices which sets out rules for developments, operating and managing buildings*" from the theoretical framework got merged. After processing and analysing our data, these were included into the new sub category, "*Limiting procurement regulations*" in our empirical framework. "*Lack of regulation for one standard*" emerged as a new regulative barrier, due to comprehensive empirical findings that pointed out this matter. "*Obsolete regulations*" from the theoretical framework are one of several other reasons for the lack of standards for adopting smart technologies and was therefore merged with this new regulation barrier. Obsolete regulation is in turn a fact because the public sector fails to upgrade the regulations in line with the technological development.

The economical barrier was to some extent also changed. The three first sub categories from the theoretical framework was merged into the category "*Limiting budgets*" in our empirical model, because of the high degree of interconnection between them. Furthermore, we found that *"uncertainty of ROI"* was prominent in our data as well as in the established theory, much related to evidence that suggest high costs and investments related to development of new infrastructures or uncertainty of technological effects in the buildings. Therefore, a new definition to this economical barrier was given to cover both aspects in our empirical model: "*High costs and uncertainty about return on investments* ". The sub category, "*Highly focused on price*" emerged as a new barrier in our empirical model as well. Several indications pointed out public procurement to be highly focused on price caused by e.g. limited budgets. The cost for adopting smart technologies indicates to some extent higher investment costs, which might negatively affect decisions around what to buy in the public sector. Further, applying digital components, which are described as severe for exploiting a variety of smart technological solutions, such as IoT sensory in buildings might increase the cost of managing and maintaining the components. Capacity of batteries could i.e. lead to regularly changes of defect components. On that note, it can be interesting to assess whether the additional costs of applying smart technologies in the long-term compensate for some over the indicated scenarios, but since there is insufficient amount of data that explain the effects of smart technologies in buildings, it might be argued that this alone is not enough in the present.

Competency was much more prominent than communication as a barrier, and several codes under communication were related to competency issues. During the process of analysing, communication as a barrier got eliminated, because the majority of our data related to this did not indicate any particular concern among our informants. Some of the communicational data got merged with the competency barrier after the cluster analysis, for instance did "*Interdisciplinarity challenges*" become a new competency barrier as a result out of identified interconnections. Our data suggests that "*Lack of technological expertise*" amongst important staff is not the only inhibiting factor related to competency. "*Lack of technological competency in procurement*" was also identified as a challenge and became a new competency barrier in our empirical framework. The reasoning for the creation of this particular barrier reflects the evidence that explain occasions of mistreatment of specifications in terms of using older ones from older projects from the past, which does not consider or facilitate relevant actors to offer smarter solutions in a satisfyingly matter. Even though this might not reflect, nor describe every procurement, the barrier can illustrate the negative consequences of doing so. In the long-term it could arguably reduce potential development of buildings and the construction industry in regards of not having updated specifications, which could impact innovation, more precisely for adoption of smart technologies.

Challenges regarding integration of new technology with established systems was prominent to a high degree in our data and became a technological barrier as "*Integrations and systems*" in our empirical framework. Lack of technological infrastructures are reflected in this barrier indirectly, because integration of new technologies would not be a problem with the sufficient technological infrastructure present in buildings. Corresponding to the theoretical framework, our empirical model suggests that the barrier, "*Immature technology*" is prominent and prevents rapid adoption of smart technologies. Relative to this, infrastructures for transferring surplus heat between buildings are also immature, or yet to be developed. In the present, surplus energy are released into the atmosphere and becomes 100% waste energy. Solutions for utilization of this energy holds a great potential for reducing energy consumption in buildings. For example, the water that are being used to cool the datacentre in MCB and produces waste heat as a result. This heated water could contribute to heating needs in other buildings. However, it depends on the necessary infrastructure being developed. The use of smart technology to transmit surplus energy through the smart-grid could be beneficial for energy efficiency measures. However, these considerations are not mature enough for the public sector and demands an extensive development of physical infrastructure as well. Building Management Systems, considerations towards procurement schemes and existing buildings mass must be prepared for these kinds of solutions. Furthermore, immature technology also relates to battery solutions that components are relying on in the present. This inhibits the adoption of smart-technologies in the public sector. Vast amounts of resources in maintenance and surveillance are needed to operate it in a sufficient way, and to avoid other obstacles occurring as a result of one or several components running out of battery. The resources needed for this are not precepted as being less cost effective than the present solutions. However, companies exist that offer solutions to this specific matter as a service.

The organizational barrier was clustered into four different sub categories in our empirical framework, as a result of treating our data instrumentally, as well as clustering it to our realization that several of the categories could be merged. "*Suboptimal distribution of responsibilities and tasks*", "*Internal attitudes*" and "*Lack of awareness of energy efficiency*" became new and comprehensive categories. For instance, did several of our informants point out challenges of delegating wrong tasks and responsibilities to employees that not necessarily have the technological expertise or competence to undertake the task. However, this does reflect the progressively more important need of having technological competence. Evidence suggest that there exists a process of growing competence in educational institutions in the region today, e.g. in machine learning. Therefore, having a suboptimal distribution does not come unexpected in the present. Another matching barrier is the barrier of "*rigidity and bureaucratic processes*". Several points were made through our informants. For instance, does it affect the use of time, as well as being costly, because it results into involvement of several public actors when accommodating inquiries. Further reasoning explains this better. When actors representing smart technologies approach public actors, it can take long time and involve a variety of people not applicable to accommodate them, and to some extent prevent rapid decision-making processes for experimenting with smart technologies for energy efficiency. This does partly have something to do with treating opportunities through bureaucratic processes, which might prevent or slow down the experimental learning and thereof, the adoption of smart technologies.

7.2 Can co-creation solve the barriers?

Addressing our sub-research question "*Can the co-creation methodology be utilized to close the gap for implementing smart technologies in public upper secondary schools?",* this section presents reflection on whether co-creation can solve the barriers. In order to resolve the prioritization, regulatory, economics, competence, technology and organizational barriers, co-creation are characterized as promising. Co-creation seems to be a possible way to address 16 out of 20 barriers that prevents the public sector from adopting smart technologies *(Table 5).* Below we will present our reflections and discuss how co-creation seem to overcome technological barriers, because our assessment is that it plays a significant role in adopting smart technologies. Then we point out the 4 barriers that cannot be solved by co-creation and the possible attenuating effect of practising it, as well as highlighting the possibility that co-creation might lead to the appearance of new barriers.

By utilizing co-creation, the actors involved can coordinate in complementary groups to discuss the various challenges of implementing smart technologies. Engaging in dialogue with relevant actors and negotiating on important considerations that must be included for adopting smart technologies, should be kept and prioritized. Another positive consequence of using co-creation is that the different actors will be more attuned to push in the same direction towards energy efficiency. Referring to the technological barrier and "*immature technology"*, developing existing infrastructure to be mature enough for transferring energy, co-creation processes involving relevant actors and competencies, may bring forth solutions for using surplus energy from district cooling to cover other buildings energy needs. Co-creation can in such cases be utilized to bring forth an agreement between the parties on the correct business arrangement which will benefit all the parties involved. In example could co-creation be useful to make sure to consider established structures and systems (BMS), in assessment of smart technologies. Further, applying the methodology might as well be useful to experiment, learn and find ways to modify smart technologies to better fit the technical and complex structures in public buildings. As we have seen, solutions for energy efficiency through new infrastructure and companies' services are promoting themselves. With the right composition of participants in co-creation processes, extensive energy efficiency in buildings may be realistically achieved through development of the infrastructure. In example, referring to the battery driven component challenge, co-creation can be used to arrange beneficial contracts for both the public actor and the company delivering the service.

Another prominent barrier that co-creation can help resolving is the technological barrier, *"Lack of open standards".* Arguably, having proprietary systems makes it challenging to harvest insights, and possibly the development of established systems. The main issue relates to the complexity and amount of time necessary to create open standards in systems consisting of data and different sensor frequencies. Practising co-creation could possible reduce some of the stress of abstracting this information needed to create open standards through delegating tasks to relevant IT actors, as well as making sure the regulative necessities are in order by including right set of advisory and legal team. Addressing the issue related to the time and effort needed to build open systems, gathering enough technological competence to cooperate in switching from proprietary to open systems would be beneficial. Dealing with lack of open standards by practising co-creation could therefore might be useful to solve this particular challenge, if the process is orientated around the barrier and coordinated with the use of the right set and amount of competences to deal with it.

Evidence indicates that co-creation is insufficient for solving 4 of the 20 barriers. However, we consider that co-creation might have an attenuating effect on one or more of the barriers that could not be solved. One relates to the regulatory barrier in section 6.2.3 which is about lack of regulations for one standard. This belongs on a higher level than actors coming together for solving regional problems. Co-creation for solving barrier *"6.4.3 – Suboptimal use of competence"* are found to be partly insufficient, because of the long-term characteristic of change and raising competence. Further, co-creation is found insufficient to solve two of the organizational barriers. More specifically "*6.6.1 - Suboptimal distribution of responsibilities and tasks*" and "*6.6.3 - Rigidity and bureaucracy*". However, it can be used to solve certain aspects of them. To illustrate with an example, co-creation could not solve challenges of allocating and distribution responsibilities and tasks (*6.6.1*) on a higher level but might be used to assist by engaging interdisciplinary group to assess whether digital infrastructures should be considered. Consequences of not being able to use co-creation to solve certain barriers, would be to allocate resources to find other approaches for solving them. A consequence for the barriers that only can be solved partly by co-creation indicates that a win-win mindset becomes even more important. This relates to both collaboration between sectors, but also facilitating resources, tools and time for employees to acquire important competencies on their own.

Furthermore, the use of co-creation might result in appearance of new barriers. In practical terms, data indicates that co-creation might not be straight forward in practise, as a result of several factors. One reflective point to make regards the potential of neglecting certain technical and technological competencies. Here we argue that involvement of actors into interdisciplinary groups might lead to important considerations not being included. In example, the rejected codes that did not fit our generated clusters of barriers for adopting smart technologies, was related to indications towards challenges as a result of different agendas and social interaction when collaborating on projects. Different actors have different deadlines and agendas for participating in co-creation processes. Different agendas can also be related to people who are giving advice about how to run public buildings, which are often the same people monitoring the costs related to energy consumption. Co-creation practices comes with social interaction. Personal chemistry between the ones working together are profoundly important for effective interactions. This might be difficult to handle during interactions and might inhibit the quality of the co-creation process. Fear of speaking up serves as an example, which can lead to revolutionary ideas not being shared.

In the following chapter we will discuss and reflect upon the public sector's knowledge about the barriers that are unfolding and preventing them from adopting smart technologies into public buildings for energy efficiency.

7.3 To what extent are the public sector aware of the dimensions?

At a higher level, innovation, competence building, smarter procurement methods and the possibilities of ICT are on the agenda in Norwegian parliamentary reports, which indicates that the public sector have knowledge about this. However, to which extent? After working through different parliamentary reports, the present technical manual related to environmental performance standard in buildings and the municipality's climate - and energiplan (Appendix 1), we see that the public sector already has knowledge about various obstacles.

There is a lack of national focus on energy efficiency of existing public buildings (before TEK10). In achieving the EU's objectives for dealing with the global climate challenges, a broad national focus towards increasing energy efficiency in established building mass could be important. To address it, the county will systematic rehabilitate the existing buildings for energy efficiency with incremental escalation (Hordaland fylkeskommune, 2014, p. 32). By looking at Denmark's use of solar heat from large-scale plants, Norway acknowledge a potential for use, which probably also compensates for the technological barriers around solar panels today (Hordaland fylkeskommune, 2014, p. 25). In county municipal buildings, it is planned for an annual rehabilitation of 5% of existing buildings and a gradual escalation to enable the county to reach 37% energy efficiency by 2030 (Hordaland fylkeskommune, 2014, p. 33). Reflecting upon how Bergen plan to become more energy efficient, the municipality's climate and energy plan, "Grønn Strategi" is planned for until 2030. Its purpose is to describe the goals, strategies and measures that are taken in account to meet the growing climate challenges, while the city's population is growing and developing into a greener city in Norway (Bergen kommune, 2016). Relative to the achievement of becoming more energy efficient, there is a current build-up of necessary competence in collaboration with various public actors and educational institutes, which is necessary for building competence in the construction and building industry (Bergen kommune, 2016, p. 56).

The technical manual “BREEAM-NOR” (Grønn byggallianse, 2019) describes an environmental performance standard in which new buildings, as well as rehabilitation projects in Norway can be assessed and awarded with a “BREEAM-NOR classification”. Among the purposes are to ensure a robust, cost effective performance standard for buildings that exceeds the regulatory demands. However, a lack of knowledge and data relating to buildings life-cycle costs, as well as the benefits of sustainable planning and construction, presents challenges related to promote more sustainable energy efficient solutions. Estimating life-cycle costs of the building are relevant throughout the whole life-cycle, especially in the planning phase, but also during the operation phase (Grønn Byggallianse, 2019, p. 26). A common standard has been compiled (ISO 15686-5) to describe a standardized method for estimating life-cycle costs for the construction industry. Among the several purposes of the ISO 15686-5 standard are to reduce uncertainties and risk that undermines the trust for using life-cycle costs as decision support in procurement (Grønn Byggallianse, 2019, p. 26). This will to a certain extent make visible lower life cycle costs in the operation phase, when the building is constructed based on the premises of technology, and thereby contribute to reduce the uncertainty around long term return on investment. Furthermore, primary data indicates that technology as a premise in buildings provides a stronger basis for energy efficiency as well as a more cost-effective maintenance in the operational phase, than the premise given by traditional constructing and rehabilitation.

The public sector can stimulate innovation and development through the use of co-creation. At a higher state level than the county municipality levels, it is signalled to use pre-commercial procurement to meet new needs, pointing to examples of procurement of gas-powered ferries as an example that can yield environmental benefits (Nærings - og Handelsdepartementet, 2008, p. 135). Furthermore, it is described as desirable to strengthen the competence of public purchasers through better use of procurement methods (Nærings - og Handelsdepartementet, 2008, p. 137). Traditional procurement procedures prevent the development of new and unknown solutions, especially in ICT development processes that works better with competitive dialogue for creating knowledge through learning and developments between the suppliers and the public buying organization.

The parliamentary report, "*Kraft til endring - Energipolitikken mot 2030*" indicates, at a higher state level, that it is desirable to put sustainable energy production and supply in a long-term perspective on the agenda, especially considering the global climate challenges. The barriers to energy and climate measures are described to vary greatly from one area to another, and that different regional approaches are needed to understand the different industries in order to be able to achieve their goals effectively (Olje - og Energidepartementet, 2016, p. 65). With an increased use of ICT, both opportunities and challenges arise. Increased use of ICT is related to scenarios where the number of unwanted ICT events are predicted to increase and introducing new technologies - such as the use of digital cloud solutions, can create safety and regulatory challenges in the public sector (Olje - og Energidepartementet, 2016, p. 151). This does also reflect from the in-depth interviews, whereof data relates to regulatory challenges regarding who should bear additional costs in developing and adopting smart technologies in public buildings.

Regulatory challenges are also reported caused be the present procurement regulations. Smarter and efficient procurements in the public sector could be crucial for it to continue to contribute to innovation and efficiency in Norwegian business (Nærings - og Fiskeridepartementet, 2019, p. 11). The Ministry has received reports and feedbacks that the term "*innovative procurement*" is not well understood, nor clear among the actors due to ambiguity of the concept, which is used for both smaller procurements that facilitates innovation and for larger ones with elements of research and development (Nærings - og Fiskeridepartementet, 2019, p. 59). Ambiguity in the procurement regulations can make it challenging to follow technological developments, and it is indicated that there is a desire for clear definitions to make it easier to develop methods and to set goals for developments (Nærings - og Fiskeridepartementet, 2019, p. 59). This is also brought forth in the in-depth interviews as a prominent reason for why the public sector experiences challenges with the correct use of innovative procurement practices and are reflected in barrier 6.2.1.

"Perspektivmeldingen" (Finansdepartementet, 2017) discuss important challenges for the Norwegian economy in a long-term perspective and aims to make good choices for the years to follow. One of the most important challenges in the future is building competence, and in order to adapt to changes in the working life and the education sector, this becomes important (Finansdepartementet, 2017, p. 6). The public sector is often described as facing conflict of interests, where the consideration of effective problem solving must be weighed against other goals and considerations. Furthermore, the Norwegian democracy is described as being consensus-based built - which implies that the political system and the policy instrument wants common agreement in ongoing challenges as well (Finansdepartementet, 2017, p. 176). At the same time, in terms of conflict of interests between actors, consensus is not given, but the information described about the importance of it is clear. For example, a strong focus on climate technology has provided opportunities for reducing greenhouse gas emissions and energy efficiency, however the effect of this effort is hard to estimate in the present (Finansdepartementet, 2017, p. 85). This is likely to reinforce a range of opinions, which could create conflict of interests around the issue of adopting smart technologies for energy efficiency matters in public buildings.

"Digital Agenda for Norge" (Kommunal- og moderniseringsdepartementet, 2016) deals with the overall policy for how Norway can utilize ICT-technology for society's best interests. The document refers to studies which has shown that lack of expertise of top managers in decision making processes are one of the biggest barriers in digitizing public services (Kommunal- og moderniseringsdepartementet, 2016, p. 52). As regards to competency, many municipalities have challenges with attracting and keeping important ICT-competency for developing digital public services. The challenge with digitization of municipalities are connected to extensive variety in competence, maturity and choices of ICT-solutions. Interdisciplinary competency combining ICT-competency with i.e. analytic and statistical competency has a rising demand (Kommunal- og moderniseringsdepartementet, 2016, p. 58). Innovative procurement processes set higher demands to purchasing competency and would contribute to a higher innovation degree in the public sector (Kommunal- og moderniseringsdepartementet, 2016, p. 132). The procurement regulation in Norway are often perceived as to detailed, formal and complicated to function as a good procurement tool. However, the public sector has potential for improvement utilizing the possibilities in the regulations, i.e. including suppliers early in the procurement process (Kommunal- og moderniseringsdepartementet, 2016, p. 88).

After going through the selected documents related to energy efficiency in the public sector, they seem to have knowledge about the majority of the barriers. However, digital infrastructure might be something that policy makers have not considered to a broad extent locally, even though awareness of EUs strategy for development of digital markets is provided for. Acknowledgement of the possibilities with increased use of smart technologies in public buildings exists. Sufficient technological infrastructure presents opportunities in buildings to produce its own energy from renewable sources, e.g. with use of solar panels, geothermal heat, heating pumps, heat storage and solutions for transferring stored heat to other purposes within the building (Hordaland fylkeskommune, 2014; Sandberg et. al, 2019), or even to other buildings. Applying a digital infrastructure, could make it easier to get in dialogue with the right actors about efficient ways to adopt smart technologies into existing buildings.

Chapter 8 - Conclusion and suggestion for further research

8.1 Conclusion

Answering our general question: *"Which barriers prevents public upper secondary schools adopting smart technologies to reduce energy consumption during the operational phase?"* Our data indicates (figure 7) that the barriers: prioritization, regulations, economical, competence, technological and organizational are preventing the public sector to adopt smart technologies. Adopting smart technologies in upper secondary schools might reduce energy consumption during the operational phase. Furthermore, the possibilities of using technologies with the goal of being energy efficient are recognized by the public, but it is suggested that further priority must be given at county level to earmark energy budgets, and to facilitate for new technologies by including digital infrastructures in future projects. There is recognized a need for collaboration between actors to include this into established frameworks in buildings, as well as for consideration of other technical aspects related to operations management of public buildings. Related to our sub-research question, our intention has been to explore whether co-creation can be utilized to overcome the barriers: "*Can the co-creation methodology be utilized to close the gap for implementing smart technologies in public upper secondary schools?"*.

Co-creation can solve following barriers:	Co-creation cannot solve these:
Prioritization	**Prioritization**
Consensus	N/A
Incentives	
Operations management	
Regulations	**Regulations**
Ambigious regulations	Lack of regulations for one standard
Limiting procurement regulations	
Economical	**Economical**
Limiting budgets	N/A
High costs and uncertainty on ROI	
Highly focus on price	
Competence	**Competence**
Lack of technological competence in procurement	Suboptimal use of competence
Lack of technological expertise	
Interdisciplinarity	
Technological	**Technological**
Immaturity	N/A
Integrations and systems	
Open standards	
Organizational	**Organizational**
Attitudes	Responsibilities and tasks
Awareness	Rigidity and bureaucracy

Table 5: Summary of which barriers co-creation can solve

The results (*table 5*) show that co-creation can solve 16 of 20 identified barriers preventing the adoption of smart technology solutions for energy efficiency in upper secondary schools and are considered as a methodology with the ability to make a significant strong contribution. Looking back at our conceptual research model in chapter 2 (*figure 4*), our results from this case study suggest that co-creation can help create an environment including relevant actors to collaborate towards energy efficiency in public upper secondary schools. Further, making it conceivable to assess the benefits of smart-technologies and close the gap creating the adoption problem to a great extent. Below we illustrate this through an applied version of our conceptual model:

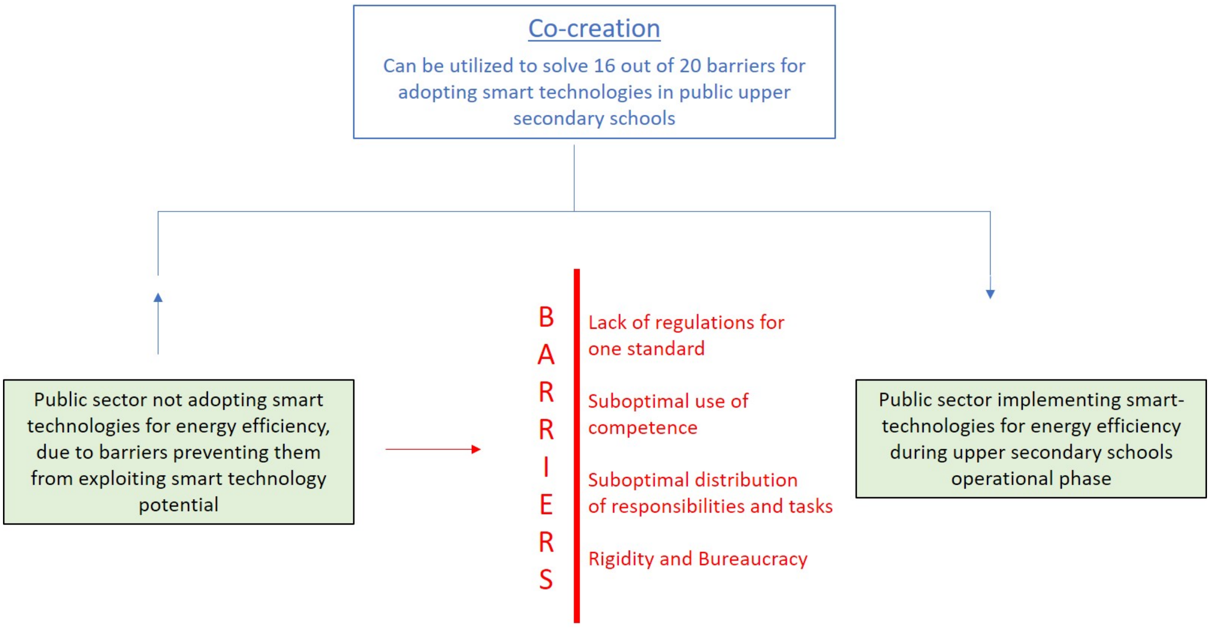

Figure 8: Applied conceptual model

8.2 Policymakers: what do they seem to do correctly, and what need to be included

Referring to chapter 7.3 were we discussed what policy makers seem to be aware of related to the barriers (appendix 1), challenges related to priorities seems to be this study's biggest contribution. Evidence suggest that the causes of this specific barrier derives from uncertainties of cost-benefit, hence uncertainty in the effects of applying smart technologies in public buildings. Our assessment is that this is due to the lack of data on the effects available, which could indicate how smart technologies affect energy efficiency as a result. A possible reason why energy efficiency is not emphasized to a sufficient degree is related to priority towards energy efficiency. Further, prioritizing energy efficiency and assess whether smart technologies might fulfil achievements on energy targets in public buildings could positively impact to a reduction in energy consumption in the county's buildings.

8.3 Recommendations of practice

Practices that contributes to raise awareness of energy efficiency potentials would be beneficial to facilitate prioritization. Politicians and managers should initiate processes for mapping potentials for energy efficiency in buildings, making visible motivating incentives, easy measures that can be done and also more complicated ones. Co-creation processes with the correct competencies and actors involved are crucial for ensuring that this is done in a sufficient way. Awareness and understanding of the different professional starting points are important, to ensure that a common understanding and a shared purpose in the group are present. If not present, time should be allocated to create it as the first step of the process. The actors related to managing and operating the buildings are dependent on each other, as well as of being included into building projects to maintain and add established knowledge into development of adopting technologies into public buildings. Practices that enables a more specific earmarking of funds relating to energy efficiency in the budgets should be assessed. Developing clear objectives through design manuals and specification documents for energy efficiency would also be a beneficial for both the public sector to adopt technologies, as well as for suppliers, because the public sector would be more aligned with the continuous technological development. Gathering correct knowledges which complements each other with the intention to bridge the conflict between perspectives of the users and offsite operations management, would be a beneficial practice to figure out to which extent the users should have regulation control of the indoor climate. These recommendations of practises would contribute to raise the awareness of energy efficiency importance and potential, but the right foundation for prioritization must be present for the necessary prioritization to be possible in the first place. Sufficient funds and resources serve as examples. Involving managers and politicians with decision power, or at least with the power to influence decision making in these processes are of significant importance.

8.4 Limitations and what we could have done differently

We consider the amount of gathered qualitative data to be sufficient for answering our research questions, even though some arrangements occurred. Due to the challenges relative to the

Coronavirus (Covid-19), two planned in-depth interviews had to be conducted digitally. We prioritize our informant's safety and wellbeing over data quality, however we assessed to which point and how our data could be compromised by the digital solution. Conducting interviews digitally made it easier to ask our last informants important questions and at the same time making sure that we were complying to national health recommendations and guidelines. When we went through the recorded digital interviews something changed. The impact of conducting in-depth interviews physically made it easier to remember the underlying meaning in what they were saying, which resulted into additional time of working through the digital ones because of the lack of presence during the actual interviews. The cancellation of the focus group which was scheduled to take place the 18th of March in Bergen did as well have some impact on our data quality. Our intention of conducting the focus group was to explore findings from the interviews even deeper by arranging an event to stimulate group discussions with the different actors. By using a topic guide as a structured way of conducting the activity based on previously in-depth interviews relative to energy efficiency in the public sector and adaptation of smart technologies, we were aiming for identify either conflicting opinions or consensus building regarding the matter (Easterby-Smith et al, 2015, p. 324).

We could have included municipalities in a multi-case study to explore local differences in achieving the county's goals on energy efficiency and reduction of energy consumption. The use of comparison of cases could enrich our study with knowledge about the actual dissimilarities among the municipalities to understand the local context' impact for adoption of smart technology in public buildings. At the same time, we consider that the value of conducting a single case study results in more in-depth information, which gave us the opportunity to develop knowledge about how the barriers to smart technology adoption are in one municipality and context. By creating a general model (figure 7), we have purposely attempted to enrich our findings to theoretical proportions, so our case' evidence better complement theoretical suggestions on barriers for innovation in the public sector. With a single case study, we did not have to consider differences in for example digital infrastructures in municipalities data systems, which we argue strengthens the study's validity. According to our data, differences in data infrastructure are an important factor to consider because it evokes concerns about the prerequisites of the individual municipality related to adoption of smart technologies. Exploring the barriers in a specific area will probably clarify the steps and processes that are needed to implement co-creation as a solution.

Since we have used qualitative method and gathered data with techniques like the snowball-method, we have relied on information from our informants to identify potential informants. Therefore, it is not certain that the results are representative for our case as a whole. This brings limitations in our study, as well as limitations in the choice of public commercial buildings. Public commercial buildings cover a variety of different purposes, and the choice of focusing on public secondary schools does not necessarily have to prove valid for other public buildings with different purposes and activities. However, even though this is a small piece of research, our findings could be useful for the necessary actors to assess and to consider for ongoing or future smart technologies adoption projects.

8.5 Suggestions for further research

We refer to the alternative to use comparative study and compare cases as an interesting area for future research. By considering the findings from this study, future research could identify the underlying conditions that make the differences among the municipalities, something that may be important for local tailoring. Since there are a lack of estimates in the effect of smart technologies for energy consumption in buildings in the present, it would be useful to examine specific cases of buildings that have implemented smart technology solutions to investigate the effect on energy consumption. Conducting this kind of study is likely to help support the value of digital change processes in buildings and make it easier to take additional costs into consideration in early phases in development projects. Practices and necessities to raise prioritization levels where needed would also be a valuable consideration for further research.

Chapter 9 - Bibliography

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Chapter 10 - Appendix

Appendix 1: Document analysis

Forklaringer -

- **Hensikt**: hva er formålet med dokumentet?

  (her er vi ute etter den generelle betydningen og hensikten i dokumentet)

- **Type barriere:** hvilke type barrierer nevnes særlig?

  (her er vi ute etter spesifikke barrierer sentrale for studien, samt sidetall for å spore tilbake til dokumentet)

Dokument	Hensikt	Type barriere
1. St. Meld. 7	Hensikten med dokumentet er å sette innovasjon enda tydeligere.på dagsorden. Meldingen belyser helheten i regjeringens innovasjonspolitikk og viser en retning for det videre arbeidet. Innovasjon og omstilling vil være en nøkkel for å få til et bærekraftig samfunn, men konkurransedyktige bedrifter over hele landet. Et samfunn som dekker våre behov uten å ødelegge for fremtidige generasjoner. Dette er i tråd med FNs overordnede hensikt med klimamålene. Gjennom hele meldingen belyse regjeringen utfordringer, barrierer og muligheter for innovasjon, og tiltak som planlegges gjennomført for å legge bedre til rette for innovasjon i samfunnet.	Mangel på kvalifisert arbeidskraft er i dag en barriere for innovasjon i mange virksomheter (s.88). Begrenset budsjett: Ulike former for samarbeid kan bidra til å realisere prosjekter som ellers ikke er mulig innenfor kommunens budsjettrammer (s. 128). Mangel åpne standarder: Regjeringen jobber for at IKT-løsningene i offentlig sektor i større grad skal basere seg på såkalte åpne standarder. Slike standarder legger til rette for at ulike IKT-løsninger kan fungere sammen, selv om de kan være laget av ulike leverandører (s.128)
2. Meld. St. 22	Hovedmålet med meldingen er å utvikle en mer helhetlige, effektiv anskaffelsespolitikk for å sette det offentlige i stand til å oppnå regjeringens ambisiøse mål på feltet (s. 11). Bruker mer enn 500 MRD/årlig på innkjøp, som er fellesskapets midler som oppdragsgiverne skal utnytte på best mulig måte. Noe som krever en profesjonalisering av innkjøpene, gjennom blant annet økt satsing på kompetanse, bedre styring, ledelse, organisering og mer samordning.	Uklarhet i betegnelsen. “innovative anskaffelse”: Departementer har mottatt tilbakemeldinger på at betegnelsen “innovative anskaffelser” ikke oppfattes som et klart og entydig begrep. Per i dag brukes denne betegnelsen både på mindre anskaffelser som legger til rette for innovasjon, og for større anskaffelser med forsknings - og utviklingselementer. Dette kan skape uklarhet og gjøre det vanskelig å følge utviklingen på området. Tydelige definisjoner vil gjøre det enklere å utvikle virkemidler og sette seg mål. (s. 59)

3.	Meld. St. 25	Hensikten med dokumentet er å belyse energipolitikken i Norge, og sette bærekraftig energiproduksjon og forsyning, i et langsiktig perspektiv på dagsorden, da med klimautfordringene hengende over oss. Betydningen av en sikker strømforsyning blir viktigere for alle samfunnsfunksjoner. Paris-avtalen skal bidra til økt innsats for utslippsreduksjoner, og forsterke arbeidet med klimatilpasning. Dette vil også påvirke utviklingen på energiområdet. Det skjer en rask teknologiutvikling samtidig med en styrket global klimainnsats. Fallende kostnader for klimavennlige energikostnader, og økt bruk av IKT, vil over tid endre energimarkedene.	Geografiske forskjeller: Barrierene for energi- og klimatiltak varierer sterkt fra område til område, og de krever ulike tilnærminger. Det er viktig å kjenne og forstå de ulike bransjene for å kunne bidra til å realisere energi- og klimaresultater på en effektiv måte (s. 65). Risiko med økt antall uønskede hendelser med IKT: Med økt bruk av IKT er det en risiko for at antall uønskede IKT-hendelser vil kunne øke. I tillegg kan introduksjon av ny teknologi, bruk av skyløsninger eller leverandører i utlandet være sikkerhetsmessig og regulatorisk utfordrende. Å sikre stabil drift, sørge for god IKT-sikkerhet, samt å ha evne til å håndtere feil og sikkerhetshendelser vil kreve kompetent personell. Denne type kompetanse kan bli krevende for selskapene å ha selv, og det kan da oppstå risiko for at selskapene i for stor grad kan bli avhengig av leverandører (s. 151)
4.	Meld. St. 27	Den digitale agendaen for Norge innebærer bruken av IKT for å skape en enklere hverdag og øke produktiviteten i Norge, og skal bidra i problemløsning rundt de store utfordringene i næringslivet og offentlig sektor. For å få til dette er det ønskelig at offentlig forvaltning skjer brukerrettet og effektivt, og at det skapes verdi og deltakelse i samfunnet (s. 11)	Manglende teknologisk kompetanse Undersøkelser viser at manglende teknologikompetanse hos øverste leder i beslutningsprosesser, er en av de største barrierene i arbeidet med å digitalisere offentlige tjenester (s. 52) Rundt halvparten av de undersøkte kommunene har utfordringer med å tiltrekke og beholde nødvendig teknisk og strategisk IKT-kompetanse for å utvikle gode digitale tjenester. (s. 57 og 58) Undersøkelser peker på at utfordringene med digitalisering i kommunene er knyttet til stor variasjon i kompetanse, modenhet og IKT-løsningsvalg (s.58) Tverrfaglig kompetanse – hvor IKT-kompetanse er kombinert med annen type fagkompetanse blir mer etterspurt (s.132) Manglende innkjøpskompetanse Innkjøpsprosedyrer som innebærer tettere samhandling med leverandører (for eksempel innovasjonspartnerskap) kan bidra til større innovasjonsgrad i offentlige anskaffelser, men stiller krav til innkjøpsfaglig kompetanse (s. 88). Begrensede systemer for offentlige anskaffelser Anskaffelsesregelverket, eller praktiseringen av det, oppleves av mange som for detaljert, formalistisk og komplisert til å være et godt innkjøpsverktøy. Offentlig sektor utnytter imidlertid ikke alltid de muligheter som ligger i regelverket når det gjelder å trekke inn leverandørene tidlig i anskaffelsesprosessen (s.88)

5. Meld. St. 29	Perspektivmeldingen 2017 drøfter viktige utfordringer for norsk økonomi, for offentlige finanser og for videreføring av de norske velferdsordningene i et langsiktig perspektiv. Formålet med meldingen er å bidra til fornuftige valg de nærmeste årene. Det fordrer at vi tar hensyn til de langsiktige konsekvensene av de valgene vi tar eller unnlater å ta. Hvordan fremtidige generasjoner utformer samfunnet, muligheter og politiske valg. Vi har ikke forutsetninger nå for å vite hvor lys eller krevende situasjonen for norsk økonomi vil være om noen år. Utfordringene som skisseres i denne meldingen, må løses gjennom kloke valg år for år. Samtidig ligger utfordringene ikke så langt fram i tid at vi kan velge å se bort fra dem.	Riktig kompetanse: Et trygt arbeidsliv for lav ledighet og høy sysselsetting (side 6). Det må bygges kompetanse, for å tilpasse endringer i arbeidslivet og utdanningssektoren. Omstillingsutfordringer: Mer igjen for innsatsen - både i private og offentlige virksomheter (side 6). Svaret på omstillingsutfordringer er nye arbeidsplasser i privat, konkurranseutsatt sektor, ikke bevaring av gamle strukturer. Smart, grønt og nyskapende skal prege vårt arbeidsliv Målkonflikter: (s. 176) Offentlig sektor står ofte overfor målkonflikter der hensynet til effektiv oppgaveløsning må veies mot andre sentrale mål og hensyn. Det kan være distriktspolitiske hensyn i valget av organisering, eller for eksempel mål knyttet til klima og miljø, likestilling og folkehelse. Hensynet til demokrati, legitimitet og tillit til offentlige myndigheter kan gjøre endringsprosesser mer omfattende og tidkrevende enn om slike hensyn ikke tillegges vekt. Det norske demokratiet er i stor grad konsensusbasert, der mange aktører gis anledning til å uttale seg om konsekvenser av ulike tiltak. Hensynet til gode beslutninger må balanseres mot ulempene ved sene prosesser, forsinkelser og merkostnader. Økt effektivitet i offentlig sektor tilsier en mer kritisk gjennomgang av rapportering, kontroll og rettighetsfesting. Selv om intensjonen med å rettighetsfeste er å sikre den enkelte bedre tjenester, kan den samlede effekten av mange beskrankninger på offentlig sektors muligheter til å møte etterspørselen med nødvendig fleksibilitet bli betydelig større (s. 176) Høye oppstartskostnader: I situasjoner med høye oppstartskostnader, er det vanskelig å bruke konkurranseutsetting (side 178) Usikkerhet rundt klimateknologiers effekt: Den kraftige satsingen på klimateknologi kan gi reduserte klimagassutslipp og energieffektivisering i industrien fremover, men effekten av denne innsatsen er svært krevende å anslå og derfor ikke tallfestet (s. 85)

6. Hordaland klima - og energiplan 2014-2030	Formålet med klimaplanen for Hordaland (aktiv for Vestlandet 01.01.20) er å legge regionale målsetninger og belyser tre typer utfordringer som fylket kan gjøre noe med. Dette gjelder reduksjon av utslipp av klimagasser, effektivisering av energiforbruket, samt hvordan fylket kan tilpasse seg de klimaendringene som er i utvikling (s. 3).	Teknologiske og energikrevende produksjon som barrierer rundt solcellepanel og bruk av solvarme: Solvarme er ein meir moden teknologi og har færre teknologiske barrierar enn solceller. Danmark har sidan 1989 installert meir enn 10 storskalaanlegg for levering av varme til fjernvarmenettet. Potensialet i Noreg er 5 - 25 TWh innan 2030. Utfordringar er m.a. at det er arealkrevjande og at produksjonen av solcellene er energikrevjande. Det trengst betre vilkår for solenergi (s. 25) Mangel på nasjonal og bred satsing på energi-effektivisering av eksisterende masse: Det største potensialet for reduksjon er i eksisterande bygningsmasse Den største utfordringa er å gjere eksisterande bygningsmasse meir klimavenleg (s. 31). Noreg treng ei brei satsing på energieffektivisering av eksisterande bustader (bygd før TEK10). Viss vi skal nå EU sine mål, treng vi ei systematisk rehabilitering for energieffektivisering, med stegvis opptrapping av innsatsen. Dette er mogleg med sterkare nasjonale verkemidlar.(s. 32) Betydelige krav til investeringer: Under føresetnad av uendra areal på bygningsmassen, årleg rehabilitering av 5 % av eksisterande bygg og trinnvis skjerp- ing i energikrava, kan ein oppnå 12 % energieffektivisering innan 2020 og 37 % innan 2030. Dette vil krevje betydelege investeringar. (s.33)
7. Bergen kommune, Grønn Strategi, 2016	Grønn strategi er klima - og energihandlingsplanen for Bergen kommune fram mot 2030. Formålet er å beskrive de mål, strategier og tiltak som gjøres for å imøtekomme klimautfordringene, samtidig som byen vokser og utvikler seg til en grønn by i Norge.	Manglende kompetanse i byggebransjen: Det pågår oppbygging av et kompetansesenter for energieffektivt og bærekraftig byggeri på Høgskolen i Bergen i samarbeid med andre lokale utdanningsinstitusjoner og ulike offentlige aktører. Dette er viktig for å få til nødvendig kompetanseheving i byggebransjen. Kompetansesenteret vil arbeide med energieffektivitet, materialbruk, plassering av bygg og rehabilitering av eksisterende bygg. (s. 56)
8. BREEAM-NOR 2016	Hensikten med manualen er en teknisk føring for nybygg. Det beskriver en miljøytelse standard som nybygg samt vesentlige rehabiliteringsprosjekter i Norge kan vurderes og tildeles BREEAM-NOR-klassifisering etter.	Lite data rundt kostnader og fordeler i bærekraftig prosjektering: Mangel på data om kapital - og livsløpskostnader samt de fordeler som bærekraftig prosjektering og bygging medfører, er en vesentlig barriere i å fremme mer bærekraftige løsninger (s. 26)

Kilder:

1. St. Meld. nr. 7 (2008-2009) *"Et nyskapende og bærekraftig Norge"*
2. Meld. St. 22 (2018-2019) *"Smartere innkjøp - effektive og profesjonelle offentlige anskaffelser"*
3. Meld. St. 25 (2015-2016) *"Kraft til endring - energipolitikken mot 2030"*
4. Meld. St. 27 (2015-2016) *"Digital agenda for Norge : IKT for en enklere hverdag og økt produktivitet"*
5. Meld. St. 29 (2016-2017) *"Perspektivmeldingen 2017"*
6. Hordaland regional climate and energy plan 2014-2030
7. Bergen kommune (2016). Grønn strategi. Klima - og energihandlingsplan for Bergen
8. BREEAM-NOR 2016 (Grønn byggallianse, 2019)

Appendix 2: Interview guide (general)

	På forhånd vil Infoskriv med samtykkeerklæring, samt skriv fra instituttleder bli sendt til deg som respondent.
Start	**I forkant og bakenforliggende informasjon** - Introduksjon - Intervjuet brukes som en del av vår datainnsamling for gjennomføring av forskningsarbeidet i masteroppgaven for å undersøke hvilke barrierer som hindrer implementering av smarte teknologiske løsninger i fylkeskommunale næringsbygg (herunder utdanningsbygg, vgs) som tiltak til å bidra til *energieffektivisering* - Svar på eventuelle spørsmål du sitter med i forkant vil bli oppklart før intervjuet starter. - I samtykkeerklæringen vil det bl.a. foreligge informasjon om opptak av vår datainnsamling. Vi vil i tillegg sikre at dette er akseptabelt for deg før intervjuet starter også. - Vi vil signalisere intervjustart og starte opptaket når du er klar, og informer deg om hvem som holder intervjuet og hvem som vil føre notater av forskningsgruppens team.
Midtdel	Generelt: ● Kan du fortelle litt om deg selv? ● Navn, stilling, hovedansvar i organisasjonen? ● Hvor ligger din særkompetanse? (spesialisering) ● Hva er det som motiverer deg til å jobbe innenfor dette feltet? Energieffektivisering og tiltak: ● Hva er et energieffektivt bygg for deg? (stikkord: opp mot klimapolitiske standarder, organisasjonsmål etc.) ● Energieffektivisering og klimavennlige tiltak er en prioritet i Vestland fylkeskommune iht. Hordalands klima - og energiplan 2014-2030. Hva mener du om potensialet og bruken av teknologiske løsninger for å møte prioriteringene? ● Hva er deres ambisjoner og målsetninger innen energiomstilling? ● Hvilke konkrete tiltak gjøres på driftssiden i dag?

- Er det noen andre særlige utfordringer på fylkes - og kommunenivå?

IoT:

- Hva slags erfaringer har du med bruken av smart teknologi eks.: Tingenes internett (IoT) for energireduksjon i nåværende eller tidligere arbeidssituasjon?
- Hvor ligger beslutningsmyndigheten for implementering av slik teknologi?
- Kan du si noe om beslutningsprosessen og dens eventuelle utfordringer?
    - Lovregulert?
- Hvilke forutsetninger mener du må være på plass for at man kan ta bruk av IoT i skolebygg for kontroll og målstyring av energibruken i bygget?

Annen smart-teknologi:

- Hvilke kompetanser har fylket for å ta i bruk eller eksperimentere med annen smart-teknologi?
- Hvilke andre teknologier kan med formål om energieffektivisering i næringsbygg kunne bidra?
- Hvilke utfordringer med bruk av smarte komponenter for bedre energistyring har fylket erfart gjennom tidligere prosjekter?
- Hvilke utfordringer mener du er til stede for bruk av smarte teknologiske løsninger generelt i offentlig sektor?
- Foreligger det noen premisser eller forutsetninger tilknyttet næringsbygget for å kunne få implementert smart-teknologi?
    - Hvordan kan evt. hindringer overkommes?
- Hvordan genereres data om energiforbruket i bygninger?
- Hvordan kan man dra nytte av dataen?
    - Hvordan gjøres analyser av den? Eventuelt hvordan kan dette gjøres mer effektivt?
- Hvilke andre kilder til lignende datamateriale finnes det?
- Hvorfor skiftes ikke analoge sensorer til digitale sensorer som er tilkoblet internett i eldre bygg?
- Hvilke barrierer eksisterer for implementering av smart teknologi i videregående skoler?
    - Teknologiske?

    - Politiske?
    - Sosiale (bruker)?
    - Økonomiske?
    - Miljømessige?
    - Lovlige?
    - Samarbeidsmessige?
    - Infrastruktur?

Det krever tverrfaglig og kombinasjoner av kompetanse for å drive en teknologisk infrastruktur for energieffektivisering i et bygg.

- Hvilke kombinasjoner av kompetanse mener du må på plass i offentlig sektor for adopsjon av smart-teknologi for energieffektivisering skal skje?

<u>Samskaping (co-creation):</u>

- Hvordan arbeider dere med utvikling av nye løsninger?
- Hvordan Involveres andre aktører inn i utviklingsprosjekter? (bl.a.: private/ andre offentlige aktører, sivilsamfunnet, kunder)
- Hvilke erfaringer har du/dere med samskapingsprosesser? (målrettet og planlagt, eller tilfeldig og iterativ)
- Hvordan initierer dere til samskapningsprosesser?
    - Er det noen spesielle hensyn?
- Har dere vært (eller er dere) i dialog med private aktører om tiltak for energieffektivisering i dag?
- Hvilke hovedutfordringer/barrierer eksisterer fra din side for samskaping av teknologi?
- Hva er det som gjør det utfordrende å få til et kontinuerlig samarbeid med privat sektor?
    - Hva mener du må til for å overkomme utfordringene?
    - Hvordan kan innovasjon oppnås i samarbeid mellom offentlig og privat sektor, mest mulig sømløst?

Tenk tilbake til sist dere skapte løsninger sammen med andre aktører.

- Hvilke momenter vil du trekke frem som det viktigste i samskapingsprosessen?
- Hvordan anses samskaping: som en mulighet eller som en kjernemekanisme for utvikling?
- Hvordan ble det skapt rom for forhandlinger/diskusjon med de involverte partene i tidligere prosjekter?

	• Hvordan ser du på brukerne i forhold til samskapingsprosesser?
	
	Anskaffelser i det offentlige er regulert av lov og forskrift om offentlige anskaffelser.
	● Hvordan ser du for deg en anskaffelsesprosess forbundet med dette?
	  ○ Andre utfordringer rundt anskaffelser i offentlig sektor?
	• Kan den nødvendige kompetansen for adopsjon av smart-teknologi i offentlig sektor hentes gjennom leverandører? (f.eks gjennom en samhandlingsprosess med kontinuerlig dialog med leverandøren?)
	  ○ Eller tenker du at kompetansen må inn internt?
	• Hvordan kan et samskapningsprosjekt gjennomføres optimalt?

	Oppfølging • Oppfølgingsspørsmål formulert under intervju kan være aktuelt.
Avsluttende	5. Oppsummering • Oppsummere funn • Har vi forstått deg riktig(?) • Er det noe du vil legge til? • Er det noen andre vi kan snakke med?

Appendix 3: A selection of customized questions for the interviews

I1

- Er dere optimistiske for å finne bærekraftige løsninger for å nå målene om energieffektivisering?
- Hvilke kompetanser har dere for å ta i bruk eller eksperimentere med annen smart-teknologi?
- Hvilke utfordringer med bruk av smarte komponenter for bedre energistyring har dere erfart i tidligere prosjekter?
- Hvordan arbeider dere med utvikling av nye løsninger?

I2

- Kan du fortelle litt om hvordan (Big) data genereres til datasjøen?
- Hvordan kan man dra nytte av dataen?
- Hvordan gjøres analyser av den?
- Eventuelt hvordan kan dette gjøres mer effektivt?
- Hvordan initierer dere til samskapningsprosesser?
- Er det noen spesielle hensyn?
- Har dere vært (eller er dere) i dialog med aktører om tiltak for energieffektivisering i dag?
- Hvilke hovedutfordringer/barrierer eksisterer fra deres side for samskaping av teknologiske løsninger?

I3

- Kan du dra oss gjennom en prosess hvor data blir analysert ved hjelp av maskinlæring, frem til en beslutning kan fattes?
- Hvilke potensial mener du maskinlæring har i forhold til å hente energidata?
- Hvordan ville datagenereringen om energiforbruket i bygg fungert med en slik teknologi?
- Hvordan kan man dra nytte av maskinlæring i næringsbygg?

I4

- Kan du fortelle litt om hvordan dere bidrar / kan bidra til at næringsbygg blir mer energieffektive i driftsfasen?
- Kan du fortelle litt om deres bygg?
- Hvilke kompetanser er det behov for tolkning og drift for å ta i bruk slike systemer?
- Hva er deres erfaringer når det kommer til mulighetene for å presentere nye, innovative og teknologiske løsninger til offentlige kunder?

Det krever tverrfaglig og kombinasjoner av kompetanse for å drive en teknologisk infrastruktur for energieffektivisering i et bygg.

- Hva kunne deres rolle vært i et slikt system?
- Hvordan gjøres det hos dere?

I5

- Hvilke aktiviteter gjennomfører dere for å engasjere til samskaping?

I6

- Hvilke teknologier er det du arbeider med for tiden?
- Hvordan opplever du videreføringen av mulighetene med det dere gjør til offentlige kunder?

I7

- Hvordan er det akademia aktualiseres i utviklingen av potensiell smart teknologi inn i næringsbygg?
- Hvordan henter leverandører av teknologiske løsninger inspirasjon

  fra dere?

I8

- Hva slags erfaringer har du med bruken av IoT for energireduksjon i organisasjonen du er en del av?

- Hvordan tilpasses deres produkt kunden?
- Hvilke komponenter kan du se for deg at fylket kunne brukt i sine næringsbygg (VGS) for å nå målene om energieffektivisering?
- Det snakkes om overskuddsenergi (varme) fra næringsbygg hvor det ikke eksisterer gode løsninger for å fange/overføre til andre potensielle områder med behov for energi.
- Kan du si noe om hvordan en eventuell lagring/overføring av overskuddsenergi fra et bygg kan gjøres?

I9

- Kan du fortelle litt om hvordan SD-anlegg fungerer som et verktøy for at næringsbygg blir mer energieffektive i driftsfasen?
- Hvordan arbeider dere for økt innovasjon for energiomstilling i byggene?
- Hvilke hovedutfordringer/barrierer har dere sett når det kommer til samskaping av teknologiske løsninger eller omkring SD-anlegg?

I10

- Hvilke kompetanser mener du må på plass i offentlig sektor for å håndtere smart-teknologiske løsninger for energieffektivisering på VGS?
- Hvordan er holdningen blant ansatte og elever på skolen for å ta i bruk ny teknologi for energiomstilling i byggene?
- Hva menes med at *Samspillskontrakten innebærer at ulike aktører kommer tett på hverandre i prosjektet*"
  - Hvordan ble det skapt rom for forhandlinger/diskusjon med de involverte partene i prosjektet?
  - Er dette et prosjektdesign du vil anse som fordelaktig i forhold til hvordan man gjør offentlige anskaffelser?

I11

Hvilke kompetanser mener du må på plass i offentlig sektor for å håndtere smart-teknologiske løsninger for energieffektivisering og drift?

"Treffer" arbeidsoppgaver med smarte teknologiske løsninger de faggruppene som er fordelt oppgavene?

Eventuelt, burde mer spisskompetanse rundt IT inn sammen med fagpersoner i bygg og SD?

Mange av byggene deres beskrives å være bygget for flere formål:

Hvorfor er det slik?

Skaper det flere interessentgrupper som engasjerer seg ved potensielle utbyggingsprosjekter? Brukergrupper - prosjektgruppe som skjærer seg med totalentreprenør

Appendix 4: Informed consent form

Formål

Temaet for masteroppgaven er knyttet til hvordan teknologiske løsninger og samskaping, i et samarbeid mellom offentlige og private aktører i Bergen kommune kan bidra til energieffektivisering relatert til Vestland fylkeskommunes klimaplan for 2014-2030. Mer spesifikt rundt hvordan dette kan bidra til energireduksjon på forbruksiden (derav effektivisering) i fylkeskommunale bygninger i driftsfase. Vi vil undersøke spekteret av barrierer fra ulike interessentgrupper, og se på samskaping som en potensiell måte for at fylket bedre kan adoptere smart-teknologier for energieffektivisering i sine næringsbygg.

Hvem er ansvarlig for forskningsprosjektet?

Høgskulen på Vestlandet er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?

Vår utvalgsstrategi forankres i strategisk utvelgelse, dvs. at vi kontakter deg som har særlig kompetanse fra enten teknologiske selskaper eller relaterte kommuneorganer for modernisering, effektivisering og/- eller digitaliseringsarbeid. Vi tar sikte på å benytte oss av "snøballmetoden" for rekruttering av potensielle nye kandidater til intervju, og oppfordrer dermed deg til å undersøke relevante aktører som kan knyttes til studien.

Hva innebærer det for deg å delta til intervju?

Vår forskningsstrategi og design er en kvalitativ singel casestudie.

Hvis du velger å delta i prosjektet, innebærer det at du samtykker til å bli intervjuet. Omfanget vil ikke overskride 1,5 timer, og vi tar sikte på intervjutiden til 1,0 time. Opplysninger som samles inn vil være arbeidstilhørighet, for/-etternavn, arbeidsstilling, e-post, samt dine kommentarer, utsagn, refleksjoner og/- eller meninger relatert til spørsmålene under intervju. Opplysningene registreres med elektronisk lydbånd for opptak av intervjuet, samt notater under intervjuet.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

- Beskrivelse av hvem som vil ha tilgang ved behandlingsansvarlig institusjon:

  David Sjåstad (student ved Høgskulen på Vestlandet), Sindre René Frydstad (student ved Høgskulen på Vestlandet), Atle Nyhagen (vitenskapelig ansatt ved Høgskulen på Vestlandet)

- For å sikre at ingen uvedkommende får tilgang til personopplysningene, f.eks. kontaktopplysningene dine, vil all data lagres i en låst mappe gjennom Google Disk med passordbeskyttelse. Vi oppbevarer ikke data på private enheter.
- Ved publikasjon av masteroppgave, vil du som deltaker kunne bli gjenkjent gjennom arbeidstilhørighet og eventuelle siteringer fra transkribert datamateriale fra intervjuet med deg.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?

Prosjektet skal etter planen avsluttes **01.06.2020**. Etter prosjektslutt vil alle arbeidsnotater relatert til prosjektet slettes, forutenom selve masteroppgaven som potensielt blir publisert på HVL Open Access (fri tilgang til ulike forskningspublikasjoner ved instituttet) med formål for eventuelle oppfølgingsstudier rundt prosjektets tema til senere forskning for andre studenter eller forskere.

Dine rettigheter

Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?

Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra *Høgskulen på Vestlandet,* har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

KONTAKTINFORMASJON

Hvor kan jeg finne ut mer?

Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, vennligst ta kontakt med:

- Prosjektansvarlig:
  - Paul Benneworth (Veileder ved Høgskulen på Vestlandet) email: paul.benneworth@hvl.no
- Studentene bak studien:
  - David Sjåstad: tlf.: 45455067 / email: david.sjaa@live.no
  - Sindre R. Frydstad: tlf.: 97109172 / email: frydstads@gmail.com
- NSD – Norsk senter for forskningsdata AS, mail: personverntjenester@nsd.no eller tlf.: 55 58 21 17.

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet *"*Et samarbeid for energieffektivisering i en norsk fylkeskommune", og har fått anledning til å stille spørsmål.

Jeg samtykker til:

(Sett kryss)

☐ å delta i intervju

☐ *at opplysninger om meg publiseres slik at jeg kan gjenkjennes (arbeidstilhørighet, stilling og eventuelle siteringer fra transkribert datamateriale fra intervjuet med deg) om masteroppgaven publiseres i HVL Open Access.*

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet, ca. *01.06.2020*

(Signert av prosjektdeltaker, dato)

Appendix 5: Approvement Norwegian Center for Research Data (NSD)

NSD NORSK SENTER FOR FORSKNINGSDATA

NSD sin vurdering

Prosjekttittel

Energieffektivisering og smartere styring av energiforbruk i fylkeskommunale bygg på Vestlandet

Referansenummer

629729

Registrert

18.12.2019 av David Sjåstad - 581526@stud.hvl.no

Behandlingsansvarlig institusjon

Høgskulen på Vestlandet / Fakultet for økonomi og samfunnsvitskap / Institutt for økonomi og administrasjon

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)

Paul Benneworth, paul.benneworth@hvl.no, tlf: 0031626864190

Type prosjekt

Studentprosjekt, masterstudium

Kontaktinformasjon, student

David Sjåstad, david.sjaa@live.no, tlf: 45455067

Prosjektperiode

06.01.2020 - 01.06.2020

Status

05.05.2020 - Vurdert

Vurdering (2)

05.05.2020 - Vurdert

Vi viser til endring registrert 07.04.2020. Vi kan ikke se at det er gjort noen oppdateringer i meldeskjemaet eller vedlegg som har innvirkning på NSD sin vurdering av hvordan personopplysninger behandles i prosjektet.

Les mer om hvilke endringer som skal registreres hos NSD før endringer meldes inn i fremtiden:
nsd.uib.no/personvernombud/meld_prosjekt/meld_endringer.html

OPPFØLGING AV PROSJEKTET
NSD vil følge ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til videre med prosjektet!

Kontaktperson hos NSD: Lise A. Haveraaen
Tlf. Personverntjenester: 55 58 21 17 (tast 1)

22.01.2020 - Vurdert

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet den 22.01.2020 med vedlegg, samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilke type endringer det er nødvendig å melde:
https://nsd.no/personvernombud/meld_prosjekt/meld_endringer.html

Du må vente på svar fra NSD før endringen gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle særlige kategorier av personopplysninger om politisk oppfatning og alminnelige kategorier av personopplysninger frem til 01.06.2020.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 nr. 11 og art. 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse, som kan dokumenteres, og som den registrerte kan trekke tilbake.

Lovlig grunnlag for behandlingen vil dermed være den registrertes uttrykkelige samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a, jf. art. 9 nr. 2 bokstav a, jf. personopplysningsloven § 10, jf. § 9 (2).

PERSONVERNPRINSIPPER
NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke viderebehandles til nye uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og

nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).

NSD vurderer at informasjonen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

Google Disk er databehandler i prosjektet. NSD legger til grunn at behandlingen oppfyller kravene til bruk av databehandler, jf. art 28 og 29.

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og eventuelt rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp underveis (hvert annet år) og ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet/pågår i tråd med den behandlingen som er dokumentert.

Lykke til med prosjektet!

Kontaktperson hos NSD: Lise A. Haveraaen
Tlf. Personverntjenester: 55 58 21 17 (tast 1)