STAVANGER SMART CITY

IMPLEMENTING REAL-TIME MONITORING OF CO_2 EMISSION FOR VEHICLES THE CASE OF STAVANGER

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IMPLEMENTING REAL TIME MONITORING OF CO_2 EMISSION FOR VEHICLES THE CASE OF STAVANGER

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FOREWORD

This master thesis is the final work on our Master's degree in Economics and Business Administration, specialization in Strategy and Management. This is the result of a fruitful collaboration of all the people involved in the EPIC project under the program of Erasmus+.

First of all, we would like to express the sincerest thanks to our thesis supervisors, Professor Jan Frick and Hilde Ness Sandvold for devoting their time and effort to support us in developing the ideas of the thesis from the very beginning days of the EPIC project. We really appreciate their precious advice and responsive feedback, which are highly insightful for our research study.

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Third, we gratefully acknowledge Gunnar Crawford, the leader of Stavanger Smart City and his colleagues for letting us explore the specific case of Stavanger Municipality in an open manner. Their guidance and priceless input have made the value of this thesis more practical both to the authority and the citizens.

Fourth, the development of the components mentioned in Appendices would not be possible without the participation of our dedicated respondents. Due to the EU General Data Protection Regulation (GDPR), we cannot name them in the thesis but we would like to express thankfulness for their great support, time and willingness to provide essential information that has been crucial for our thesis.

Last but not least, we want to thank our families and significant others for their constant support and patience. Without you the project would not be possible.

ABSTRACT

The rapid urbanization has placed significant pressure on infrastructure and natural resources, leading to numerous consequences related to environmental, energy and climate issues. As such, the majority of countries have made effort to reduce greenhouse gas emissions and promote good urban environments. Norway has also placed high emphasis on maintaining environmental sustainability not only at the national but also at the local level. Joining this target, Stavanger Municipality is also working towards the fossil-free transport sector with the zero-growth target.

Over the last decade, the concept of "smart cities" has become more popular in terms of exploiting new technologies to help effectively address these challenges. However, there exists a situation that technological products and solutions are favored over end-users and their quality of life. Often citizens are only informed of what should be done without real engagement, resulting into cities less livable and far from their real needs.

Given the limited amount of literature on how smart city can help citizens achieve better living conditions in a sustainable environment, this thesis proposes an idea of implementing real-time monitoring of CO_2 emissions for vehicles in Stavanger Municipality. In this research, both the municipality's and the citizens' point of view are taken into account, so the model can be considered to be applied in practice. On the one hand, the authorities can get more inhabitants involved in achieving both environmental gains and cost savings (sensors are installed at the existing facilities). On the other hand, citizens will get engaged in the national policy and feel contributing to it. In this way, the case study of Stavanger will outline the potential impacts of smart solutions on sustainability goals and citizen-centric approach.

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CONCEPTS

Abbreviation / Acronym	Description
EPIC	Improving Employability through Internationalization and Collaboration
GDPR	General Data Protection Regulation
EU	European Union
GHG	Greenhouse Gasses
ICTs	Information and Communication Technologies
GWP	Global Warming Potential
CO_2	Carbon dioxide
CH_4	Methane
HFC	Hydrofluorocarbons
PFC	Perfluorocarbons
N_2O	Nitrous oxide, laughing gas
SF6	Sulphur hexafluoride
UNFCCC	United Nations Framework Convention on Climate Change
IOT	Internet of Things
IR	Infrared
UV	Ultraviolet
IALS	International Adult Literacy Survey
NTP	National Transport Plan
T&E	Transport & Environment
RDE	Real-Driving Emission
RS	Remote Sensing
VSP	Vehicle Specific Power
EDAR	Emission Detection and Reporting
2D	2 Dimensional
NGO	Non-Governmental Organization
ICLEI	International Council for Local Environmental Initiatives
EV	Electric Vehicle
CCS	Carbon Capture & Storage
PPD	Public Private Data
POD	Public Open Data

CHAPTER I: INTRODUCTION

Chapter I presents the research area and explains why the research topic is useful to study. Research questions are clearly defined to be elaborated on in further chapters. Also, an outline of the overall structure of the thesis will be given.

1.1 Motivation

1.1.1 The importance of CO_2 emission management in smart city

According to the United Nations (United Nations, 2018), 55% of the world's population lives in cities, and that share is expected to reach up to 68% by 2050. In Europe, 75% of population lives in urban areas (European Commission, 2019). It is widely expected that this urban sprawl will continue to expand in the future, leading to a range of complex climate issues. Despite the small coverage of less than 2% of the Earth's surface, cities consume 78% of the world's energy and produce more than 60% of all carbon dioxide (Fried, 2017).

Emissions of human-caused greenhouse gases will lead to the increase in the earth's temperature time, causing global warming. The most important greenhouse gas is carbon dioxide (CO_2), accounting for three quarters of the human-caused global emissions of greenhouse gases and is mainly related to the combustion of fossil fuel (Olivier & Peters, 2018). In 2007, 82 percent of the Norwegian greenhouse gas emissions were CO_2 (Bergen City Coucil, 2010). Emissions of GHG are measured in CO_2 equivalents on the basis of the Global Warming Potential (GWP) for each individual gases in relation to the warming potential for CO_2, which is set equal to 1 as shown in Table 1.1.

Table 1.1 Greenhouse gases – Most important gas is CO_2

Gas	**GWP in CO_2**	**Important emission sources**
Carbon dioxide (CO_2)	1	Road traffic, heating (using fossil energy sources), oil activity, industrial processes
Methane (CH_4) Nitrous oxide, laughing gas (N_2O)	21 310	Landfills (waste disposal sites), livestock and use and production of farmyard manure, heating
Hydrofluorocarbons (HFC)	1300	Refrigeration plant, fire extinguishers, plastic foam
Perfluorocarbons (PFC) Sulphur hexafluoride (SF6)	6500 23900	Aluminum production Magnesium production

Source: (Fedoryshyn, 2017)

Urbanization is a global megatrend that is also shaping Norway. The country's urban regions continue to grow steadily. In 2017, 81.87% of Norway's total population lived in urban areas and cities (Statista, 2019). As a result of this population trend, a substantial number of Norway's small municipalities is projected to have disappeared within 30 years (Haraldsen & Lie, 2012).

To combat these threats to sustainable development, numerous cities have taken steps to build resilience and address the growing climate-related risks posed to inhabited areas. The issue of climate change is being addressed through the United Nations Framework Convention on Climate Change (UNFCCC). According to the United Nations (United Nations, 2006), the EU's commitments are to stabilize CO_2 emissions by 2000 at 1990 levels and to reduce emissions of the main six greenhouse gases by 8% in 2008-2012 from 1990 levels (Kyoto Protocol). As part of a joint implementation towards European climate goals, Norway has committed to cutting GHG-emissions by 40 percent in 2030, relative to 1990 (Hovi & Pinchasik, 2016).

"Smart cities" are expected to play a pivotal role in achieving these objectives. For example, It is estimated that only the traffic management and parking systems in the new generation of smart cities could reduce global CO_2 by 164 million metric tons, equivalent to the emissions of 35 million vehicles annually (Eltringham, 2015). Through the integration of advanced Information and Communication Technologies (ICTs), Big Data, and Internet of Things (IoT), efficiency and effectiveness of urban operations and resource management in urban areas can be achieved.

Across Europe, the first generation of 78 cities has undertaken smart city development and Europe aims to have a critical mass of 300 smart cities by the end of 2019 (Taylor, 2018b). Twelve "Smart Cities and Communities" projects have been funded up to €270 million since 2014 via the European Commission's Horizon 2020 research and innovation program (Taylor, 2018a).

Deployment of advanced technologies is no doubt an important component in reducing climate change and its impacts. However, past studies have shown that focusing on science and technology alone does not guarantee successful climate change mitigation. Avoiding this tunnel-vision is vital. Implementation of strategies aimed at mitigation are largely contingent on the active cooperation of society (Blake, 1999). Hence, without proper and active engagement of the general public, solving the problem of climate change often posed challenge to scientists, politicians, engineers as well as government (Etim, 2012). By securing active cooperation and support from inhabitants and continuously monitoring CO_2 emissions, we can reduce risks of the environmental issues.

1.1.2 The climate challenge for Norway

The UN's Climate Convention and the Kyoto Protocol

According to the United Nations (2006), the United Nations Framework Convention on Climate Change (UNFCCC), which came into effect in 1994, and its Kyoto Protocol, which came into effect in 2005 jointly called for an international effort of 189 countries, including Norway to stabilize atmospheric concentrations of greenhouse gases, thus reducing the impact of climate change.

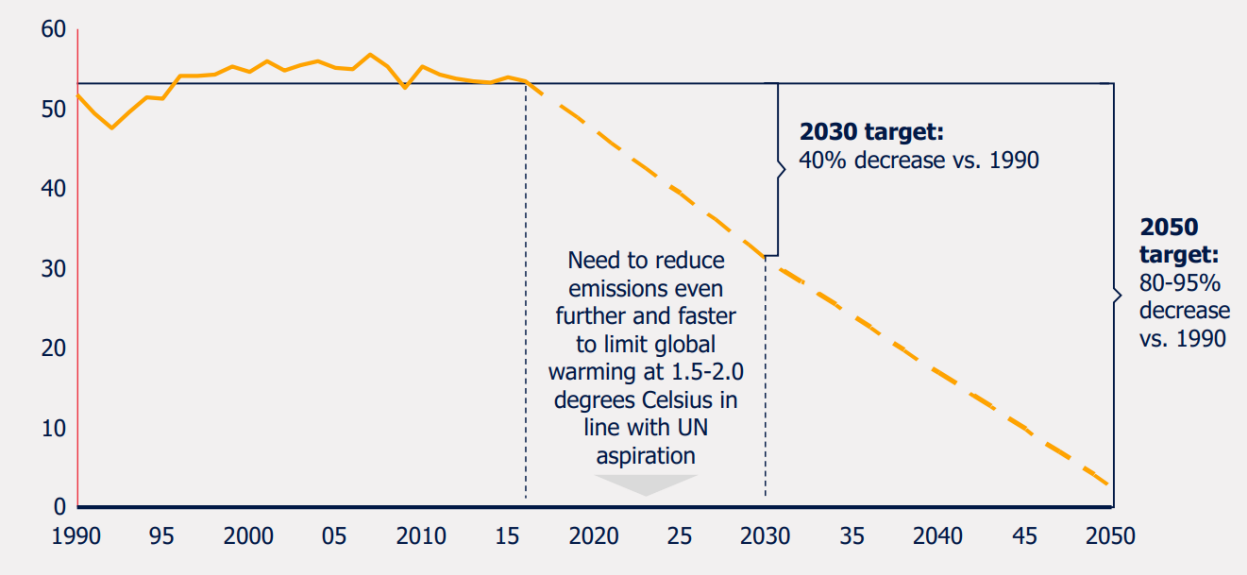
Under the Kyoto Protocol, the participating countries have committed themselves to reducing total greenhouse gas emissions by at least 5 percent by (the average of) 2008-2012 compared with the 1990 level (UNFCCC, 2008).

The Paris Agreement and the Norwegian Climate Act

As a signatory to the Paris Agreement, Norway has committed to reducing emissions by 40% from 1990 levels by 2030 – just 10 years away (Enova, 2017). Also, the Norwegian Government has set itself more ambitious objectives than were agreed in the Kyoto Protocol. The new Norwegian Climate Act sets a target of 80-95% reduction by 2050 in line with EU aspirations – meaning that industry emissions would need to approach zero. Therefore, Norway has set itself the following long-term objectives:

- Up to 2030, Norway will cut its total emissions of greenhouse gases to equate to 40 percent of the country's emissions in 1990 as shown in Graph 1.1.
- By 2050, Norway should be a low emissions society, as shown in Graph 1.1 with the reduction of 80-95 percent cut in current emissions based on emission levels in 1990.

Graph 1.1 A radical shift is required to meet 2030 and 2050 abatement aspirations Norwegian GHG emissions (Mt CO_2e) – Ambitious goals



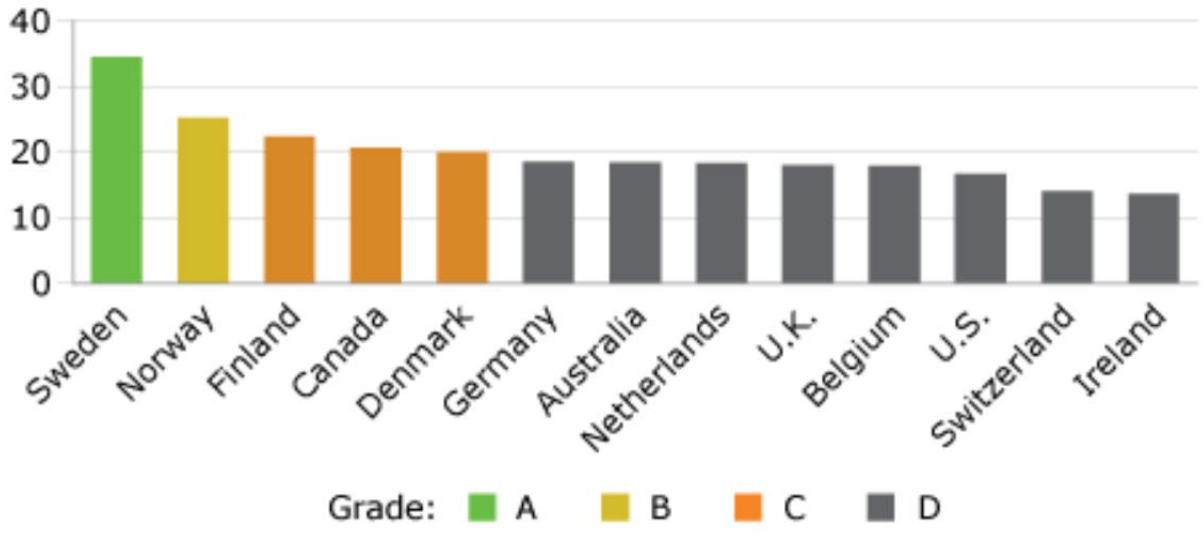
Source: (Enova, 2017)

1.1.3 High literacy rate, technological skill rate and environmentalism of Norwegian

The International Adult Literacy Survey (IALS) revealed that Norwegians are the world's second "most literate" people as shown in Graph 1.2.

Graph 1.2 Adult literacy rate: High level skills, 1994-2003

(Percentage of population aged 16 to 65)



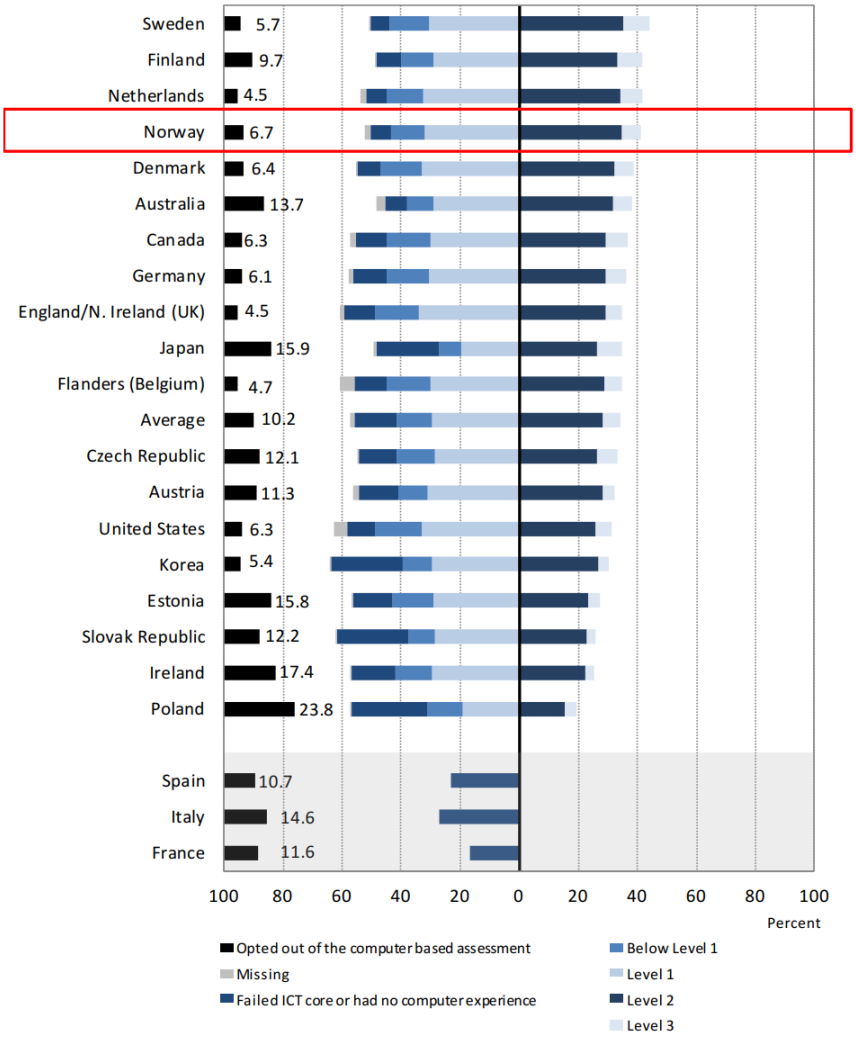
Source: (Ranking, 2005)

Norway enjoys high literacy rate, consolidated by a well-developed lifelong learning system thanks to a wide range of newspapers, a high number of public libraries, easy access to computers and strong educational resources. "Literate behaviors" of citizens are thus formed since their childhood.

Besides the proficiency in literacy, adults in Norway show above-average proficiency in problem-solving skills in technology-rich environments compared to adults of other countries in the same survey as revealed in Graph 1.3. Therefore, Norwegian people have the capacity to access, interpret and analyze information found, transformed and communicated in digital environments.

Graph 1.3 Proficiency in problem solving in technology-rich environments among adults

Percentage of 16-65-year-olds scoring at each proficiency level



Source: (OECD, 2013)

Moreover, several Norwegian studies have concluded that young people regard environmental issues as being among the most important societal problems (Skogen, 1996) (Hegna, 1996). A survey regarding the environmentalism among Norwegian (Strandbu & Skogen, 2000) also found out that there is a high propensity that Norwegian people have a strong environmental concern and their willingness to join an environmental organization.

1.1.3 Background choice of research

There are several reasons explaining the interesting topic of introducing smart solutions to the Municipality of Stavanger to help citizens increase awareness of their CO_2 emissions and help the Municipality have more support to achieve its CO_2 target.

First, a review of the abundant literature on smart city theories and practices reveals that there is a limited effort to capture a comprehensive understanding on how smart solutions can help to achieve the environmental target (particularly the CO_2 emissions), and the public awareness.

Second, Norway pledges to become climate neutral by 2030. To be able to achieve national targets, the municipalities play an important role in reducing their local CO_2 emissions, the Municipality of Stavanger included. In addition, the Stavanger region is regarded as one of the most innovative regions in Norway, so developing a smart solution here is an advantage.

Third, smart cities cannot be "smart" without citizen engagement. In other words, it is people that make "smart cities" smart, not the infrastructure. This view also shares with the nature of democratic organization of Norway where popular demands and interests are communicated bottom-up.

Fourth, Norwegian people have the advantage of high literacy, technological skills and environmentalism. These attributes of people can work together with "smart technology" to create a positive impact on the environment, hence facilitating the ambitious target of the country and the municipality.

All in all, with an advent of a smart intervention related to CO_2 emission reduction, a platform can be created to increase the "climate literacy" among people, encourage changes in their attitudes and behavior, and help them adapt to climate change related trends. Thanks to this education and awareness-raising, the municipality can empower citizens to adopt sustainable lifestyle and achieve its CO_2 emission goal faster.

1.2 Research questions

The aim of this research is to provide the citizens in Stavanger Municipality an application to get more awareness about their CO_2 emissions and provide the local authorities a tool to manage its CO_2 goal. As such, a conceptual interaction model will be defined in order to help these stakeholders in reducing CO_2 emissions. In order to achieve the main research objective, the following central research question is defined:

"How to define smart interventions that facilitate interoperability between Stavanger Municipality and citizens to achieve the CO_2 emission target?"

In order to answer the central research question, a decomposition of the main problem is applied. This decomposition identifies the sub questions that assist towards answering the central research question. The following sub questions are defined:

1. What are the primary sources of CO_2 emissions in Stavanger Municipality?
2. How are the citizens aware of their pollution and the importance of the municipality's CO_2 goal?
3. What are their motivations to make them more engaged in the municipality's CO_2 target?
4. What are the difficulties of Stavanger Municipality in terms of managing its CO_2 reduction target and engaging citizens?
5. Which smart interventions can be implemented to reduce the CO_2 emissions and enhance the citizens' awareness?
6. Once set in motion, how are the benefits of such smart interventions evaluated?

1.3 Disposition

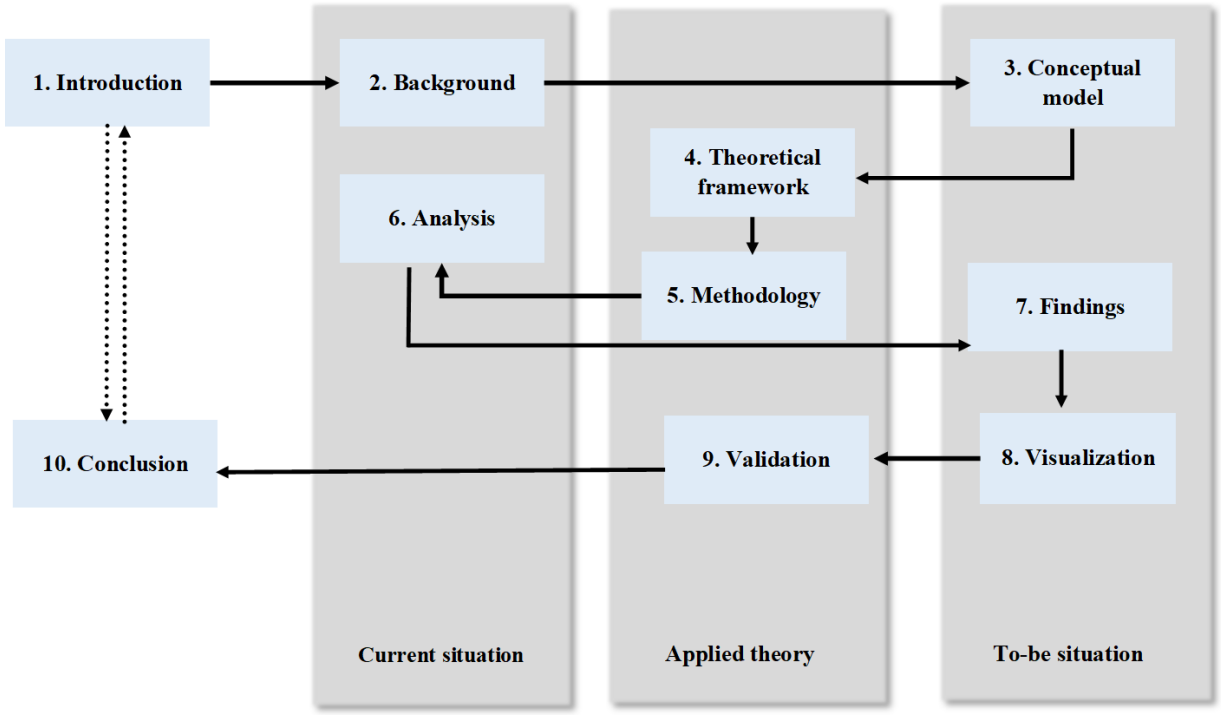
The current research has been structured as follows:

- Chapter 1 introduces the motivation to pursue the research topic and presents research questions.
- Chapter 2 is to describe about the background of the study. The local factors and conditions are presented to make a foundation for the conceptual model in Chapter 3.
- Chapter 3 will introduce the conceptual model of installed sensors to measure real-time CO_2 emissions in Stavanger Municipality. Descriptions of the mechanism of the proposed system is also illustrated.

- Chapter 4 elaborates on the literature review of smart city. Details on how the academia and literature defines the smart city definitions and dimensions. As such, the connection between smart city and the CO_2 mitigation goal is theoretically made. Besides, the summary of smart city research is also presented.
- Chapter 5 explains the methodology and research strategy. It will also present the research design, data collection and data analysis.
- Chapter 6 introduces the results from the data analysis by theme and sub-themes.
- Chapter 7 discusses the findings of the study.
- Chapter 8 visualizes the findings in Chapter 7.
- Chapter 9 examines the methodological rigor by multiple validation criteria.
- Finally, a conclusion is given; theoretical implications, recommendations, limitations of the research, and suggestions for future research are made.

The connections among chapters are illustrated in Figure 1.1.

Figure 1.1 Thesis structure



Source: Own illustration

CHAPTER 2: BACKGROUND

2.1 Stavanger smart city roadmap towards the CO_2 emissions target

The main direction of the smart city development in Stavanger is to develop and apply technological solutions that provide real contributions to the objectives adopted for emissions cuts. The solutions will also make it easier for citizens, industry and commerce to make choices that contribute to a climate neutral city.

According to Stavanger City Council (2018), the objective in the plan is to cut greenhouse gases by 80 percent by 2030 compared with 2015, and to be a fossil-free city by 2040. As shared by the same report of the municipality, around 52 percent of CO_2 emissions in Stavanger come from road traffic. The most serious challenges Stavanger faces from transport are:

- the high proportion of transport carried out using cars
- GHG emissions from cars, buses and goods transport
- airborne dust and hazardous gases from road traffic
- noise, especially from road traffic, but also from airplanes and ships
- emissions from air and ship traffic

The main objectives are:

- 70 percent of passenger transport takes place by bike, foot and public transport in 2030
- making it easier to carry out everyday chores without a car in Stavanger
- meeting any increased need for transport through cycling, walking and public transport

The municipality is also contributing other measures that support climate policy regarding transport such as parking standards, toll charges, low emission zones, facilitating cycling, walking and public transport. By setting high environmental standards for procurements and stipulating requirements for the municipality's units, the municipality can help to mature markets, e.g. for zero-emission vehicles. Car sharing schemes such as Nabobil, Bilkollektivet, electric car sharing schemes, e.g. through priority parking have also been facilitated. Stavanger Municipality will support and become a HjemJobbHjem ("the Home-Work-Home commute") company. By involving companies to sign a contract and pay a certain fee per month, the employees can purchase a mobility card to use the bus and train system and even electrical bicycles to commute to work (Polis, 2016).

The municipality will not be able to do everything required to achieve its climate and environmental objectives alone. Residents, the business sector, organizations and others will be

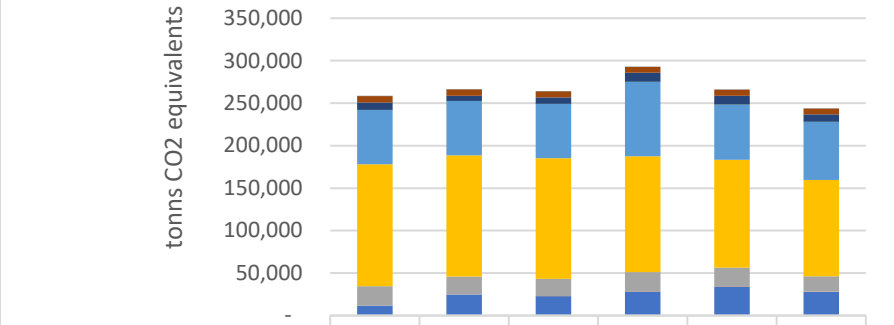
important partners. Hard-hitting, professional and targeted climate and environmental communication is required to invite residents to get actively engaged and to work systematically with others. Good communication is important to ensure that the municipality's climate and environmental goals are achieved. Stavanger Municipality currently provides information about climate and environmentally-friendly everyday actions on the municipality's website and in social media, through the media and regular campaigns such as Environment Sundays and European Mobility Week (Stavanger City Council, 2018).

2.2 Status of CO_2 emissions in Stavanger

According to the Norwegian Emission Inventory (2016), Norway's emissions totaled 52.4 million tons CO_2 equivalents in 2017. This amounts to 9.89 tons per resident. According to Miliø-Direktoratet (2017), in the same year the total emissions of GHG in Stavanger Municipality were 243,888 tons of CO_2 equivalents, accounting for 0.5 percent of Norway's total emissions. This translates to 1.99 tons per resident in Stavanger for 2017, which is approximately 20 percent of the CO_2 emissions per capita on a national level. Overall in percentage terms, Stavanger has much lower emissions in comparison with that for Norway as a whole.

Graph 2.1 shows the development of GHG emissions in Stavanger from 2009 to 2017. Compared to 2015, there was a steady reduction of 9 and 17 percent in the total emissions of GHG in Stavanger Municipality in 2016 and 2017, respectively. The road transport sector accounts for the clearly largest share of CO_2 emissions with roughly 47 percent of CO_2 emissions in Stavanger.

Graph 2.1 CO_2 emissions in Stavanger by source – Mostly from road transport

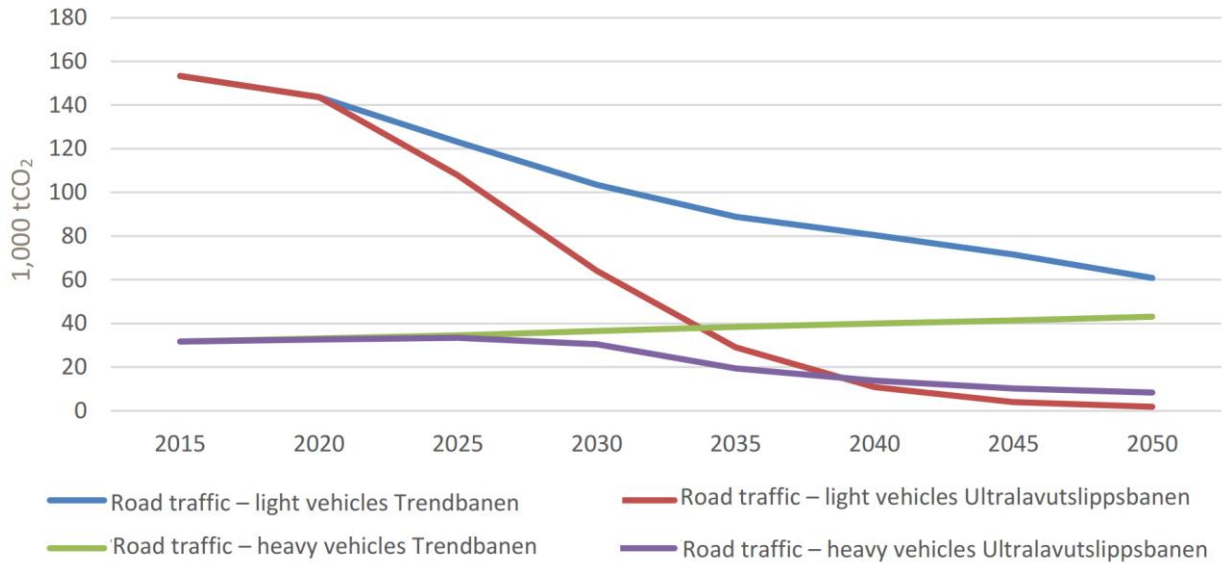


	2009	2011	2013	2015	2016	2017
Waste and drainage	199	191	188	181	178	176
Agriculture	7,664	7,358	7,027	6,897	6,907	6,825
Other mobile combustion	8,688	6,044	7,402	10,668	10,424	8,875
Aviation	1	0	0	1	1	3
Maritime	64,058	64,058	64,058	87,584	65,045	68,547
Road traffic	143,302	142,858	141,935	136,259	126,983	113,088
Heating	22,947	20,761	20,471	22,910	22,111	18,270
Energy	-	-	104	77	217	252
Industry, oil and gas	11,767	24,972	22,768	28,242	34,052	27,854

Source: Own illustration with reference from (Miliø-Direktoratet, 2017)

Two scenarios for CO_2 from road traffic in Stavanger in the lead up to 2050 are projected as can be seen from Graph 2.2. This is based on the assumption that the development in Stavanger Municipality mirrors the development expected for Norway as a whole. There are two types of paths estimated for light and heavy vehicles, namely the trend path and the "ultra-low emissions" path. The trend path is constructed based on the rate of development that the vehicle fleet in Norway has experienced over the period of 2010-2015. The "ultra-low emissions path" can be achieved by taking the objectives of the National Transport Plan (NTP) for 2018-2029 into account. According to the Ministry of Transport and Communications (2016), after 2025 all new private cars should be emission-free. Until that time, they should be plug-in hybrids and should be able to use biofuels. Undoubtedly, the significant difference between the two scenarios indicates that the aspirations of reducing emissions from the transport sector in local targets are no less ambitious than the national ones.

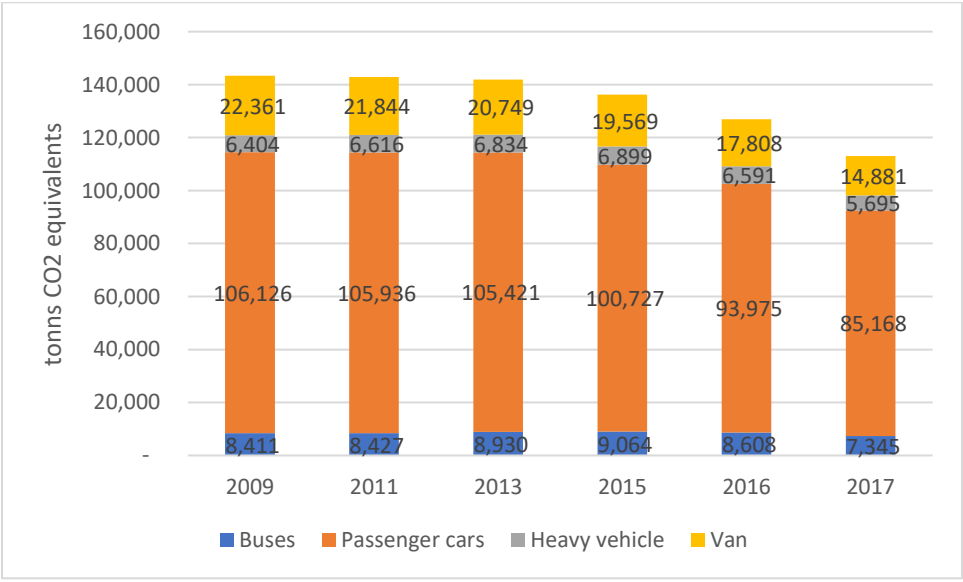
Graph 2.2 Projected emissions from road traffic in Stavanger Municipality – Trend-path and ultra-low-emission path



Source: (Stavanger City Council, 2018)

2.3 Distribution of emissions from road traffic

Graph 2.3 CO_2 Emissions from road transport within the municipality – Mostly from passenger cars

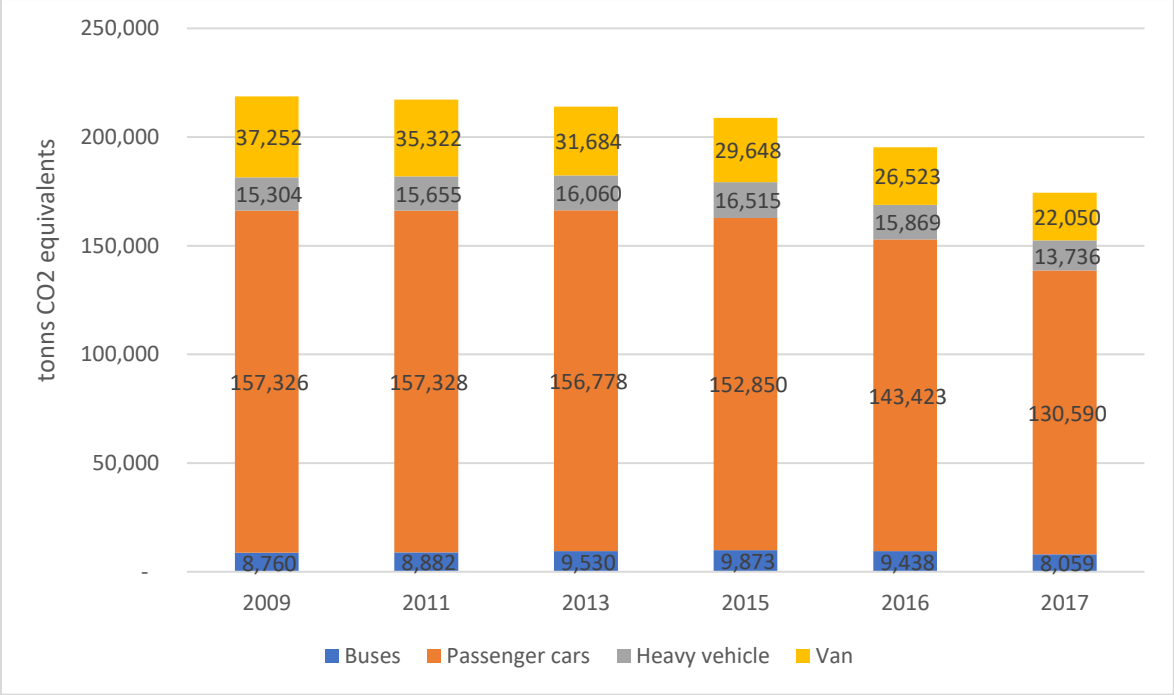


Source: Own illustration with Reference: (Miliø-Direktoratet, 2017)

Graph 2.3 shows that there was a notable reduction of 6 percent in CO_2 emissions in Stavanger from 2013 to 2017. One of the reasons was that the oil and offshore industry seriously started

slashing jobs due to the oil price crash, causing less traffic on the road. However, the transport sector still strongly dominates the mobile emissions in Stavanger Municipality. The municipality of Stavanger has a huge challenge with private transportation; about 75% of all CO_2 emission comes from private transportation driving both inside and outside the municipality's boundary as shown in Graph 2.4

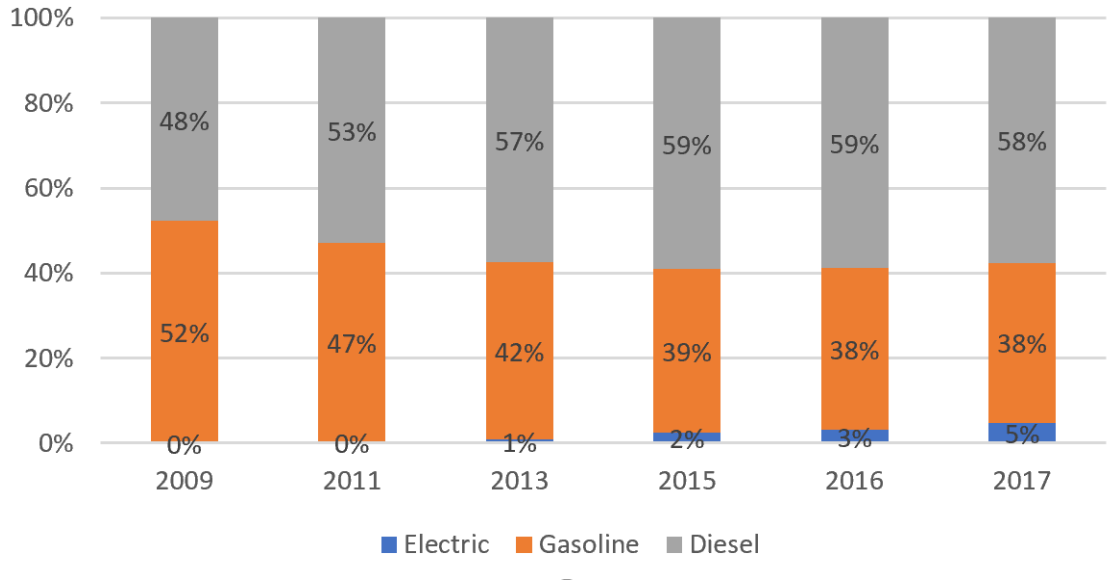
Graph 2.4 CO_2 Emissions from road transport within and outside the municipality – 75% from passenger cars



Source: Own illustration with Reference: (Miliø-Direktoratet, 2017)

Regarding the driving with passenger car and van divided by fuel type, vehicles run by diesel is 1.5 times higher than those run by gasoline. A study by Transport & Environment (T&E, 2017) shows that diesel cars not only pollute the air but also emit more climate-change emissions (CO_2) than petrol cars. The proportion of electric cars is still very negligible but there was a significant increase from merely 0.1 percent in 2011 to 4.8 percent in 2017 as shown in Graph 2.5.

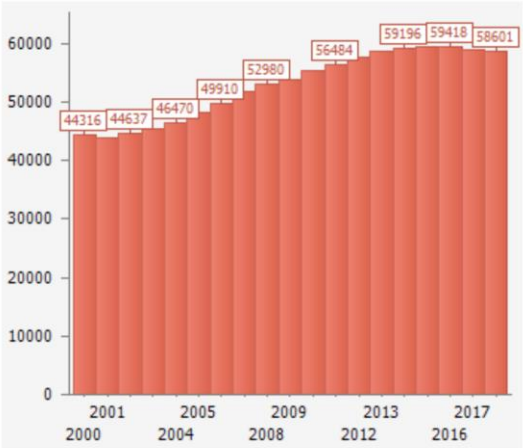
Graph 2.5 Driving passenger car and van divided by fuel type – Mostly diesel cars



Source: Own illustration with Reference: (Miliø-Direktoratet, 2017)

According to Stavanger City Council (2018), the population growth in the Stavanger region in recent decades has led to an increased need for both passenger and commercial transport. Approximately 500,000 journeys were made per working day in Stavanger in 2017, almost 120,000 more than in 1998. Consequently, the number of passenger cars kept increasing in the last two decades.

Graph 2.6 Number of passenger cars in Stavanger Municipality – increasing trend



Source: (Municipal Profile, 2018)

The car ownership obviously exhibits a clear upward trend in Graph 2.6. The changes in travelling habits include an increase in work journeys as a result of the rising labor market after the Norwegian economy went into crisis mode. Oil and krone fuel thousands of jobs in Stavanger, the traditional heart of Norway's oil industry (Berglund, 2018). That in turns has ripple effects and boost demand for everything including personal travelling convenience.

CHAPTER 3: CONCEPTUAL MODEL OF REMOTE SENSING OF MOTOR VEHICLE EXHAUST EMISSIONS

3.1 The context of the model

3.1.1 Citizens are the vocal stakeholders of the smart city

In recent years smart city trend is developing faster and wider to mitigate the urban city problem using ICT as technology innovation. The modern infrastructures are not sufficient to assess a city performance It also needs to be supported by the availability of smart interventions to improve social communication. Therefore, transformation from a non-smart city to a smart city entails the interaction of governments and citizens with technology as the smart city innovation (Mayangsari & Novani, 2015).

Thus, in order to socially address the CO_2 target, the application of smart city innovation in Stavanger Municipality should implement ICT to increase the inter-connection of its citizens and the effectiveness of governance for the city government. Since road transport generates the most CO_2 emissions in Stavanger, the open innovation of ICT in Stavanger smart city is expected to encourage the citizens to take advantage of information for the most efficient driving. This in turns translates to less CO_2 footprint on the environment. Meanwhile, the collaboration between citizens and government on a platform created by ICT fulfils their social needs and at last co-create better values for the smart city itself.

City government would perform two basic functions which are general governance function and service delivery function (Mayangsari & Novani, 2015). Public policy making, public policy performing, and public policy monitoring and evaluating could be seen in the tasks of Stavanger city government to serve citizens. This is also reflected in Stavanger smart city's master plan that citizens are one of the most important stakeholders to make a city even "smarter" (Stavanger City Council, 2018).

3.1.2 Road toll system in Norway

Norway is one of the pioneers in the world to lead the most cost-effective and customer-friendly road tolling when replacing manual toll booths on highways and at toll gates into central urban with an automatic system (Berglund N. , 2012). These fully automatic tolls can scan license plate numbers of cars when they go past the toll booths. Also, most Norwegian car drivers have toll tags from AutoPASS, the Norwegian system for collection of tolls, on their front windshields to interact with scanners.

Automatic toll collection points are marked with the symbol: 

The AutoPASS tag in a car is pictured: 

There are approximately 245 toll collection points in Norway where drivers can pay using an AutoPASS tag (AutoPASS, 2014). The AutoPASS tag in vehicles is linked to the registration number of the vehicle and offers a discount of 20% on the road tolls as illustrated in Table 3.1.

With the aim of reducing CO_2 emissions, relieving traffic congestion and noise and providing new transport options, several toll booths have been strategically placed to discourage driving into the downtown areas of Stavanger and into the Forus area that's home to many oil companies including Equinor (formerly Statoil) (Garza, 2017). Also, toll price counts double for driving in rush hours between 07:00-09:00 and 15:00-17:00.

Table 3.1 Toll rates for passenger cars

	Full price	**AutoPASS price**
Outside rush-hours	22 kroner	17.6 kroner (-20%)
Inside rush-hours	44 kroner	35.2 kroner (-20%)

Source: (Ferde, 2018)

The one-hour rule is applied to vehicles with a valid AutoPASS agreement in which drivers pay for only one passage if they pass more than one toll station or toll rings with the same vehicle. Besides, the monthly-ceiling rate also favors those who have AutoPASS by charging maximum 75 passages per calendar month for each vehicle in the agreement.

With regard to payment methods, generally there are two types of contract: pre-paid and post-paid. This varies among toll road companies: some might offer both forms whereas others offer only one. In Stavanger, the payment method used to be pre-paid, which means that all registered car owners would make a prepayment of a certain amount. When that amount of tolls tied to their license plate number approaches zero, they will receive a new invoice for payment. However recently it has changed into post-paid contract which records all passes within a set time frame, then a bill will be sent out in the mail for payment.

3.1.3 Open data of Stavanger Municipality

Open government data initiatives have exploded around the world together with the trend of smart cities. Open data are defined as non-privacy-restricted and non-confidential data, produced with public money and made available without any restrictions on their usage or distribution (Janssen, Charalabidis, & Zuijderwijk, 2012). Openness is also considered a good governance principle to enhance transparency and participation (Ruijer, Grimmelikhuijsen, Berg, & Meijer, 2018).

Stavanger is one of the leading cites in Norway in terms of open data (Nordic Smart City Network, 2019). 234 open datasets have been made available to the public on the open portal of the municipality (https://open.stavanger.kommune.no/dataset) since 2016. Range and variety of data generated and collected have increased over time, including Stavanger parking, phone list, bathing water temperature, city bikes, air measurement, municipality events, alert of errors, etc. Even though the abundant datasets look promising, their full potential has not yet been reached since people normally do not love reading raw data but they are willing to use the services built on top of open data. In this light, two examples of applications that have been developed from the open data in Stavanger are a map over the nearest public toilet and an app that lets the citizens locate the nearest defibrillator (Nordic Smart City Network, 2019).

The question revolves around whether open datasets can help Stavanger Municipality "enhance transparency and participation" as said by Ruijer et al. (2018). The free access to these data is a "nominal" transparency since there are still few people who can make use of it. "Nominal" transparency can be transformed to "effective" transparency if receptors are capable of processing, digesting and using the information (Heald, 2006). Therefore, the open data platform is not established for the richness of data itself but should be seen as a social construction from practice lens of citizens. Regarding transportation, there are 6 datasets for biking, 4 datasets for parking, 1 dataset for speed limit, 1 dataset for traffic, 2 data set for air measurement and air quality made available on the municipality's open portal up to May 2019.

3.1.4 EU Control in Norway

EU control is a mandatory roadworthiness test that was introduced in Norway in 1988. More than 2 million vehicles go through EU controls in Norway every year (Vegvesen, 2019). A third of these are post-controls in 2018 (Motor editors, 2018), which means that vehicles were not approved on the first attempt. It is the responsibility of owners to get their vehicle tested for roadworthiness at regular intervals and approved within the deadline. The control needs to be

conducted within four years of the first registration date and then within two years of the last EU check (Røed, 2019).

The EU inspection comprises two parts: traffic safety part and environmental part. As the content of the control implies, the aim of EU control is to guarantee a safer and environmentally-friendly car fleet (Vegvesen, 2019). The exhaust gases are measured in the environmental part but are not deeply captured by the control (Vegvesen, 2019). This situation is also true in Europe when air pollutant emissions from light-duty vehicles has not been effectively controlled by regulatory requirements (Borken-Kleefeld & Dallmann, 2018). Consequently, deficiencies in the regulatory approach might lead to the excess emissions of CO_2, which in turns exacerbates urban air quality problems in smart cities, especially when it comes to the ambitious CO_2 reduction target of Stavanger Municipality. Thus, there is a need to have a surveillance framework for managing and reducing CO_2 emission from road transport.

3.2 Suggested remote sensing of on-road vehicle emissions in Stavanger

Measurement of exhaust emissions from vehicles on road is necessary for an effective system of controlling air pollution in the transportation sector (Dallmann, 2018). Two widely known techniques are portable emissions measurement system (PEMS) and remote sensing (RS), which differ mainly on which/how many vehicles are selected and how their emissions are measured (Sjödin, et al., 2018). PEMS uses sensors mounted on an individual vehicle to analyze tailpipe exhaust and produce a detailed, second-by-second record of emissions on a single basis (Dallmann, 2018). On the other hand, remote sensing can measure emissions from thousands of vehicles per day as they pass by sensors on the road by absorption spectroscopy without interference with the vehicle, its driver, or the driving (Borken-Kleefeld & Dallmann, 2018). In this way, CO_2 ratios (expressed in g per kg or litter fuel burned) can be measured directly through the raw vehicle exhaust and the fuel combustion equation (Sjödin, et al., 2018). Compared to PEMS testing, remote sensing is argued as less time consuming and less expensive (Dallmann, 2018). Additionally, the “remote” nature of sensors makes remote-sensing technique well-suited to fleet monitoring and surveillance since it can scan a potentially very large number of vehicles. For these reasons on-road remote sensing is inherently an effective, economical and socially acceptable tool for automobile emission control.

The remote sensing instrument was first developed in the late 1980s (Bishop, Schuchmann, Stedman, & Lawson, 2012). The recent remote sensing system is Emission Detection And

Reporting (EDAR), which has been developed since 2009 with laser light usage (Borken-Kleefeld & Dallmann, 2018). This allows to determine gas pollutants with much higher accuracy. Besides CO_2, a variety of other environmental critical gases such as CO, NO, NO_2, HC and PM coming out of moving vehicles can be measured by EDAR with infrared (IR) and ultraviolet (UV) beam sources and detector (Hager, 2017). Each gas has a specific wavelength attenuation to be detected in the IR and UV regions when the beam passes through the exhaust plume (Huang, et al., 2018). Table 3.1 lists the beam wavelengths covered by EDAR.

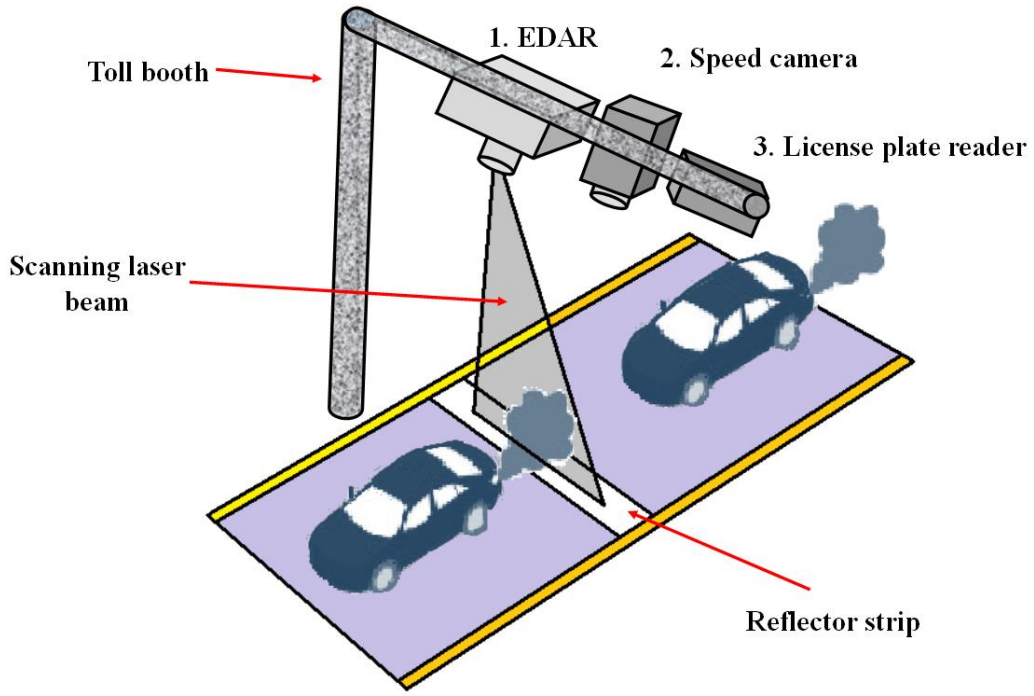
Table 3.2 Wavelengths of the IR and UV beams used in remote sensing – CO_2 is covered in IR beam

Pollutant	**IR beam wavelength**	**UV beam wavelength**
CO_2	4.3 µm	N/A
CO	4.6 µm	N/A
HC	3.4 µm	N/A
NO	N/A	227 nm
NO_2	N/A	438 nm
PM	3.9 µm and 240 nm	3.9 µm and 240 nm

Source: (Huang, et al., 2018)

As shown in Table 3.2, CO_2, CO and HC emissions are measured in the IR spectrum whereas NO and NO_2 emissions are measured in the UV region. PM belongs to both IR and UV region. Although remote sensing can measure a wide range of emissions in the vehicle exhaust, in this thesis, we focus only on CO_2 emissions as the main source of pollution from road transport in Stavanger Municipality. Therefore, only IR beam source is included in the EDAR system as illustrated in Figure 3.1

Figure 3.1 Sensor above the Roadway - Three units



Source: Own illustration combined with (Borken-Kleefeld & Dallmann, 2018)

EDAR is an unmanned automatic system that consists of a laser-based infrared gas sensor, a vehicular speed sensor, and a license plate reader.

- The first unit is an above-road gas sensor that measures passing vehicle emissions by absorption spectroscopy (Borken-Kleefeld & Dallmann, 2018). Laser plays the role of a light source, making CO_2 measurement more selective and precise. Laser is triggered when a forward-facing camera detects an on-coming vehicle. Infrared laser light is then scattered off a reflector strip on the road surface. Because the gas sensor looks down from above, it can sweep a whole lane of the road and detect entire exhaust plume as it exits the vehicle (Hager, 2017). After that, the scattered light is reflected back by the reflector strip to EDAR sensor with required data (Ropkins K., 2017). The CO_2 concentration is proportional to the measured attenuation of the laser light. The background pollution such as pollutants beside the vehicle or just before the vehicle crosses the beam is subtracted to leave the remaining difference as the vehicle exhaust (Borken-Kleefeld & Dallmann, 2018). Furthermore, infrared images of the vehicles passing below the sensor can also be

taken by EDAR, allowing their shape to be determined whether it is a passenger car, heavy truck, or a vehicle pulling a trailer (Hager, 2017) . In the case of Stavanger where toll booths are well set in place, laser and detector can be mounted together with other sensors of toll booths above the road, with the beam looking down the street. In addition, this overhead configuration makes it easier to conduct measurements at roads with multiple lanes and/or denser traffic.

- The second unit captures the speed and acceleration of vehicles, which provides a measure for the vehicle's engine load. This load is correlated with the instantaneous emission rate. Besides the function of supporting to measure CO_2 emissions, this unit can act as a tool for Stavanger Municipality and traffic police to monitor proper driving of citizens by comparing actual speed of vehicles and speed limit on particular roads.
- The third unit is a camera to record the license plate of the vehicle, which is already well-established in Stavanger on toll booths. Recall the road toll system in Norway with AutoPASS tag in each vehicle linked to the registration number and interacted with the camera of toll booths (part 3.1.2). As a result, it enables the retrieval of essential vehicle information such as make, model, manufacturing year, certified emission standard, fuel type etc. from the vehicle registration database for further decision-making process.

The combined information generated from these three units indicates the emission rate expressed in grams of pollutant per kilogram (or litter) of fuel burned at a certain engine load. The US Environmental Protection Agency has officially approved this technology for use in vehicle exhaust emission measurements and air quality management (Borken-Kleefeld & Dallmann, 2018). This all-in-one EDAR system has also been used in Europe in various applications (Sjödin, et al., 2018).

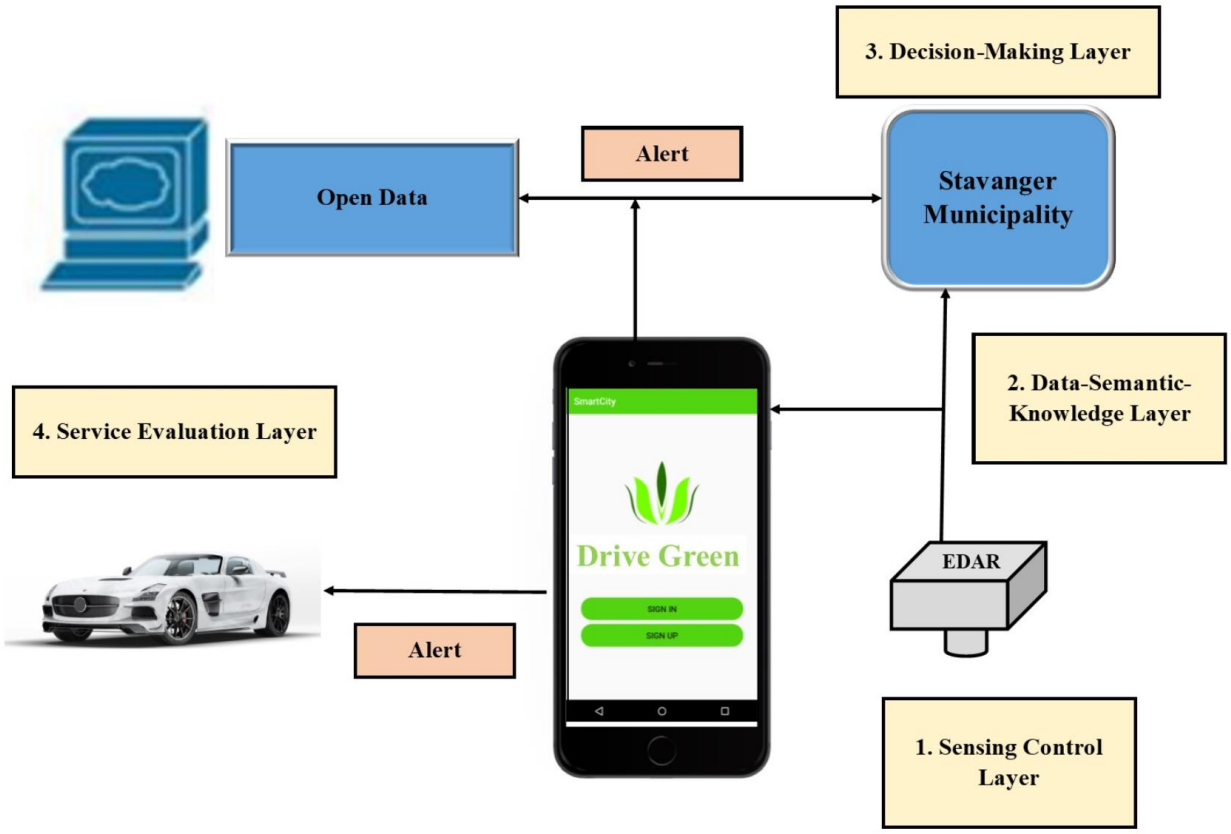
By and large, vehicle emission remote sensing can join with the current facilities of the road toll system in Stavanger to determine CO_2 emission rates of the whole fleet in a relatively quick and cost-effective manner. There are several clear areas in which remote sensing could supplement the governance of CO_2 reduction target of Stavanger Municipality. First of all, the Background chapter of this thesis reveals that vehicle emissions are a major contributor to air pollution in Stavanger. There is abundant room to shrink this huge contribution by better monitoring CO_2 emissions locally with EDAR system. Second, the municipality cannot achieve the ambitious CO_2 reduction target in both short and long term without citizen engagement. EDAR system can act as an enabler

for an interactive urban data platform in the conceptual model below (part 3.3). Third, it is advantageous for Stavanger Municipality to apply this technology since the technical characteristics are known from the vehicle's registration data through the road toll system. In addition, EDAR system occupies a humble space in either a temporary or permanent application and is fully weatherproofed against environmental elements such as temperature, humidity, fog, rain, snow, wind, etc. while other technologies in general cannot operate in severe weather conditions (Hager, 2017). Fourth, the social decision-making is increasingly data-driven. Selected data from EDAR system can be combined with the open data portal of Stavanger Municipality to be made available to public. There are 23 categories of data processed by the toll collection systems (AutoPASS, 2019) while another 100 parameters, two thirds of which related to remote sensing parameters and one third related to vehicle information, can be produced by EDAR system (Sjödin, et al., 2018). In total, 123 datasets can potentially enrich the open data platform of Stavanger Municipality on top of the current 234 datasets to reach up to 357 datasets, which is the highest ever in Norway for a municipal level. The categories of toll data and database parameters of EDAR system are listed in the Appendices.

3.3 Conceptual model of the remote sensor

Since citizens are the vocal stakeholders in a city, it is necessary to place their needs at the center of a smart initiative. Less CO_2 emissions from driving mean less fuel consumption and in return less cost incurred. Thus, understanding real driving emissions is crucial for citizens to take cost-effective actions to reduce air pollution and improve air quality. A mobile application for citizens is proposed to develop out of the EDAR system with the aim of raising awareness about carbon footprint and changing their driving behavior. Since EDAR system is capable of measuring thousands of vehicles and yielding snapshots of emission rates across a wide range of driving conditions, the data can be sorted by vehicle category, brand, model, and can be traced back to even individual vehicles. As a result, it is a possibility that drivers can obtain their own CO_2 emission data on a real-time basis with a mobile application named "Drive Green".

Figure 3.2 Proposed model of the mobile application developed from EDAR system – Four layers



Source: Own illustration combined with (Shahane & Godabole, 2014)

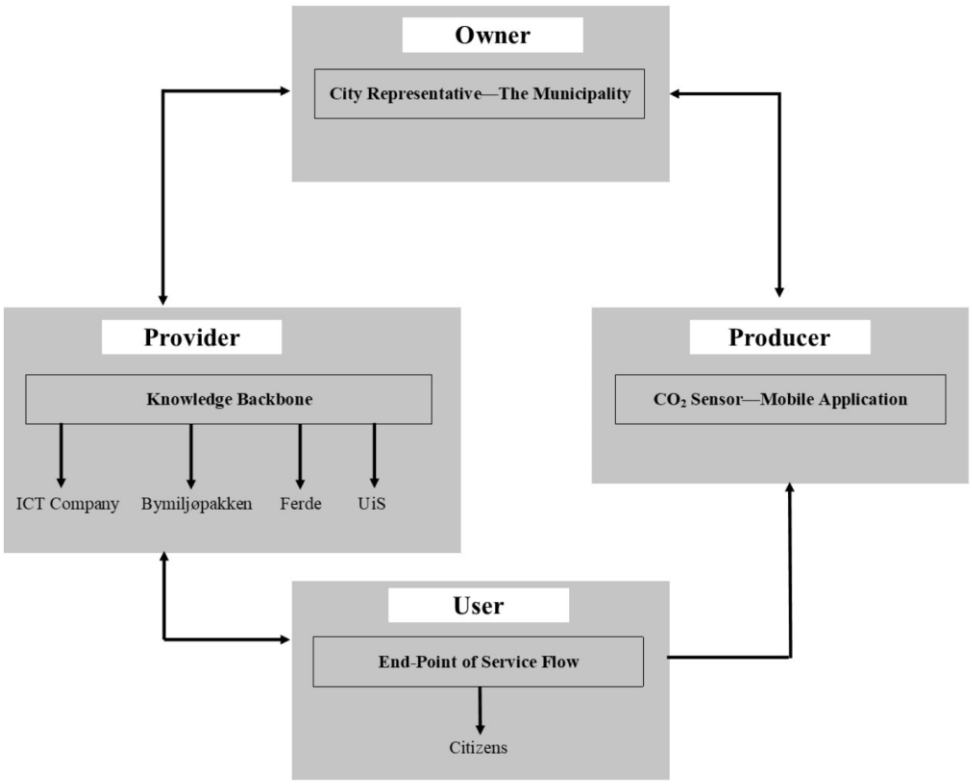
The mobile app serves as a transparent bridge between Stavanger Municipality and citizens to work together towards the CO_2 reduction target. The cognitive process of the model where CO_2 in the vehicle exhaust is monitored by EDAR system, consists of four major phases as illustrated in Figure 3.2:

- The first phase is sensing control. This layer is facilitated by directly interacting with the physical environment, in which the remote sensor of EDAR system senses the CO_2 gas emitted from vehicles. These data are then sent to the upper layer controlled by Stavanger Municipality.
- The second phase is characterized by data-semantic knowledge. At this stage, the data from sensors are put in the database for future analysis by Stavanger Municipality. Part of the data are shared directly through the mobile app to citizens and the remaining are kept internally for decision-making process.

- The third phase allows Stavanger authorities to make effective decisions given the knowledge abstracted from the lower semantic layer. The decisions or alerts of CO_2 emissions status are then sent to vehicle owners through the mobile app, and at the same time to the open data portal of Stavanger.
- The final phase involves a service evaluation. Feedback of citizens are shared with Stavanger Municipality and vice versa. In this way, the evaluation result forms the cognition process.

In the case of Stavanger smart city, the value co-creation of the stakeholders is drawn to better achieve the proposed model of the mobile application, as illustrated in Figure 3.3.

Figure 3.3 Conceptual urban data platform in Stavanger – Four roles



Source: Own illustration

Four roles of stakeholders are defined in the scheme, namely owner, producer, user, and provider. City council, strategic committee, and the smart city alliance can act as the owners of the model

or the service enablers. These municipality representatives are responsible for financial and political support of running the platform. Providers of the service might be university, research institution, ICT company, Bymiljøpakken and/or Ferde (toll service provider in Stavanger) and professionals, who represent both public and private organization collaboration and act as knowledge backbone of the project. The next stakeholder is producer which is composed by EDAR system to produce data of CO_2 emissions from vehicles. This technology is the root of CO_2 innovation in Stavanger smart city. While the mentioned stakeholders hold their own importance, the most important stakeholder in Stavanger smart city are citizens as the users of the mobile application. Their knowledge, skills, expectations and personal data are the capital of Stavanger smart city as they can be integrated to resources in the municipality. When users can exploit the CO_2 knowledge from the app and build their own participation motivation, they are optimally empowered to become value co-creators who pave the way to the smartness of Stavanger city based on the transparent two-way communication.

Thus, besides the good investment of EDAR technology in the city, sustainable collaboration among stakeholders is the significant key of positive and interesting outcomes for the CO_2 reduction target in Stavanger smart city. From literature perspective, this study contributes to complement the existing literatures about smart city definitions, smart city dimensions, stakeholder collaboration theory and urban data platform, which are subject to further explanation in Chapter 4.

CHAPTER 4: THEORETICAL FRAMEWORK

4.1 Smart city definition

The use of ICT in cities have led to the increased effectiveness of city operations and these cities are called "smart cities" (Elias Kougianos, 2016). The backbone of smart city concept is based on using Internet of Things (IoT). The aim of smart city is generally to make life easier for people where technologies are used, not necessarily in a brand-new way, but in an innovative way in order to reach resource optimization, effective and trustworthy governance, sustainability and high quality of life (Gretzel, 2015).

The literature suggests a variety of "smart city" definitions, however, there has not been consensus among researchers on a single definition that can cover all aspects (Albino et al., 2015). According to Nam et al. (2011), many definitions are ambiguous and inconsistent (Nam & Pardo, 2011). One of the reasons given by EU Parliament (2014) (Europarl, 2014) is that each "smart city" has its own policies, objectives, economic and social factors, mix of technology, governance and businesses. Table 1 presents some definitions of "smart city" that have been proposed by various authors.

Table 4.1 The "smart city" definitions – Multi-faceted meanings

Definition	**Author(s)**
"A city well performing in a **forward-looking way** in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens."	(Geller, 2003)
"Smart city generally refers to the research and identification of **intelligent solutions**, which allow modern cities to **enhance the quality of the services** provided to citizens."	(Giffinger, Fertner, Kalasek, & Meijers, 2007)
"Smart community […] will undoubtedly focus on building its **high-speed broadband infrastructures**, but the real opportunity is in rebuilding and renewing a **sense of place**, and in the process of a **sense of civic pride.**"	(Eger, 2009)
"Smart cities are cities that have a **high quality of life**; those that pursue **sustainable economic** development through investments in human and social capital, and traditional and modern communications infrastructure	(Thuzar, 2011)

(transport and information communication technology); and **manage natural resources** through **participatory policies**. Smart cities should also be **sustainable**, converging **economic, social, and environmental goals**."	
"A city can be defined as "smart" when investments in human and social capital and modern transport and communication infrastructure fuel **sustainable economic** growth and a **high quality of life**, with a wise **management of natural resources**, through **participatory governance**"	(T. Nam, 2011)
"A smart city, according to ICLEI, is a city that is prepared to provide conditions for a **healthy and happy community** under the challenging conditions that global, **environmental, economic and social** trends may bring"	(Guan, 2012)
"Smart city […] a local entity – a district, city, region or small country which takes a holistic approach to employ information technologies with **real-time analysis** that encourages **sustainable economic** development	(IDA, 2012)
"Smart cities have high productivity as they have a relatively high share of highly **educated people**, knowledge-intensive jobs, output-oriented planning systems, creative activities and **sustainability-oriented initiatives**."	(Kourtit & Nijkamp, 2012)
"A smart city […] addresses several innovative **socio-technical and socio-economic** aspects of growth. These aspects lead to smart city conceptions as **"green"** referring to urban infrastructure for environment protection and **reduction of CO_2 emission**"	(Zygiaris, 2013)
"Smart cities initiatives try to improve urban performance by using data, information, and information technologies (IT) to provide **more efficient services to citizens**, to monitor and optimize existing infrastructure, to increase **collaboration** among different economic actors, and to encourage **innovative business models** in both the private and public sectors"	(Marsal-Llacuna, Colomer-Llinas, & Melendez-Frigola, 2014)
"A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to **improve quality of life**, efficiency of urban operations and services, and competitiveness,	(A. Zanella, 2014).

while ensuring that it **meets the needs of present and future generations** with respect to **economic, social and environmental** aspects"	

Source: Own illustration

Although literature in Table 4.1 shows the multi-faceted meaning of a "smart city", there exist some intersections among different definitions.

First, smart city is born for the purpose of a sustainable city. "Modern communications infrastructure" (Thuzar, 2011) with "real-time analysis**"** (IDA, 2012) can be utilized to "manage natural resources" for "economic, social, and environmental goals"((Thuzar, 2011), (Guan, 2012), (IDA, 2012), (Zygiaris, 2013), (A. Zanella, 2014)) such as "reduction of CO_2 emission" (Zygiaris, 2013) in a "forward-looking way" (Geller, 2003).

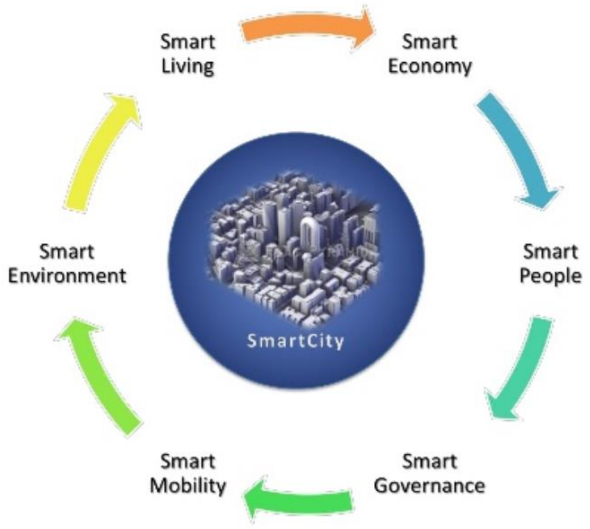
Second, a city is meant to be a "smart city" not only by its technological advancement but also the people and communities. The identification of intelligent solutions (Giffinger, Fertner, Kalasek, & Meijers, 2007) can help to make a "healthy and happy community" (Guan, 2012), "improve quality of life" (A. Zanella, 2014) and create a "sense of civic pride" (Eger, 2009) for citizens.

Third, "smart city" goes hand in hand with "smart governance" as cited by (Nam & P., 2011) and Thuzar (2011) through "participatory policies". As such, stakeholders of a smart city, of whom citizens are the majority, will have an opportunity to collaborate more effectively with each other.

4.2 Smart city dimensions

Six defined dimensions of the smart city as illustrated in Figure 4.1 are developed by ASCIMER as an integrated approach to gain a multidisciplinary vision of cities (ASCIMER, 2015). Fragmented definitions of smart city mentioned in part 3.1 can now be allocated within six main city dimensions: Governance, Economy, Mobility, Environment, People and Living. Technology is absent in those six smart city dimensions because "Smart Cities should focus on People, not Technology" (Martinidis, 2019). According to ASCIMER (2015), technology is not an action fields but an to achieve the expected goals of a Smart City strategy (sustainability, efficiency and high quality of life).

Figure 4.1 Six smart-city dimensions



Source: (ASCIMER, 2015)

- Smart Environment: According to Marsal-Llacuna et al. (2014), smart cities should be environmentally friendly and livable cities besides technological development. The smartness of environment is a product of using data collection from utility networks and resources in order to improve the quality of life for citizens (ASCIMER, 2015). Therefore, protecting environment is also developing a smart city (Rui, 2017).
- Smart Governance: Smart governance exploits technology to increase governments efficiency and effectiveness, actively engage and collaborate with stakeholders (Slob & Woestenburg, 2017). In this view, smart governance represents "a collection of technologies, people, policies, practices, resources, social norms and information that interact to support city governing activities" (Chourabi, et al., 2012). Municipalities are the "enablers of interaction and collaboration of multiple actors who have corresponding interests or needs" (Walravens, Breuer, & Ballon, 2014). The e-governance projects success depends on stakeholders relations where "Stakeholder relations refers to four main issues: the ability to cooperate among stakeholders, support of leadership, structure of alliances and working under different jurisdictions" (Scholl, 2009).
- Smart Economy: An economy is called "smart" if it is characterized by innovative ideas that can increase the productivity and reduce cost (Anttiroiko, Ari-Veikko, Valkama,

Pekka, & J. Baile, 2014). With the widespread use of ICTs and digitalization, the economy can become more competitive to earn higher profits with efficient costs. New business models can also be enhanced in a resilient economy to compete both locally and globally (ASCIMER, 2015).

- Smart Mobility: Traffic problems such as congestions, long queues and delays, are not new to urban areas and are not exclusive to larger cities. The gradual phasing out of "conventionally-fueled" vehicles by electric vehicles (EVs) is a contribution to the reduction of pollution. Smart Mobility pursues to offer the most efficient, clean and equitable transport network for people, goods and data by leveraging the available technologies to gather and provide information to users, planners and transport managers (ASCIMER, 2015).
- Smart People: Cities cannot achieve smartness without the participation of citizens in smart initiatives. One of the main tools to improve this dimension is through education (ASCIMER, 2015). Smart cities can empower talents by encouraging partnerships between the private and public sectors (Moritz, 2017). Keeping smart people in smart cities will create opportunities for unparallel development.
- Smart Living: Smart Living is a fruitful result of the wise management of facilities, public spaces and services using ICT technologies with the aim of improving accessibility and getting closer to the citizens´ needs (ASCIMER, 2015). Smart living is somehow the ultimate objective of smart cities to improve the life of people using technological improvements.

4.3 Stakeholder collaboration theory

The origin of the stakeholder concept can be traced back to 1984 when Freeman defined that "a stakeholder in an organization is any group or individual who can affect or is affected by the achievement of the organization's objectives" (Freeman, 1984). Based on (Clarkson, 1995), participation of contributing stakeholders is required to sustain the activity. Another definition has also been settled that "Stakeholders are individuals or groups who have an interest or some aspect of rights or ownership in the project, can contribute in the form of knowledge or support, or can impact or be impacted by, the project" (Bourne, 2005). However, the stakeholder concept is wider than just projects or companies. Stakeholders also include the project personnel, suppliers,

partners, communities, as well as economic, social and ecological perspectives (McGrath & Whitty, 2017).

In the context of a smart city development project, the key internal and external stakeholders are academia and research institutions, local and regional administrations, financial suppliers/investors, energy suppliers, ICT sector representatives, citizens, government, property developers, non-profit organizations, planners, policy makers, experts and scientists, political institutions and media (Jayasena, Mallawaarachchi, & Waidyasekara, 2018). When it comes to the social partnership, stakeholders need to know how to succeed in collaborative endeavors since collaboration helps the community tackle social or macroenvironmental problems, which cannot be solved by any single organization acting alone. Collaboration enables smart cities to pool resources, capitalize on complementary capabilities, achieve economies of scale, and enhance innovativeness (Savage, et al., 2008).

The factors influencing collaborative success have been explored by various researchers from different theoretical perspectives. A commitment to collaborate is built on the foundation that partners are interdependent and mutual benefit oriented and have common definition of the problem they are jointly tackling (Gray, 1985). Appreciation without structure is not enough for a successful collaboration. They also need to structure their interaction (Trist, 1983).

Building on this work, (Lawrence, Hardy, & Phillips, 2002) emphasized on a collective identity, building generalized and particularized membership ties, and engaging stakeholders in both cooperative and assertive talk. In addition, the level of trust in collaboration is also important to generate a sustainable relationship. The processual issues such as benefit conflicts or power difference can make a collaboration fail (Hardy & Phillips, 1998).These three sets of factors that foster a strong cooperation are summarized as: (1) appreciative linkages, e.g., the extent of shared goals; (2) structural features of the collaboration, e.g., how tightly coupled and institutionalized it is and the power differential among partners; and (3) processual issues, e.g., the degree of trust among partners and the quality of leadership (Savage, et al., 2008).

In another qualitative research, six generic stakeholder management strategies are “collaborate, defend, educate, involve, lead, and monitor” in order to achieve ‘‘win–win’’ outcome (Bunn, Savage, & Holloway, 2002). Another study by IAP2, the International Association for Public Participation, defined five levels of public participation in the spectrum depending on the goals, time frames, resources and levels (Barrenetxea, et al., 2016) as illustrated in Figure 4.2.

Figure 4.2 IPA2's Public Participation Spectrum

	INFORM	CONSULT	INVOLVE	COLLABORATION	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balances and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decision.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions ans incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Source: (IPA2, 2014)

The objective of "Public participation" is to provide participants with information they need to be involved in a decision-making process. The level of such public involvement varies according to the situation. At times, the local government may just "inform" citizens of the ongoing activities, a new program or upcoming events. There are also other times that inhabitants "involve" in the authorities' service to study the issue in depth and address it in a way that satisfy citizens. The highest level of the public participation is to "empower" citizens. In this way, it is desirable for the government to partner with citizens to create ideas, develop strategies and solutions to community-wide concerns. This helps to sustain the relationship between policymakers and public since their input are taken into consideration to enhance their quality of life.

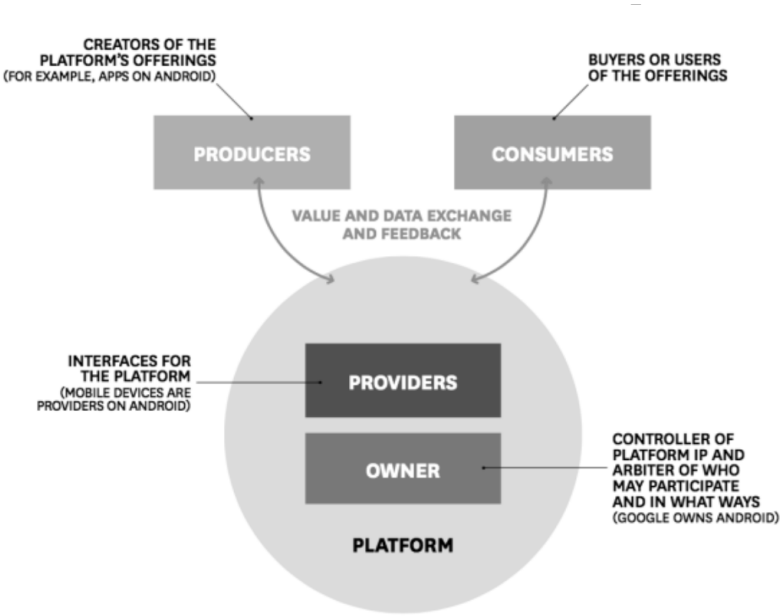
4.4 Urban data platform

The increasing level of digitization and interconnection in every domain in society has been followed by the exponential growth of data. Urban data stem from public, industrial, scientific or

private sources. From these sources of urban data, cities and communities can provide new services for the monitoring, understanding, decision making, steering, and control (Schieferdecker , Tcholtchev, & Lämmel, 2016).

A platform is a physical, technological or social base on which sociotechnical processes are provided (Anttiroiko, Valkama, & Bailey, 2013). There are at least two distinct interdependent groups interacting through platforms typically the demand and supply side. Platforms can take a variety of forms but generally they all have a similar structure consisting of four main types of actors as shown in Figure 4.3: (1) owners of platforms control their intellectual property and must make decisions on who and what is allowed on the platform, (2) providers of platforms create and serve as the interface with users, (3) producers deliver their offerings to the platform and (4) consumers use those offerings (Das, 2018).

Figure 4.3 Platform structure – Four roles



Source: (Das, 2018)

The performance of users on the platform can be assessed by four criteria: (1) complementarity, referring to products or services which strengthen one another, (2) connectivity, referring to the ease of interaction within the network, (3) innovation ability, referring to occurrence of new ideas within the network and (4) efficiency, referring to the increased interoperability with other actors offered by the platform (Lee, Kim, Noh, & Lee, 2010).

The existence of urban data platform enhances the role of government in facilitating wider access to government's open data, and encourages external users, especially citizens (Barns, 2015). Created by local governments, data-driven services help to improve the responsiveness of government, rather than the accessibility of the data. Therefore, urban data platforms are more more geared towards monitoring progress or performance against agreed indicators (Barns, 2015). In this way, they serve to monitor performance against targets. Therefore, an effective approach of data management can help a municipality to address the city challenges through increasing real time, data-driven performance metrics (Barns, 2015).

4.5 Summary of smart city research in relation to CO_2 emissions

For the last two decades, the smart city concept has emerged in parallel with the development of communications infrastructure and the continued maturation of applied ICT as a way to address the growing challenges of urbanism. This growth was predicted as far back as 1997, where the World Forum on Smart Cities suggested that around 50,000 cities and towns would develop smart city initiatives in the coming decade (Hollands, 2008).

The literature basis for this review is drawn from a selection of prolific smart city researches that concern themselves with “Smart cities” in relation to the CO_2 emissions. Table 4.2 illustrates smart city literature across different domains where CO_2 is mostly derived from. Together with the challenges, suggested smart interventions are displayed accordingly to deal with these challenges and some of the stated benefits of implementing these interventions.

Table 4.2 Smart city application across different domains

Scope of action		Smart Intervention	Benefits
Domain	Challenge		
Transportation	Monitoring CO_2 emissions from vehicles	Real time monitoring and controlling of CO_2 emission using cognitive IOT	"model has to be installed one time and goes on for 10 years." "the model can reduce the greenhouse gas in the environment as compared to the existing system of pollution check." "can cut down and control the emission considerably" (Shahane, 2013).
	CO_2 from vehicular traffic in urban areas	Traffic optimization system based on the current traffic situation in the city	"a system that continuously measures traveling times along all road segments within a given area and according to that, updates the list of the quickest routes between any pair of points." "It is shown that drivers who have access to information about optimal routes computed by the system are able to reduce the amount of emitted greenhouse gases" (Ishii, 2008).

Energy efficiency	Household energy management	Cooperation of electric vehicle and energy storage in reactive power compensation	"not only reduce the customer's billing cost but also to compensate the reactive power at the point of grid integration." "The obtained results approve both the economic and technical successes." (Golshannavaz, 2018).
	Building energy management	Integrated land use-energy model: combine smart grid system with appropriate land use (compact city with energy efficient buildings and photovoltaic panels, transportation and energy system)	"The results suggest that ''compact'' urban form can reduce the electricity demand from the residential sector comparing with ''dispersion'' one." (Yamagata, 2013)
Aviation	Sustainable fuel	Development of jet fuels produced from sustainably sourced biological material – namely plant material	"Fuels produced from such biological feedstock have potentially up to 80% less carbon dioxide emissions (in their overall lifecycle) than traditional fossil-fuel derived kerosene
Heavy industry	Carbon capture and storage	- Co-firing of biomass and wastes	"CCS is an important transition technology such that we minimize the CO_2 emissions and at the

		- Integrated industrial CO_2 Capture and Storage (CCS) plants	same time develop renewable resources." (Singh, 2013).
Chemicals industry	Biotechnology	Industrial scale biotechnology: produce bulk chemicals like ethylene, butanol or acrylic acid, which are the basic raw materials used in the production of many materials, such as plastics and electronic components	"they showed that some biotechnology processes were capable of reducing CO_2 emissions by 100%." "With biotechnology advances in the future, the researchers suggest that worldwide CO_2 savings in the range of 500-1000 million tons per year are possible." (Hermann, 2007)

Source: Own illustration

CHAPTER 5: METHODOLOGY

The objective of this chapter is to describe and discuss the chosen methodological approach and the justification of such approach based on the nature of the research questions. In addition, an evaluation of sample will be presented, followed by the design of an interview and how data is collected and coded.

5.1 Research design

According to Ghauri et al. (1995), types of research methods in business studies can be broadly divided into two quantitative and qualitative categories. In quantitative research, a deductive process is employed (Boeije, 2010), which commences with generalizations, and seeks to see if these generalizations apply to specific instances. In other words, quantitative methods are related to numerical interpretations with statistics collection and interpretation. On the other hand, in qualitative research inductive approach is paramount (Boeije, 2010). Case studies are often referred to and a social phenomenon is explored in order to find empirical patterns (Bryman & Bell, 2007). According to Bryman et al. (2007), qualitative research is an appropriate approach for research in business and management administration.

Qualitative methodology approach allows researchers to explore the relevant themes and topics in-depth (Bazeley, 2009). As such, the researchers can investigate the topics from various points of view. Unlike quantitative approach focusing on large numbers of data from a large group of population, qualitative approach is more concerned with a small sample since to gain rich in-depth date (Veal, 1992). According to Creswell (1998), the essence of qualitative research is drawing a conclusion based on the respondents' opinions and experiences from their point of view rather than the researchers' point of view.

Since this research topic is a new emerging field of interest that has not yet been extensively examined, we need methods with a maximum of explorative power. Qualitative method lives up to this because of its flexible approach. In terms of the result application, Boeije (2010) stated that qualitative methods hold the promise to yield findings that reflect the participants' perspective and that fit the substantive field. Consequently, it is expected that the findings will have relevance to both citizens and authorities of Stavanger Municipality. Results relevant to the target groups might encourage the adoption of new policy measures.

By and large, the characteristics of qualitative research as described above have the potential to produce the findings that are going to realize our research objective in a way that quantitative method cannot. Collection of non-numerical data in the small municipality is necessary for identifying potential interactions, contextual similarities, and appropriate policy in the future.

In this thesis, thematic analysis is employed as a method for systematically identifying, organizing, and offering insight into patterns of themes across a dataset (Braun & Clarke, 2012). Through focusing on themes developed from a dataset, the researchers can see and make sense of collective meanings and experiences across different perspectives of respondents. In addition, matrix display is also used in this research to assist better understanding of the complex and massive qualitative data from interviews. Applying matrix display in qualitative data analysis is useful for answering research questions and a comprehensive analysis that include all relevant information (Miles & Huberman, 1994). In addition, readers can also be provided with a clearer perspective because data in texts can be compared.

5.2 Population, participants, and sampling techniques

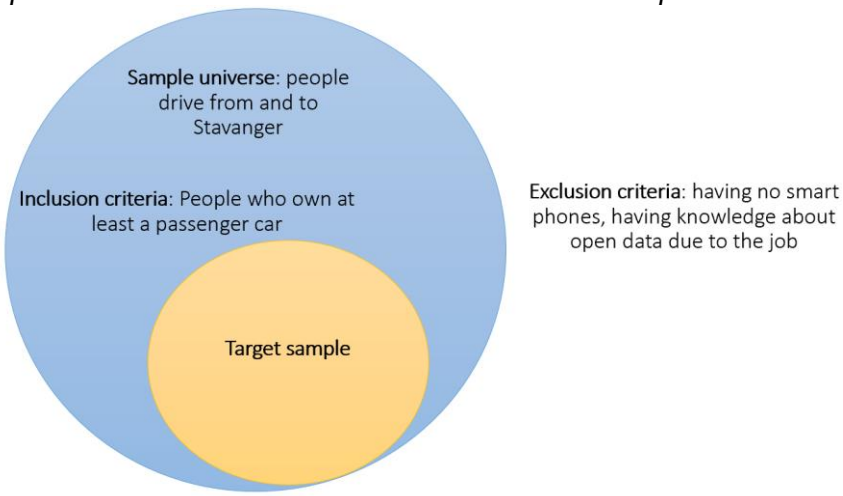
5.2.1 Target sample

According to Robison (2014), a target sample can be drawn from a sample universe based on the technique of employing inclusion and exclusion criteria. Mason (2002) defines the sample universe as the level of generality to which a study's findings is relevant and logically inferable. From that, the sample universe is the total population of possible cases for the sample (Robinson, 2014). According to Mason (2002), the more explicitly a sample universe is described, the more transparent the generalization will be.

In this research, the sample universe is for those who travel to and from Stavanger Municipality as illustrated in Figure 5.1. In order to contract this sample universe into the target sample as discussed in part 5.2.3 below, we introduced the inclusion and exclusion criteria to the whole population as follows:

- Inclusion criteria: People who own at least a passenger car (from citizens) and managers of the municipality related to environment (from the municipality).
- Exclusion criteria: People who do not have smart phone, and/or have knowledge about Stavanger municipality's open data because of their job.

Figure 5.1 Sample universe - inclusion/exclusion criteria and sample



Source: Own illustration

5.2.2 Sample size

The sample size in qualitative research is different from quantitative research. In quantitative research it is paramount that statistical representation is implemented. In other words, the sample size should reflect the proportional distribution of relevant population characteristics to reach the generalization or statistical inference (Boeije, 2010).

In qualitative research the number of respondents cannot follow the procedures of quantitative sampling because the purpose is to explore the "in-depth" understanding of different opinions (Gaskell, 2000). Thus, sampling in qualitative research is more concerned with the richness of information than the number of participants required (Kuzel, 1992).

The basis for generalization in qualitative research is analytical generalization with the aim of expanding and generalizing theories but not the frequency (Yin, 1994). Therefore, the sample size ends up 18, 16 of which are citizens and 2 of which are authorities. This research typically uses "purposive sampling", as opposed to random sampling. Because we focus on the quality rather than the quantity. The sample is selected referred to as "purposive sampling" to represent the analytical generalization, rather than to replicate their frequency in the wider population (Boeije, 2010).

5.2.3 Sampling techniques

The "purposive sampling" technique used in this research is "maximum variation sampling", which can maximize the diversity relevant to the research questions through a selected small number of units (Rai & Thapa, 2004). Therefore, we chose a purposeful sample to represent the views of eight cohorts: students, people aged from 30 to 50 with and without dependent children, and people aged over 50; all subject to living either near downtown or far from downtown area. Because these segments of drivers can capture a wide range of perspectives

related to attributes, behaviors, experiences, incidents, qualities, situations, and so forth. Consequently, central themes, core elements, and/or shared dimensions that cut across a diverse sample can be analyzed to document unique or diverse variations.

Table 5.1 Stratified sample in the thesis – 8 cohorts of respondents

Near downtown area				**Far from downtown area**			
Students	**Aged 30-50**		**above 50**	**Students**	**Aged 30-50**		**above 50**
	With dependent children	**Without dependent children**			**With dependent children**	**Without dependent children**	
2	2	2	2	2	2	2	2
Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8

Source: Own illustration

Table 5.1 illustrates a stratified sample with three typological variables: gender, age and presence of dependent children. In order to achieve the desired number of respondents, the referral processes or "Snowball sampling" is employed. This involves asking participants for recommendations of acquaintances who might qualify for participation, leading to "referral chains".

Besides, we also interviewed two people working for Stavanger Smart City related to Environment and Climate. Therefore, eighteen in-depth interviews have all been taking place in Stavanger and all transcribed material from the interviews have been approved by the respondents in order to reduce possible misunderstandings.

5.3 Design of an interview

Before the interview, the researcher gave brief information about the objectives and topics to be discussed, confidentiality of information and the informants' right to withdraw at any time. The informants were aware of the fact that the interviews would be tape-recorded as well as their right to decline to have the interview recorded. The informants were anonymous during the analysis and presentation of results.

Given the various parties involved in the initiative, two different interviews guides were prepared to ask the respondents as citizens and the municipality representatives. In total, 18 interviews were conducted from March to May 2019. Seventeen of them were conducted verbally while there was one interview with the municipality representative conducted by texts (sending questionnaires and receiving typed-answers) according to preference of the interviewee.

The interviews guides for the two stakeholder groups can be found in Appendices. Since qualitative researchers are often looking for a true understanding of what is happening, the interviews are usually not entirely pre-structured with respect to content, formulation, sequence and answers. Neither are they left entirely open. Rather, thorough preparation results in a list of topics and/or questions to be asked at some point in the interview. This type of interview is semi-structured interview. The semi-structured interviews enable respondents to answer without restrictions and give them a chance to contribute new knowledge that has not been mentioned in the literature.

The first interview was designed for the citizens and the second one was developed for the local authorities. The interview guide includes questions to identify problems and priorities, motivate participation and mobilize resources, create interaction for citizens and the municipality work together and finally sustain the enabling environment. However, the questions of the categories have been slightly adapted for each of the two interview settings as below.

From citizens:

- Problems of driving in Stavanger
- Motivation to contribute to the CO_2 emission target
- Motivation to use the application of the conceptual model
- Suggestion for other improvements

From the municipality:

- Problems of managing CO_2 emissions
- Ongoing strategy to achieve the target and motivate citizens
- Perspectives of municipality on the conceptual model
- Suggestion for other improvements

5.4 Data collection and coding

Two researchers independently analyzed the transcripts. Text coding was conducted based on a constant comparative method (Glaser & Strauss, 1967) where all lines, sentences, and paragraphs of the transcribed interviews and field notes were reviewed to decide what codes fit the concepts suggested by the data. The assignment of three levels of codes - open, axial, and selective (Boeije, 2010) was employed.

Open coding entails “breaking down, examining, comparing, conceptualizing and categorizing data” (Strauss & Corbin, 2007). This means that all data collected are compared and divided

into fragments, grouped under different categories, and labelled with a code. The result of open coding is a list of codes as illustrated in Table 5.2.

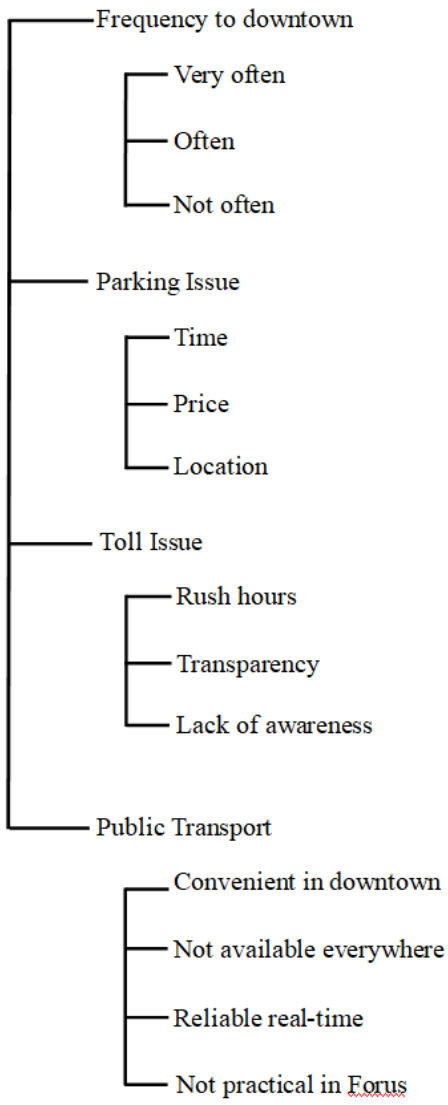
Table 5.2 Example of open coding of an interview with Respondent 1.1

Code	Interview transcript
	I: Which problems of driving you are facing now in Stavanger?
Location	**R:** Not really. Because I live right outside of Sentrum, so I usually take bus.
Toll issue	I don't use car because toll stations have ruined travelling for us.
	I: How do you decide when to use car?
Convenience of cars	**R:** It depends if I am going to buy some stuff which I need to carry then I use my bigger car. If I am going to pick up a person or meet someone then I usually use bus. I usually drive my small car but if I have to transfer or carry stuff then I use my bigger car.
Toll issue	I have problems with toll stations. Other than that, I have no major problem.
Parking issue	Parking in downtown maybe tricky sometime but not particularly. Parking cost like a lot of money to park for very short time; this is also one of the reasons I use bus. But to Forus I always take car, never taken the bus, because it is further away and more practical to drive out and drive back.
Public transport	
Convenience of cars	**I:** Have ever faced traffic jam?
	R: Usually I don't drive during rush hour; I drive before or after rush hour. And also, to Forus there is no bus lane, so bus is also stuck in same traffic.
Rush-hour avoidance	

Source: Own illustration

After open coding comes axial coding. This refers to "a set of procedures whereby data are put back together in new ways by making connections between categories" (Strauss & Corbin, 2007). In this phase, categories are generated and modified to gain insights among the codes and the connections between them. This in turns helps to reduce and reorganize the data set where synonyms are crossed out, redundant codes are removed, and the best representative codes are selected. An example of a code tree in our axial coding process is illustrated in Figure 5.2.

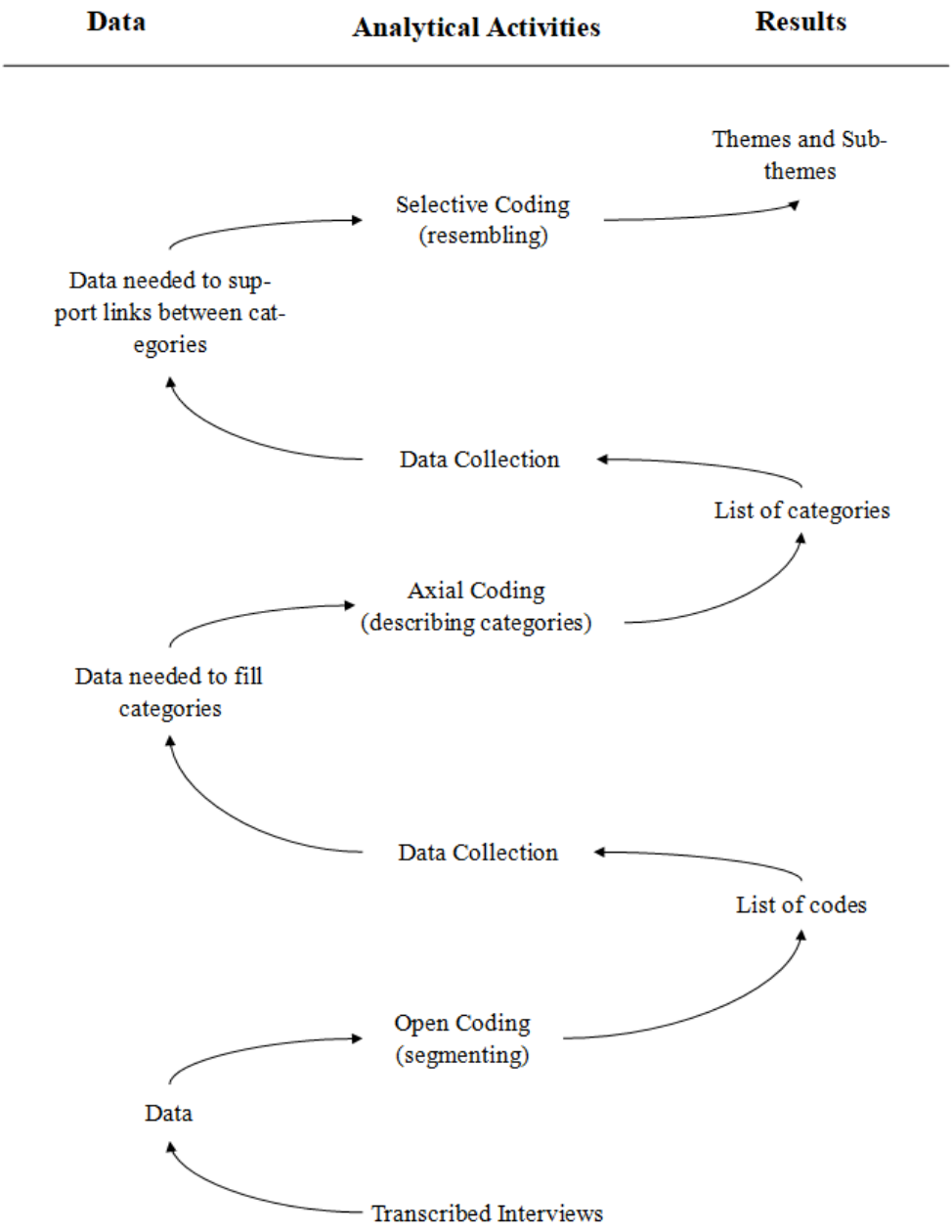
Figure 5.1 Example of a code tree in axial coding in our data analysis



Source: Own illustration

Selective coding marks the end of the coding phase. Selective coding is characterized by "connections between categories in order to make sense of what is happening in the field" (Boeije, 2010). The synthesis of data lies in the selection of core categories in order for themes to emerge. Figure 5.3 shows three separate rounds of data collection with three types of coding: open, axial, and selective coding.

Figure 5.2 The spiral of analysis integrated into coding process



Source: Own illustration combined with (Boeije, 2010)

The qualitative research process is characterized by the spiral of analysis. Although three types of coding are depicted in a linear approach in Figure 5.3 but in practice, we conducted these three activities interchangeably. Because there are some codes explicitly subject to axial coding whereas others need further exploration to reach the findings. The following chapter presents and elaborates on the themes and sub-themes generated from the spiral of analysis.

CHAPTER 6: ANALYSIS

The conceptual model illustrated in part 3.3 is a smart intervention that is expected to connect citizens with the CO_2 target of Stavanger Municipality. However, technology is just the tip of the iceberg which is never sufficient to solve a social problem. In order to make open data useful, it is critical that the government reach out to people rather than make assumptions about what they might want. By conducting user research, the conceptual model utilizing open data in part 3.3 will be targeted toward community needs. This can help the municipality act on the insights gained from that research and make open data a catalyst for action in the community (Jordan, 2018).

Therefore, this chapter laid the focus on analyzing the respondents by the "bottom-up" approach. During this analysis the conceptual model in part 3.3 will be completed based on exploring the causes of problems and the motivation of residents to facilitate the goal. As stated in part 5.1, thematic analysis was used as data analysis method. Thus, the findings are reported and discussed based themes and sub-themes.

6.1 Demographic profile of the respondents

The relationship between urban structure and travel patterns have been traditionally considered at the aggregate level by transport researchers. In order to better understand it, it is encouraged to take travel behavior of individuals into consideration (Chapin & Hightower, 1965). Since then travel behaviors have been studied from disaggregated data at the individual or household level, in the reference framework with characteristics of the built environment and a range of other determinants, primarily socio-demographic conditions such as gender, employment status, and income (Schwanen, Dijst, & Dieleman, 2005). Therefore, we believe that empirical analysis of the conceptual model in Chapter 4 can be taken by taking account of the interactions of smart city and socio-demographic characteristics of different population segments.

A profile of citizen respondents is presented in Table 6.1. In total, 16 in-depth interviews were conducted with local people in Stavanger and all 16 interviews were considered usable. Although the research initially does not aim to gain nationality variety, we end up having two foreigners as informants. The respondents therefore include Norwegian, French, Irish, and Turkish. The identities of the respondents are anonymous; therefore, the profiles only show some general information such as gender, age, living area, number of cars, fuel of the car and number of dependent children. The demographic information is important to understand the driving behavior of local people. The respondents are grouped under the criteria set by part 5.2.3.

Table 6.1 Profile of respondents

Group	No.	Gender	Age	Nationality	Career	Live near city center	Number of cars	Fuel of the car	Number of dependent children
1	1.1	Male	33	Norwegian	Student	√	2	Both diesel	0
	1.2	Female	27	Norwegian	Student	√	1	Gasoline	0
2	2.1	Male	38	Norwegian	Warehouse worker	√	1	Gasoline	2
	2.2	Male	34	Turkish	Researcher	√	1	Hybrid	2
3	3.1	Female	30	Norwegian	Client consultant	√	1	Diesel	0
	3.2	Female	34	Irish	Teacher	√	1	Hybrid	0
4	4.1	Female	67	Norwegian	Retired	√	1	Gasoline	0
	4.2	Male	56	Norwegian	Teacher	√	1	Diesel	2
5	5.1	Male	34	Norwegian	Student	×	1	Gasoline	0
	5.2	Female	22	Norwegian	Student	×	1	Gasoline	0
6	6.1	Male	39	Norwegian	Teacher	×	1	Diesel	1
	6.2	Female	36	Norwegian	Researcher	×	1	Diesel	2
7	7.1	Male	33	Norwegian	Oil engineer	×	1	Gasoline	0
	7.2	Male	34	Norwegian	Journalist	×	1	Gasoline	0
8	8.1	Female	63	Norwegian	Teacher	×	1	Gasoline	0
	8.2	Male	52	French	Self-employed	×	1	Diesel	0

Source: Own illustration

Table 6.1 is listed in the order of Table 5.1 where respondents living near city center are mentioned first, and then those living far from city center. They are students, people aged from 30 to 50 (with or without dependent children), and people aged over 50. Although, the study did not aim to achieve an equal balance of gender, both male and female were included. The study managed to achieve a wide range of age groups ranging from 22 to 63 years old with various backgrounds from students, to working people to retired people.

The majority of respondents own one car while the first student of 33 years old owns two cars. Since this student has a part-time job as a driving instructor, he has two cars with the support

of the company. The ratio between diesel and gasoline cars is 1:1. There is only one solitary hybrid car in the sample.

Besides four respondents under group 2 and group 6 purposively chosen to have dependent kids mentioned in part 5.2.3, there is one extra respondent having kids, who belongs to group 4. As such in total there are five cases of having dependent children. The remaining interviewees do not have dependent children. Except students and retired people, the rest of the respondents have a full-time job.

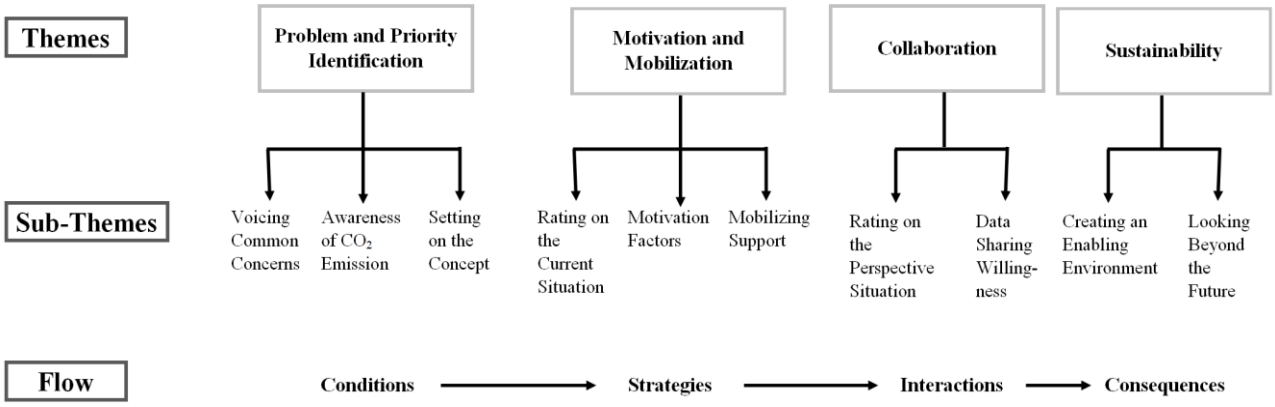
6.2 Thematic analysis

The approach to build features for the applications used by citizens is a process of development-focused collaboration among various stakeholders. At this beginning stage, the research aims to focus on the needs of citizens. The underlying theory of this analysis is that "collaboration increases the productivity of resources and creates the necessary and sufficient conditions for community-driven development" (Bowen, 2005). Therefore, the structure of this chapter represents a people-centered approach to achieve a collective CO_2 goal. Local actors thereby take the lead in conceptualizing the application that address their social needs. The application is developed from local-level problems by involving the prospective local users from the beginning.

For our data analysis, we decided to conduct a thematic analysis as a qualitative research method that are widely used across a range of epistemologies and research questions (Nowell, Norris, White, & Moules, 2017). In this way, themes and sub-themes generated from the spiral analysis in part 5.4 can be described and reported in a systematic manner. As confirmed by (King, 2004), thematic analysis allows the researchers to take a well-structured approach to summarizing key features of fragmented data set handling and helping to produce a clear and organized final report. Since there are eight distinct cohorts of respondents in this research, thematic analysis is a useful method to compare and contrast similarities and differences in their perspectives (Braun & Clarke, 2006). Hence unanticipated insights can be gained. Also, we combined quantitative data in this qualitative research, so thematic analysis is a right choice to enable those languages to communicate with each other (Boyatzis, 1998).

Based on the inductive approach of qualitative method, patterns in the data are identifies by means of thematic codes. Recurrent patterns and linkages among the codes and categories through the spiral analysis are then organized into distinct themes and sub-themes as illustrated in Figure 6.1.

Figure 6.1 Themes and sub-themes generated from the interviews



Source: Own illustration

Four themes that emerged from the data are indicated as (1) Problem and priority identification, (2) Motivation and mobilization, (3) Collaboration, and (4) Sustainability, which shape the backbones of further analysis below. Under each theme, there are several sub-themes to support better understanding and illustration.

6.3 Problem and priority identification

At the initial stage, an array of social and environmental problems is identified and discussed in relation to eight cohorts of respondents mentioned in part 6.1. Then the features of the application are built based on priorities of the prevailing conditions and the informants' ideas about ways to deal with the problems.

Therefore, the theme of "Problem and priority identification" is divided into three sub-themes: (1) Voicing common concerns, (2) Awareness of CO_2 emissions, and (3) Settling on the concepts.

6.3.1 Voicing common concerns

Driving problems in Stavanger are identified by eight different cohorts as mentioned in part 5.2.3 as the basis of the social needs that will eventually be addressed by the application. Table 1 provides an overview of the eight cohorts with their related comments to the codes. Differences in frequency of comments are described with statistical comparison, as mentioned by Mason (2002) in part 5.2.1 and Boeije (2010) in part 5.2.2 that the purposeful sampling design to some extent provide better "analytical generalization". The following discussion describes each code with illustrative comments.

Table 6.2 Common driving concern in Stavanger cited by eight cohorts of respondents

Codes	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Group 6**	**Group 7**	**Group 8**	**Total (N=16)**	**Total (N=100%)**
Frequency to travel downtown	Often (2)	Very often (2)	- Often (1) - Very often (1)	- Not often (1) - Very often (1)	Often (2)	Often (2)	Often (2)	- Not often (1) - Very often (1)	Often: 9 Very often: 5 Not often: 2	Often: 56% Very often: 31% Not often: 13%
Parking space issue	2	1	0	1	1	1	0	1	7	44%
Traffic jam issue	2	2	2	1	2	2	2	1	14	88%
Toll issue	0	2	1	1	0	1	0	1	6	38%
Rush hour fee issue	0	2	2	0	0	0	0	0	4	25%
Speed limit issue	0	0	0	0	0	0	0	0	0	0%
Time adjustment to avoid traffic	0	2	1	1	1	0	0	1	6	38%
Convenient route for children	N/A	2	N/A	1, N/A	N/A	2	N/A	N/A	5	100%*
Public transport / Walking preferred in downtown	1	0	1	2	0	0	2	1	7	44%

Source: Own illustration

Legend:

** (special case with N=5): As mentioned in part 6.1, there are totally five respondents having dependent kids. Therefore, the ratio is conducted on the denominator of 5.*

Very often = more than twice a week

Often = once a week or similar

Not often = once a month or similar

0, 1, 2: number of respondents per group having the particular code
N/A: people do not have dependent kids to drive them to school

As can be seen from Table 6.2, the demand of going downtown is very strong in Stavanger for different purposes such as recreational activities, shopping, or work. More than 80 percent of respondents go to the city center on a regular basis, 30 percent of whom travel downtown very often. It is obvious that group 1, group 2, group 3 and group 4 who live close to the city center have the tendency to be there more often that the remaining groups. The same practice applies to people having kids (group 2 and group 6) because of their activities. Some quotes are cited below:

"Could be shopping, could be work […] when I work with a client in the city center, I obviously travel there every day." (Respondent 3.1)
"I have small kids. I often take them to the library in city center for them to read and have some activities. I sometimes go to the cinema too." (Respondent 2.1)
"I try not to use my car much but then my son needs to go to some places for activities." (Respondent 6.2)

When it comes to the means of transport to go to city center, nearly half of the respondents preferably opt to take bus, walk or ride a bike depending on how close they live. Comments are included:

"Because I live right outside the city center, so I usually take bus. I don't use car because toll stations have ruined travelling for us." (Respondent 1.1)
"I mostly walk. I never drive." (Respondent 3.2)
"We do often take bus to go to town. We don't drive there very much." (Respondent 4.1)
"When I go to the city center, I prefer to take a bus rather than a car." (Respondent 7.2)

The parents with small kids however do not face problem of driving kids to school. The reason is that in Stavanger, kindergartens and schools are located in close proximity to the residential area. Children are prioritized to be allocated to kindergarten and school places through the use of kindergarten catchment areas (similar to school catchment areas). As a result, wherever possible, kindergartens must not lie on the other side of a toll zone boundary in relation to the home (Stavanger City Council, 2018). Some respondents' reviews are cited below:

"That's not very inconvenient because both the kindergarten and primary school are pretty close to where we live." (Respondent 2.1)
"The route is very straightforward. There is no problem. The school is only 5 kilometers from home." (Respondent 2.2)
"He can take bus, so I let him go to school by himself." (Respondent 6.1)

There are prevalent issues repeatedly cited by people such as traffic jam, parking space, toll and rush-hour fee. 88 percent of respondents are concerned about the traffic jam, mostly in the city center and in Forus, which is the headquarter of multiple oil and gas companies. These two particular places have attracted the most traffic during rush hours when people commute to work although several toll booths have been strategically put in place to discourage driving into these areas. The comments of respondents are:

"But to Forus I always take car. I have never taken a bus there. To Forus there is no bus lane, so buses are stuck in the same traffic." (Respondent 1.1)
"Rush-hour traffic, especially in the city center, is a problem." (Respondent 2.2)
"Traffic jam every day from here […] so many people working in Forus." (Respondent 3.1)
"I have to wait in the queue a certain time of the day." (Respondent 6.2)

Being accustomed to the local traffic, people choose to flexibly adjust their time to avoid rush-hour fee and traffic jam. It indicates that rush-hour fee works to reduce the traffic during "rush hours", but the demand to travel by car of citizens is not significantly scaled down. However, it is the driving pattern that is shifted. As a result, there are more and more people coming to work earlier or delaying going home to avoid the congestion, which triggers the traffic jam in another way: "It feels like the rush hour is before 7 now" (Respondent 2.1).

Some comments related to the modified driving habit of citizens include:
"I drive before or after the rush hour." (Respondent 1.1)
"It (rush-hour fee) changes the driving pattern for the people who can't actually change their working time." (Respondent 2.1)
"Now that they introduced the rush-hour fee, I foresee the traffic being smaller than it has been in the last few months." (Respondent 5.1)
"My travel is before and after rush hours." (Respondent 5.2)

Another type of problem is finding a parking lot, but this is not as popular as the traffic jam as said by Respondent 1.1 and 5.1:

"Parking in downtown may be tricky some time. […] Parking costs a lot of money for a very short time." (Respondent 1.1)
"I have problem when going to the downtown area because the tolls are around that so there is more money involved." (Respondent 5.1)

Regarding the toll fee and rush-hour fee, most of the informants do not have problem of paying for that since it is the national law and legally binding. However, it is a matter of checking the amount of money associated with the route they have taken in order to make sure of the proper charging. Therefore, they accept the number and pay for it when the invoice comes without paying attention to the details. According to Respondent 2.2, knowing the toll payment in real time can help citizens to have a more efficient trip. Other concerns of tolls are excerpted:

"It's bothering me because I can't check the details. So that's luck or out of luck. I want to have control over that. Like every time I pass a toll, I know a certain amount has been deducted. […] that it costs zero because I pass within an hour." (Respondent 2.1)
"It is not real time, so I guess it causes problem. […] it would be good if it was real time to see the balance amount because maybe it would help to organize your trip in a better way." (Respondent 2.2)
"If you do a journey to Forus you go through three toll stations, do you pay for all three or just one? I just don't understand, and I don't really know how to access the information." (Respondent 3.2)
"I don't know how to check it. I have to find that out." (Respondent 6.2)
"I have to trace my last six months to see where I have travelled, and it is really hard to keep track of my travelling. To me it is a very obscure system." (Respondent 8.2)

None of the respondents finds it difficult to drive at the proper limit although most of their car do not have the function of sign detector. As a result, they have to pay attention to the sign along the roads without the support of any device in case they get lost or forget to see the sign first. Some comments include:

"By reading the sign. […] where there are a lot of houses, it's 60 km/h and where there are no houses, it's 80." (Respondent 2.1)
"I usually read it from sign boards next to the road." (Respondent 5.2)

However, foreigners initially often have trouble with following the speed limit signs in Stavanger since the traffic rules and law varies from country to country. Yet it is perceived to be a good point of discipline to follow in Stavanger traffic. Respondent 2.2 said: "It was difficult for me to drive here because I'm coming from Turkey and rules are not much followed there. But here rules are followed strictly and now I am comfortable with it."

All in all, there exists high demand of citizens across different cohorts to travel downtown. The travelling habit is to take public transport to avoid traffic and toll fee. However, when it comes to other areas such as Forus people would not be willing to take bus. Traffic jam is the most cited problem in the municipality. In order to avoid it, people have a tendency to adjust their time to drive on the street but somehow it causes another common pattern among them. As such, traffic jam moves to another time frame which is sooner or later than usual. Besides the traffic jam, finding a parking space and checking the toll payment are of the interest in knowing in real time by citizens.

6.3.2 Awareness of CO_2 emissions

Although Stavanger Municipality has acted on facilitating the primary objective of cutting CO_2 emissions from the transport sector (47 percent of CO_2 comes from passenger cars) by 80 percent by 2030 in relation to 2015 and reaching 100 percent by 2040, most of the respondents are not highly aware of their role in realizing this collective goal. The respondents do not perceive themselves as a positive contributor to the initiative and the community. They rather see the CO_2 emissions from the perspective of cost saving for drivers as described by respondent 1.1 that "Emissions are not the main thing, it is the economy of the car", however, they wish to have a more proactive role in the future. Table 6.3 illustrates the response of informants regarding their own car emissions, their knowledge about EU control including CO_2 condition, and their view about the importance of CO_2 target of the municipality and how it is related to their personal life. The codes are labelled as "own car emissions", "EU control", "CO_2 goal", and "Related", respectively.

Table 6.3 Rating the responses regarding to CO_2 emissions – Important but not relevant

Code	**Own car emissions**	**EU control**	**CO_2 goal**	**Related**
Respondent 1.1	1	1	2	0
Respondent 1.2	0	0	2	0
Respondent 2.1	0	0	1	0
Respondent 2.2	0	1	2	1
Respondent 3.1	0	0	1	1
Respondent 3.2	0	1	1	1
Respondent 4.1	0	0	1	1
Respondent 4.2	0	0	2	2
Respondent 5.1	0	0	2	0
Respondent 5.2	0	0	2	1
Respondent 6.1	0	0	2	0
Respondent 6.2	0	0	2	1
Respondent 7.1	0	0	0	0
Respondent 7.2	0	1	2	1
Respondent 8.1	0	1	2	0
Respondent 8.2	0	0	2	1

Source: Own illustration

Legend:

For code "Own car emissions" and "EU control": 1 = aware, 0 = not aware

For code "CO_2 goal" and "Related": 2 = highly important/highly related; 1 = quite important/quite related; 0 = not important/not related

The matrix data in Table 6.3 highlights several key findings.

First, the knowledge about car emissions is very limited and is not seen as an important factor to the environment by car drivers. Too many zeros for the code "Own car emissions" implies that they are not very well aware of their emissions. There is also a small number of respondents knowing that their car is subject to CO_2 test in the EU control. Fifteen out of sixteen informants cited similar answers such as "Not that much", "I don't know", "Nothing at all" or "Very low" when it comes to CO_2 emissions from their car. The age of the car and the fuel consumption

are often referred to as educated guesses for respondents to estimate how polluted their car is to the environment. Some comments are:

"Better fuel consumption means lower emissions." (Respondent 1.1)
"We have a new car of one year old. Since it is a new car, it would have less emission than cars of 8-10 years old, but I don't know the exact amount." (Respondent 4.1)

Respondent 1.1 is the only respondent that knows about CO_2 emissions from his car. Because his old car experienced technical issues of high CO_2 emissions during the EU control test. Since then he has invested in buying a small sensor for his own car to check on the gas status by himself in order to avoid the repeating problem.

Second, the importance of CO_2 emissions goal of the municipality is communicated quite well to the citizens. Most of them perceive the critical role of having a target for the community to strive for together. Some constructive views are excerpted:

"It is a good goal. We need to take care of the environment." (Respondent 1.1)
"Putting a target that can be achieved some time in the future by the municipality is a good thing." (Respondent 2.2)
"I think it is very important. They need some target for direction and some measures in order to achieve that." (Respondent 6.2)

Taking public transportation or cycling or walking is a means for the informants to see themselves contributing to the municipality target, albeit not in a clear visualizable way. According to respondent 4.2, as "a member of environmental party in Stavanger", cycling is his family's habit to have a positive influence on the environment.

However, the third point drawn from Table 6.3 is that the magnitude of the CO_2 importance and the magnitude of its relation to personal life do not consistently go hand in hand. The zeros for code "Related" are in stark contrast with the twos for code "CO_2 goal" for the same informants. This means that citizens are not completely engaged to the municipality's environmental activities as much as they think they should be. This means that the high awareness of the municipal target of CO_2 reduction on the surface through social media does not guarantee the success of target internalization into their personal life. Most of the reasons

cited by the respondents below are a lack of knowledge for their own cars, a very big collective target of CO_2 reduction and a low motivation to get engaged. This therefore calls for more collaboration improvement in the future. The inconsistence between the importance of CO_2 goal and the motivations to work for it is illustrated below:

"I think it is on a very big scale. It looks very big from my side. But of course, citizens like me should have, in some way, our personal responsibility to think about it." (Respondent 2.1)
"I think it's important but at the same time I feel guilty because I don't know much about it regarding to my car." (Respondent 3.1)
"I'm quite skeptical. I just feel it's a target, but someone has to take control of making decisions and reducing it." (Respondent 3.2)
"It's difficult to relate the goal to your life if you can't see how much you contribute to it that day. If you just have your value and an abstract collective goal by 2050, it's not relatable. My head isn't capable of thinking something big like that. I need something short, sweet and relatable. Then I will be interested." (Respondent 5.1)
"CO_2 issue causes global warming. But sometimes things left uncertainty or things are far ahead in future and people think that this is something which is not bothering us now, so they don't feel related." (Respondent 6.1)

6.3.3 Settling on the concepts

Now that several problems and needs from the citizens, particularly the car drivers have been identified, the municipality should make a choice as to which problem or need they would deal with first. The core reason that can explain why environmental initiatives proposed by the municipality and the engagement of the citizens fall apart is a lack of collaboration, which is an intrinsic drive to make cities "smart". It has become clear that achieving ambitious climate protection target, specifically CO_2 emission reduction, is hardly possible without sufficient cooperation from inhabitants.

An empirical research by Cimander (2012) reveals that online media, CO_2 calculation and feedback on the Internet help the citizens better with reducing their CO_2 emissions than traditional media and peer-to-peer approach. In order to provide sustainable learning for citizens in the area of climate protection, an e-platform is therefore needed. In this way, information can save the energy. As cited by respondent 7.2, it is interesting for the car drivers to be more conscious about how they are affecting the environment. Knowing the individual impact of travelling habits might lead to behavioral changes with less pollution. Also, citizens would like to see the progress of the municipality and their own effort against the target. Although tackling

CO_2 emissions appears to be “on a very big scale” for citizens to have “personal responsibility to think about it” (Respondent 2.1), respondent 5.1 suggested breaking down the goal from a decade into a year, from a year to months and days and kept track of it on an accumulative way “illustrated in a circle with the green, red, and yellow signals”.

A non-established competition to perform better than other people in the neighborhood is found to be contributing to the CO_2 reduction. The own ambition to improve the CO_2 balance can be boosted if measurements and comparisons are made available to citizens. Some representative comments include:

“It could be cool to see the neighborhood effect. […] you can see how you are rated compared to others, so you feel that you are doing better. If I am doing worse, I can try to adjust.” (Respondent 6.2)

“My car shows real time fuel consumption. And that’s quite interesting to look at and easier on the gas pedal. It makes me feel like a competition. So, I want to keep it as low as possible. Maybe it will be the same if someone tells me about the CO_2 emissions as well.” (Respondent 7.2)

6.4 Motivation and mobilization

After identifying the priority to focus on social collaboration, it is necessary to motivate citizens based on their personal demand and mobilize support from them to achieve the collective agreement. The prevailing conditions shown in part 6.3.1 help to produce strategies at this the second stage of the collaboration process.

Three sub-themes are (1) Rating on the current situation, (2) Motivation factors and (3) Mobilizing support would shed the light on how to motivate and mobilize the support of citizens.

6.4.1 Rating on the current situation

As a quick reflection of part 6.3, the current situation of traffic and citizen engagement is evaluated in quantifiable data by taking the comments of respondents into consideration. Respondents are asked to rate the current traffic and citizen engagement from 1 to 5, in which 1 is the worst and 5 is the best.

Table 6.4 Evaluation of respondents regarding current traffic circumstance and citizen engagement

Code	**Current traffic**	**Citizen engagement**
Respondent 1.1	3	2
Respondent 1.2	3	3
Respondent 2.1	4	2
Respondent 2.2	4	0
Respondent 3.1	2	2
Respondent 3.2	4	0
Respondent 4.1	3	3
Respondent 4.2	2	3
Respondent 5.1	4	2
Respondent 5.2	2	0
Respondent 6.1	3	0
Respondent 6.2	3	0
Respondent 7.1	3	0
Respondent 7.2	3	3
Respondent 8.1	4	1
Respondent 8.2	2	3
Average	*3*	*1.5*

Source: Own illustration

Legend: from 1 to 5, in which 1 is the worst and 5 is the best

As can be seen from Table 6.4, the average rating for current traffic in Stavanger is 3 out of 5 while that for citizen engagement in the municipality's environment activities is merely 1.5. Regarding the traffic, the local sense is often used as a tool for drivers to achieve the most comfortable drive. As said by Respondent 5.1, "This is one thing important when I say 4. I'm from here. I know the traffic pattern. I know where rush traffic is usually is. I know how to avoid it if I can. Sometimes it's unavoidable. But if outsiders come in here, they will rate probably 1 or 2 I guess."

Speaking of this, it is also noticeable during the interviews that foreigners who cannot speak Norwegian feel not engaged much in the municipality's activities due to the language barrier. Some comments of foreign respondents are included:

"For me I don't. The most important problem is the language barrier. Most of the things are in Norwegian and I don't speak Norwegian now. But I am not aware of other local Norwegian people if they are engaged or not." (Respondent 2.2)
"I don't feel like I've received any information. Maybe in Norway there's a definite sense that people need to use cars less. But I'm not sure because we live in the city center, and our neighbors prefer to stay in the local area. They are Norwegian, so maybe they are more engaged." (Respondent 3.2)

However, the situation of involvement in the community project is not much better as reported by some Norwegian respondents. The comments include:

"I don't know. I'm not aware of any activities." (Respondent 7.1)
"It is not because the municipality board is doing a lot of things that nobody really cares about. Very often people don't like the consequences what they do. There is a lot of political power. If they want to have most of the citizens participate, they should let them be able to part of the decision." (Respondent 8.1)

6.4.2 Motivation factors

As mentioned in part 6.3.2, local people already have good knowledge about the importance of the municipality target but the inclination to pursue the municipality's goal is not at the same level. The overall traffic is good enough on average for local people (average rating is 3 out of 5 according to part 6.4.1). However, the engagement level is quite low (average rating is 1.5 out of 5 according to part 6.4.1). Therefore, it is necessary to explore the motivation factors that can both improve the traffic and enhance the engagement, and consequently make the target more feasible at the individual level.
With the introduction of real-time CO_2 sensor at every toll booth as mentioned in part 4.3, the concept can provide citizens with their car emissions in real time through an online application. As such it is expected to raise the drivers' awareness of their carbon footprint in order to adjust their behaviors. Together with this main feature, other features would be developed from the

needs of citizens to address their real-life issues. Table 6.5 is a summary of quotes demonstrating the wishes of car drivers to improve the traffic.

Table 6.5 Suggestions from respondents for other features of the mobile application

Code	**Example from the interviews**
CO_2 indicator	"If the car is emitting way too much CO_2 on average then there is really something mechanically wrong with it. Maybe it gets the wrong mixture. There is leakage somewhere. So, this is a way to see troubles." (Respondent 1.1) "If this app can also check the level of CO_2 emissions that EU control requires, then it is a good indicator. I would fix my engine to reduce CO_2 emissions." (Respondent 6.1)
CO_2 Comparison/Competition	"Could be a nice thing that you are able to see whose car it is, to see what kind of car it is in your neighborhood but not identify the exact car. You can have the type of car in the region or the general average amount of CO_2 in your neighborhood. So, it's a nice possibility to compare." (Respondent 8.1)
CO_2 target follow-up	"The target and the progress should be visible and updated. The goal should be broken down to every citizen, illustrated in a circle with the green, red and yellow signals." (Respondent 5.1)
Municipality update	"I haven't quite mastered how the municipality distribute its information. For me it would be really great if they have updates like "new toll roads" or any activities through the app". (Respondent 3.2)
Interaction with the municipality	"I don't have many apps to use but if there is an app which I can interact with the municipality directly, I would try to learn to use." (Respondent 4.1)
Real-time toll payment	"If it is real time, it is very practical. Like every time I pass a toll, I know a certain amount has been deducted. And I also hope it will also tell me that it costs zero because I pass within an hour. So, it's really nice to know that." (Respondent 2.1)
Real-time traffic jam	"It would be nice to know where the traffic is in advance so I can avoid wasting my time and fuel in the queue." (Respondent 1.2)

Environmentally friendly route	"I would like to have an app that can calculate the most efficient route by looking on the traffic. It can suggest the road than it normally would, which might be longer but faster because I can avoid the traffic jam. In this sense, it would be quite environmentally-friendly." (Respondent 7.2)
Real-time parking lot	"I am a newcomer to Stavanger. I am not used to the parking system here. I don't know to find it out in advance unless I really drive to the place. If it's full, then I have to drive around and hope." (Respondent 3.2)

Source: Own illustration

As can be seen from Table 6.5, the respondents would like to insert other functions to the conceptual model in order to solve their driving issues which are already discovered in part 6.3.1 such as toll payment issue, traffic jam issue and parking lot issue. The corresponding solutions are real-time toll payment, real-time traffic jam and real-time parking lot. An addition function related to driving is demonstrating the most environmentally friendly route with the estimated least carbon footprint.

In order to enhance the citizen engagement, the respondents themselves would like to receive updates from the municipality on its news and activities through this mobile application. Also, they wish to interact with the municipality via this platform.

Besides the main feature of showing real-time CO_2 emissions from cars, there are three implied factors that are appreciated by the respondents. First, CO_2 emissions can play as an instrument for drivers to be aware of the technical performance of their car. By taking the standard CO_2 emissions of EU Control and the average CO_2 emissions of the same model into consideration, the mobile application can make a signal to drivers about their car status. Second, people have the tendency to be more enthusiastic when it comes to comparison or competition. They always want to become better in the region, so they would have motivation to strive for a more individual goal. Third, the progress against the CO_2 goal of both municipality and citizens should be updated on a frequent basis. It is showing the dynamic partnership between citizens and the municipality in realizing the ambitious goal together.

Speaking of the competition, Stavanger Municipality is divided into seven boroughs: Eiganes and Våland, Hundvåg, Madla, Tasta, Storhaug, Hinna and Hillevåg (Stavanger, 2019). Under boroughs, there are different neighborhoods. Forus is within Hinna's area, however, it is also spread out over three different municipalities (Sola, Sandnes and Stavanger). For the purpose of clarity in this thesis, Forus will be used as a separate entity to avoid confusion. Therefore

there are 26 neighborhoods in Stavanger Municipality: Byhaugen, Old Stavanger, Bekkefaret, Bergjeland, Eiganes, Forus, Gausel, Godeset, Indre Tasta, Jåtten, Johannes, Kampen, Kvalaberg, Kvernevik, Madlamark, Nylund, Øyane, Paradis, Stokka, Sunde, Tjensvoll, Ullandhaug, Våland, Varden, Vaulen, and Ytre Tasta. Based on this geographical structure, CO_2 emissions can be traced back to each neighbourhood, thus motivating each of them to strive for their CO_2 reduction.

6.4.3 Mobilizing support

The influencing effect of addressing social concerns of part 6.3.1 on the willingness to collaborate in the municipality's CO_2 target is mentioned during the interviews, as mentioned in part 6.4.2. As such the respondents elaborated their motivation factors to contribute to the environmental activities; these factors would be conceptually developed in the mobile application used by citizens and suggested by them. This concept refers to a "bottom-up" approach where "smart city" initiatives place citizens ahead of technology to design future together. In other words, this is a citizen-centric model where the collective overarching goal is shared by all stakeholders.

The next step after motivating citizens to take part in social projects is mobilizing their support. In order to see how the concept of mobile application for citizens regarding CO_2 responds to their needs, a small survey included in the interview was made. Four codes have been recorded as "Current mobile apps" (asking the respondents which mobile applications they are using to support their driving), "Liking" (asking how much they like the concept that would integrate all features in part 6.4.2), "Like best" (asking which feature they like best), and "Like least" (asking which feature they like least). Table 6.6 summarizes the answers of 16 respondents.

Table 6.6 Summary of mobilizing support from the respondents

Code	**Current mobile apps**	**Liking**	**Like best**	**Like least**
Respondent 1.1	Google map, Kolumbus, Kolumbus Sanntid	5	CO_2	Route suggestion
Respondent 1.2	None	5	Parking	Toll payment
Respondent 2.1	Easypark	5	Toll payment	Speed limit

Respondent 2.2	Google map, Easypark, Kolumbus	4	Toll payment, CO_2	Speed limit
Respondent 3.1	Google map	4	CO_2	Toll payment
Respondent 3.2	Google map	5	Toll payment, CO_2	Speed limit, traffic jam
Respondent 4.1	Kolumbus, Min traffik	4	Route suggestion, municipality interaction	Speed limit, CO_2
Respondent 4.2	None	4	CO_2	Route suggestion
Respondent 5.1	Easypark	4	Toll payment, traffic jam	CO_2
Respondent 5.2	Google map, Kolumbus	5	CO_2	Parking
Respondent 6.1	Google map, Wayze	5	Route suggestion	Signals
Respondent 6.2	Kolumbus	5	Toll payment, route suggestion	Parking, traffic jam
Respondent 7.1	Google map, Kolumbus, Easypark	5	Route suggestion	Speed limit
Respondent 7.2	Google map	4	Traffic jam	Parking
Respondent 8.1	Apple map, Ways	5	Traffic jam	CO_2
Respondent 8.2	Google map	4	Route suggestion, parking	Speed limit
Most/Average	**Google map**	**4.6**	**CO_2**	**Speed limit**

Source: Own illustration

According to Table 6.6, the respondents use Google map the most to support their driving mainly in terms of foreseeing the traffic jam by "marking out the red area which has a lot of

traffic" (Respondent 7.2). Besides, the local bus applications named Kolumbus are also popular among the respondents because nearly half of them prefer to take bus to go to the city center as shown in part 6.3.1. They are "Kolumbus Billett" to buy the tickets, "Kolumbus Reise" to search for the trips, and "Kolumbus Sanntid" to see the busses in real time.

The idea of having an application developed from their own practical needs is highly appreciated by all of the respondents. The average rating for the mobile application on the scale from 1 to 5 is at 4.6, which is nearly the maximal point. Respondent 8.1 says "It's nice to have everything on one place rather than many places." Similar comments have been collected as being "useful" (Respondent 7.2) and "interesting" (Respondent 5.1). It is not surprising to guess "Speed limit" as the least concern to the respondents since it is not identified as the common concern in part 6.3.1, but it is interesting to have features related to CO_2 as the most favorite point of the respondents. CO_2 listed in the Table represents four features of the mobile application: Real-time CO_2 emissions, CO_2 indicator, CO_2 Comparison/Competition, and CO_2 target follow-up, as shown in part 6.4.2.

6.5 Collaboration

After recognizing problems and identifying priorities in part 6.3, exploring motivation factors and mobilizing support in part 6.4, the third stage is focusing on developing collaboration between citizens and the municipality. First, taking the results from part 6.3 and 6.4 into consideration, positive results are expected to foster the community relationship, cooperation and unity. Second, in order to make the application successful, all available resources need to get pooled on the condition that citizens accept to share their data with the open data of Stavanger Municipality.

The theme "Collaboration" of this part therefore encompasses two corresponding sub-themes: (1) Rating on the prospective situation (with the mobile application), and (2) Data sharing willingness.

6.5.1 Rating on the prospective situation

In connection with part 6.4.1, this part aims to bring the same content but with different results. Assuming the mobile application with all features listed in part 6.4.2 is already available and can be used by the respondents, they are asked to rate the prospective traffic and citizen engagement from 1 to 5, in which 1 is the worst and 5 is the best.

Table 6.7 Evaluation of respondents regarding prospective traffic circumstance and citizen engagement

Code	**Prospective traffic**	**Prospective citizen engagement**
Respondent 1.1	5	4
Respondent 1.2	4	3
Respondent 2.1	4	3
Respondent 2.2	5	4
Respondent 3.1	4	3
Respondent 3.2	5	4
Respondent 4.1	3	3
Respondent 4.2	4	4
Respondent 5.1	5	3
Respondent 5.2	4	3
Respondent 6.1	5	2
Respondent 6.2	5	3
Respondent 7.1	5	2
Respondent 7.2	4	4
Respondent 8.1	5	3
Respondent 8.2	4	4
Average	*4.2*	*3.3*

Source: Own illustration

Legend: from 1 to 5, in which 1 is the worst and 5 is the best

Compared to the results from part 6.4.1 where the current traffic and citizen engagement are rated 3 and 1.5 respectively, Table 6.7 shows a significant improvement. Once the real needs of the respondents are addressed through the features of the mobile application as shown in part 6.4.2, people have more confidence in better traffic and engagement with the municipality. This is expressed through the average rating for the prospective traffic of 4.2 out of 5 and the engagement of 3.3, assumed to be brought by developing the mobile application. The motivation factors in part 6.4.2 in addition to the support in part 6.4.3 can be seen as the explanation for an increase in the belief of the respondents from 3 to 4.2 in terms of traffic rating. Because most of the common concerns described in part 6.3.1 are now solved.

The engagement with the municipality looks also optimistic with the existence of the application. In particular, the rating in Table 6.7 is more than double the previous one in Table 6.4 (part 6.4.1) (3.3 versus 1.5). Some positive comments include:

"Many people just don't care about what the municipality is doing. But if they have an app like this to interact, then it would be a chance for a person to be more interested in such activities." (Respondent 1.1)

"It would show my personal contribution. I would feel as part of the system." (Respondent 2.2)

"There's more transparency and information now. I'm able to engage with them." (Respondent 3.2)

"Maybe if I have some questions that I want to ask the municipality, now I have an easy tool to do that." (Respondent 6.1)

"It sounds like it is easier to interact with them now." (Respondent 7.2)

"The application helps to raise the concern. And it is not a negative concern. It's a positive one." (Respondent 8.2)

6.5.2 Data sharing willingness

The mobile application is only a success if an amount of data is being generated by both public and individual on an ongoing basis. This data is taken from the open data of the municipality, any current available data portal, and on individual electronic devices, in this case personal data of car drivers from their mobile application. An open database should permit the two-way flow of information. This means that anyone can gain access to or contribute to information about the city.

Regarding the privacy concerns, anonymity must be ensured to prevent misuse of an identifiable individual's behavior or personal history, especially in Europe when the General Data Protection Regulation (GDPR) took effect in 2018. As such it may directly influence on how the municipality implements the data management retrieved from the citizens' mobile application to allow citizens a more active role in decision-making processes. The interview also includes questions related to how willing the respondents would be to share their personal data from the application with the municipality and other people as illustrated in Table 6.8.

Table 6.8 Respondents' awareness of open data and personal data sharing willingness

Code	**Awareness of open data**	**Willing to share data with the municipality**	**Willing to share data with other people**
Respondent 1.1	×	√	√
Respondent 1.2	×	√	√
Respondent 2.1	×	√	√
Respondent 2.2	√	√	√
Respondent 3.1	×	√	√
Respondent 3.2	×	√	√
Respondent 4.1	×	√	√
Respondent 4.2	×	√	√
Respondent 5.1	×	√	√
Respondent 5.2	×	√	√
Respondent 6.1	×	√	√
Respondent 6.2	×	√	√
Respondent 7.1	×	√	√
Respondent 7.2	×	√	√
Respondent 8.1	√	√	√
Respondent 8.2	×	√	√

Source: Own illustration

While Stavanger smart city is making their data publicly accessible, the open data portal has yet to take off, with a very small percentage of the respondents (12%) knowing this. The findings of a research about open data works reveal that processes of collaborative learning might be hampered by the absence of a shared cognitive framework for understanding open data and a lack of high-quality datasets (Ruijer, Grimmelikhuijsen, Berg, & Meijer, 2018). A majority of the respondents (14 out of 16 respondents) are not aware that the information exists. Two respondents are aware of the open data but fail to know how they will be able to use it for their decision-making process and engaging with the local government. Some comments include:

"I'm aware of the open data but I have never visited it." (Respondent 2.2)

"I think there is quite a lot of information on open data that is not available for use by the public because the data is there but no one estimates and give in-depths." (Respondent 8.1)

When it comes to the open data website of the municipality, the language barrier exists for some foreigners who cannot speak Norwegian. Because of this, citizens might feel more difficult to understand the system and less motivated to keep studying it. An example is cited below:

"I think maybe it's hard. I know a lot of stuff is translated into English. And I'm trying to learn Norwegian, but I don't know if the information is so dynamic." (Respondent 3.2)

The conceptual mobile application for car drivers described in part 6.4.2 aims to take advantage of the current open datasets related to traffic and call for citizens' openness to share their CO_2 data with the urban platform in order to achieve transparency and accountability, or better service delivery to citizens. Speaking of this, all of the respondents find it comfortable to share their CO_2 data with the municipality's open data with the purpose of enhancing their quality of life and not tracking their travelling. Some comments are included:

"If it's used on enhancing my life, then yes. If not, I don't want to get controlled by them. It sounds that this is a tool for them to raise tax to people who have cars like I do." (Respondent 2.1)

"I would not be comfortable if you track me when I am travelling all the time. I would not be aware of how the data is stored. Then I would feel like under control." (Respondent 6.2)

6.6 Sustainability

The most sustainable results for a smart city stem from people who live in it. The application developed from their own needs helps to change the role of citizens from passive recipients to active agents.

Two sub-themes, namely (1) Creating an enabling environment, and (2) Looking beyond the present would discuss how the application makes a smart city sustainable.

6.6.1 Creating an enabling environment

The existence of the mobile application described in part 6.4.2 can be used as a good tool to integrate the CO_2 goal of the municipality with the interests of average citizens to create an enabling environment. According to (Bowen G. , 2003), an enabling environment is "the aggregate of social circumstances or conditions in which local actors have the means, capacity, and opportunity to be agents of their community's endogenous development." Creating an

enabling environment in Stavanger therefore is a gradual and ongoing process that takes the voices and views of ordinary people into account. As a result, the smart city has active citizens who have knowledge about the collective goal and the individual target coupled with the corresponding contribution. Most of the informants hold a positive perspective about changing their behaviors to improve the environment if they are aware of their CO_2 footprint. The interest of sustaining their support to reduce CO_2 emissions is revealed in the following quotes:

"I would choose my route with the least carbon footprint by looking at this app. I will feel more relaxed by thinking that I am not polluting that much." (Respondent 2.2)
"CO_2 feature is the best feature of this app. It will really help me to control myself for reducing CO_2 emissions. This app would have some positive impact for making Stavanger greener." (Respondent 4.2)
"I will be more aware and obviously I will take more actions. Because if I am not aware of how much CO_2 I am contributing then I don't know how to help the municipality. But if I have this information available, then I would be happy to contribute." (Respondent 5.2)
"If I have this app, I will try to emit less CO_2 and have better route. I will also have knowledge about that so I will be more aware. Now I am not." (Respondent 6.1)
"Then I would feel that I am making a difference. I could see that I am actually contributing. […]. I think that it could be quite motivating to get this. Then maybe I guess people will feel more contributing than previously. You understand that you have an impact more than like recycling stuff. You don't see the impact. So, I think that could be sort of, very important." (Respondent 6.2)
"It would certainly be helpful because it's an ambitious goal. And everyone has to contribute to make that goal. It would certainly make people more conscious about CO_2 that they emit. Because honestly, I don't know how much CO_2 I emit a year for example or during the day travelling to work. But if I know about it, I might probably change my lifestyle a bit." (Respondent 7.2)
"If this app become useable, it shows that municipality really cares about the environment and it is very positive. It will engage all the citizens to be more conscious about the driving and environment. This is how municipality can show that they are doing something for environment, and I would support them." (Respondent 8.2)

By and large, the key message conveyed by the respondents above helps to facilitate an enabling environment between the municipality and citizens. With the introduction of the mobile

application described in part 6.4.2, citizens have the "means, capacity and opportunity" (Bowen G. , 2003) to actively participate in the collective CO_2 goal that Stavanger Municipality is pursuing in both short term and long term.

6.6.2 Looking beyond the present

Besides raising awareness of citizens about reducing CO_2 from road transport, it also paves the way for them to think more about future solutions. Now that the respondents can relate the CO_2 goal to their personal life, they would find ways to achieve the goal in the most efficient way. One of the suggestions is to own an electric car, which perfectly goes along with the long-term target of the municipality in 2040 (zero-growth target). Some comments include:

"I would buy an electric car and use that instead. Zero emission cars, that is the future. But this is not what I would do now because I need a car that can go longer and travel long distance. But eventually there will be an electric car for me." (Respondent 1.1)
"I finally will try to have an electric car. That's the most efficient way to reduce CO_2 although I think that at the end of the day, the incentives for electric cars will not be there." (Respondent 5.1)

The respondents not only think about their actions in the long run to achieve the CO_2 target, but they also pointed out some suggestions for the municipality to carry out in other community projects. This reflects an inclusive, open and deliberate process that empowers citizens to make a smart city work for everyone. Updating activities on social media, improving public transportation and setting good examples from the city leaders are areas that the municipality should focus on improving according to the respondents. Some recommendations from the respondents are:

"They should try to be environmentally friendly and make it easy for people to be environmentally friendly. Besides making people walk and use bike, try to reduce cars in downtown and have more people on buses." (Respondent 1.1)
"I feel everywhere you go in Stavanger you have to take the car. Because there's not a good offer for buses, especially where I live. […]. I feel Stavanger doesn't give us a choice, because the offer of buses is very limited. […]. They should do a better job with the bus service in order for it to be easier to reach standards." (Respondent 3.1)

"More transparency in their information. I don't understand, and I'm sure other people understand. I don't mind paying, that's a fact of life, but I want to understand. Maybe it's because I'm relatively new here, but everybody should be included." (Respondent 3.2)

"When it comes to the overall CO_2 emissions, it's quite important so the leaders should take the responsibility and go ahead to make an example, I guess. It sounds like an unpopular decision to make but something like that might help citizens to get involved." (Respondent 7.2)

"Maybe the municipality website should be more updated and easier to navigate. It's a bit difficult unless you know what you're looking for." (Respondent 5.1)

As part of the strategy to motivate the community and mobilize support for the collective target, the long-term benefits have been realized by the respondents that could accrue to individuals, families, and the entire community. It is important that the effort of individuals can be seen and appreciated by the public. The results should also be tangible or measurable in order to make citizens feel more recognized and valued. As a result, a feeling of trust is created and the belief about making the social target come true is formed. According to Respondent 5.2, the knowledge from the mobile application "would make more positive impacts than now. It all starts from the awareness.". Some other respondents also expect a brighter outlook when the application is not a conceptual model but a real product. Positive feedback from respondents about the mobile app are included:

"If you get real time information available and you know that you can have an impact then you will feel better and more active in the society. If you can't get the information and you think that you don't have an impact, then you will feel less inclined to engage. I think it is quite unrealistic to reduce 80% but would be nice to see 10-15% can be reduced by people." (Respondent 8.1)

"It will raise awareness. I think that what's we need. And then gives us some concrete numbers. I think it would be very useful for a lot of people. Then you can see how much or little you are contributing. I think it is extremely helpful." (Respondent 6.2)

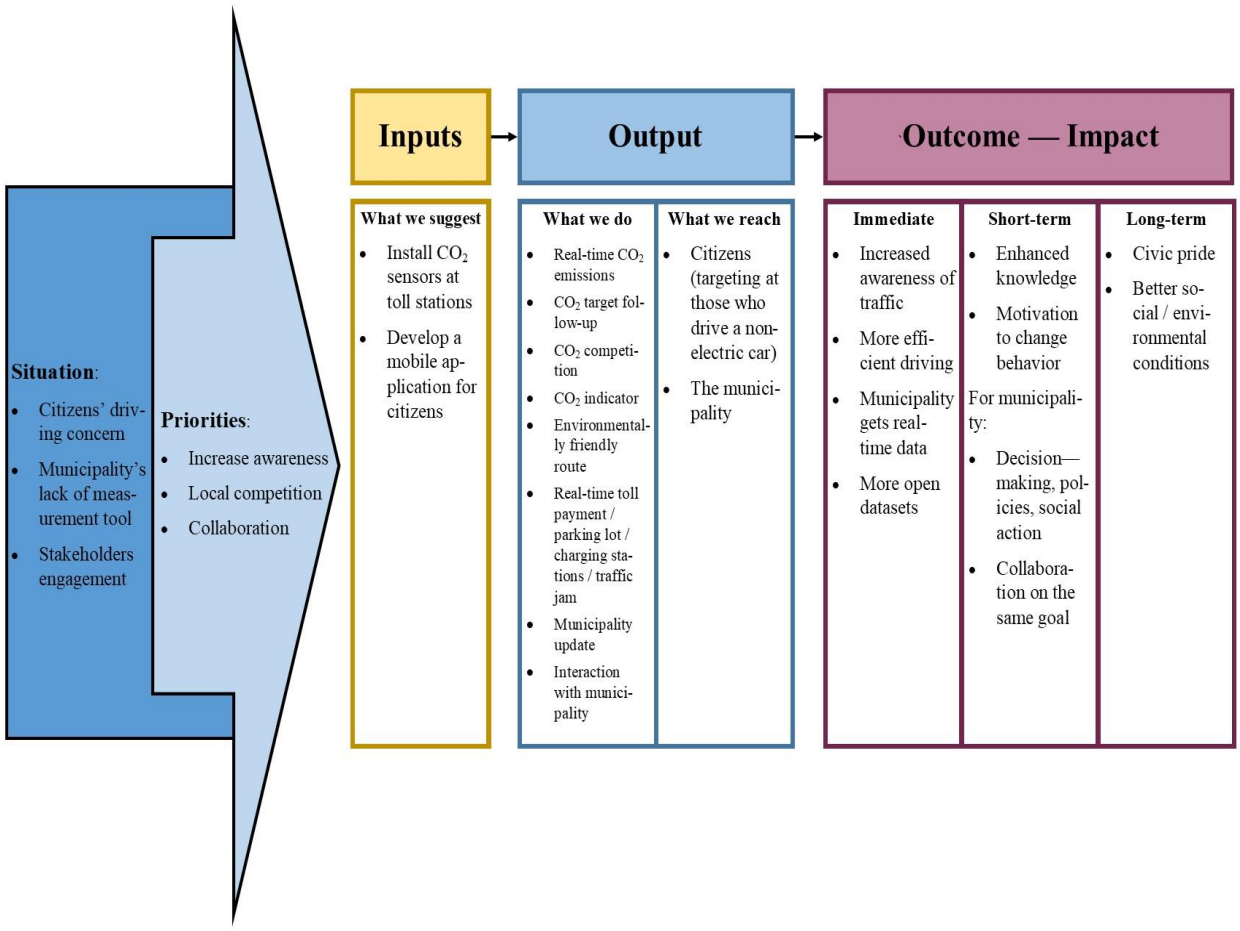
CHAPTER 7: FINDINGS

Now that Chapter 6 completes the additional features of the conceptual model proposed in Chapter 3, this Chapter will discuss findings from the analysis by taking the interviews with Stavanger Municipality into account.

7.1 Dynamic partnership between the municipality and citizens

The analysis above reveals that the individual incentives can be aligned with an overall goal to achieve a desired outcome for the community as a whole. This stakeholder relationship is dynamic in its nature since citizens and the municipality are interdependent in the goal of reducing CO_2 emissions as summarized in Figure.

Figure 7.1 Logic model for the dynamic partnership to reduce CO_2 emissions from road transport – Impacts of the model



Source: Own illustration

As can be seen from the Figure 7.1, installing sensors at the toll booths will give benefits to both the municipality and citizens. First, it makes citizens aware of their carbon footprint and

change their behaviors accordingly. Second, the local government can have real-time CO_2 data in order to better manage their target since in the interview with the municipality, the utmost problem in terms of managing CO_2 from road transport is that they "don't have real-time CO_2":

"*We get the data from the statistics office of Norway two years later. So now we have the data of 2017. We don't have information about CO_2, but we have the rough idea."* (Municipality 2)
"The current tool to track CO_2 emissions are from the number of charging points for electric cars, the development of vehicle fleet, members of car sharing scheme, means of travel distribution, indicators for land use, city bike rent, number of households that do not have cars, number of calls by cruise ships, counting public transport journeys, travel habit survey, etc." (Municipality 1)

As such there exists a lag of two years between the time an event happened and the time the authority can make decision to solve it. Additionally, a target set out today has to wait another two years to get the results, so it is a challenge to act in a timely manner. In order to make an estimate for CO_2 emissions, the municipality might wait days, let alone weeks or months to fully leverage the value in data retrieved from an endless list of variables. Therefore, decision-making based on data seems to be slow and cumbersome due to the time and effort.
With the support of the CO_2 sensor, it becomes more viable for the local authority to stream CO_2 data in real time. New available technologies in smart cities are expected to replace manual processes and their shortcomings. Actionable insights based on that can drive decisions and optimize outcomes to ensure committed CO_2 target, keep operations inside the municipality running at optimal levels, and averting or minimizing the consequences of service disruptions.
The CO_2 target of Stavanger municipality is "very important" that involves not only politicians, the municipality and most importantly, the inhabitants. It calls for "a big engagement" among stakeholders in order to "make it happen". The municipality also tried to put the target down to people by reflecting their opinions through phone calls in the master plan. Some activities to raise awareness are also put in place such as the Environmental Sunday on a yearly basis, communication on Facebook and practical training for kindergartens and schools. In this sense, the mobile application developed for citizens can help the municipality to reach to an even higher number of citizens. In addition, the mutual communication and transparency in the progress against the CO_2 target can also be enhanced. As per respondents, they are eager to receive the CO_2 target on a personal level so that they feel being a part of the system. This feature therefore can act as a tool for the municipality to measure citizen engagement and

"sensitize the awareness of the inhabitants" (Municipality 1) since they "don't have any measurements about that" (Municipality 2).

Regarding a platform where the citizens can communicate with the municipality, the form of "VOF" (Varsle om feil-Alert on problems) on the municipality website is frequently used to report errors in the system (Municipality 1). However, "it is a bit difficult to navigate unless you know what you are looking for" (Respondent 5.1) and English version of the form is not available yet for foreigners who cannot speak Norwegian to feel "included". According to Municipality 2, it would be better to integrate this form with the mobile application to give better service to citizens.

Consistent with the theoretical literature of smart city definition ((Geller, 2003), (Giffinger, Fertner, Kalasek, & Meijers, 2007), (Thuzar, 2011), (T. Nam, 2011)) in part 3.1, installing CO_2 sensors and developing an mobile application on top of the data is to empower citizens in a forward-looking way. A smart city is not laid on the technology, but it is a result from the participation of community residents to develop the civic pride and enhance their quality of life. In this manner, the conceptual model fits well with the smart city definitions.

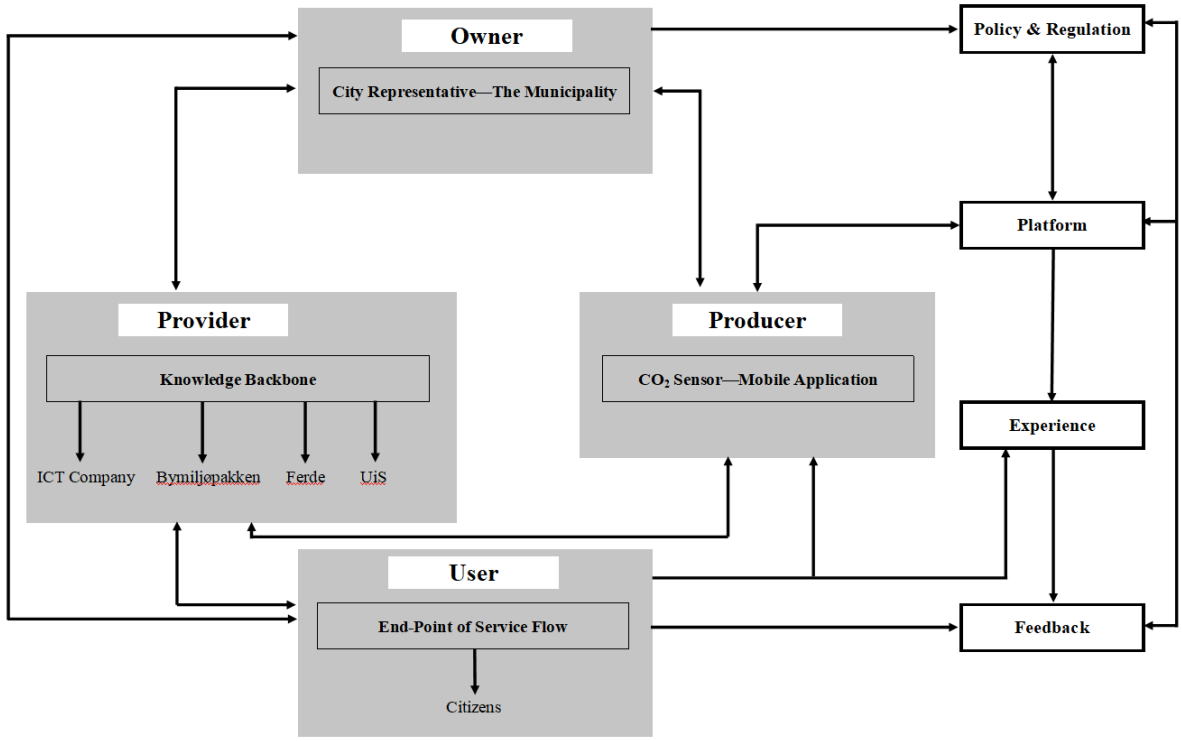
On the other hand, five out of six smart city dimensions introduced by (ASCIMER, 2015) in part 4.2 can be tapped on by the dynamic partnership between Stavanger Municipality and citizens built from the model. They are Smart Environment, Smart Governance, Smart Mobility, Smart People and Smart Living. The connection with the remaining Smart Economy can also be drawn in an indirect way through integration with the municipality's open data to reduce the costs.

When it comes to the stakeholder collaboration theory described in part 4.3, the dynamic partnership facilitated by the mobile application enables a "win-win" collaboration for all stakeholders. Two typical representatives for stakeholders in Stavanger smart city, namely citizens and the authority are jointly tackling the CO_2 problems which cannot be solved by any single party. The theory on collaboration of Savage et al. (2008) is therefore satisfied because the partnership can pool resources, capitalize on complementary capabilities, achieve economies of scale, and enhance innovation.

The conceptual model in part 3.3 in conjunction with the motivation factors of citizens in part 6.4.2 facilitates an urban data platform that is developed from the citizen's own needs and subject to the municipality's governing. The local government can take the role of a funder, coordinator and regulator of the ecosystem. The role of funder was mentioned by Municipality 2 since the project utilizes toll booths, which are the current facilities of the government. However, the provider can be an ICT Company and/or Bymiljøpakken and/or Ferde, the

operator of the toll booths in Stavanger. Figure 7.2 is an advanced version of Figure 3.3 related to the conceptual model.

Figure 7.2 Value co-creation scheme of the conceptual urban data platform in Stavanger – Four roles



Source: Own illustration combined with (Mayangsari & Novani, 2015)

Four basic roles in an urban data platform are divided among the stakeholders in Stavanger Municipality: The owner is the municipality, the producer is the CO_2 sensor and the mobile application, the provider can be an ICT Company and/or Bymiljøpakken and/or Ferde. The municipality is taking the role of an enabler to regulate and coordinate different stakeholders on a continuous level. The platform is established by the mobile application and regulated by the policy of the municipality. Experience and feedback of citizens as end-users are sent back to the project owner to lead the development and monitor the outcomes. Most of the interactions in this closed circle are two-sided to ensure openness and transparency. The success of the goal therefore depends on the joint participation and collective contributions of the interactive social actors.

From literature perspective, this urban data platform contributes to explain the existing theory of stakeholder partnership in a practical way. Four principles of complementarity, connectivity, innovation ability and efficiency suggested by Lee et al. (2010) to assess the performance of users can also be elaborated in this mutual framework. Through the platform, citizens can

actively join the effort to reduce CO_2 together with the municipality (complementarity), feel more updated about the social activities (connectivity), suggest ideas to make the smart city even smarter (innovativeness), and adjust their driving pattern to have less impacts on the environment (efficiency).

7.2 Governance of the partnership

Smart technology, smart people and smart collaboration signify features for smart cities in the dynamic partnership as illustrated in part 7.1. In order to have the comprehensive perspective of smart city, it is argued that smart city governance should also be obtained through the use of ICTs for an open collaboration process. Having the engagement from citizens is an advantage, but how to manage it with the target is another challenge of the municipality. The conceptual model of developing a mobile application on top of the real-time data from CO_2 sensors aims at developing Stavanger into a smart city with a focus on the theme of environment and open data. This partnership enables knowledge exchange and learning between all the actors in the society for more efficient transportation and more (digital) citizen participation.

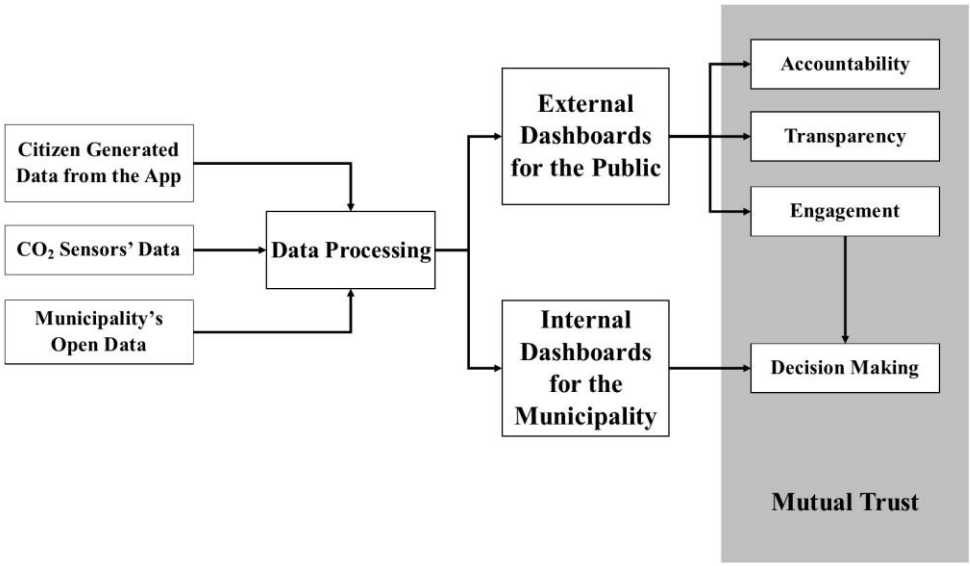
Environmental sustainability, particularly CO_2 goal in this context, has transformed a smart city from a linear approach towards a circular approach where every stakeholder gets involved in a closed communication circle as illustrated in Figure. The quest for governance and performance management of the municipality, who is the main coordinator in that ecosystem, needs to be addressed because “cities need to develop a performance measurement model, able to explain how smart initiatives can produce value and how they are able to generate positive results for people” (Dameri, 2017).

Therefore, the city managers should also consider designing and nurturing synergies between social structure and new technology to improve the efficiency and quality of life for citizens in real time. An important area of data management is to visualize the data in dashboards. This point of view is also shared by Stavanger Municipality. According to Municipality 2, the dashboards are not only “internal for the leaders to see” but also “visible even to those people who don’t use the app, e.g. having big screens on highway or city center where everybody can see the information”.

The municipality can use dashboards for both internal and external purposes, including reporting, planning, policymaking (internal), performance monitoring and transparency (external). For the internal purpose, dashboard can be used for decision-making by the local public based on the input from citizens. In particular, data generated through the mobile application of citizens and the open data can be collected to be processed and visualized in a connecting way between the current status and the potential outlook. By this meaning, the data

today is implied to facilitate for the goal in the future. Whereas high-level statistics such as CO_2 from road transport, toll payment, number of passenger cars, number of walkers, bikes and buses, etc. can show the trend towards the collective target and identify bottlenecks, detailed data can give insight for how to overcome a specific cause to the problem. The possibility to drill into the details of time, date, place, and description is important when it comes to having solutions. In this sense, both data can be used for the same theme, but with different objectives. Besides serving the internal decision-making purpose, the external use of dashboards should also result in transparency and accountability and ultimately in more trust in the municipality (Harrison & Sayogo, 2014). Data can be exhibited in public in the form of tables, graphs, or an overview of traffic on the electronic panels to reduce information asymmetry between citizens and the municipality. In this way, dashboards are used to both communicate with the public and gain feedback from them to stimulate interaction. Engaging citizens in scrutinizing data transparency plays a crucial role in achieving the benefits for both sides. Figure 7.3 visualizes the value creation logic behind dashboards in smart cities. Data collected from citizens is processed internally by the municipality; part of them is kept inside for internal dashboards and part of them is visualized in public for accountability, transparency and engagement. All of these supports to develop trust in the local authority and societal decision-making.

Figure 7.3 Value creation logic behind dashboard – Internal/External



Source: Own illustration

Based on the logic model for the dynamic partnership to reduce CO_2 emissions from road transport in Figure 7.1, a conceptual design of a dashboard for both internal and external use is illustrated in Table 7.1.

Table 7.1 Conceptual design of dashboards – Internal/External

No.	Use	Feature	Description	Data source
1.	Internal	Overview of transport	Information for monitoring the traffic and the goal at a glance are visualized in a general way. Some indicators can be used such as number of passenger cars, bikes, buses, walkers, CO_2 checkpoint (toll booths) map, air quality, CO_2 footprint, types of cars, charging capabilities for electric cars, etc.	Open data and data from CO_2 sensors
2.	Internal	Fleet screening	Surveillance of vehicle fleets and models can benefit the municipality and citizens to detect high-emitting vehicles and have timely maintenance service to correct the faults.	Data from CO_2 sensors
3.	Internal/External	CO_2 emissions from road transport and toll payment	CO_2 emissions are broken down to categories of transportation in the reference framework of the CO_2 target. The goal per year and per month shown in the mobile application for citizens is also illustrated in the same way. Toll payment in regular and rush hours are also captured.	Open data, data from CO_2 sensors and mobile applications.

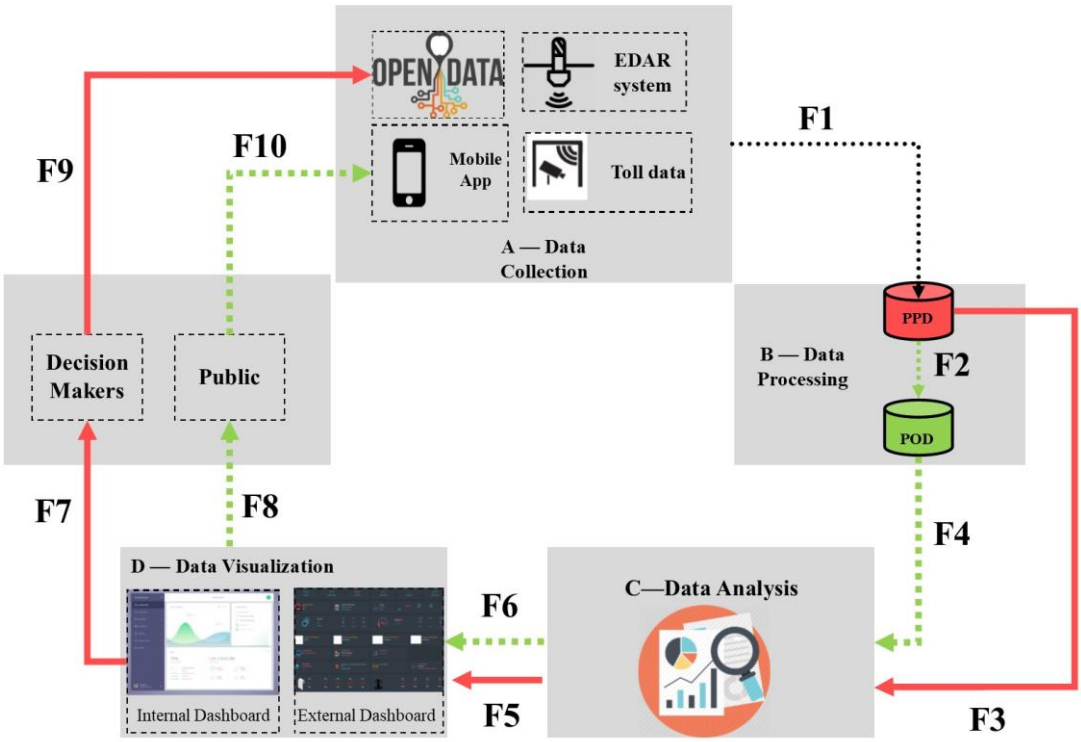
4.	Internal/External	Local traffic	Showing the map of the local area with real-time parking lot, traffic jam, charging stations, and toll booths.	Open data
5.	Internal/External	CO_2 checkpoints	Showing the map of local area with signals of high, medium, low CO_2 concentration.	CO_2 sensors
6.	Internal/External	CO_2 neighborhood checkpoints	Data of neighborhood location entered by the application users can be used to see which area has cars that generate higher CO_2 than average. This also serves the purpose of having competition among districts within the municipality suggested by the respondents.	Data from mobile application
7.	Internal	Citizen voice	Measuring the citizen service level through their feedback via the mobile application.	Data from mobile application

Source: Own illustration

The features shown in table 7.1 are the main content of the dashboards. A single view of each feature might result in a limited picture on the context. Besides the generic visualization, the dashboards should also enable customized views in order for decision makers to gain insight about the situation. An enormous volume of open data, data from sensors and the mobile application should be capitalized on in every way. For example, by providing an overview of "CO_2 by district", the municipality should also have the opportunity to zoom in on details about how much CO_2 has been emitted, which type of transportation, how much toll has been paid in which time, and the historical data etc.

The data cycle for internal and external dashboards is represented in Figure 7.4. There are two main information flows in the cycle: One flow is used for creating a dashboard for internal use by the municipality to support policy-making (in red) while the objective of the other flow is to create transparency and accountability for the public (in green). The data cycle for dashboards is constituted by five chronological stages: data collection (Stage A), data processing (Stage B), data analysis (Stage C), data visualization (Stage D), and data usage (Stage E).

Figure 7.4 Data cycle for dashboards – Red for internal, Green for external



Source: Own illustration combined with (Matheus, Janssen, & Maheshwari, 2018)

- In Stage A, data is collected from CO_2 sensors attached to the toll booths, and data from the mobile application of citizens. The first flow F1 depicted in a dashed line starts from Stage A to Stage B for data processing.
- From Stage B, there are two parallel flows of information taking place for the rest of the cycle. Public Private Data (PPD) collected from Stage A is treated for internal and external purpose before being integrated with Public Open Data (POD). As can be seen in the Figure, two flows are generated from PPD. Part of it would have to be normalized and standardized through the flow F2 to POD, and part of it would be kept internally by the municipality for policy-making decisions. There is such a database division because of the confidentiality of citizens' personal data such as the plate number, the geographical positions, etc. In the context of the data taken from the mobile application, the PPD of CO_2 emissions per car, and per district, toll payment and car model through flow F2 can be converted into POD, which is freely accessible by individuals and enterprises in open format at the Open Data Portal (https://open.stavanger.kommune.no/dataset). The other PPD such as the feedback from

citizens via the application, the location and the plate number through flow F3 are subject to further analysis to help the municipality gain the insight into an issue if any.

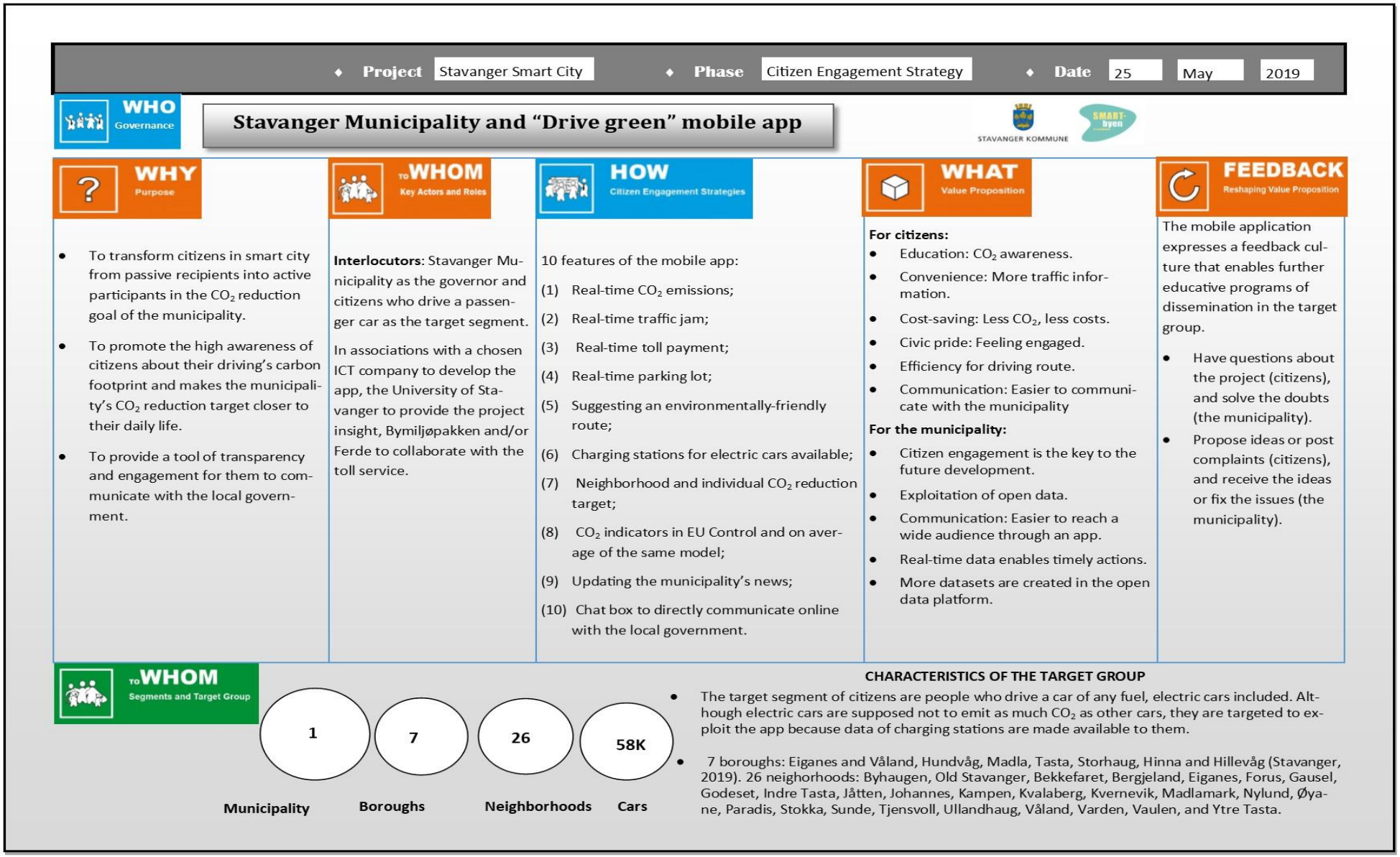
- The internal flow of information is shown in red by a continuous solid line of flow F3, F5, F7 and F9. The external flow of information is shown in green by a dashed line through flow F4, F6, F8, and F10.
- In Stage C, data will be analyzed and/or verified by the service provider (Recall from Figure that it can be an ICT company, and/or Bymiljøpakken and/or Ferde). Big Data Analytics Processes can be conducted manually by data scientists or automated.
- In Stage D, the results from the statistical analysis and geographical analysis are compiled to be displayed on dashboards for internal and external audiences. Flow F5 represents flow of information for politicians, whereas flow F6 enables the creation of public dashboards.
- In Stage E, the internal dashboards serve the decision-making process of the municipality and the public dashboards share the progress update and overall traffic with citizens.

CHAPTER 8: VISUALIZATION

8.1 Visualization of the mobile application

A value proposition of the mobile application named “Drive green” is exhibited in Figure 8.1, encompassing the key areas of the citizen engagement process. There are seven questions to be addressed by the developed app: Who (Governance), Why (Purpose), Whom (Key actors and roles), How (Citizen engagement strategies), What (Value proposition), Feedback (Reshaping value proposition) and Whom (Segments and target group). The conceptual app in part 3.3 was then visualized based on the insights of the respondents in Chapter 6 in accordance with ten features cited in section “How” of Figure 8.1

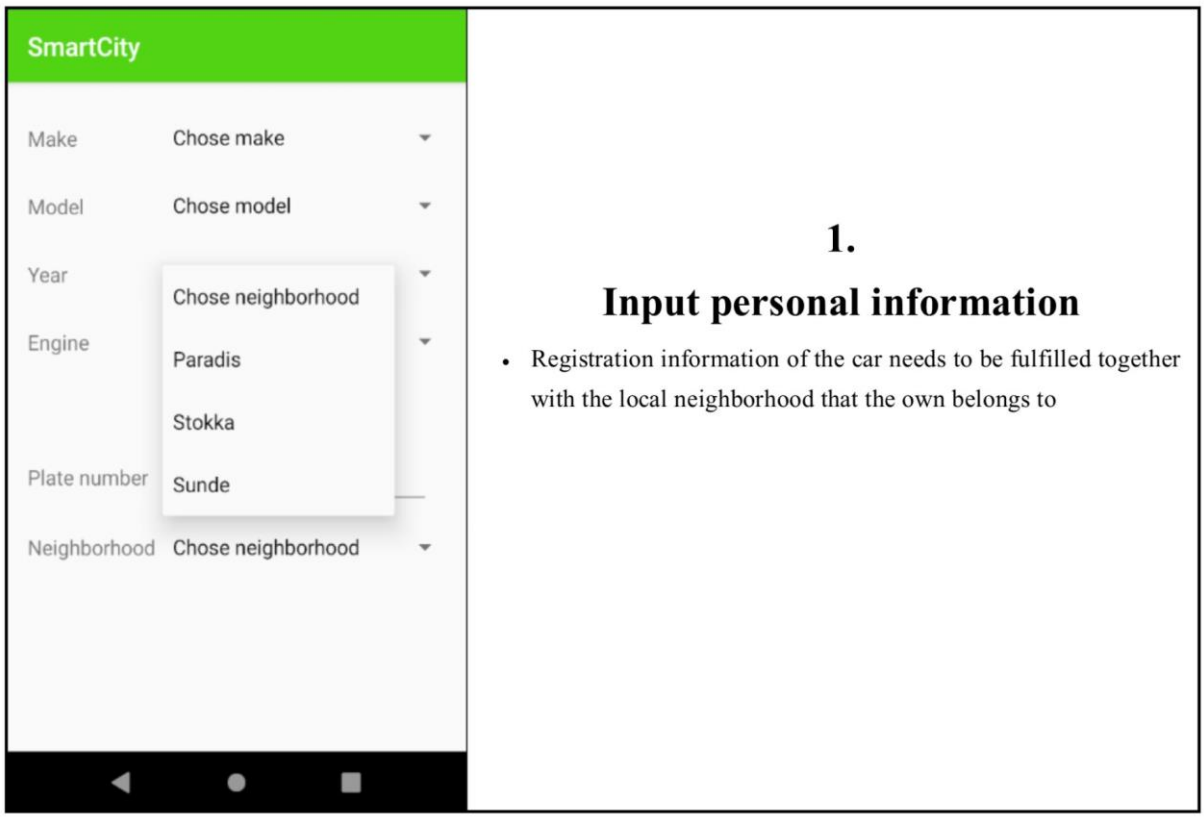
Figure 8.1 Value proposition of "Drive Green" mobile application



Source: Own illustration combined with (Barrenetxea, et al., 2016)

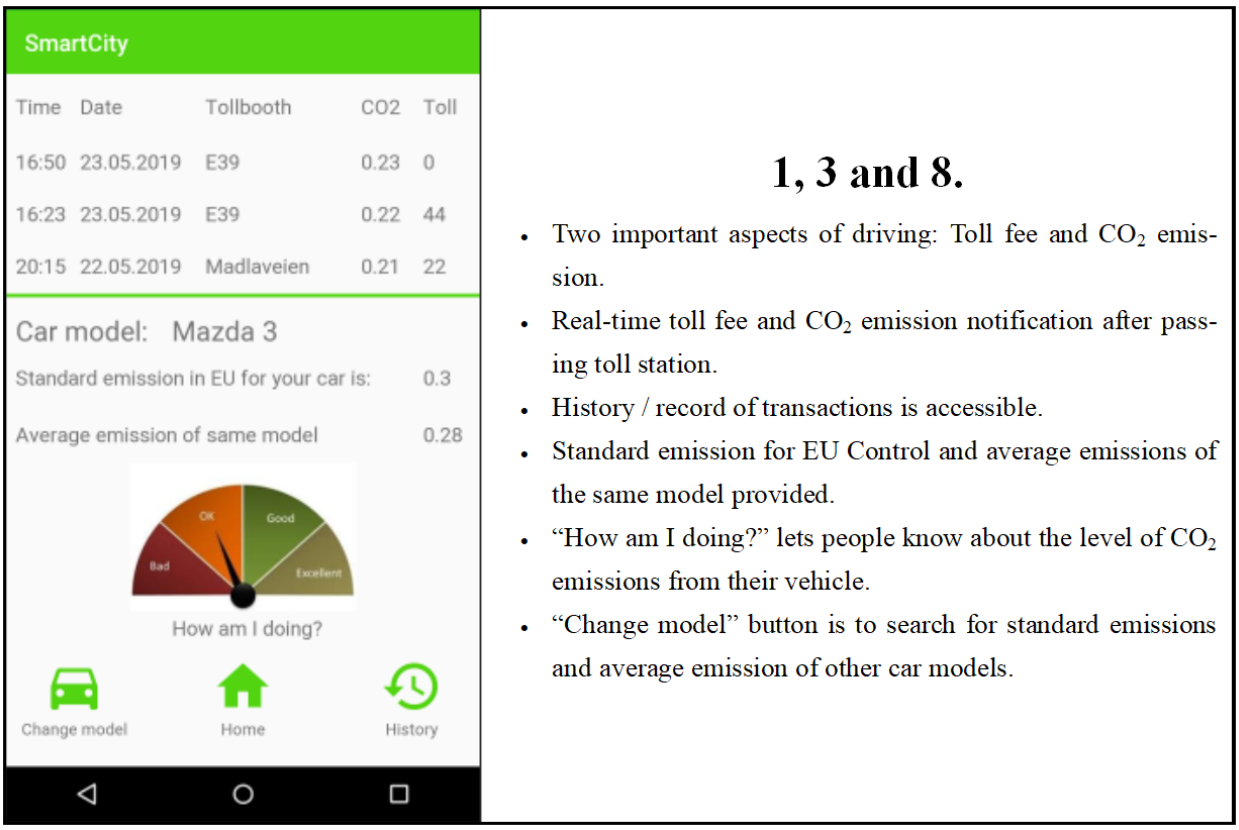
Ten features of the “Drive green” app in Figure 8.1 are visualized as below:

Figure 8.2 Mobile App: Input personal information



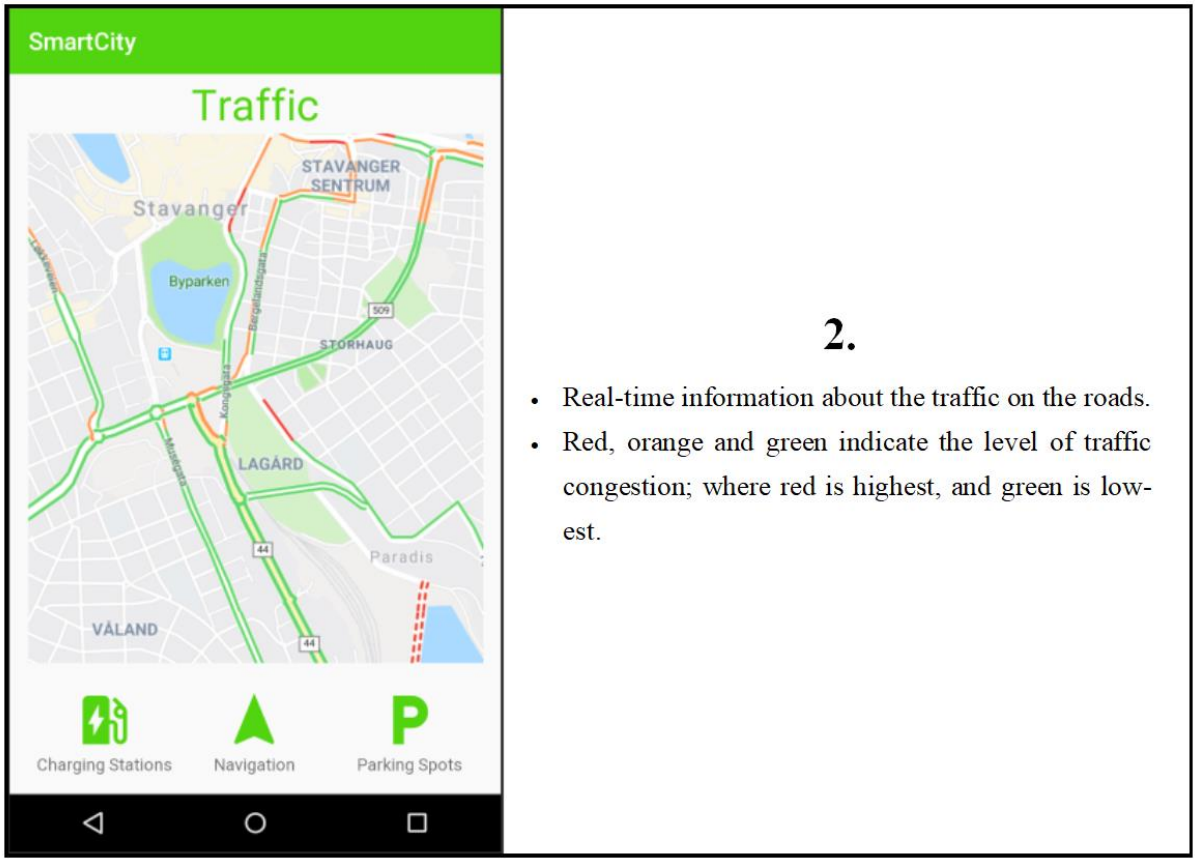
Source: Own illustration

Figure 8.3 Mobile App: Toll fee and CO_2 Emission – Feature 1, 3 and 8 in Figure 8.1



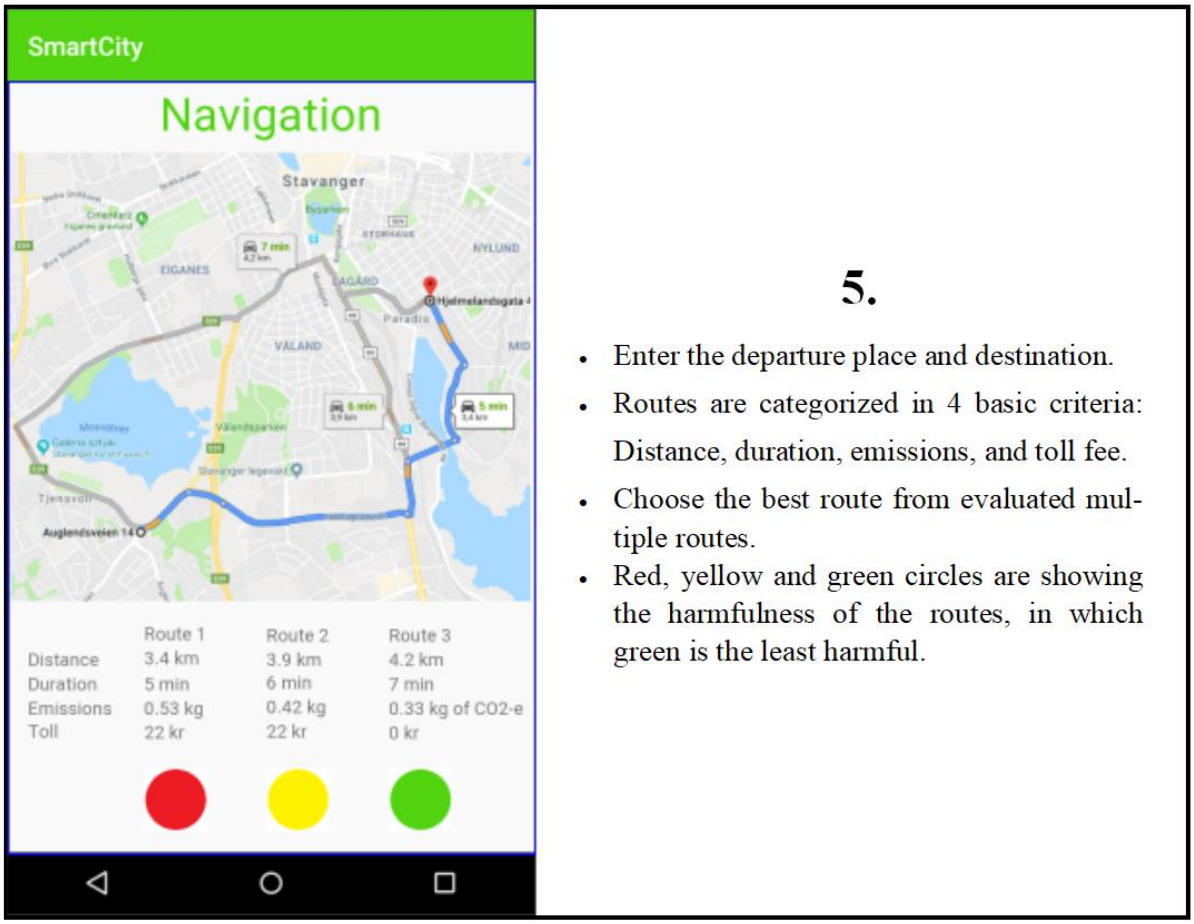
Source: Own illustration

Figure 8.4 Mobile App: Real-time traffic – Feature 2 in Figure 8.1



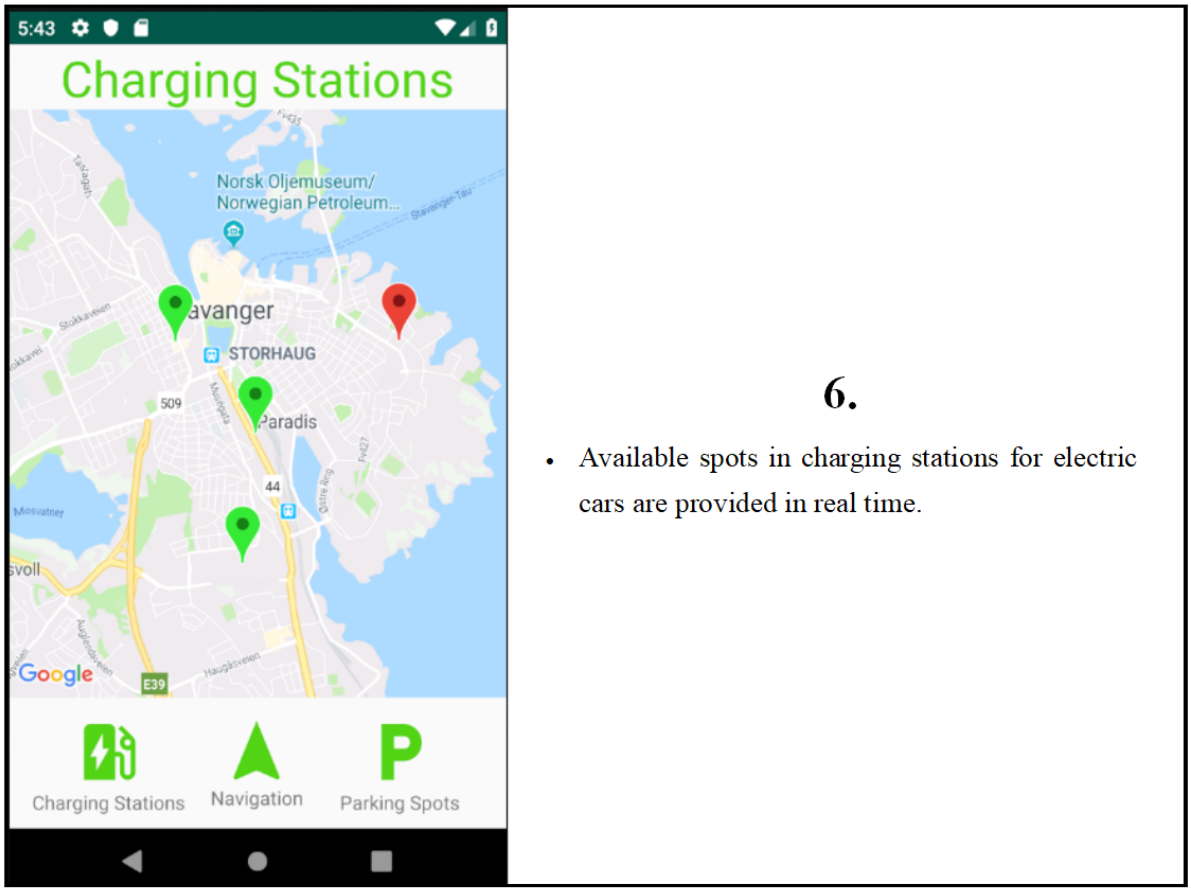
Source: Own illustration

Figure 8.5 Mobile App: Finding best route – Feature 5 in Figure 8.1



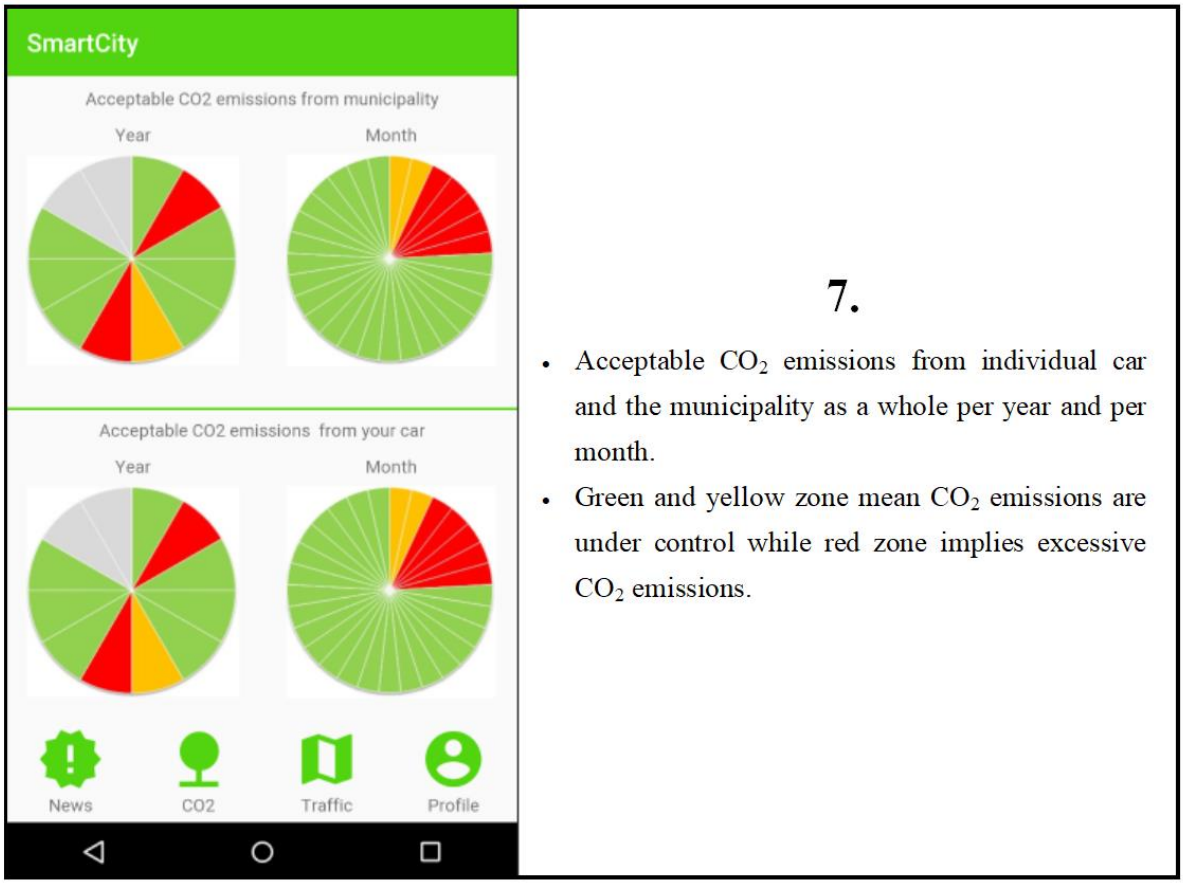
Source: Own illustration

Figure 8.6 Mobile App: Electric-car charging stations – Feature 6 in Figure 8.1



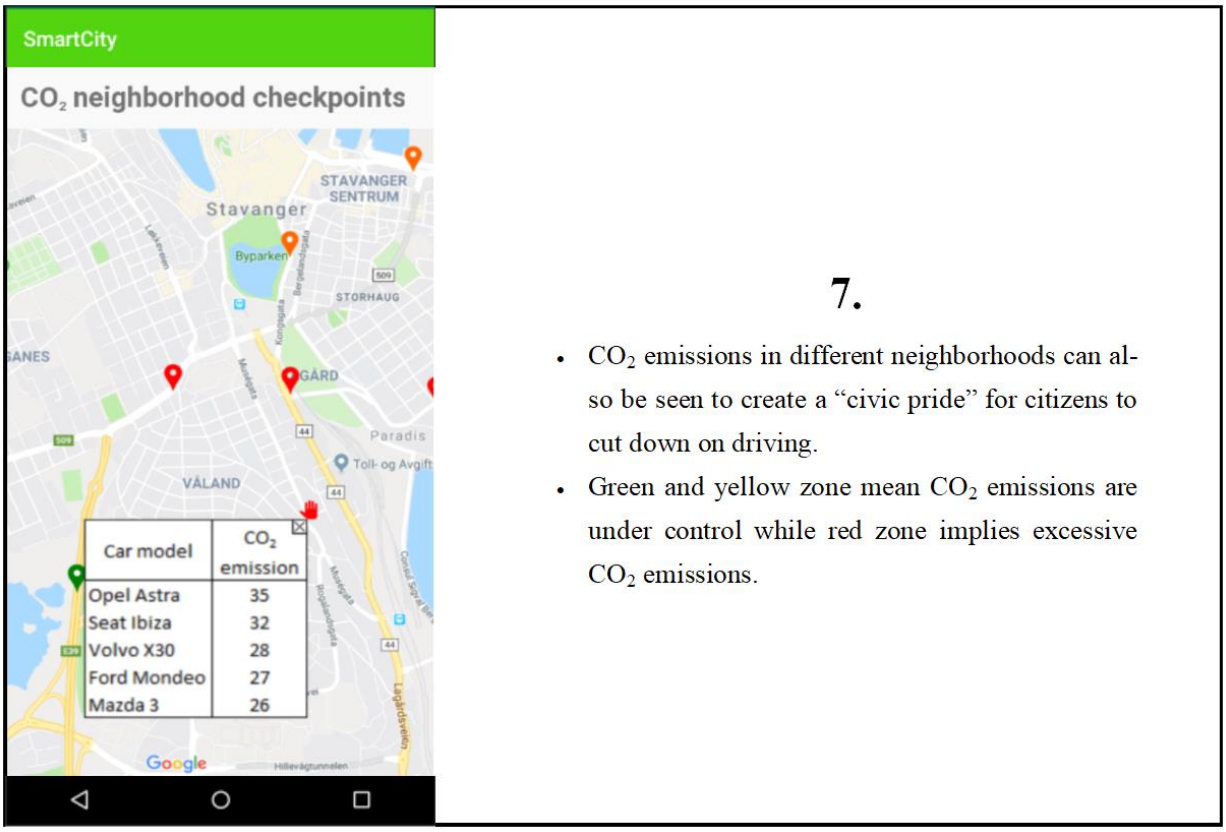
Source: Own illustration

Figure 8.7 Mobile App: Real-time acceptable CO_2 emission – Feature 7 in Figure 8.1



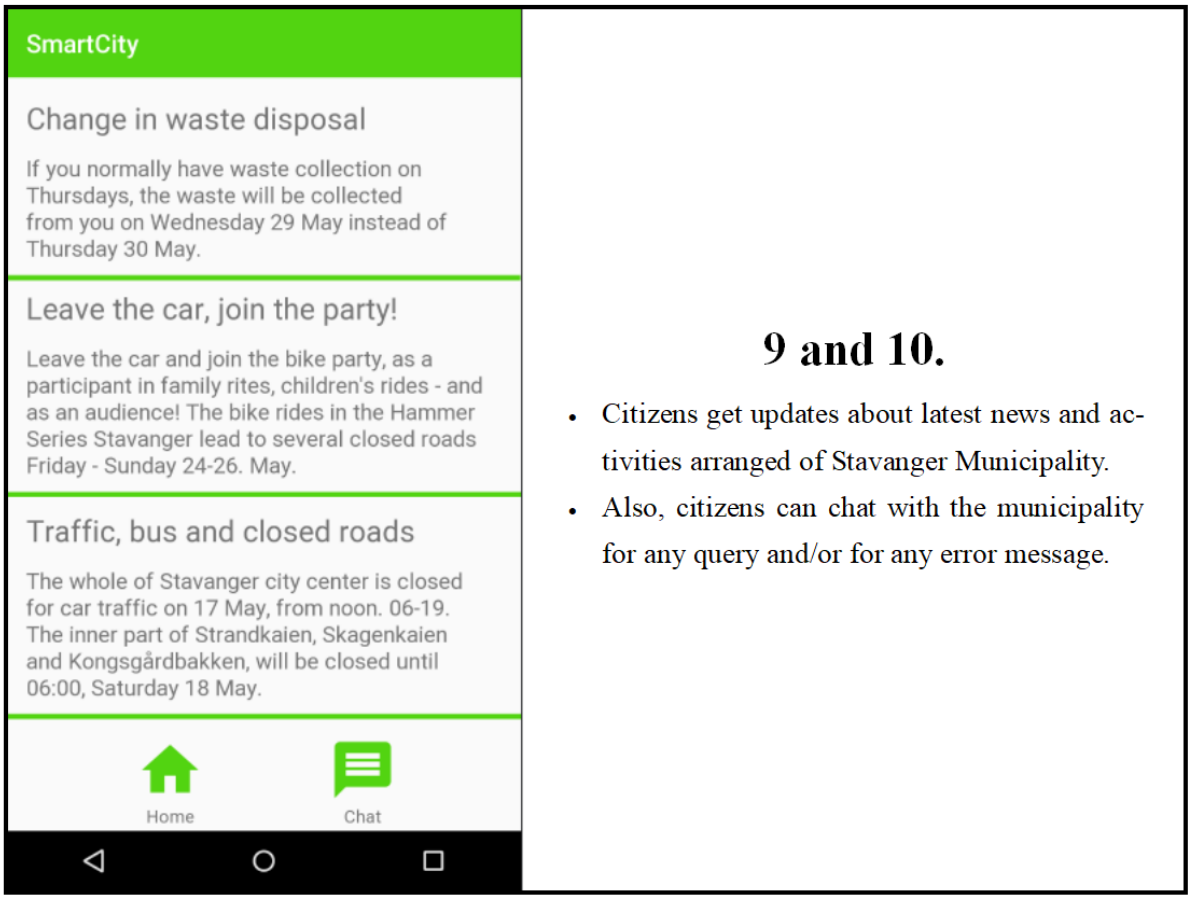
Source: Own illustration

Figure 8.8 Mobile App: CO_2 emissions of neighbourhoods – Feature 7 in Figure 8.1



Source: Own illustration

Figure 8.9 Mobile App: Newsfeed update from municipality – Feature 9 and 10 in Figure 8.1

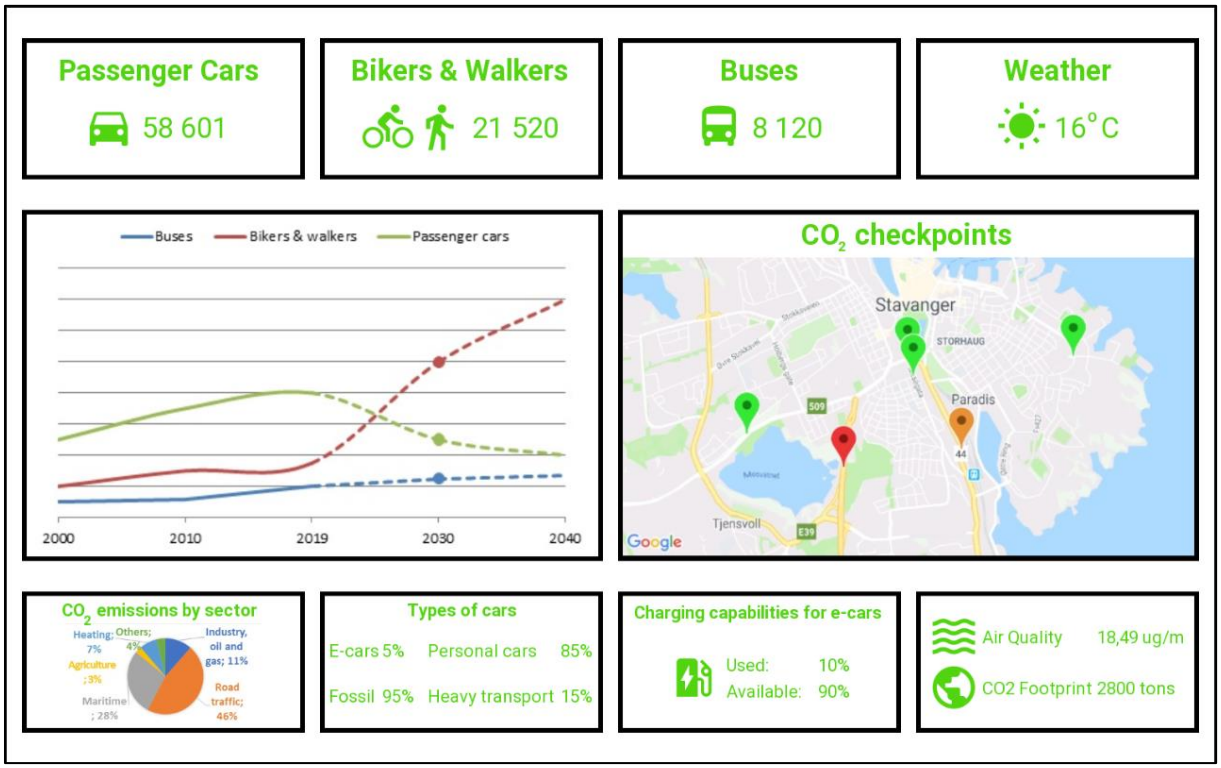


Source: Own illustration

8.2 Visualization of the dashboards

Dashboards enable users to see what is happening and to initiate actions drawn from consolidated datasets. There are two types of dashboards: internal dashboards for decision-making process of Stavanger Municipality and external dashboards for citizen engagement. Suggested features for internal/external dashboards for Stavanger Municipality in part 7.2 will be visualized as below with the numbered point in Table 7.1.

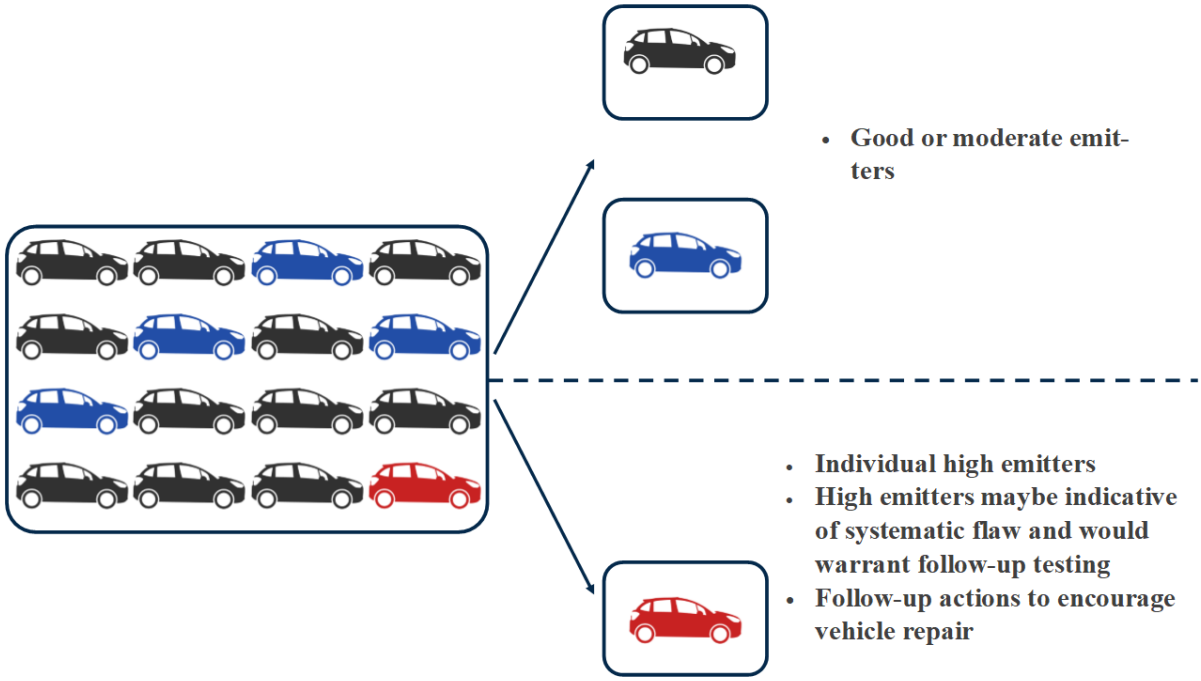
Figure 8.10 Municipality Dashboard: Overview – Internal use – Point 1 in Table 7.1



Source: Own illustration

Information for monitoring the traffic and the goal at a glance are visualized in a general way. Some indicators are highlighted such as number of passenger cars, bikes, buses, walkers, CO_2 checkpoint (toll booths) map, air quality, CO_2 footprint, types of cars, charging capabilities for electric cars, and CO_2 emissions by sector. CO_2 checkpoints are where EDAR systems and toll booths are located. Different colours (green, yellow, red) indicate different level of CO_2 emissions at each location. By looking at these figures, the authorities can quickly see the areas that need to be improved and better manage the local traffic situation to reach the desired amount of transportation means.

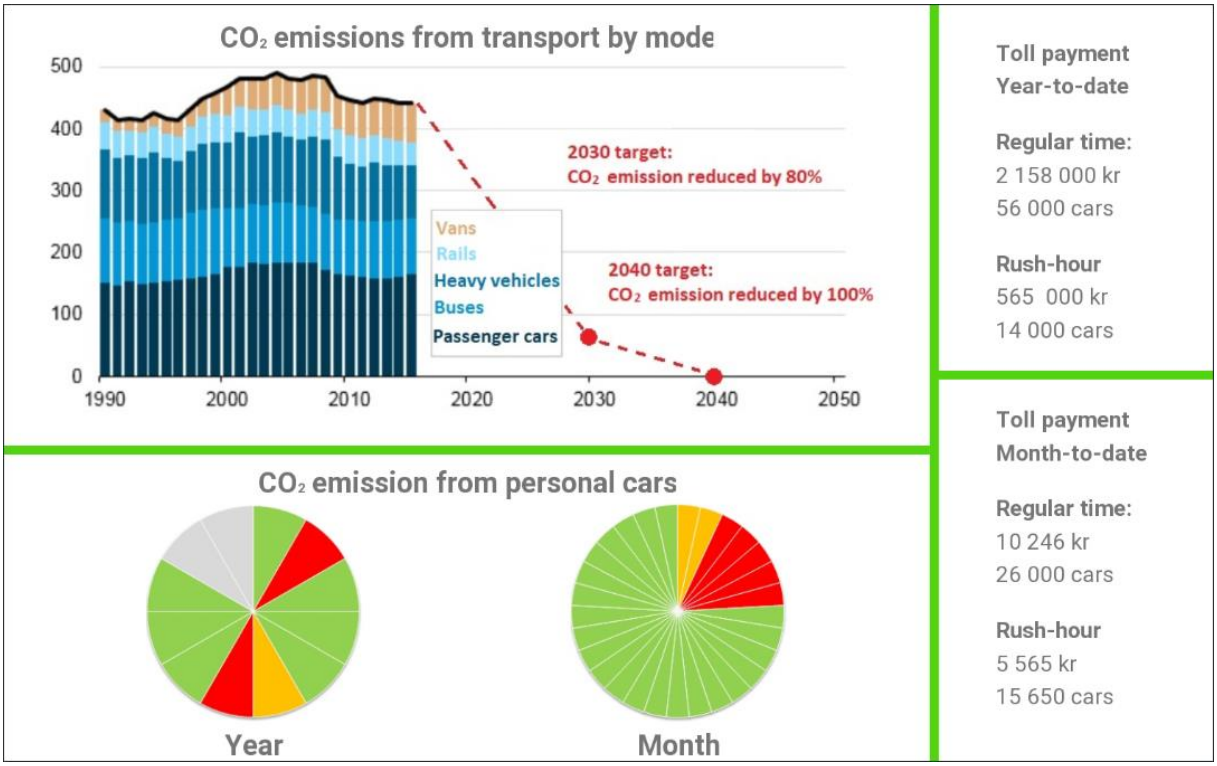
Figure 8.11 Municipality Dashboard: Fleet Screening – Internal use – Point 2 in Table 7.1



Source: Own illustration combined with (Borken-Kleefeld & Dallmann, 2018)

This fleet-screening internal dashboard can help the municipality to have surveillance of local vehicle emissions. Since EDAR system can scan thousands of vehicles in a single day as they pass toll boots, this high sampling rate is very useful as a screening tool for filtering clean and dirty vehicle models in actual use. Some warnings can be made to citizens for a timely maintenance or for a smarter vehicle purchase.

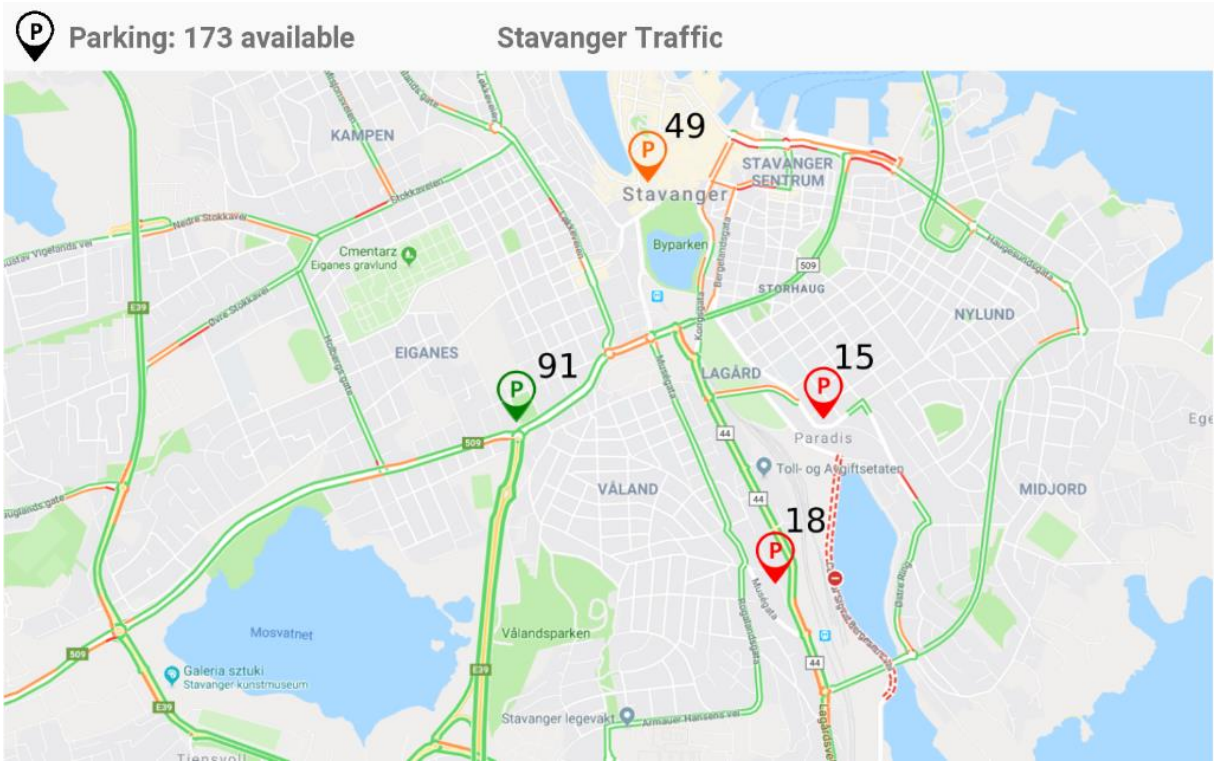
Figure 8.12 Municipality dashboard: Real-time CO_2 emission and toll payment – Internal use – Point 3 in Table 7.1



Source: Own illustration

This internal dashboard takes a closer look at the CO_2 emissions from road transport and toll payment. The CO_2 contribution of each vehicle type is captured in the framework with the reduction target. CO_2 emissions from passenger cars are illustrated as in the mobile application used by citizens to show the consistency and to let the municipality and citizens strive for the same goal. Toll payment in regular and rush-hour time is also presented on a yearly and monthly basis.

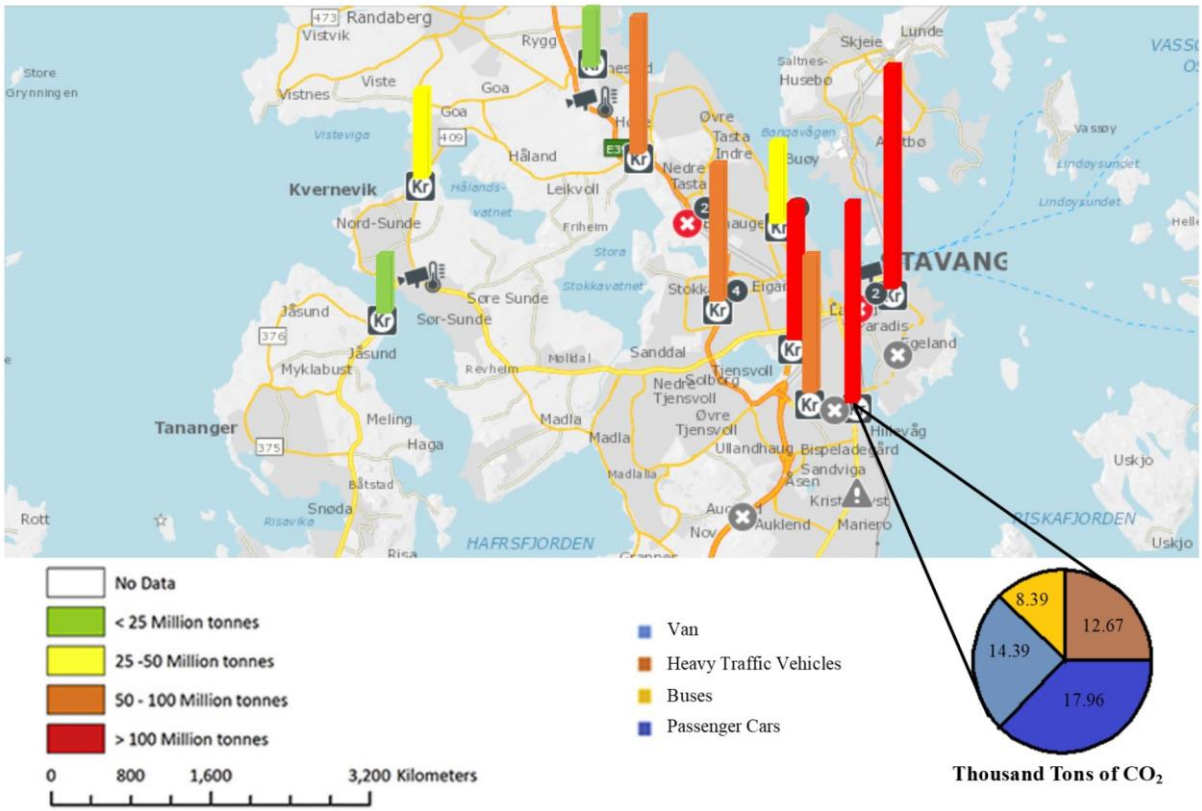
Figure 8.13 Municipality Dashboard: Traffic and parking condition – Internal/External use - – Point 4 in Table 7.1



Source: Own illustration

This dashboard of parking lot can be shown internally and externally. For the municipality, it is a vivid example of exploiting open data for usable information. For citizens, it is a tool for car drivers to have an efficient route to the destination with sufficient parking space. Not all citizens would use the “Drive green” app, so this external dashboard will help to provide more traffic information to a wider public.

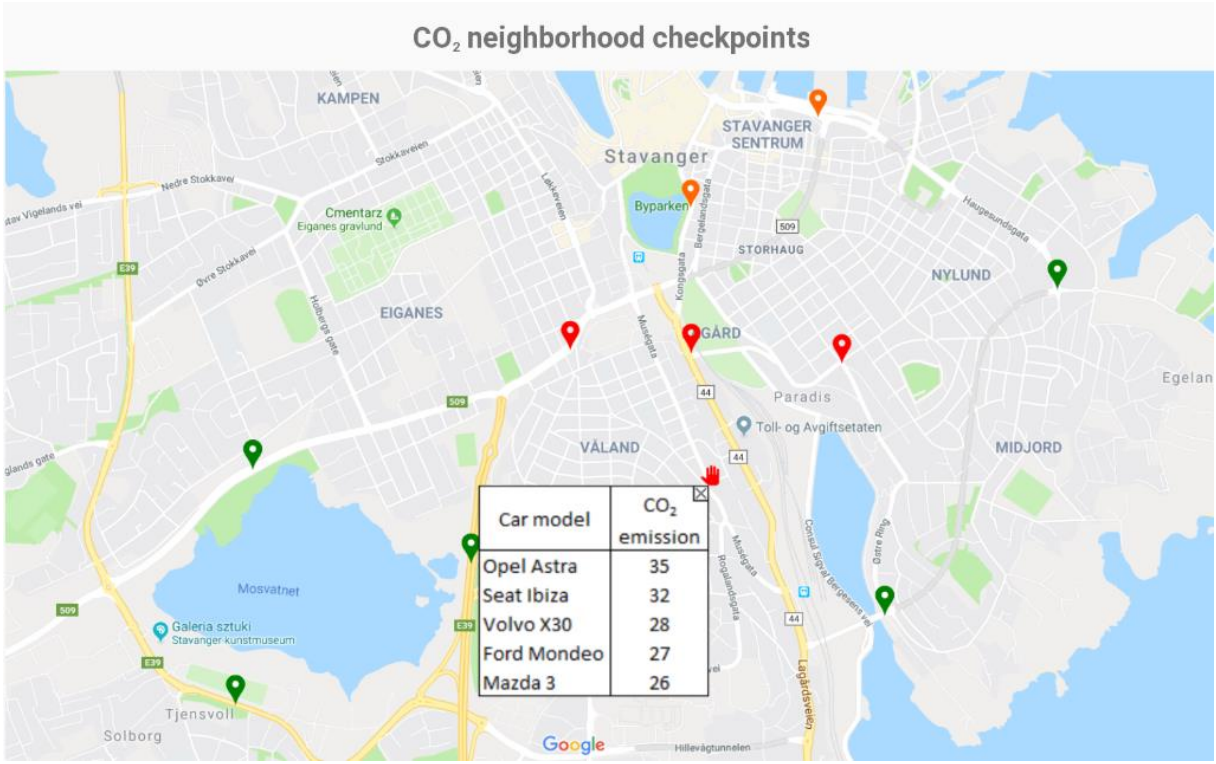
Figure 8.14 Municipality Dashboard: CO_2 checkpoints – Internal/External use – Point 5 in Table 7.1



Source: Own illustration

The internal and external dashboard of CO_2 checkpoints can make both the municipality and citizens aware of where in Stavanger vehicles travel to most often and leave the highest carbon footprint. The columns with indicative colors can visualize the concentration of CO_2 at each toll station. Further information related to the type of transportation passing toll stations can be traced back at each column, expressed in a circle graph.

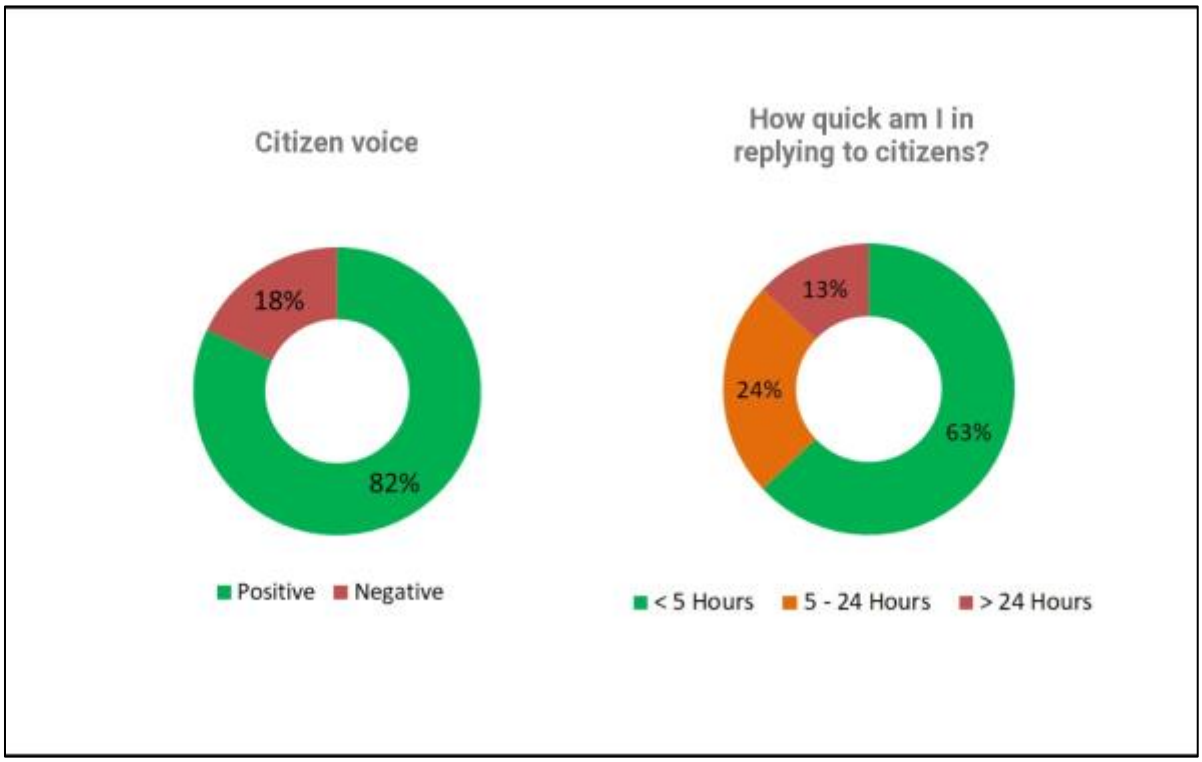
Figure 8.15 Municipality Dashboard: CO_2 neighbourhood checkpoints – Internal/External use – Point 6 in Table 7.1



Source: Own illustration

This dashboard of CO_2 neighborhood checkpoints can be shown internally and externally. Recall that when citizens log in the "Drive green" app, they are recommended to put the name of neighborhood they are living in. Stavanger Municipality consists of 26 neighborhoods as specified in Figure 8.1. Therefore, the CO_2 concentration in terms of vehicle emissions can be retrieved at the neighborhood level to create motivations for citizens to cut down on CO_2 emissions either by driving less or by taking public transportation, etc. The table of car model and CO_2 emissions shows up in an interactive manner. The municipality can dig down to each "red" neighborhood to see which kinds of car are emitting much CO_2 and how much it is.

Figure 8.16 Municipality Dashboard: Feedback – Internal use – Point 7 in Table 7.1



Source: Own illustration

The internal citizen-voice dashboard is a tool for Stavanger Municipality to assess their service level in terms of positive feedback from citizens and how quick the municipality is to reply to citizens' concerns.

CHAPTER 9: VALIDATION

This chapter is dedicated to show that this qualitative research is conducted in a rigorous and methodical manner to yield meaningful and useful results. As mentioned in Chapter 6, this thesis employs thematic analysis as a qualitative research method. Since qualitative research has become more popular, it is necessary to provide tools for researchers to conduct a trustworthy and rigorous thematic analysis (Nowell, Norris, White, & Moules, 2017).

According to (Thorne, 2000), data analysis is the most complex phase of qualitative research to create sensible findings. Therefore it needs to be conducted in a systematic approach so that readers can be clear about what the researchers are doing, why they are doing it and can evaluate the trustworthiness of the research process (Malterud, 2001).

Although there are numerous ways to prove the validation of a research, in this thesis we discuss how our thematic analysis is conducted theoretically and methodologically to derive insightful and trustworthy research findings. If benchmarks for a rigorous quantitative research are internal validity, external validity (or generalizability), reliability and objectivity (Guba & Lincoln, 1994), those for a quantitative research are defined as "parallel criteria", namely credibility, transferability, dependability and confirmability (Guba & Lincoln, 2000).

Accordingly, besides giving evidence on adequacy of data and interpretation, we also discuss four factors of credibility, transferability, dependability and confirmability to explain the role of validation in this research.

9.1 Adequacy of data

Unlike quantitative research, adequacy of data in qualitative research does not depend on the number of interview participants. Although a variety of research participants are important, those sheer numbers are not assurance of the quality of the findings (Morrow, 2005). Validity, meaningfulness, and insights generated from qualitative analysis determine the information-richness of a research (Patton, 1990). Typically, the concept of "data saturation" is employed to indicate the level of data adequacy in qualitative research.

Data saturation entails gathering data to the point of redundancy where no new information can be added (Bowen N. , 2008). In other words, new participants are brought continually into the study until data replication or redundancy exists. Ultimately, sampling procedure is more paramount than sample size in a way that quality, length, and depth of interview data are closely paid attention to by the researchers.

Bowen (2008) defined an "appropriate" sample as a collection of participants who best represent or have knowledge of the research topic with the objective of ensuring "efficient and effective saturation of categories, with optimal quality data and minimum dross" (Morse,

Barnett, Mayan, Olson, & Spiers, 2002). In this research, we chose to conduct "purposeful sampling" where participants are deliberately selected to gain the depth as well as breadth of information.

Recognizing the diversity in the background of car drivers, we recruited informants based on specific criteria such as age, location (living in downtown area or not), having dependent children or not, and being a student or not. Although we did not try to reach out to other different factors due to the limited scope and time, our final sample is enriched with people of various careers and countries and having different types of cars. All of these demographical elements help to achieve maximum variation and increase the adequacy and appropriateness of the qualitative data. Snowball sampling is also a legitimate technique that we employed purposefully to identify good exemplars of the experience in local area based on the recommendation of the former interviewees.

The adequacy of data is also implicated in the quality, length, and depth of interview data. The interview strategy resembles a "conversation with a purpose". The interview questions are semi-structured, which means that we can take advantage of open-ended and standardized interview data. Allowing for changes in the interview ensures emergent interesting themes whereas having the core questions in advance structures a smooth focused conversation. We used mixed methods in this research in which quantitative and qualitative data are generated simultaneously; however, priority is given to qualitative data. Quantitative part is used to confirm and cross-validate the findings of qualitative part. For this purpose, we had different types of questions including short questions for long answers and quantifiable questions for short answers. The qualitative data analysis primarily helps to gain insight into the participants' situational experience of driving in Stavanger, and then the quantitative data helps to detect and confirm the validity of the textual answers. For example, initially the respondents' answers in the form of texts are explored to get their views about the current driving situation in Stavanger and their expectations of a conceptual smart intervention to improve their driving habits with the aim of cutting down on CO_2 emissions. After that, the quantitative data is collected from their evaluation in numbers about the current traffic and prospect traffic with support of the mobile application. As a result, the combined data can show wide-ranging impacts and indicate that the smart intervention has a positive outcome.

The combination of methods therefore allows a broaden and deepened insight into the research subject.

9.2 Adequacy of interpretation

In addition to adequacy of data, the adequacy of interpretation is also an essential criterium when it comes to validating a qualitative research during the process of data analysis, interpretation, and presentation (Morrow, 2005).

The data interpretation is an interactive process where the researchers frequently go back and forth between raw data and written analysis to seek additional data from information fragments. Thus, despite various separate stages in the interpretive process, all of steps from transcribing, coding, theming, to analyzing and presenting should be seen as an integrated whole.

Next, an analytic framework of thematic analysis is articulated to systematically interpret the data. A good thematic analysis not only summarizes the data but also, more importantly, interprets and makes sense of it (Maguire & Delahunt, 2017). Our framework of data analysis is consistent with the six-phase guide of Braun & Clarke (2006):

Table 9.1 Braun and Clarke's six-phase framework of doing a thematic analysis

Step 1: Become familiar with the data	Step 4: Review themes
Step 2: Generate initial codes	Step 5: Define themes
Step 3: Search for themes	Step 6: Write-up

Source: (Braun & Clarke, 2006)

Our analysis was driven by the data collected from the respondents' stories of their experiences and points of view. Thus, the conceptual model is completed by the bottom-up approach since our aim is to create a practical and straightforward application that can both address the CO_2 target of Stavanger Municipality and common driving concerns of citizens.

The data interpretation begins to take place during data gathering and transcription of interviews when patterns are recognized by repeated codes. The review of codes on a continuous basis ultimately led to a deep understanding of how parts of answers are interrelated. Then comes the organization of sub-themes and themes in the thematic analysis.

Finally, the writing and the matrix analysis as a complementary analytic strategy compared and contrasted data across different cohorts and individuals in the sample. The findings also exhibit a balance between the researchers' interpretations and supporting quotations from participants. We tried to intertwine our interpretations and participant quotes at a moderate rate because readers would be suspicious of the analysis and findings if the interpretations dominate the quotes, and they would become lost if the quotes are excessive (Morrow, 2005).

The writing is also characterized by "thick description" described by (Geertz, 1973) as a way to not just capture the behavior but also to indicate how and why events occurred in a particular

context. In our research, the participants' attitudes and experiences are placed at the heart of thick descriptions with clarity and consistency in the context of driving in the local community of Stavanger. Furthermore, the presentation of subheadings, tables, and figures assist readers in better following the interpretation.

9.3 Credibility

Credibility can be understood as the confidence in the truth of the research findings (Holloway & Wheeler, 2002). In this way, credibility examines whether or not the research findings are a correct interpretation drawn from the participants' original views. There are some credibility strategies to establish the rigor of the inquiry such as prolonged and varied field experience, time sampling, reflexivity (field journal), triangulation, member checking, peer examination, interview technique, establishing authority of researcher and structural coherence (Anney, 2014).

In this thesis, we employed two techniques, namely use of peer debriefing and triangulation. The frequent debriefing sessions among three members of the research group (once every week) and between the group and the professors (once every two weeks) during the whole semester provide an external check on the research process, which might in turn increase the credibility. Multiple researchers together investigating the same problem bring different perceptions of the inquiry and helps to strengthen the integrity of the findings. Through discussion, the vision of the researchers was widened as different perspectives are taken into account to interpret the insights from raw data. Such collaborative sessions were useful to discuss alternative approaches, and flaws in the proposed course of actions were pointed out by the supervisors to make timely corrections. The meetings played an important role for us to test our developing ideas and interpretations; and probing from others made us recognize our biases and preferences.

Triangulation is defined as the mixing of data or methods to capture diverse viewpoints upon the same topic (Olsen, 2004). The mixing of data types, known as data triangulation, between the use of survey data and interviews in this thesis is a profound from of triangulation. The purpose of triangulation is not only to cross-validate data but also to grasp different dimensions of the same phenomenon, which involves eight different cohorts of participants in the sample and two informants from the municipality. Here individual experiences and viewpoints are verified against others in a comparable position in order to draw a rich picture of the behaviors and needs of a wide range of informants. In this way, the informants act as both service users and service consultants for the mobile application since they are ultimately the end-users of the product that they contribute their ideas to develop. Once the needs of citizens are shaped, the

availability of the municipality is taken into account to address the collaboration. As a result, the dashboards are initiated to foster this partnership.

9.4 Transferability

Transferability is concerned with "how far a researcher may make claims for a general application of their theory" (Gasson, 2004). In quantitative research, this means the possibility to apply the results of statistical analyses to a wider population (Shenton, 2004). In qualitative research, this refers to case-to-case transfer (Tobin & Begley, 2004). Considering that enhancing citizen engagement is key in smart cities to tackle the CO_2 problems, it is possible to find alternative contexts with common social and geographical characteristics, especially in Norway and Europe that can transfer the findings. Given thick descriptions of the contextual information of the respondents and the municipality, those who believe their situations to be similar with the context of Stavanger Municipality may relate the findings to their own positions. As such, we do not make transferability inferences to readers but we presented sufficient information for them to make such a transfer on their own as shared by (Lincoln & Guba, 1985).

In recent years this transferability approach has been used by many qualitative researchers. It is the responsibility of the researchers to provide the description of the context in which the study was undertaken, but readers must determine how they can transfer the results and conclusions presented to their own situation (Shenton, 2004). Because, as noted by (Firestone, 1993) that factors considered by the researchers to be important may be seen negligibly critical in the eyes of readers and vice versa. The work of (Cole & Gardner, 1979), (Marchionini & Teague, 1987) and (Pitts, 1994) emphasized on the importance of the boundaries of the study that the researchers should provide the researchers at the outset. This includes "the number of organizations taking part in the study and where they are based, the number of participants involved in the fieldwork, the data collection methods that were employed, and the time period over which the data was collected", which were mentioned in Chapter 5 of this thesis.

9.5 Dependability

According to (Polit & Beck, 2014), dependability refers to the "stability of the data over time and over the conditions of the study". In other words, "the way in which a study is conducted should be consistent across time, researchers, and analysis techniques" (Gasson, 2004). Thus, the consistency and the reliability of research findings should allow someone outside the research to follow, audit, and critique the research process (Polit & Beck, 2014).

Detailed description of the methodology and data collection (sampling, interview guides, coding, etc.) employed in Chapter 5 allows readers to assess the extent to which appropriate

research practices have been followed. Researchers also document the transcripts in the appendix for readers to compare and contrast to increase transparency and reduce bias. We also employed a technique of audit trail to facilitate the criterium of dependability.

An audit trail is characterized by an examination of the inquiry process to show how the data were collected, recorded and analyzed (Bowen G. , 2009). We accomplished this audit trail by carefully tracking the emerging research design and keeping detailed chronology of research activities from data collection to analysis and findings to make sure that all of emerging codes and themes were captured. The audit trail was then examined among peer researchers and it can also be auditable by another researcher to follow the decision trail. By keeping records of the raw data, field notes, and the transcripts, the researchers could systemize, relate, and cross reference data. This helped to ease the reporting of the research process to create a clear audit trail (Halpren, 1983), which can enable another researcher to arrive at the same or comparable, but not contradictory conclusions with the same data, perspective and situation as argued by (Koch, 1994).

9.6 Confirmability

Confirmability is "concerned with establishing that data and interpretations of the findings are not figments of the inquirer's imagination, but are clearly derived from the data" (Tobin & Begley, 2004). Studies of (Lincoln & Guba, 1985; Koch, 1994; Bowen, 2009) suggest that an audit trial and triangulation help to achieve confirmability of qualitative inquiry. According to Guba and Lincoln (1985), confirmability is also established when credibility, transferability, and dependability are addressed.

All in all, different techniques of qualitative validation including an audit trail, triangulation, and peer debriefing were used to conduct an independent rechecking of the transcripts, codes, emergent themes, and theory with the aim of accomplishing credibility, transferability, dependability and confirmability simultaneously.

CHAPTER 10: CONCLUSION

This section will provide answers to the research questions and sub-questions defined at the outset in Chapter 1. Then, recommendations for the municipality, limitations of this research and suggestions for future research will also be discussed.

10.1 Conclusion

Smart city is an emerging concept which has been raised over the last few years. Using IoT technologies in the city's operations can enhance the quality of life for citizens and make the authorities' governing job more efficient. Stavanger Municipality has been working to implement smart city towards the goal of cutting 80% of CO_2 emissions by 2030 in relation to 2015, and 100% by 2040 (Stavanger City Council, 2018). This ambitious goal could not be achieved by the municipality's action plan only; it needs to be shared among different stakeholders in the society, primarily citizens. This study has investigated the CO_2 drivers behind the local emissions, built a conceptual model of an urban data platform and made a complete version of it based on the bottom-up approach beginning from citizens. Then the perspective of Stavanger Municipality is taken into account to stimulate the collaboration with citizens in tackling the CO_2 problem.

The importance of collaboration for the performance of a smart city was established in previous researches. However, very limited research has been conducted to examine the influential factors on the willingness of these stakeholders to collaborate on an environmental target. Therefore, this case study of Stavanger Municipality is an exploratory study to illustrate the collaboration theory in a vivid and practical way, revolving around the main research question:

"How to define smart interventions that facilitate interoperability between Stavanger Municipality and citizens to achieve the CO_2 emission target?"

In order to answer the central research question, the answers for five sub-questions are provided below.

Sub-question 1: What are the primary sources of CO_2 emissions in Stavanger Municipality?

The empirical findings have identified the three key drivers of CO_2 emissions in Stavanger, which are the passenger cars, the ships, and the heating. Of all these three factors, passenger cars provide more room to improve CO_2 emissions and potentially bring the most influential impacts for a wide range of citizens. Since the road transport contributes to nearly 50% of the CO_2 emissions locally (refer to part 2.2) and passenger cars account for 75% of it (refer to part 2.3).

Sub-question 2: How are the citizens aware of their pollution and the importance of the municipality's CO_2 goal?

Three points made in part 6.3.2 shed light on this question. First, the knowledge about car emissions of the respondents is very limited and is not seen as an important factor to the environment by car drivers. Second, most of them appreciated the importance of CO_2 emission goal of the municipality. However, the third point is that the magnitude of the CO_2 importance and the magnitude of its relation to their personal life are not consistent. This therefore calls for more collaboration improvement to be embedded in the smart intervention.

Sub-question 3: What are their motivations to make them more engaged in the municipality's CO_2 target?

The sub-theme of motivation factors in part 6.4.2 summarized the reasons that citizens might feel more engaged with the municipality. First, they prioritized to have a smart tool that can help them to address their common driving issues such as checking toll payment, traffic jam, and parking lot. Then comes the motivation to have less negative influence on the environment by demonstrating the most environmentally friendly route with the estimated least carbon footprint.

The respondents themselves would also like to be a part of the system by receiving updates from the municipality on its news, activities and progress against the goal and interacting with the municipality through a convenient tool. In order for them to engage in the CO_2 goal, they shared the point of breaking down the whole goal into smaller ones for each neighborhood and letting them manage that on the neighborhood and even individual level. The feeling of getting in a competition would motivate them to cut more CO_2 emissions.

Sub-question 4: What are the difficulties of Stavanger Municipality in terms of managing its CO_2 reduction target and engaging citizens?

Part 7.1 revealed the challenges of Stavanger Municipality in terms of CO_2 data collection and citizen engagement management. The local government only has a rough idea about the current CO_2 emissions inside the municipality based on a number of related variables and has to wait two years to get the complete data from the upper level. Consequently, there exists a lag of two years between the time an event happened and the time the authority can make decision to solve it. Additionally, there is not a proper tool to measure how they foster the relationship with the citizens, which is paramount in the context of a smart city.

Sub-question 5: Which smart interventions can be implemented to reduce the CO_2 emissions and enhance the citizens' awareness?

The conceptual model of installing CO_2 sensors at the toll booth is initially introduced in part 3.3 with general features such as real-time CO_2 emissions and a mobile application developed out of it. After studying the insights of the respondents through the bottom-up process in Chapter 6, a set of complete features for the mobile application used by citizens is introduced to visualize in Chapter 8.

From the side of the municipality, the internal dashboards are found to be effective in decision-making, managing the open data and the CO_2 goal while the external dashboards can help to gain more trust from citizens. An illustration of how dashboards look is also included in Chapter 8.

Sub-question 6: Once set in motion, how are the benefits of such smart interventions evaluated?

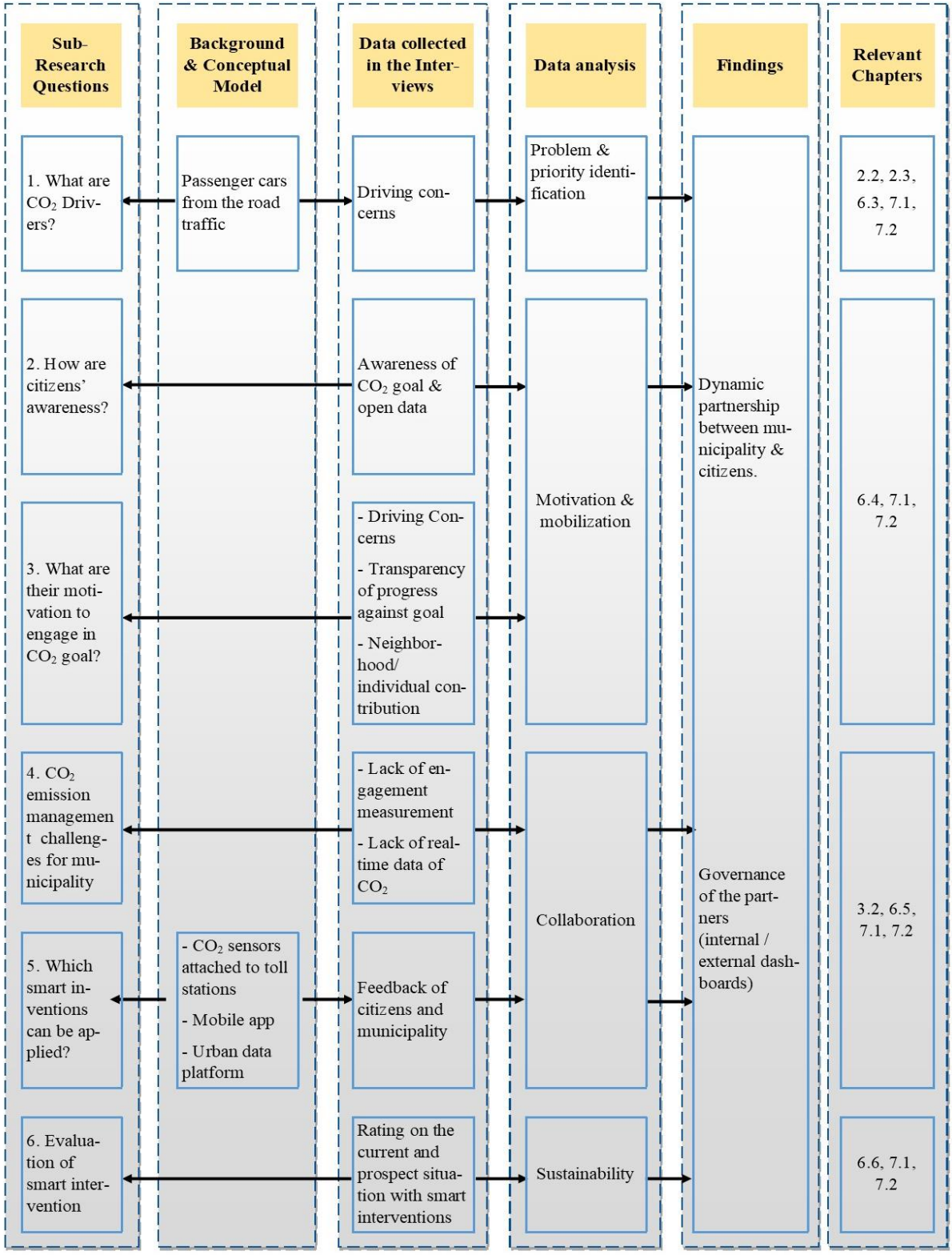
The suggestion of internal/external dashboards makes Figure in Chapter 7 complete to see the benefits of two smart interventions introduced in this thesis. With the development of the mobile application and dashboards developed from CO_2 sensors as smart interventions for sub-question 5, both the municipality's and citizens' challenges found from sub-question 2 and 4 above can be addressed. In this way, citizens can relax their common driving concern and have higher motivation to participate in the goal of the municipality. Meanwhile, the authorities can have real-time data at hand to better take timely actions towards the goal and can measure the interaction with citizens. The immediate, short-term, and long-term impacts of these smart interventions are mentioned in Figure 7.1.

10.2 Theoretical implications

Our empirical study has several theoretical implications. First, our findings well reflect the theory of smart city definitions and dimensions. It is clearly conveyed in the dynamic partnership between Stavanger Municipality and citizens. The mobile application is an example of using smart initiatives to improve "quality of life" for citizens by touching most of smart city dimensions: smart living, smart environment, smart mobility, smart governance and smart people according to ASCIMER (2015) (part 4.2). In addition, the environmental features of this app can sustain social benefits to meet the needs of not only the present generation but also the future generation. Second, our bottom-up research illustrates the stakeholder collaboration theory in real life. The highest level of public participation spectrum introduced by IPA2 (2014) (part 4.3) can be seen through this approach. In this light, the municipality "empowers" citizens in the decision-making process of finding solutions for a societal issue. Third, the discussion in the literature framework of urban data platform is re-exhibited in the particular case of Stavanger. Four actors of a platform structure introduced by Das (2018) (part 4.4) are employed to draw the conceptual urban data platform in Stavanger. The practical lens that we applied

provides insights of citizens' need to transform raw open data into usable data, and to convert "nominal transparency" by removing generic barriers into "effective transparency" where mutual trust is enhanced.

Table 10.1 Overview of information flow and logic linking from research questions to findings.



Source: Own illustration

Table 10.1 shows an overview about how our sub-research questions can be answered throughout the thesis. The chapter of Background (Chapter 2) and Conceptual model (Chapter 3) directly answer sub-question 1 and 5. However, the concept of smart interventions in Chapter 3 is not a thorough answer for sub-question 5. More data collected through the interviews and data analysis help to enhance the conceptual model, considering that views of the respondents are taken into consideration. Our analysis shows the process of fostering the partnership between Stavanger Municipality and citizens through the mobile application developed from CO_2 sensors. Participants in our study constructed joint knowledge, experience and solutions for real-life issues to make the app practical. At the same time our research also revealed the absence of a shared cognitive framework for understanding open data, which is the valuable resource of Stavanger Municipality with more than 200 datasets. Therefore, the findings suggest governance of the partnership by internal and external dashboards to evaluate the cooperation process and create effective transparency.

10.2 Recommendations for the municipality

The study has drawn attention to the important dynamics of the stakeholder partnership in a community and has generated a conceptual model based on smart solutions to foster that partnership. We focus more on the process than the outcome to provide a paradigm of development, with the citizen engagement as the locus of social change. In order for Stavanger Municipality to facilitate the partnership in the smart city ecosystem, several recommendations are made based on the analysis and findings of this study.

First, smart city governance is twofold. Innovation enabling conditions should be triggered in a way to stimulate smart city collaborations. Because actors in an ecosystem would be willing to join in a program if they find that they are a part of it. Also, the local government should minimize the effect of contextual constraints (e.g. language barriers, lack of information, etc.) since these factors hinder effective collaborations.

Second, the implications for community to follow a collective CO_2 reduction target should be specific. A sustainable social program is rooted in sound actions taken by stakeholders - public, private, and civic - as part of an inclusive process. The degree to which the benefits of a development program are sustained depends on the degree to which stakeholders are willing to jointly address issues and are capable of doing that. In this light, translating the big number of the CO_2 target into neighborhood/individual objectives and making it transparent and visible for all stakeholders via a mobile application and dashboards are recommended.

Third, the analysis of the study, as encapsulated in the stakeholder collaboration theory, suggests that citizens' voice needs to be scaled up to a higher level. As indicated in part 3.3, the

collaborative process should have less “informing” elements and instead more “empowering” factors according to IAP2's Public Participation Spectrum (IPA2, 2014). In this regard, citizens need to have a central role in the decision-making process in relation to the municipality’s environment program. The bottom-up approach in the analysis of this study is an example of enhancing a smart intervention from a practical lens: a mobile application aimed at solving driving concerns and fostering collaboration for a long-term environmental project. However, the policy approach is not necessarily exclusively bottom-up. It can be a balanced, collaborative process of top-down and bottom-up perspective. Significant inputs from the “bottom” such as local concerns and self-help energies can complement political points and technical expertise from the “top”.

Fourth, our research highlights that the open data platform of Stavanger Municipality is a great resource to provide convenient tools for citizens in their real life and managerial tools for authorities to make decisions. Therefore, a specific understanding of technology-in-context is needed to prevent a situation where there is abundant room for smart initiatives, but it is still underexploited. A meaningful open data platform provision requires that government organizations engage in a continuous learning process with citizens and other stakeholders. More potential uses of available open datasets should be explored to develop meaningful forms of transparency.

Last but not least, the local government not only stimulates the relationship with citizens but also cooperates with other governing partners such as Ferde and Bymiljøpakken and education organizations to regulate resources in an ecosystem. Different authorities should facilitate joint strategies to act on behalf of the national government at the municipal level. Data and talents across organizations can be pooled together to create an even stronger community instead of being hampered by bureaucratic norms and procedures. In this way, the multi-organizational collaboration can leverage resources more efficiently, reduce duplication of effort, and ensure that the joint service makes them more responsive to the needs of citizens and bring effective results to their serving task. Hence, as the community develops, so will the authorities at large, and the two will be mutually reinforcing.

10.3 Limitations

There are some inherent limitations in this thesis. First, the CO_2 picture of Stavanger Municipality in this study will not hold true in the future. Because as of 01.01.2020 Finnøy and Rennesøy will merge with Stavanger into a new municipality (New Stavanger Municipality, 2019). Therefore, additional information related to CO_2 need to be gathered and the CO_2 goal might be adjusted since CO_2 emissions mainly come from agriculture and aquaculture in Finnøy

and Rennesøy. Second, the interviews have been conducted solely with two representatives of a smart city ecosystem, namely citizens and the municipality. Due to the limited scope of a Master thesis, we cannot reach to all participants of the urban data platform. There is a lack of views from other organizations such as Ferde, Bymiljøpakken for toll service consultancy and an ICT company for technical development. Also, Stavanger smart city has not achieved the maturity of its smart city roadmap so the findings of the case study emerging from the interviews are just at the early planning stage. Therefore, the continuation of this study can be pursued by extending the analysis to other stakeholders' perspective on a longer time span to better evaluate the possibility of suggested smart interventions.

10.4 Suggestions for future research

Although this study has provided some insights on the citizens' willingness to collaborate in the CO_2 target of the municipality, some ideas for further research have risen. First, considering the broad scope of the topic, researchers can further investigate the perspectives of other stakeholders in the ecosystem such as ICT companies, toll service providers, start-ups and private sectors. In addition, the standardization of the platform and open data standards also need to shed a light on. Further research in this regard can be conducted to explore important determinants of platform adoption in order to optimize the collaboration of multiple stakeholders in a smart city ecosystem. It is also a concern of Stavanger Municipality during the interview about the role clarification, especially when it comes to ownership, funding, and governance. Therefore, it could be valuable to have a thorough answer on this matter.

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Appendices

1. Citizen questionnaires

1) Which problems of driving you are facing now in Stavanger?

2) If you have to drive your children to school, how inconvenient the route is?

3) How much are you aware of the level of CO_2 emission your car is emitting?

4) What do you think about the importance of CO_2 emission target of the municipality?

5) How can you relate the municipality's CO_2 goal to your personal life?

6) How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

7) How are you aware of when you will send your car to EU control?

8) Do you know that CO_2 emission is subject to the EU control condition?

9) Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

10) How do you know how much you pay for the toll? Is it real time?

11) Do you have any trouble with the transparency of the toll?

12) How do you know where there is a toll station?

13) In which way are you designing your route to have less toll fee?

14) If you want to park somewhere, how do you find an available spot in a parking lot?

15) How do you know if there is traffic jam somewhere?

16) How do you know about the speed limit of the street?

17) What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

18) Do you feel normal citizens are engaged to the municipality's activities or policies now?

19) If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

20) Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

21) How do they work to help you achieve the traffic efficiency?

22) If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

23) Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

24) Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?
25) How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?
26) If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?
27) Do you have any other suggestions to make the app better? (easy to use, free, etc.)
28) What is your expectations for the municipality to serve you better?
29) Do you feel comfortable sharing your CO_2 emission with the municipality open data?
30) Do you feel comfortable sharing your CO_2 emission with other people?
31) Do you want to see other people's CO_2 emission and compare it to your own?
32) Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?
33) Do you want to share the type of your cars and the type of fuel you are using with the other people?
34) Do you want to see other people's type of cars and the type of fuel they are using?
35) Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)
36) Do you feel more engaged to the municipality's activities or policies if you can exploit the app?
37) What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

2. Municipality questionnaires

1) Which problems you are facing now in terms of managing CO_2 emitted from cars in Stavanger?

2) How important the CO_2 target is to the municipality?

3) What is the plan of the municipality to reduce CO_2 from cars?

4) What is the current tool to track CO_2 emission from cars?

5) What kinds of transportation data is available on the open data?

6) How can the municipality engage citizens in the CO_2 target?

7) what do you think about the current visualization of open data, esp. data related to transportation in terms of usability for citizens? (parking, cycling, etc.)

8) do you have any current dashboard to manage CO_2?

9) Does the municipality own any app? Who owns it?

10) Have you implemented any instrument/sensor(s) for CO_2 emission from transport?

11) Have you had effective or positive results? Please give a brief description of the achievements

12) How interested the municipality is in knowing how much CO_2 is emitted from cars in real time?

13) What kind of procedure/approach do you use to collect the real-time data?

14) Who is in charge of the toll system in the municipality?

15) Where is the data of toll fee stored?

16) Is such statistical data be made available for the citizen?

please list the main difficulties and/or uncertainties in collecting the data?

17) Is the toll fee managed by the municipality as well?

18) What do you think if the toll data is made open on the municipality website?

19) How the municipality gets the information of which place is having traffic congestion?

20) What is the current tool for the municipality to interact directly with citizens?

21) What do you think about the current utilization of open data on the website of the municipality (parking lot, walking and cycle paths, roads with speed limit?) of citizens?

22) Do you feel normal citizens are engaged to the municipality's activities or policies now?

23) If you are to rate the present circumstance of the municipality providing supporting knowledge to citizens on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

24) If you are to rate the present circumstance of the collaboration between the municipality and citizens on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

25) Does the municipality own or support any app to help citizens get better information about transportation (Traffic jam, parking, maintenance, etc.)?

26) How do they work to help citizens achieve the traffic efficiency?

27) If there is an app that can show you how much CO_2 cars is emitting, how much toll has been paid and suggest which route citizens should take to make it more environmentally-friendly and more cost-saving, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

28) What are the advantages of installing a CO_2 sensor at some toll stations?

29) What are the challenges of installing a CO_2 sensor at some toll stations?

30) Do you have any other suggestions to make the app better? (easy to use, free, etc.)

31) If citizens can exploit the app, how much impact do you think they are contributing to the CO_2 target?

32) Do you want to interact with citizens directly via this platform? (see an accident, report traffic jam, report errors)

33) if you can have a dashboard to manage it, what do you think it should look like?

How do you set the target of CO_2 reduction for cars in the municipality?

34) How much do you feel the municipality engage citizens if they can exploit the app and the municipality can utilize the dashboard?

35) If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

36) If you are to rate the present circumstance of the collaboration between the municipality and citizens on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

37) Which role could the municipality take if the app exists? (regulator, funder or coordinator)?

38) To what extent you think this idea is possible to sustain the benefits for citizens in the long term?

3. Interview with citizens

Interviewee: 1.1

Interviewer: Kim Ngan

Date of interview: May 17, 2019

Location of interview: Interviewee's own place

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 33

Gender: Male

Job: Student

Number of dependent children: 0

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 2 – both diesels.

I: Where do you live?

R: City center.

I: Do you often travel to the city center?

R: Once a week

I: Which problems of driving you are facing now in Stavanger?

R: Not really. Because I live right outside of Sentrum, so I usually take bus. I don't use car because toll stations have ruined travelling for us.

I: how do you decide when to use car?

R: It depends if I am going to buy some stuff which I need to carry then I use my bigger car. If I am going to pick up a person or meet someone then I usually use bus. I usually drive my small car but if I have to transfer or carry stuff then I use my bigger car.

R: Which problem of driving are you facing? Toll stations. Other than that, I have no major problem. Parking in downtown maybe tricky sometime but not particularly. Parking cost like a lot of money to park for very short time; this is also one of the reasons I use bus. But to Forus I always take car, never taken the bus, because it is further away and more practical to drive out and drive back.

I: Have you ever faced traffic jam?

R: Usually I don't drive during rush hour; I drive before or after rush hour. And also, to Forus there is no bus lane, so bus is also stuck in same traffic.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: I know for my small car which is 60gm per Kilometer which is Euro6 standard. When I buy a car, this information came with it about range, fuel economy, fuel class, etc. that is where it says that this car is euro6. That is one of the most clean standard.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: It is a good goal. We need to take care of the environment. Earlier days municipality was very concerned about CO_2. So, they forced people to buy diesel cars to reduce CO_2 emission. After few years the concern changed to NOX because this is something diesel engine emit. So, CO_2 is kind of global issue where NOX become more local. Suddenly they started advice people to buy fuel car; benzene, gasoline. So, it was a weird time back then.

I: Diesel is more pollutant than the gasoline car?

R: No, I think they didn't know what they are going for. They didn't know the consequences of everything and the emissions of cars. People knew that diesel is worst for local perspective. They knew about the politicians.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: I don't think much about it. I got relatively lower emissions and for me it is not the most important things. Its fuel economy, but hey both go hand in hand. So, I have been diving car for years, it should be cheap to run with lower emissions. So, this was a sales point when I bought the car, I don't think much about it.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: Not particularly. Of course, everything points down to economy for my better fuel consumption means lower emissions. So, emissions are not the main thing, it is the economy of car.

I: How often do you take your car to the EU control?

R: 2^{nd} year.

I: Do you know that CO_2 emission is subject to the EU control condition?

R: Yes, I do. I had a car that had some technically different engine. EU control does not have a proper tool to carry out the emission test. As a result, it always says high emissions. They pass my car by taking special approval. As I told you the other car pass or fail all the time, so I am very much aware of this. Well, from the manufacturers point of view it is been a focus to have low emissions now. So usually if there is not something wrong with the car they pass very easily. But if there is some problem with fuel mixture or working that is something they fail.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: I think it is important to focus on it. Get low emission as much as it is possible to reduce carbon. But I don't know, honestly.

I: If there is another car same model and you can compare emission level to see if your car is doing fine, is it a good indicator?

R: Yes, actually as I also said, if the car is way off of CO_2 emission then there is really something mechanically wrong with it. It gets the wrong mixtures, there is leakage somewhere, something is wrong. So, this is a way to see troubles.

I: How do you know how much you pay for the toll? Is it real time?

R: I have an accountant who does all of that for me. So, she pays my bill related to company car. But I know people say that they drive, they use car daily to work and these toll stations have affected life economically. I heard people got NOK 20,000 - just for toll stations for one year for one car, which is a lot. Often people have two cars. I can go check my toll fee if I want to. But I handed over this to my accountant and I know she can handle it because she knows her work. So, she takes care of my company car bills. Every month or so I receive history of paid bills.

I: Do you have any trouble with the transparency of the toll?

R: No, I have not seen any. I don't drive much to downtown. And let say I added NOK 5,000 in it, so I keep driving until it dries out. So, I have not noticed too much onto that.

I: How do you know where there is a toll station?

R: I just the local area and I have the knowhow of its location but for any strange place, I don't know.

I: Is there some way to find out?

R: If you use google maps to travel it sometime tell you about toll stations and ferry, and stuff like this that it will cost money. But I don't pay much attention to it. Because it is a company's car and they pay the tax and everything that is why I don't pay much attention. But if it was my car then I would probably care.

I: In which way are you designing your route to have less toll fee?

R: I don't care about it. Because it is not me who is paying for it. It's company who is paying so I don't care much. And on my personal trips, also company pays for it because I pay advantage tax. If I have a car, I pay certain amount of tax every year and get tax reduction on everything about car. Like toll station, repairs, gasoline, etc.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: I drove around and find for spot. Unless like I'm traveling to Madla center which is telling how many available spots are in the parking. Sometimes it takes time to look for spot, but it is a part of driving.

I: How do you know if there is traffic jam somewhere?

R: Usually, I know about this area that after 4 o'clock I know there will be a traffic jam so I travel accordingly otherwise I know I will be stuck. I usually try finish my work around 2 o'clock so that I can reach home before rush hour. So, it is just a local knowhow.

I: How do you know about the speed limit of the street?

R: Usually follow the signs. If it is 40 or 60 KM/hr. I follow it. If it says 100 then maybe, I will go 110 KM/hour. But my car has sign detector. So, if I pass 80 KM/hr. sign then it tells me. So usually I look at the screen if I am lost. So, whatever the speed limit is, I prefer to travel 10% above it.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: Not aware of.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now?

R: Yes, now you have this "nei til bompanger" means "no to toll station" party and that is valid to lot of local people. That is what engages most of the people. Because it affects the life of citizens. If they have to sell their cars to buy new electric cars or stop doing activities in their spare time and stuff like this because it affects them too much.

I: If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 4.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: Google maps, Kolumbus billet, Santid.

I: How do they work to help you achieve the traffic efficiency?

R: It helps me for looking bus timing because it tells the real time location of the busses. Sometime bus passes by earlier than the time so I use this app to be at bus stop on time, so I do not miss the bus. If I really need to know about traffic jam, then I use google maps.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: 5.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: Fuel consumption.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Environmentally friendly route.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: I would buy electric car and use that instead. Zero emission cars, that is the future. More and more cars are electric now, more producers are producing electric. Many producers have this target by 2030 there should be 100% electric or hydrogen cars on the road. But this is not what I would do because I need car that can go longer, travel long distance and are more dependable. Because if I get stuck in the middle of nowhere, I can get fuel and come back, but in the case of electric it is not possible. But eventually there will be an electric car for me.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 5.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: If there can be real time updated fuel prices within that area that would be really a good selling point. Because if people know where they can get cheaper fuel, they will put that in their route and follow that route. Even if it will cause detouring but this will be a selling point for that app.

I: What are your expectations for the municipality to serve you better?

R: They should try to be environmentally friendly and make it easy for people to be environmentally friendly of course. In terms of trying people to use bike and stuff, try to reduce cars in downtown. Try to have more people on busses. This is easy in big city like Stavanger, but if you go to Egersund, a smaller town, it is not practical that bus is going far just for two houses.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: I don’t think much about it.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the other people?

R: Yes.

I: Do you want to see other people’s type of cars and the type of fuel they are using?

R: Yes.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: That would be a good idea. Until people use it for what it is intended for. Because sometimes people abuse or misuse things, otherwise it is a good idea.

I: Do you feel more engaged to the municipality’s activities or policies if you can exploit the app?

R: Yes, many people just don’t care about what they are doing. They just do it and complain. That is usually what people do. But if they have an app like to interact then it would be a chance for a person to be more interested in such activities.

Interviewee: 1.2

Interviewer: Abdur Rehman

Date of interview: April 16, 2019

Location of interview: University of Stavanger

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 27

Gender: Female

Job: Student

Number of dependent children: 0

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 by gas

I: Where do you live?

R: In Stavanger Sørmarka, 10 minutes from city center

I: Do you often travel to the city center?

R: Maybe once a week, but then I take the bus. But I use my car to go to the university.

I: How far from the university to your home?

R: It is only 10 minutes to drive.

I: So approximately 5 kilometers one way, so 10 kilometers back and forth?

R: Yes.

I: Which problems of driving you are facing now in Stavanger?

R: Not any problem. It is just like it takes a bit more time to travel with the car and parking.

I: Do you have any problems with parking?

R: Yes, but it is more expensive to drive to the city center, so no.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: Not that much.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: I know it is important. I know that. I shouldn't take the car and instead take a bus. But to school I'd like to take the car because it's easier when I want to go home. I know that CO_2 is a problem but is that what you are asking about. What will the consequences be? There will be more pollutions but are you thinking about the ozone layer? I don't know. I think it's important to reduce CO_2.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: I am helping with taking the bus to the city center, walking to my job and not taking the car.
I: As much as you do, you try to do it right?
R: Almost. I couldn't walk to school or anything.
I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?
R: I am not that interested. But maybe when it comes to comparing my CO_2 with other cars of the same model. But I have an old car and I know that it may be not the best. I don't know it I will likely change the car.
I: How are you aware of when you will take your car to EU control?
R: Every second year.
I: Do you know that they will also check CO_2 emissions in your car?
R: No, I don't know.
I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?
R: Yes, I agree.
I: How do you know how much you pay for the toll?
R: No.
I: Do you have prepaid or post-paid?
R: Post-paid. I get the invoice and I just paid for it. I don't really care that much. I just drive. If I have to drive, I drive.
I: Do you have any trouble with the transparency of the toll?
R: I don't travel through toll stations from home to the university. So, if I have to travel far away, I will travel but I haven't checked the toll invoice.
I: If you want to park somewhere, how do you find an available spot in a parking lot?
R: Anywhere. I just drive there and look for them.
I: How do you know if there is traffic jam somewhere?
R: Based on my experience. I don't use any apps. I know that after work the traffic will get worse, so I try to avoid. But it would be nice to know where the traffic is in advance so I can avoid wasting my time and fuel in the queue.
I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)
R: No
I: Do you feel normal citizens are engaged to the municipality's activities or policies now, if you can rate from 1 to 5?

R: Both. Some do. Some don't. But for me it's 3. For example, my husband has a car which is hybrid. He is travelling far away so we'd like to think about it. And I also like to travel. But we also know people don't care who drives diesel cars.

I: If you are to rate the present circumstance of driving supporting knowledge on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 3 maybe.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: 5.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: I said that I wasn't very interested. But I still want to know all of these if I can. Maybe parking spaces.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Toll payment.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: No, I can feel a part of it.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 5.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: I am not that sure but maybe if the app can show how much I can contribute to the target of the municipality; it would be better.

I: What are your expectations for the municipality to serve you better?

R: I don't have any.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: Yes.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app? Can you rate from 1 to 5?

R: Yes and 3.

I: What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

R: Maybe it will take a bit more time than 5 years to be like super green.

Interviewee: 2.1

Interviewer: Kim Ngan

Date of interview: May 16, 2019

Location of interview: Interviewee's own place

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 38

Job: Warehouse worker

Gender: Male

Number of dependent children: 2

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 by normal petrol

I: Where do you live?

R: Near city center

I: Do you often travel to the city center?

R: Yes. I have small kids. I often take them to the library in city center for them to read and have some activities. I sometimes go to the cinema too.

I: But during the rush hours, is there a lot of traffic jam?

R: Yeah when I am going to work in the morning, but it is not so bad from here.

I: Which problems of driving you are facing now in Stavanger?

R: Not really

I: How about parking lots?

R: I am not worried. I use my eyes.

I: If you have to drive your children to school, how inconvenient the route is?

R: That's not very inconvenient because both the kindergarten and the primary school are pretty close to where we live.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: I am not sure I know that.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: I don't know. I think it is on a very big scale. It looks very big from my side. But of course, citizens like me should have, in some way, our personal responsibility to think about it. I know that cows and extracting crude oil produce CO_2 very much in the world.

How can you relate the municipality's CO_2 goal to your personal life?

R: I don't really relate it to my personal life. I have an old car and it is what it is.
How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?
You know that when you buy the car. Like on the average, how much CO_2 your car will emit per km.
I: But over time, when the car is older, it tends to emit more CO_2. DO you want to know how much actually your car is emitting?
R: It would be fun to know. It can be a good indicator too.
I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?
R: Yeah absolutely.
I: Do you know that CO_2 emissions are subject to EU control too?
R: I have no idea about that actually.
I: How do you know how much you pay for the toll? Is it real time?
R: I get bills.
I: Every month?
R: No, I think you don't get a bill every month. It is up to a certain amount. When you just get through a couple of times, you don't get bills. Maybe it is up to 1000 NOK that they send a bill to you. I am not sure actually. Before you could see everything when you pass and how much but now you can't actually see all the details. So that's luck or out of luck. I want to have control over that. So, if it is real time, it is very practical. Like every time I pass a toll, I know a certain amount has been deducted. And also, I hope it will also tell me that it costs zero because I pass within an hour. So, it is really nice to know that.
I: Do you have any trouble with the transparency of the toll?
R: It's kind of bothering me because I can't check the details. I would really love to have like, in my bank, if I can get the details of every time, I pass so I can see that it is right. I haven't thought it is really much because it should be around 800 or 900 NOK a month, maybe 1000 NOK if I go to the cabin. Because I have to go in the rush hour. I don't like rush hour fee because I really think it is not social. It doesn't reduce the traffic. It just changes the driving pattern for the people who can't actually change the working time, like people with kids and maybe they have two cars also. They have to drive in rush hour. No choice. So, it's really unsocial. I would rather have a higher fee, and then no rush hour fee. It would be much better. Instead of paying 17.80 NOK if I have the chip in my car for normal hours and for rush hours it is 35.60 NOK, I can pay 25 NOK on the average. It will be better. And I think they might earn more money because a lot of people drive before 7 now. It feels like the rush hour is before

7 now. So, for me it's good because the traffic is good although it might be a bit expensive for me.

I: But do you think that the rush hour fee works in terms of reducing fuel thanks to reduced waiting line?

R: I don't know. Maybe I use less fuel thanks to the reduced waiting time during the rush hour but there is still fuel consumed.

I: In which way are you designing your route to have less toll fee?

R: I don't think about it. In the weekends, there's no rush hour fee, so I don't care really much. When I drive to Sandnes, I just drive to Forus because I only have to pay once. One time I drove to Sola to get to Bryne, I actually spent more gas by taking another route that doesn't have toll booth. It was just 17 kr. So, it was opposite to what I wanted.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: Usually I see the board in front of the parking lot. But it would be nice that I can see the overview of the available parking spots so I can easily head there initially.

I: How do you know if there is traffic jam somewhere?

R: When I get there, there is traffic jam. Or usually I know where the traffic jam is during the rush hour. But if it is an accident, I don't really know. I can just see if the queue starts really early, I can maybe take another road.

I: How do you know about the speed limit of the street?

R: By reading the sign. But usually now in Stavanger, what I learn is that where there are a lot of houses, it's 60 and where there are no houses, it's 80. But now I think it's 40 and 70.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: I have no idea what it is.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now, if you can rate from 1 to 5?

R: I think so but not all. So, I would rate 2.

I: If you are to rate the present circumstance of driving supporting knowledge on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: I don't know what information is out there because I hardly use any app. And the traffic isn't too bad. I only use from 5-15 minutes to go to work. So, 4 for me.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: Only the parking app. I have my license plate on it and just log in the time, mainly for payment.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: 4 or 5

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: Toll payment.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Speed limit.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: No. My car is old.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 4.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: It should be free to encourage people to use but I guess eventually it is going to be commercial.

I: What are your expectations for the municipality to serve you better?

R: No. I don't have the insight into what they are providing, so I don't know.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: If it's used on enhancing my life, then yes. If not, I don't want to get controlled by them. It sounds that this is a tool for them to raise tax to people who have cars like I have. Why would they be interested in sharing the emission. Like you are a bad guy, you should pay more for having that car. And electric cars win.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: People are interested. I don't really care. People will just say that 'Your car has a lot of CO_2'. It is fine. I have an old car.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: It's interesting and fun to see maybe in the first couple of years to see the emission of the neighborhoods. Just like the tax list, you can see how much people earn and pay taxes. But after that, I don't care anymore. So, I guess it's going to be like that because it's new.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: They know it actually. They know what type of car I have. But they don't know the exact amount.

I: Because when you bought the car, you have to register the number plate?

R: Yeah, and also the producer has tested the car, so on average it uses that amount of CO_2 according to that. And also, the size of the engine, the weight and everything. The taxes for that kind of car is estimated. So, if you buy it abroad, you have to pay more tax to bring it in.

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: If it has an E on the number plate, I know it's an electric car. Otherwise, it is either gas or diesel.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: Could be nice. They have that. I ride my bike to work sometimes. They have an app for cyclists. If they notice something wrong on the street, they can notify the municipality to come and fix it.

I: Besides that, does the app have any other function?

R: I don't know. I downloaded it but I rarely use it.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app? Can you rate it from 1 to 5?

Maybe because information is more available there. So maybe 3.

I: What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

R: I think it is not going to have a big effect. It is just like some more information to know. You can't do anything with your car. The only thing we can do is to know if it needs any service. It can be useful but other than that, I have to drive to work. If I take bus, I will work less and earn less money. And that less money is not good because I have kids.

I: How about if the app can suggest the most efficient route for you to go to work?

R: I don't care much about it. Because it's a freeway. There's like no other options. Or I can go over Ullandhaug. I have to go on a freeway anyway to get to Forus. Because the other way is illegal to drive through. So, there are not many different ways to go for me.

I: To what extent you think this idea is possible to sustain the benefits for citizens in the long term?

R: I like the idea. Like I can see if my car needs service. Would be nice if the app can have the average rating, and if the car exceeds that limit, it will make a notification to people. Because it is going over the normal average emission.

Interviewee: 2.2

Interviewer: Kim Ngan & Abdur Rehman

Date of interview: March 27, 2019

Location of interview: University of Stavanger

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 34

Job: Researcher

Gender: Male

Number of dependent children: 2

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 - Hybrid

I: Where do you live?

R: City center, Stavanger

I: Do you often travel to the city center?

R: Yes, Once a week.

I: Which problems of driving you are facing now in Stavanger?

R: It is only the rush hour traffic other than that it is good. Sometime, yes, but not always. Especially in the city center it is kind of a problem. But rest of the parking places are quite well established.

I: If you have to drive your children to school, how inconvenient the route is?

R: My older child goes to school. Route is very straight forward. There is no problem. I drove him to school. School is not very close it is 5 KM from house and route is not very bad.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: No, I don't know. I never checked this I was just looking for the car that I can buy. But the reason why I choose hybrid one is partly because price saving and environmentally friendly.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: I think it is very good, it should be targeted it is very significant or severe problem in Stavanger. Here in Stavanger it is not a big problem but other part of world it is a big problem. But putting a target that can be achieved sometime in future by municipality is a good thing.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: As I said, the reason I choose hybrid card is for environmental reasons. And if the weather is nice, I do not use my car but bike to school. So, this is how I try my best to reduce my carbon emission.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: It would be good to know carbon footprint of my car. If I would be aware of this, then I might be changing my car with more environmentally friendly one.

I: How often do you take your car to the EU control?

R: I think it is every 2nd year. And tomorrow I will have mine.

I: Do you know that CO_2 emission is subject to the EU control condition?

R: Yes, I know.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: Yes, I think so.

I: How do you know how much you pay for the toll? Is it real time?

R: Yes, I know it, but it is not real time. I can check time to time from the website. I think they recently changed the system and now they will be sending invoices/faktura at the end of month.

I: Do you have any trouble with the transparency of the toll?

R: It is not real time, so I guess it causes problem. So, when you pass through toll station, it appears in your account after three days. It will be good if it will be real time to see balance amount may be to organize your trip in a better way. The prepaid system is now changed to post-paid system. But I think prepaid system was better to control how much you paid when pass because I was able to see how much I have been deducted but now, I will get to know at the end of month where I had been travelling.

I: How do you know where there is a toll station?

R: In my route, I know where it is. But if I travel some place new then I don't know but I try to check through the website. But this is something I don't pay much attention to.

I: In which way are you designing your route to have less toll fee?

R: I usually do not pay much attention to tolls while designing my route.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: I use "easepark" app. Most of the time, I just drove near parking lots to find for free spot. Also, sometimes I follow the signs that shows free spaces in parking lot. Since I have children, and younger one is less than 1 year so I have to choose the closest parking spot.

I: How do you know if there is traffic jam somewhere?

R: I check google maps they show red color.

I: How do you know about the speed limit of the street?

R: I follow the signs. It was difficult for me to drive here because I'm coming from turkey and rules are not much being followed there. But here rules are followed strictly and now I am comfortable with it.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: I am aware of the open data, but I have never visited it.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now?

R: I don't know, to be honest. For me, I don't. most important problem is the language barrier. Most of the things are in Norwegian and I don't speak Norwegian now. But I am not aware of other local Norwegian people if they are engaged or not.

I: If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 5.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: Google maps, easypark, and kolumbus.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: 4.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: 1) Toll payment, 2) CO_2 measurement.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Speed limit.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: I would choose my route by looking at this app. I will feel more relaxed by thinking that I am not polluting.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 5.

Theme: Working together

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: “Three figures suggestion” it would be nice to have it.

I: What are your expectations for the municipality to serve you better?

R: I think language is the most important. Information is not all shared in English.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes.

I: Do you want to see other people’s CO_2 emission and compare it to your own?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the other people?

R: Yes.

I: Do you want to see other people’s type of cars and the type of fuel they are using?

R: Yes.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: Yes. It could be one the suggestion to add as a feature in app.

Theme: Creating an enabling environment

I: Do you feel more engaged to the municipality’s activities or policies if you can exploit the app?

R: Yes, it would show my personal contribution. I will feel as a part of system.

I: What can you imagine how ‘green’ Stavanger will be in the next 5 years if people start using the app?

R: People are already contributing to green Stavanger. People commute on bicycle etc. but this app will obviously have some extra impact for greener Stavanger.

Interviewee: 3.1

Interviewer: Abdur Rehman

Date of interview: April 11, 2019

Location of interview: Forus, Stavanger.

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 29

Job: Client consultant

Gender: Female

Number of dependent children: 0

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 car, Diesel

I: Where do you live?

R: Vaulen, in Hinna bydel. Not on the beach, on the other side, I guess. Still Vaulen

I: Do you often travel to the city center?

R: Probably once a month. Could be shopping, could be work, different purposes. Sometimes when I work with a client in the city center, I obviously travel there every day. But maybe once a month, I guess.

I: Distance to work?

R: 10 kms, 20 in total.

I: Which problems of driving you are facing now in Stavanger?

R: What do you mean by traffic problems? Traffic jams could be seen as a problem. Only traffic jams, every day from here when you are going back. So many people working in Forus. E39 and Solasplitten, which goes out on E39 from here, so that's often stop, and the traffic jam starts.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: Nothing at all.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: I think it's important, but at the same time I feel guilty, because I don't know much about it, or I don't know anything about it in regard to my car.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: I come from the east coast, and we don't drive that much cars. So, when I came here the first time, I was shocked, because there were so many cars driving. So, I think it's weird that the

municipality is not prioritizing more to get more busses up and running and that sort of stuff. So, I think that should be a bigger focus area. I think Stavanger is one of the worst cities in Norway when it comes to driving cars everywhere.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: When you told me what you were writing about, I thought that must be more interesting for the municipality than for me.

I: So, you are not that interested?

R: Not every time, if I go through. I could have an app with a monthly rate where I could check it if I want. But I would not have an app that push up how much I use. Because I think that would just make me feel guilty all the time. Obviously, you know that you use some when you drive, you don't know how much, but you know that it's not too good to drive every day. So obviously I would think I would like it more if I go to somewhere to see it, not get it pushed out to me.

I: So maybe not push-ups messages or pop-up messages?

R: No, I don't think I would like it.

I: What about if it just stores in your app?

R: Yes, whenever I want, I could go there. You can always decide if you want push or not, but I would not get push on that.

I: How are you aware of when you will send your car to EU control?

R: I don't know, whenever it's needed.

I: Do you know that CO_2 emission is subject to the EU control condition?

R: No idea. Now I feel guilty as well.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: I mean, if it could help when I go for EU-control, of course I would like it.

I: How do you know how much you pay for the toll? Is it real time?

R: Because of my job I work a lot with clients, so I often have to expense it. So, I often go to the webpage to see what I spent and try to figure out what was private and what was work. I don't think I would check it if I didn't have to expense it.

I: Do you have any trouble with the transparency of the toll?

R: No. Never. I know there was a lot of trouble when they changed the prices, but I haven't seen anything like that.

I: In which way are you designing your route to have less toll fee?

R: I don't think I have that issue. I never thought about it. But I know a place close to here where you can go instead of going on E39, instead you just go on another road close to it, and you don't get any toll. I know about it, I know I can go there, so one time I did. But obviously I don't face it a lot, because I go from here, to go to work I have to go through one and to go home I don't go through any. I don't face it much. But I think about it, for example in the morning, this morning I woke up earlier because I knew I would have a lot of meetings. So, I was thinking if I go to work before 7, I don't have to pay double.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: I don't know. I just go. Because I don't go often to the city center, and when I do, I park at the same place every time. Under Arkaden, and it's never been full.

I: How do you know if there is traffic jam somewhere?

R: I google it, use Google maps.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: Don't use it.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now? If you can rate from 1 to 5?

R: Not much actually. You don't see it much; you don't hear about it much. I think it's 2 for me.

I: If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 2.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: Google Maps.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: 3 to 4, I like parts of it.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: I like it to tell me what I time need to or as you said if I use too much carbon emission and have to go somewhere, I feel safer with it. But I feel that some parts of it I already get, I have

knowledge about. For example, to see how much I paid in toll. I just use Nord-Jæren (Ferde). So, I don't feel that's new information.

I: But it's not under one app?

R: So, you mean put everything into one app? I would like that, so maybe a 4. If I don't have to go to Nord-Jæren webpage, obviously that would be better to get all the information I needed.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: I like the practical ones. The ones that I use, to see how much I've paid and as I said, to see how much C02 my car uses would be nice to know, but not practically needed.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: Probably not. I feel everywhere you go in Stavanger you have to take the car. Because there's not a good offer for buses, especially where I live. I'm more frustrated about that. I lived in Oslo, I am from Lillehammer, and I'm not used to driving everywhere. I'm not used to driving at all actually. In Oslo, I just took buses, and in Lillehammer I just walked. I lived in England and just walked everywhere. I feel Stavanger doesn't give us a choice, because the offer of buses is very limited. Super-limited. I feel that's a bigger problem. I think it would help a lot if it was easier to take the bus. If it was easier for me, I would take the bus. For example, to come here, it would probably take me between 45 mins and 1 hour to go here from home, with car it would take 7 minutes. Obviously, that's super-frustrating. If I got information about the C02 it would be interesting, but I still need to take the car anyways.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 4.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: Could get parking as well into it. The more you can get into an app the better. For example, when I'm parking, I use EasyPark, so if that could be worked in as well that would obviously be good.

I: What are your expectations for the municipality to serve you better?

R: They should do a better job with the bus-service, in order for it to be easier to reach standards.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: Yes

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes

I: Do you want to share the type of your cars and the type of fuel you are using with the other people? Yes

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: Yes

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)?

R: Maybe

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app? Can you rate from 1 to 5?

R: Probably a bit. Maybe 3. but as long as they don't sort out the buses it won't matter. I like to take the bus, I don't feel good about driving, but I have to. For me the most important part is improving the bus offer.

Interviewee: 3.2

Interviewer: Abdur Rehman

Date of interview: April 17, 2019

Location of interview: Stavanger Sentrum

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 34

Job: Teacher

Gender: Female

Number of dependent children: 0

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: My husband and I have one car. It's a hybrid.

I: Where do you live?

R: Stavanger Øst, Pedersgate. Quite central

I: Do you often travel to the city center?

R: Yes, mostly walk. I never drive.

I: Which problems of driving you are facing now in Stavanger?

R: No. The odd time we might have to travel through, but in general we avoid driving. The traffic I find is ok, but I'm not commuting. It's only been one time where it was really bad, Bergelandstunnelen, we just sat there for 20 mins. I know everyone complains about traffic to Forus. It might have been rush-hour, we don't know, it was really strange. My husband takes the buss, hjem-jobb-hjem, to Forus and that works. Sometimes I drive him to work, but we go early enough, about 7, so it's not too busy. The bus comes from Hundvåg.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: I don't know. I know that's terrible. I feel, that whenever we're in the center or in like going part and divide going home, we try to make sure we have battery, so it's on electric. Sometimes it runs on fuel, and then I feel bad.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: I think, I guess I'm quite skeptical. I just feel it's a target, but I guess someone has to take control of making decisions and reducing it. For example, with the bompenger, I get why there's bompenger, but I don't connect that to them trying to reduce carbon emissions, but I just think of them trying to reduce traffic congestion. I don't know why, I just haven't made the link, but obviously there is a link.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: My husband and I like to go outdoors and take longer journeys, so having a solely electric car wasn't viable. I think Diesel can be more efficient for longer journeys than petrol sometimes. My hybrid is Diesel-electric.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: It would be interesting to know, especially if it then becomes something like the idea you suggested, where it's tracked. I think it's because I don't really know to find it out on a daily basis that I don't know it.

I: How are you aware of when you will send your car to EU control?

R: Only got it last summer.

I: Do you know that CO_2 emission is subject to the EU control condition?

R: They would.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: I would presume so. I'm not completely familiar with that control, but in Britain you have a MOT every year. You have to pass the MOT, and that will have partly to do with your emissions.

I: How do you know how much you pay for the toll? Is it real time?

R: It's prepaid. I still don't really understand the bompenger and what I'm getting charged. We will just see at the end.

I: Do you have any trouble with the transparency of the toll?

R: Wasn't there not a massive hiccup where they refunded? Yeah, I don't understand at what point if you do a journey to Forus you go through three bompenger, do you pay for all three or just one? I just don't understand, and I don't really understand how to access the information.

I: How do you know where there is a toll station?

R: I just hope that there's not, and I just accept that every time I drive, I will be charged money to drive. It's a bit sad. We have a dog, and the municipality doesn't provide any facility for dogwalkers to let the dog run free there's just one tiny park...so it's a 60-minute round-trip from our house to get to such a facility. So, I often drive to a bigger space to let our her the lead. I never had to pay to let my dog off the lead, and then I've never had to drive in any other country I've lived in to take my dog for a walk. It seems really absurd. I think that's Stavanger.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: That's another thing, I don't understand the parking system in Stavanger. I know that there are zones, cause obviously we have a zone-ticket outside the house. But I don't always

understand, and I like to park on the street. I just don't, in general. I guess because we don't really drive into the center, I don't have that predicament. And if I park outside somebody's house, they will tell me, or if you're going to an office or somewhere else there's usually parking. So, I don't know to find out. In the parking lot I just roam around. I like the light-indicators. I am a newcomer to Stavanger. I am not used to the parking system here. I don't R: know to find it out in advance unless I really drive to the place. If it's full, then I have to drive around and hope.

I: How do you know if there is traffic jam somewhere?

R: If it's a long route I've obviously put into google, then Google tells me. If it's a journey that I know, then it's unfortunate that I get caught in a traffic jam.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit)?

R: I have not used it. I think maybe it's hard, I know a lot of stuff is translated into English, and I am trying to learn Norwegian, but I don't know if the information is so dynamic.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now?

R: I don't feel like I've received any information. Maybe in Norway there's a definite sense that people need to use cars less. But I'm not sure because we live in the center, and our neighbors prefer to stay in the local area. They are Norwegian, so maybe they are more engaged.

I: If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: About 4, but I think I it might be because I don't use Facebook a lot. Maybe stuff goes out on Facebook. They like Facebook here, and I find the website quite clunky.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: Google. My phone doesn't have app-space.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: I think for some of the features, definitely 5. Like traffic jams, speed-limit, that sort of thing I can get on Google. I like the idea of getting real-time toll-costs and C02, and notification if there's anything wrong. Or good. Or maybe alternative routes. But I just don't believe any routes here don't have bompenger. I guess 5 in general.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: Bompenger, then C02 in general to keep an eye on the car.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Speed-limit and traffic jam.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: I think that they are then providing a tool, in order to enable me to do that. Whereas if they are like "we are just going to charge you more and it's not really clear how much we're charging, but we expect you to have this level in your car", if you're not providing me acceptable tools to engage with that it's not fair, but if they provide me with a tool that's good. And it's more efficient and better for everybody.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 4 or 5, because then you have real time information. Maybe they can do notifications and updates, and it can come through that way.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: Pop-up information. For communication. I don't know. But maybe that's because I haven't quite mastered how the kommune distributes its information. That's what lacking for me, but maybe someday I will grasp it and maybe other people think it's completely fine. For me it would be really great if they have updates like "new bompenger-road", then tell me through the app.

I: What are your expectations for the municipality to serve you better?

R: Just more transparency in their information. I don't understand, and I'm sure other people understand. I don't mind paying, that's a fact of life, but I want to understand. Maybe it's because I'm relatively new here, but everybody should be included.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes. I think so.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: It would be interesting to know. Maybe it's driving styles.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes

I: Do you want to share the type of your cars and the type of fuel you are using with the other people?

R: Yes

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: Yes

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)?

R: It would be good to have information on what to do in case of an accident. I think that's interesting.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app? How can you rate from 1 to 5?

R: Yes. Because it's more transparency and information, and I'm able to engage with them. I am rating 4.

I: Green city in five years?

R: I think, I mean maybe more public transport of some sort. Just quicker frequency. It's not bad. Maybe more bikes, I think they are bringing in more bikes. I think it would be great for everyone to have electric cars, but not everyone can afford them. And also, people want to travel. Again, it's transparency, and lack of charging stations. That's another cattle of fish. People really have to think.

Interviewee: 4.1

Interviewer: Kim Ngan

Date of interview: May 10, 2019

Location of interview: Interviewee's own place

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 67

Job: Retired

Gender: Female

Number of dependent children: 0

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 car by gas

I: Where do you live?

R: Amfi Madla, near city center

I: Do you often travel to the city center?

R: Not very often

I: Which problems of driving you are facing now in Stavanger?

R: Not much because we often take bus to go to the center.

I: Have you often faced any traffic congestion here and there?

R: Not really. Because we retired, I mean we can go another time of the day, rather than go to the street around 8 or around 4.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: Only that we have a new car, only 1 year old. It has less emission. So, since it is a new car, it would have less emission than cars of 8-10 years old. But I don't know the exact amount.

I: Some people I interviewed thought similar. They said it depends on how old the car is to see if they should be aware or not.

R: But maybe that can't afford a new car. They have to live with what they have.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: I think it is important to have the target, but I don't really have enough knowledge to coordinate on it.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: It's like we do often take the bus to go to town. We don't drive very much. But we are aware of the problem. I don't think it would have been very different. We drive less now as retired

people but if we had been going to work, we would have had the transportation to and from work but not much in addition to that. So, the problem with the traffic has gone. And the place where I used to work, they had buses for people who worked there. I didn't normally use it in the morning. My husband would take me to the office. And then he would go onto Sandnes and then go to a gym in Sandnes and then he may go and visit his father. And I came home by bus. So, my husband would cook the dinner while I was on the bus. And that was a good solution. But now with the new tolls, I would have gone by bus or waited if I had still been working. Because the rush hour is extra cost. It is a lot.

In the past when we were still working, we had one car each because my husband worked at a car dealer and he had to have the company car, which meant that I couldn't say 'Today I need the car'. So, we ended up, like I had a small car and he had the company car. And he changed car once a year, more or less. Because his job wanted the new model on the road to be seen. So very practical. But all the costs were for the company. But then he was taxed for the benefit of the company car.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: I guess I wouldn't be very interested because I see that, as I said, new models mean less emission. And that applies for all the brands.

I: How are you aware of when you will send your car to EU control?

R: I don't know when it starts when you already have a new car. I don't know whether it's up to 2 years when it is still relatively new.

I: Do you know that CO_2 emission is subject to the EU control condition?

R: I didn't know but I am not surprised.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: Yeah. I think I would be conservative if I use that.

I: How do you know how much you pay for the toll?

R: I don't really check the invoice. I don't think I would check that unless it is surprisingly high. Then it could be a problem. Otherwise, I don't think so.

I: Do you have any trouble with the transparency of the toll?

R: Not really. I mean it has started like some kind of surveillance and people can ask questions at least. Or maybe we have to accept it but gradually since we are accepting more and more surveillance and since we can be checked anywhere because you leave those digital traces everywhere.

I: How do you know where there is a toll station?

R: We normally see them, but we don't see them that easily anymore, I think.
I: That means there are less or?
R: You don't see the lights go on anymore. Just drive through. You don't see if you are photographed or anything. In the past, you would see. In the past you pre-paid. Once you used up the amount of money, you got a new invoice and then you paid for it again. And then when the light turned from green to white, you knew that there was a new invoice coming within a short time. But now it is the other way around. First you pass the toll station, then you get the invoice. So, it is not prepaid anymore. So that's the change now.
I: In which way are you designing your route to have less toll fee?
R: Only if it doesn't take too much time. I know I can go to Sola without paying and then you take that route. But that means that it takes a long detour to get there to avoid paying. I don't think I would.
I: If you want to park somewhere, how do you find an available spot in a parking lot?
R: We normally don't check. That's because we normally go to town in the middle of the day when there aren't so many cars. So normally it has not been a problem finding a parking place. When we get downtown there are big boards saying there are so many free spots here and there. But we don't bother.
I: How do you know if there is traffic jam somewhere?
R: I have the app named Min trafikk. When it's green it's ok. When red, there's traffic. And orange, there's traffic but not very much. When I worked in Tanager between 3 and 4:30, there would normally be a lot of red color that side.
I: Cool. But is there any other route you could take to avoid the traffic?
R: No. But it's good to know you might delay a bit to go home.
I: Are there any other functions?
R: Yes, but I normally use the app to see the traffic. Not often though. Maybe I can stop somewhere to have a look to see if it is only a couple of minutes or half an hour.
I: How do you know about the speed limit of the street?
R: Both from the sign along the road and on the GPS of the car. The GPS can note the speed limit. You can see it on the board. There is a sign for the speed limit and you also see your own speed. In the past, our previous car, the GPS was not online so there was a temporary change, they would catch that. So, let's say the limit is 80 per hour while it shows only 50 for that period of time. So, you have to know about that. So, you have to follow the signs and not rely on GPS. But our current car is online, so it's real-time. So, it's less emission on new models. The GPS is also better.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)
R: No.
I: Do you feel normal citizens are engaged to the municipality's activities or policies now? If you can rate it from 1 to 5?
R: I don't really know. For me it's 3.
I: If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?
R: 3. It is a guess. I mean I can't say it definitely.
I: Do you think the municipality, or the traffic can do something to improve it?
R: I can't really explain. I know it can be hard to go to the town center in the afternoon. So, after the rush hour I mean from Madlakrossen to Tjensvoll, even at 6 you can be stuck in the traffic jam. And that isn't surprising. And it's only short distance, only from Madlakrossen to Tjensvoll roundabout. Then things sort themselves out.
I: So, if you want to skip the traffic jam in that short distance, can you take another route?
R: Then it would be a long detour. So better take the bus. It is very good bus connection. I grew up here. I moved into here when I was four and a half years old. And when I went to high school, I took the bus. I could stand at that window and look over to the other side. The bus came from there. When I saw the bus coming, I got ready and came down. But it was once an hour. So, if you missed it, you would have to wait another while until the next bus. Now it's very good. After a few years, it increased to 2 per hour. That was good already. And now you just need to go to the bus stop, it will come within 5 minutes. So, I never check the time schedule.
I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?
R: I am using the Kolumbus app to check the time if I am going to other places.
I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?
R: I think that would be an app for younger generation. We are old. I think we are trying to take the shortest route if we are driving. So, if the app can suggest that, would be 4
I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: I am not sure because we don't need an app to know the speed limit. And CO_2 emissions, they are what they are, whether we have an app or not.

I: How about the toll?

R: Since we don't drive a lot. If we drove more, maybe it would be important. Since we are now, I don't think it is really important.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

Speed limit, CO_2

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: Not relevant either to me.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 3.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: Again, I think it's probably the question for the younger generation, for the IT generation. Because they will be more genuinely interested in.

I: What are your expectations for the municipality to serve you better?

R: That would be technology developments and digital solutions. As long as it doesn't take over direct contact between people. It means that not everything is run automatically. Like if you have a problem you can talk to someone instead of looking everything up. But I mean many things are ok to look up. In other cases, maybe you just need someone to talk to. So yes, there has to be a balance.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: It would be anonymous, I guess.

I: I mean like just the CO_2 amount and the type of your car. Everything else is anonymous. So, you feel OK to share?

R: Yeah, I think so.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes.

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: No, I am not. I don't think it is for everybody to know.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: I don't have many apps to use but if there is an app which I can interact with the municipality directly, I would try to learn to use.

I: How do you usually interact with them?

R: I go to the home page of the municipality just to search for the topic. I will write a comment, or I can send them an email. But I don't often interact with them.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app to report the issue?

R: I think it won't make any difference.

I: What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

R: It's hard to answer.

Interviewee: 4.2

Interviewer: Abdur Rehman

Date of interview: March 29, 2019

Location of interview: University of Stavanger

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 56

Job: Teacher

Gender: Male

Number of dependent children: 2

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 - Diesel

I: Where do you live?

R: Sentrum of Stavanger

I: Do you often travel to the city center?

R: Cycle or feet

I: Which problems of driving you are facing now in Stavanger?

R: I feel like it is very congested on the street of Stavanger center. It seems like streets are keeping up with the numbers of cars. Capacity the of the road is less than the cars on road. Especially in rush hours, back and forth from job.

I: If you must drive your children to school, how inconvenient the route is?

R: Kids go by themselves.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: No.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: I fully support that target.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: First, I agree and support the toll stations policy that it is becoming more and more expensive, I don't oppose that. We, as a family, try to cycle as much as possible. We try to shop within city center. So, I think our habits are contributing. Also, I am a member of environmental party in Stavanger.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: In my case, I'm not particularly interested because I know it is too much. I know I cannot influence this, and I know that my next car will not be diesel or gasoline.

I: How often do you take your car to the EU control?

R: 2nd year.

I: Do you know that CO_2 emission is subject to the EU control condition?

R: I'm not sure, I would expect that.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: Yes.

I: How do you know how much you pay for the toll? Is it real time?

R: We are not aware of that. We have not identified the new costs after the change in system.

I: Do you have any trouble with the transparency of the toll?

R: My travel routine is not changed but still they charged more. But I believe we have paid way more than what we used to pay. But I trust the system.

I: How do you know where there is a toll station?

R: No, I do not check. Because we both, husband and wife are working so we do not check for each toll or count ever kroner.

I: In which way are you designing your route to have less toll fee?

R: We do not design according to money.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: To have 2-3 apps, this will cover the parking spots of almost whole city, but I do not want to fill my mobile with a lot of apps. Result, I spend a lot of time while finding for free spot and sometimes it is annoying.

I: How do you know if there is traffic jam somewhere?

R: I have not used any kind of tool for this except my habit and knowledge of traffic.

I: How do you know about the speed limit of the street?

R: Follow the signs.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: I have no idea about this data, and I have never used.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now?

R: My contacts, my links have less interest in such activities, but overall, they support it.

I: If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 2.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: I don't use any app except traffic cams, but that is more for entertainment than getting traffic information.

I: How do they work to help you achieve the traffic efficiency?

R: They don't.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: 4.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: Real time emission with every time passing through toll station.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Suggesting me best route.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: CO_2 feature is the best feature this app has so it will really help me to control myself for reducing CO_2 emission.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 4.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: "three figures feature" I like the idea, but I don't want to see individual contribution. Rather I would like to total and mutual contribution as a city.

I: What are your expectations for the municipality to serve you better?

R: App has to be organized. To make this app national and introduce this app to other cities so as whole country can fight for reducing CO_2 emission.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the other people?

R: Yes.

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: Yes.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: I think this will be disorientation of the app. It will be incorporating too much in the same app. There are other apps for this.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app?

R: Definitely.

I: What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

R: 5 years is small period but still this app would have some positive impact for making Stavanger greener.

Interviewee: 5.1

Interviewer: Kim Ngan

Date of interview: May 5, 2019

Location of interview: Interviewee's own place

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 34

Job: Student

Gender: Male

Number of dependent children: 0

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 - Gas

I: Where do you live?

R: I don't live near the city center

I: Do you often travel to the city center?

R: I often travel to the city center because of my freelancing job.

I: Is there any traffic jam when you commute to work and the way back?

R: That depends. Now that they introduced rush-hour fee, I foresee the traffic being smaller than it has been in the last few months because of the tolls. I know you have a question regarding to that, we will get back to that of course. But right now, I would say no traffic jam in particular. It is a bit slow a few times but no jam so to speak.

I: Which problem of driving you are facing now in Stavanger?

R: I don't really face any problems in driving in Stavanger, except when going to the downtown area because the tolls are around the downtown area, so there is more money involved but at the same time I don't have any problems faced me right now. I think the traffic is ok.

I: You don't have any children to drive to school but actually are you a bit annoyed at the traffic when you have to go to work every day and you have to be in the queue?

R: In my case, if I had children, it would not be inconvenient driving my kids to school because it is literally one minute away by feet. But it is inconvenient driving out of here sometimes because there is a lot of traffic coming down to drop off their children. I drive past two schools. I often get the traffic jam near Revheim undom skole because it seems that there are a lot of parents stop by the schools to drop their children off. So, I guess that's the problem.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: I have no idea actually. I know it is driving by gasoline. It is pretty fuel-efficient. But I don't know the level of CO_2 emission my car generates.

I: But when you bought the car, there are some metrics or some indicators that somehow let you know how much CO_2 your car is emitting to the environment.

R: It is an old car from 2004 so it doesn't really have that much that type of stuff. It just shows how much gas you use per kilometer or no, per mile. So, it doesn't really give you a good indicator of CO_2 emission, at least not to my knowledge. It is also because I don't take that as my interest.

I: What do you think about the importance of CO_2 emission target of the municipality? You know that the municipality now has to find the answer for the question of reducing from 80 to 95% of CO_2 by 2050. And cars are the main CO_2 contributor in the municipality of Stavanger.

R: I think it is important. At least we need to strive for something. You need to strive for improvement. Obviously fossil fuel isn't the future as much as we live in the oil city, and as much as I'd like to think so. It's not our future. So, I think the target is important. Realistically on the other hand I am not sure it's manageable.

I: Why not?

R: Because I think that the incentives for choosing electric cars will eventually not be there. Because I think that at the end of the day, the electric cars will be subject to toll and there might not be a lot of people just driving gas car unless there are more rules put in place, which might have to come from a national level about what car you drive. I don't think you can realistically expect that the level of CO_2 going down drastically. Of course, we are looking at it in 2019. 2050 is 31 years away so I guess, or I know that there will be a lot of changes in the next 10 years because there was a bit of changes in the last 10 years. It will come down to what kind of rules and regulations you get regarding cars and type of fuel if the goal is realistic or not.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: I haven't at all. That's the answer. I don't relate it at all. I drive my gas car. I fly. I do pretty much everything that they say you are not supposed to do. I eat red meat. This is part of CO_2 emission. That's not part of this discussion though. That's beside the point. My point had rather being that I can't really relate to my personal life. Maybe because it hasn't been communicated well, or maybe because it has been communicated well but I choose not to care much.

I: So basically, you mean that it doesn't affect your life.

R: No. I live my life the same way I always have.

I: Do you know that CO_2 emissions are one of the conditions of EU control?

R: No.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: Because like I said I am driving an old car from 2004. I am not really interested in knowing CO_2 from the same model. Same model pretty much does the same thing. Because I don't think it has any practical use. As long as my car functions as it should, I don't see a big interest in knowing its CO_2 compared to other cars. But one little thing. Of course, if my car is emitting 50% of CO_2 much more than others of the exact same model, then yes, I should probably look at something of the car. But I am not really that interested in comparing.

I: So only if your car emits 50% more than other cars, you will pay attention to the CO_2 emission. If not, you will not care?

R: Because then there are probably some other problems with the car. If it is like 5-10 percent more, it could be the age or the number of miles I've driven. It doesn't have to indicate anything. 50% indicates something. 30% indicates something. So, it could be 30% as well. But if it's like 5-10%, it doesn't really tell me anything.

I: But do you think if it's good to have a tool like that though?

R: If the tool is available, yes, it's probably good to have it.

I: So again, do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: If I have a new car, yes. Because the standard is different now than in 2004.

I: I'm wondering why owners of old cars don't care much about CO_2. I asked Jon this question and he had pretty much the same answer.

R: Because it's not an integral part of a car. Like at that stage, they were aware of it, but it wasn't the big focus back in 2004. Like my car is 15 years old. It's old. That's why we don't care. Because it wasn't a lot of thought put into it but now the cars are very much built with the emission standard in miles. That's part of how they get the approval. Like they can't emit a certain amount of CO_2.

I: Is it also one of the conditions of that EU control?

R: I am actually not sure because I haven't got the EU control yet.

I: How often do people have to send their cars to EU control?

R: Every two years.

I: How do you know how much you pay for the toll? Is it real time?

R: I know because they have set price on what it costs to go past the toll. I know when I go through the toll between 7 and 9am. It's a certain price. It's a high price. And I know between

3 and 5pm. It's a certain price. I can't really remember the price on top of my head, but I know how to look for it.

I: But do you know how much actually you have paid for the toll?

R: Yes, I do. You get the bill. If I want to, I would know. I just count the amount of times I pass through it.

I: But is there any tool to help you though? Or you just count it manually?

R: Yes, you get the bill. That's the tool. You can divide it.

I: Do you have any trouble with the transparency of the toll?

R: I have no problem with it. You have the price on the website. You know how much it's going to cost. It doesn't matter to me. I think it's transparent enough.

I: How about if they miscalculate something?

R: Well. That's a problem.

I: If you don't know and if you trust them 100%, you will risk paying too much?

R: That's why you check your bill. I believe in the government. I just pay my bill.

I: How do you know where there is a toll station?

R: Usually I know exactly where the toll booths are.

I: How?

R: Website.

I: Which website?

R: The Bymiljo-parken website? But another way is just by driving. That's why I find where stuff is by driving.

I: That's not a problem for a regular driver. But for new drivers, how can they know?

R: They will have to look at the website. There are signs. Maybe they pay too much. I don't know. But for somebody who lives here, it's not a problem. It all comes down to you. If there is an issue, you complain. It's not the job of the people running the toll stations to hold your hand in every little thing.

I: But do you think it's efficient to have a tool integrating everything?

R: Always. I would love a tool like that.

I: In which way are you designing your route to have less toll fee?

R: Well, this is the perfect example. I live in Kvernevik. But I work in Sola. I can drive across bridge to Tanager but there's a toll booth. I will have to pay a toll ticket. That's the shortest way. I can drive for 20 minutes instead around Hafrsfjord and get to Sola without paying any toll. So, I use 5 more minutes but pay less money.

I: Do you think driving a little but further is worth it? Because maybe it will consume more gas?

R: The extra money spent on gas is around 16 NOK per litter. And I don't have to pay anything in toll. It's better to drive the way I'm doing because toll at that time will be around 35 kr.

I: How does the toll work?

R: You only pay once every hour. You don't pay two times per hour. Like if you go through 3 toll stations in 1 hour, you only pay for the first one.

I: But when you go back from your workplace to home, supposed that you take the route with the toll booths, are you subject to the toll for the second time?

R: Yes. I can potentially pay 70 NOK per day.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: By looking in the parking lot. I use my eyes.

I: Do you think it is irritating?

R: Yeah. But one problem with the app is that when you are driving, you really can't pull up your phone to look at stuff. That's illegal. You have to park somewhere to do it. That's also annoying, and also time-consuming. And if it's during rush hours, for me I would prefer driving and using my eyes. Besides, they have the signs saying the number of available parking space.

I: How do you know if there is traffic jam somewhere?

R: By driving into the traffic jam. Because I don't really listen to the radio. Radio would be an option, but I just listen to music and my own stuff. So basically, I know where there is traffic jam by heading towards it.

I: How do you know about the speed limit of the street?

By seeing the signs.

I: Is it also annoying because you have to see and remember everything?

R: It's not about the speed limit but about the type of road your drive on. Like you have to pay attention to the traffic coming from the right. Are you the one who drive straight past when somebody wants to get out or do you have to stop? Because there are not only speed limit signs you have to look for. You have to look for what kind of roads it is. That's not always easy to remember.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: I have never looked at it. I can't comment on it.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now? Can you rate from 1 to 5?

R: Depends on activities and policies. I guess I am not involved much, like around 2. But it's good on the website or social media saying what's going on. I like Stavanger municipality social media. I think they are good at letting people know what is happening.

I: What is the platform?

R: Facebook. I think the municipality is good on Facebook.

I: If you are to rate the present circumstance of driving supporting knowledge on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: I'll say 4. This is one thing important when I say 4. I'm from here. I know the traffic pattern. I know where rush traffic is usually is. I know how to avoid it if I can. Sometimes it's unavoidable. But if outsiders come in here, they will rate probably 1 or 2, I guess.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: Nothing. For parking, I use the payment app but it's not really information though.

I: How do they work to help you achieve the traffic efficiency?

R: Unable to comment. I don't use them so I can't comment.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: 4. The app to show how much your car is emitting, I think it's unrealistic. It requires too much data. It's interesting. Yes. But how will you know the CO_2 emission if there is not something installed in the car?

I: By installing a sensor at every toll booth. Every time the car goes past the toll booth, it will read the car plate, the car model, and measure CO_2 emission at that time.

R: OK. So many variables though. I think that's the feature that I am most skeptical to. It's interesting but I am not sure it's feasible.

I: Why not?

R: Because like you said, it would take the CO_2 emission at the toll station. However, at the toll station mostly you drive 60 or whatever. You will emit more CO_2 if you are standing in the traffic jam. So maybe it will show you that you have a low CO_2 emission when you drive through 60. But if you are stuck in the traffic jam in 10 minutes, and all of a sudden you emit a lot more. But you won't know it because you have just been registered to the toll station. So, I am not sure the value will be correct.

I: Of course, it's not exactly correct but somehow it can give you an idea.

R: I am still skeptical.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: Traffic jam and toll payment just because it's good to know.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: CO_2.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: I finally will try to have an electric car. That's the most efficient way to reduce CO_2 although I think that at the end of the day, the incentives for electric cars will not be there. But with the app I still can see how much CO_2 I'm using compared to the target of the municipality. If the municipality has the daily goal?

I: Not that I know

R: That's an issue. Because it's difficult to relate the goal to your life if you can't see how much you contribute to it that day. If you just have your value and an abstract collective goal by 2050, it's not relatable. My head isn't capable of thinking something big like that. I need something short and sweet, relatable. Then I will be interested.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 5. That's an easy 5.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: It has to be free and easy to use. It's just like a couple of clicks and registered by Facebook. The target and the progress should be visible and updated. The goal should be broken down to every citizen, illustrated in a circle with the green, red and yellow signals. Maybe the municipality website should be more updated and easier to navigate. It's a bit difficult unless you know what you are looking for. And sometimes, you kind of need help find what you are looking for. I use the website mostly for opening time of swimming pools and stuff like that. It's pretty easy to find but not for everything.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes, with one little thing. I don't want them to know my name and license plate number. Just the model of the car and the emission.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: I guess.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yeah

I: Do you want to share the type of your cars and the type of fuel you are using with the other people?

R: Yeah

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: Could be interesting.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: In general, it's a good way to get updated about traffic jam and everything. At the same time there's a lot of stuff that falls under the jurisdiction of Statens vegvesen, not the municipality. SV are responsible for the road, construction etc. Google them.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app? Can you rate it from 1 to 5?

R: Maybe 3.

I: What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

R: Really difficult question. I think there is a chance that could be the conclusion, yes.

I: To what extent you think this idea is possible to sustain the benefits for citizens in the long term?

R: I don't know.

Interviewee: 5.2

Interviewer: Abdur Rehman

Date of interview: March 27, 2019

Location of interview: University of Stavanger

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 22

Job: Student

Gender: Female

Number of dependent children: 0

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 - Gas

I: Where do you live?

Sola

I: Do you often travel to the city center?

R: 3-6 Days a week

I: Which problems of driving you are facing now in Stavanger?

R: There is not a big problem. 15Km per side travel to Stavanger. My travel is before and after rush hours.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: No idea.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: It is really important, Obviously, we need to do something. but it is not something that I am thinking about.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: I know I travel alone in car on daily basis which I know is not ideal, but I do it because it saves time for me, but at the same time I'm not eating meat because actually that industry also create lot of CO_2, so that sort of adds up. I mean I'm not contributing to reduce CO_2, but I am contributing in other way.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: I would like to know.

I: How often do you take your car to the EU control?

R: every 2nd year

I: Do you know that CO_2 emission is subject to the EU control condition?

R: I'm not sure.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: no idea

I: How do you know how much you pay for the toll? Is it real time?

R: I usually calculate because I know. After this new system installed, I check and calculate once a month regarding my transactions. but usually I know how much I travelled in a week.

I: Do you have any trouble with the transparency of the toll?

R: not that I know of, also my mom helps me pay this money so mainly she is handles it.

I: How do you know where there is a toll station?

R: In my travelling there is just one toll, so I know about it.

I: In which way are you designing your route to have less toll fee?

R: I don't care much about this and use the same route either it has less toll fee or not because I need to travel, and I cannot change my route because of tolls.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: In university I just look for spot as I go and usually there is always spot outside my department. In city center, I usually use an app called "parkopedia" to find where is its free spot and where is it cheaper.

I: How do you know if there is traffic jam somewhere?

R: I check google maps.

I: How do you know about the speed limit of the street?

R: I usually read it from the sign boards next to the road.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: I have never been to their website and I never need to use it.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now?

R: No, because I feel that people don't care that much. People are more aggressive maybe. People don't try to fix the problem, but they get more angry. From my experiences, people really don't participate in the decision they are just feel like left out. Stavanger municipality is working mainly for their benefits and making money.

I: If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 2.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: Google maps, kolumbus.

I: How do they work to help you achieve the traffic efficiency?

R: By using google maps I can see where traffic jam is, so it helps me in route efficiency.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: 5.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: CO_2 measurement.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Parking.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: I will be more aware and obviously I will take more actions. Because if I am not aware of how much CO_2 I am contributing then I don't know how to help municipality. But if I will have this information available handy, then I will be more happy to put my contribution.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 4

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: I think you have covered most of the things. On the main page of the app, if there could be 3 main figures coming: 1) CO_2 emission target of municipality, 2) Combined contribution to that target, 3) Individual contribution to that target. This will be a good idea.

I: What are your expectations for the municipality to serve you better?

R: Just being more available. I don't know how to contact them, just want them to be more available. They don't engage the community and people.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the other people?

R: Yes.

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: Yes.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: Yes.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app?

R: Yes, I think so.

I: What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

R: It would make some positive impact than it is now. It all starts with the awareness.

Interviewee: 6.1

Interviewer: Abdur Rehman

Date of interview: March 28, 2019

Location of interview: University of Stavanger

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 39

Job: Teacher

Gender: Male

Number of dependent children: 0

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 - Diesel

I: Where do you live?

R: Jattavagen, (6KM from) Stavanger.

I: Do you often travel to the city center?

R: Once a week.

Theme: Identify problems and priorities

I: Which problems of driving you are facing now in Stavanger?

R: Sometimes traffic jam during rush hour, other than no. When I'm in downtown on Saturdays then it is easy to find parking.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: Not aware.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: It is very important if you think about the climate change. So, everyone should be aware of CO_2 emission.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: Not that much. Maybe I should be more aware of CO_2 emission. Because using diesel car is not the best option.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: I have not thought much about it until now. If it is easy to get to know how much my car is emitting, then it is nice to know. But to get to know if I have to go to garage, then it is not convenient.

I: How often do you take your car to the EU control?

R: 2nd year.

I: Do you know that CO_2 emission is subject to the EU control condition?

R: I am not sure. I have not check details like this.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: If this finding CO_2 emission is one of the check EU control does, then it is a good indicator and then I can fix my engine to reduce CO_2 emission.

I: How do you know how much you pay for the toll? Is it real time?

R: I have not thought much about it. Maybe, I receive invoice of 1500NOK every second year. But I am not aware of how much. I am not paying toll while coming to workplace but when I travel to city center I pay, but it is once a week. But if I get the information about paying toll every time, I pass under it, it will reduce my habit of driving.

I: Do you have any trouble with the transparency of the toll?

R: Not much because on my daily travel there is no toll station.

I: How do you know where there is a toll station?

R: They are making a lot of new toll stations around the city which I am not aware of.

I: In which way are you designing your route to have less toll fee?

R: I don't plan my route with the toll fee, I prefer the fastest route to my destination.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: When you drive through highway to city center there are light board explaining the details of available parking spot, I look for them.

I: How do you know if there is traffic jam somewhere?

R: I use google maps. But I use it mostly for long route, like going to Sirdal on weekends. I almost never check within in Stavanger. Because on route to my workplace I do not face traffic jam.

I: How do you know about the speed limit of the street?

R: I follow the road signs.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: No, I never used.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now?

R: No, I think one of the problems is that CO_2 issue causes global warming. But sometimes things left in uncertainty or things are far ahead in future and people think that this is something

which is not bothering us now, so they feel engaged. I don't know if municipality is doing too much for citizen.

I: If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 3.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: Google maps, wayze.

I: How do they work to help you achieve the traffic efficiency?

R: I get route efficiency from google maps, it finds me the shortest and fastest route.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: 5.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: Cost saving routes.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Signals if my car needs maintenance.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: If I have this app, I will emit less CO_2 and have better route and I will have knowledge so I will be more aware because now I am not.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 5.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: "three figure suggestion" is good. But I cannot think of anything else.

I: What are your expectations for the municipality to serve you better?

R: To make me aware of CO_2 emission.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the other people?

R: Yes.

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: Yes.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: Yes. Maybe I have some questions that I want to ask municipality. Maybe regarding making my car more CO_2 efficient.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app?

R: Oh yes.

I: What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

R: They would have some impact.

Interviewee: 6.2

Interviewer: Abdur Rehman

Date of interview: March 29, 2019

Location of interview: University of Stavanger

List of acronyms: I=Interviewer, R=Respondent / Interviewee

Generally:

Age: 36

Job: Researcher

Gender: Female

Number of dependent children: 2

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 diesel

I: Where do you live?

R: Forus

I: Do you often travel to the city center?

R: I go to my workplace every Weekday and go to the city center a few times a month, maybe like 4 times a month. So, it is once a week or more.

I: Which problems of driving you are facing now in Stavanger?

R: Yes. More like congestion, or I mean I have to wait a certain time of the day. I mean for me it is not a big problem, but it is noticeable.

I: Have you faced any problems of parking?

R: Yes, even here at the university. Sometimes when I arrive late, it can be difficult to find a parking space. And sometimes in the city center as well.

I: Even when you go to the city center once a week, you also face this problem?

R: Yes

I: If you have to drive your children to school, how inconvenient the route is?

R: The older kid can bike or take bus to school. And for the other kid, I actually have to drive her to kindergarten. But it is on the way to the university and only 400 meters away, so I just drop her and go to school, then pick her up after school.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: I have awareness about it. I would say that I normally drive 11-12 km. And then sometimes I would take my children to activities then it would a little bit more, but this car burns less fuel compared to the age of car.

I: How old is your car?

R: Since 2012

I: What do you think about the importance of CO_2 emission target of the municipality?

R: I think it is very important. They need some target for direction and some measures in order to achieve that.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: To go to the city center these days, I prefer to take bus actually. The bus works really well to go to the city center. So, I prefer taking bus to city center rather than driving a car and finding a parking space. From my house to city center, I think it is easier to take bus. But for going to work, it becomes a bit more tricky. It drops me off further away from my house, and then I have to pick up my children and everything when you have the time constraint. So, I don't think it is that easy with bus. But I don't know. I think it depends on the demand as well. If the demand is not that high and you want to go to that particular area. So, I try not to use my car much but then my son needs to go to some place for activities. It is impossible to go there by bus. So, I have to drive him. My wish would be that there could be bus to there so he can just take bus himself.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: I think it could be quite interesting because it is easier for drivers to know something about their car. I don't drive much but generally I think people would be interested to know how much it actually is in numbers. Maybe it could be more interesting for people who drive more than I do.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: Since I drive so little, I am not sure how much difference it would be. Obviously, it would be much better to have electric cars.

I: Are you aware of when you need to send your car to EU control?

R: I do it when they tell me to do it. I think it is every second year.

I: Do you know that EU control check CO_2 too?

R: I am not so interested in knowing those things. Looking at different cars I owned in the past, they are older cars. They did not tell me about environmental things. It was not the focus. They just told me about like "is it working", "is it up-to-date". And also, because in the past they graded from 0, 1, 2 and these are things that I need to improve in order to pass the test. This has not been the case with this car because it has been fairly new. So, in the past it is more like OK, then I need to buy some new stuff for the brakes, because it was like a tube, but it was nothing

like “oh, this is a very polluting car”. I don’t think this has been the focus. The focus is the car you are driving as long as it is safe.

I: How do you know how much you pay for the toll?

R: It is like 30 or 33 NOK per time.

I: Do you pre-pay or post-pay? Like you put the money first then it gets deducted or you get the bill at the end of the month?

R: I don’t know. I just have this little thing, autopass and I hope it works, doesn’t it?

I: But for that thing, do you put the money in advance?

R: Yes, I put the money in advance and they just deduct the toll from that.

I: Do you know that they stopped that and changed into the method that you will pay later?

R: I don’t know that. I haven’t registered like that. I think I am still using the prepaid system. I know that like this week they also raised the ticket, so it was more expensive because it was not working and now, I heard they publicly solved it. Because now it is working from this week onwards, but I only pay when I go back home, not to come here.

I: Because you have different route when coming here?

R: No, but then I leave Forus, there’s no toll stations coming in. There is when I come back to home. So, I pay once. If I have to leave before 5 o’clock because I have to pick up the children.

I: Do you have any trouble with the transparency of the toll?

R: I don’t know how to check it. I have to find that out. Actually, I have to think about it. But I heard there were a lot of issues. That’s why probably they changed the system.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: I always use the parking lot that I am used to. So, for me it is like a routine.

I: Is it always free there?

R: Normally it is. If not, I can use the one on the top of Kolumbus station. But now I need to change my routine because I heard that they are taking it away this year. So, there will be no parking lot there. I sometimes also park in another building right behind the harbor. But it is very narrow. My car is not that big, but it is very narrow. So, I prefer to park at the first place because it is big and nice. So, whenever I travel downtown, this is my first priority to park. It is just like smoking. The first brand you smoked; you tend to stick with that. That’s why I always you the first parking lot.

I: How do you actually know that there is available parking space there?

R: I just have to drive to that and read the signs. I think I only experienced, like once or twice when it was like Saturday or 11am, like busy time that there was no space then I just had to go somewhere else.

I: How do you know if there is traffic jam somewhere?

R: I don't know. I just use my eyes. I start and I hope. But I think know there exist apps and stuff. My husband has some different things so you can see. He is more into it. I just can avoid going to some ways I know they will be traffic jam for example Ålgård on Easter when everybody goes to Sirdal. Then I just use common sense. But I have no app so no tools.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: The only thing I use is camera.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now?

R: No.

I: If you are to rate the present circumstance of driving supporting knowledge on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 3. I mean for me it is not a big problem. I don't travel long distances. But It is like a mixture because I wish there was better infrastructure in terms of public transport. But I am also very aware of the low demand and that we are living in Stavanger which is also joining a bit to Sola and Sandnes. So, it is kind of not clear to define the city center in the same way I guess with Forus. Sometimes I wish there would be infrastructure for this like in Oslo and Bergen maybe. In Bergen the city center is a lot more concentrated. And Oslo you have very different systems and urban planning. So, I understand these are constraints as well as they are not easy to plan. And I often take the bus to city center in the evening at least. There are not a lot of people on the bus. So, I understand that that's a problem as well. And in the evening to the city center the bus is perfect. I mean they go every half an hour and they are on time. So, the bus is working really well. The problem is more when I am going to work actually. Very few problems though. When I leave Forus for Sandnes, that's when the problems start. I can see a lot of traffic coming from there.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: I use the Kolumbus app and Travel Planner of Kolumbus. So, when I go to the city center, I can check the time.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: I think it's 5. Particularly because I have some issues with my car when I drive up from where I come from at 7 or 8 am and sometimes my car is not working in the middle of deep tunnels here. And when I took the mechanic to go through, but you haven't been driving the car a lot so suddenly it has experienced some problems. But there was no warning signal prior to this happening. Nothing told me to maybe I need to drive the car a longer trip to avoid this problem. So, I feel that you know since I do not have these technical skills, I don't know what to test for or not. I used to have old cars and I always checked the oil and these kinds of things. But then I also rely a lot on the automatic system of the car. That is not good as well you know. In a way, I am blind a little bit. I just find it comfortable just to drive to work right. So, I don't really pay attention to the fact that I have to pay 30 kroner every day to do this, which is a bit strange because I am quite price-conscious for everything you know. And if I see like OK if I know I won't find the cucumber if I accept that price because I know the price of milk, the price of bread and this kind of thing. So why do I let this slip? Maybe because it is very comfortable. So, these kinds of things, knowing that this will cost you this, and it is supposed to be like this. Like having that information would be helpful. Because I think that a lot of consumers, they just close their eyes a little bit.

I: So, the idea of this app is when you know your actual emission, maybe you will have kind of psychological impacts. And you will feel more eager to help the municipality to achieve the target.

R: And I think the other point that you raised about having knowledge about how much other types of transportation, other brands of cars are emitting. It could be useful for understanding. But I think it could be the money that people use electric cars. Probably electric cars are free to go on ferry or they can help to reduce taxes. Those are big incentives.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: The most environmentally friendly route and the real-time toll.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Parking lot and traffic jam.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: Then I would feel that I am making a difference right. I could see that I am actually contributing. I think it is also important in terms of smart city initiatives. Because it is a global policy level but how do we get inhabitants involve, how could we get this bottom-up approach

more. I think that could be quite motivating to get this. Then maybe I guess people will feel more contributing than previously. You understand that you have an impact more than like recycling stuff. You don't see the impact. So, I think that could be sort of, very important.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: It could be 5.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: It could be cool, for example, have a neighborhood effect so I could see this is my emission, this is my neighborhood's. Of course, I understand the reason you can't have the specific neighbor, but you can see how you are rated compared to others. So, you can feel that Oh, you are doing better than your neighborhood. If I am doing worse, I can try to adjust. That is sort of, I don't know, competitive.

I: It is anonymous for this kind of information.

R: But maybe like another competition between small municipalities like Hinna versus Hillevåg.

I: What are your expectations for the municipality to serve you better?

R: I know they are now working on the biking route, which I think is really good. So, I expect that they carry out this CO_2 goal and facilitate it even more for people to involve in. But I don't know. It depends on people as well.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Depends. I would not be comfortable if you track me when I am travelling all the time. I would not be aware of how the data is stored. Then I would feel like under control. But if it's used for management or things like that, then they can take it.

I: It is just your CO_2.

R: In that way, yes.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: Yes

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes

I: Do you want to share the type of your cars and the type of fuel you are using with the other people?

R: Yes

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: Yes.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: Yes, I think it would be very cool. I used to see like a big bump in the road. And I knew that I could report this on the web. And I have been reported things there. But it is a bit like hassle. So, if there is an app that I can take a picture and send it, I will use it, good for both the municipality and citizens.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app? Can you rate it from 1 to 5?

R: Yes, I think so. I would rate 3.

I: What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

R: It will raise awareness. I think that's what we need. And then it gives us some concrete numbers. I think it would be very useful for a lot of people. Then you can see how much or ow little you are contributing. I think it is extremely useful.

Interviewee: 7.1

Interviewer: Kim Ngan

Date of interview: May 14, 2019

Location of interview: Interviewee's own place

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 30-50

Gender: Male

Number of dependent children: 0

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 - Gasoline

I: Where do you live?

R: Sola.

I: Do you often travel to the city center?

R: Once a week.

I: Which problems of driving you are facing now in Stavanger?

R: Sometimes on the highway like a traffic jam.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: Very low.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: I have no opinion to this.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: I have no relation.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: Not sure, maybe a little.

I: Do you know that CO_2 emission is subject to the EU control condition?

R: No.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: Yes, it seems like.

I: How do you know how much you pay for the toll? Is it real time?

R: I don't check and just pay the bill.

I: Do you have any trouble with the transparency of the toll?

R: Not that I am aware of.

I: How do you know where there is a toll station?

R: If I am not sure I check over the internet on the website regarding toll stations.

I: In which way are you designing your route to have less toll fee?

R: Usually I cannot avoid toll fee, so I have to drive where I suppose to drive. I cannot take any other route. Because my workplace is within the toll station area so I cannot avoid it.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: Look for the green light (LED) above the parking spaces. If I travel to new place, then I just drive and look for available parking spot.

I: How do you know if there is traffic jam somewhere?

R: Google maps.

I: How do you know about the speed limit of the street?

R: Use my eyes.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: No.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now?

R: I don't know. I am not aware of any activity. I may read them on media or newspaper about such activities.

I: If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 3.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: Google maps, kolumbus, easypark, etc.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: 5.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: Most cost saving (efficient) route

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Speed limit.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: Yes, I think so that it will help me to reduce CO_2 emission.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 4.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: There should be some integration between this app and other traffic related apps that we use. For example, google maps and easyparking.

I: What are your expectations for the municipality to serve you better?

R: No.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the other people?

R: Yes.

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: Yes.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: Yes.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app?

R: Yes, probably.

Interviewee: 7.2

Interviewer: Kim Ngan

Date of interview: May 14, 2019

Location of interview: Interviewee's own place

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 34

Job: Journalist

Gender: Male

Number of dependent children: 0

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 by gasoline

I: Where do you live?

R: It is 20 minutes by bus to the city center

I: Do you often travel to the city center?

R: It depends. I had a period when I was travelling every workday and now it's like once a week maybe. Maybe not. Or once every two weeks. But when I go to the city center, I'd prefer to take a bus rather than a car.

I: Which problems of driving you are facing now in Stavanger?

R: I primarily use the car when I go to work so my main problem there is actually the traffic jam I would say. Also, I have to pay a lot of toll. But the main issue I have with driving to work is traffic jam. I don't mind so much paying the toll. I get a little help from home, so it helps it. Still probably traffic even if I had to pay for the toll myself.

I: Where does the traffic jam begin?

R: It's before when I get onto the highway.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: I read it once because it stands in the certificate given with the car, but I am not well aware of it.

I: How old is your car?

R: It's 2010 model, so it's actually 9 years now. But I used to drive with a much older the car. I changed it a year ago. It was 98 model. So, it was very old, like over 20 years. I remembered now that I was thinking so much about the CO_2 emissions when I had an older car. So, when I

bought the new one, I was quite eager to check the CO_2. It has something to do with the consciousness, I think. I want a newer car that doesn't pollute as much as the old one.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: I think it's really important.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: If you think about driving, there has been some sort of transportation like train or bus in a quick and simple way to use. I would love to do that. I like to relax on the bus or on the train. So that would at least help me to reduce my CO_2 emissions. But I think it also has to come with a personal cost you have to sacrifice something to make that kind of goal which the municipality has. The current busses of the municipality are good if you go to the city center, the university or area close by. But when I go to work at Ålgård, for example, I don't have many alternatives. I remember looking how long it would take me to take the bus from here to work in Ålgård. It was like one and a half hour or so, and three buses.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: That would be really interesting. Maybe it would make me more conscious about how I am affecting the environment. It would be nice to be a bit conscious about this and that's why I'd like to know.

I: How are you aware of when you will send your car to EU control?

R: I get a letter in a mailbox. And last time I also checked when it was due, and I sent the car to Eu service a bit earlier, so you get it done. It's every second year.

I: Do you know that CO_2 emission is subject to the EU control condition?

R: Yes

I: Have you ever faced any problems of CO_2 emissions with your car?

R: No

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: Yes probably.

I: How do you know how much you pay for the toll?

R: I just kind of briefly do the Math in my head. But I don't know how much it is. I guess at least 45 krone each time you pass in the rush hour. I have autopass so I get a discount, but I can't remember how much it is. So, 45 kroner is the price that you don't have the chips. I guess it's 30 or something. So, I pay on the way to work and on the way home as well.

I: Do you have any trouble with the transparency of the toll?

R: No. My parents paid for it. But I asked them a couple of times. I drive a lot to work and so I ask for it. Now I am working I should pay but they said that they haven't noticed so much of the problem. Probably I would have a complaint from them in the next few months when the bill of the rush hour fees arrives.

I: How do you know where there is a toll station?

R: By road signs. And also, you the toll station itself.

I: In which way are you designing your route to have less toll fee?

R: I didn't look it up so hard. I don't think I have so many alternatives to avoid the tool on my way to work. And if I drive here in Stavanger, I try to think about it, but sometimes it's inevitable. If I go to the city center, I will take a bus.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: When I go to the city center by my car, I try to use the parking houses because they are usually free there. Maybe I paid a bit more in there but it's worth it.

I: How do you know if there is traffic jam somewhere?

R: When I go to work, I am used to it because I know where the traffic jams are. I actually use Google map to find where is the traffic jams and so on.

I: How do you know about the speed limit of the street?

R: Because of the road signs. My car doesn't indicate that.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: I haven't checked that actually.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now? Can you rate it from 1 to 5?

R: Not so much, I guess. But as a journalist, it's a part of my job to know what's going on. In that sense, I am quite interested in what is happening. Maybe it could be wrong to say, "Not so much". I would rate 3.

I: If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: Maybe 3. This is based on the feeling like it doesn't feel efficient standing in the traffic jam. I spend the fuel, and time but actually I calculated the extra time. And feel how inefficient it is to waste the fuel there.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: Just Google. I don't use any app except that.

I: How do they work to help you achieve the traffic efficiency?

R: Google map can tell me something about how much extra time I am spending in the rush hour, in the traffic. Would be better if your app can also calculate the most efficient route by looking on the traffic. It can suggest the road than it normally would, which might be longer but faster because I can avoid the traffic jam. In this sense, it is quite environmentally friendly.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: It is quite useful actually. Maybe 4.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: Traffic jam. In my car it shows real time fuel consumption. And that's quite interesting to look at it. And it's easier on gas pedal. Because I look on the numbers and it feels a little bit like a competition. I want to keep them as low as possible. Maybe it will be the same if someone tells me about the CO_2 emissions as well.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Parking lot

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: It would certainly be helpful because it's an ambitious goal. And everyone has to contribute to make that goal. It would certainly make people more conscious about CO_2 that they emit. Because honestly, I don't know how much CO_2 I emit a year for example or during the day travelling to work. But if I know about it, I might probably change my lifestyle a bit.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 4.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

easy to use and free. It's probably hard to make something free but at least easy to use. But if it's not free, maybe the app should come with the car. My parents have BMW i3, the electrical BMW. They have an app, which can show you how much power it has. So, if the app goes with the car, I would probably download it to use with the car.

I: What are your expectations for the municipality to serve you better?

R: When it comes to the overall CO_2 emissions, it's quite important so the leaders should take the responsibility and go ahead to make an example, I guess. It sounds like an unpopular decision to make but something like that might help citizens to get involved.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes, but should be anonymous

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: Yes. That would be nice, I think. At least traffic accident.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app? Can you rate it from 1 to 5?

R: Maybe. It sounds like it's easier to interact with them now. So, it's a 4.

Interviewee: 8.1

Interviewer: Abdur Rehman

Date of interview: March 27, 2019

Location of interview: University of Stavanger

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 63

Job: Teacher

Gender: Male

Number of dependent children: 0

Interview:

I: How many cars?

R: One by petrol

I: Where do you live?

R: In Sandnes

I: Do you often travel to the city center?

R: Once a month or something like that.

I: Which problems of driving you are facing now in Stavanger?

R: Not really

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: Not much.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: I think it is important with all kinds of emissions. CO_2 is one of them. I am not sure how much impact CO_2 has with all kinds of emission. Regarding cars, I think the other generators are more dangerous, but it depends on how you use it. One significant to reduce CO_2 from this area is to get rid of the crew ships and the airport. Because they are very big emissions compared with the number of users. There are also problems with petroleum and diesel cars. There are also problems with the electric ones because in the life span of the car, electric cars are usually worse than diesel cars due to the battery. So, it depends on what kinds of pollution do you prepare.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: The municipality has set up the goal for 80% reduction. It has a very little impact on my personal life. Due to the amount of travelling and most of my travelling is going to the rural area, not going to downtown.

I: But even when you try not to go the city center, CO_2 is still emitted to the environment?

R: The problem is by far the area I am mainly travelling doesn't have any public transport. So, I have to travel by car.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: Not very much because it is hard to make some kind of impact. I was travelling a lot downtown where the importance of the number of cars is bigger. That could be more interesting.

I: But if you know how much your car is emitting, you might try to reduce it?

R: You can try to reduce it, or you might buy a newer car that has less pollution. Regarding daily use, of course electric cars are much better. Regarding life length, they are worse but that's a different type of problem. Then you move the problem to other places instead of where you are using the car.

I: How do you often take your car to EU control?

R: I think I do it as much as I remember every 6 years or something like that.

I: As per my information, it is every two years.

R: I am doing it according to the regulation I have. It used to be 10 years and after 10 years, and then somehow, they changed it. It is still publicly following up on that one. But then I am doing it when it is still valid.

I: Do you know that CO_2 is one of the conditions of EU control?

R: I think I do.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: It is a good indicator if you have the car on test. And of course, if you expect that there is too much pollution one way or the other then people will do something about it. You get noticed if you are losing too much dust on the brakes, and information about other issues of the car.

I: How do you know how much you pay for the toll?

R: I am paying 22 NOK in the normal time, and in the rush hour it is 44 kr. That's part of using the car.

I: Is it real time?

R: I think they get it deducted from the bank account and get me updated about the list of passing once a month.

I: So, every month you get kind of faktura?

R: It is different because up to last year we paid in advance and now they are taking out afterwards from the bank account.

I: Do you have any trouble with the transparency of the toll?

R: No as far as I know.

I: How do you know where there is a toll station?

R: I know where they are.

I: In which way are you designing your route to have less toll fee?

R: I can travel to work without paying for toll but longer distance. Due to the rush hour limit there are small queues. Standing in a queue is also pollution. So actually, travelling to the toll road is the shortest distance and less pollution.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: Normally I am travelling to the place I want to go and look for it, except special days like 17th May celebration. Then you have a problem going downtown. But for normal days it is not a big issue. If you go to the university after 9 o'clock, then you might have to travel around to look for the parking spots. If you travel there by 8, it is more or less free.

I: How do you know if there is traffic jam somewhere?

R: On my phone.

I: How do you know about the speed limit of the street?

R: You have the signs on the road, so it is not a big problem.

I: What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: I think there is quite a lot of information on open data that is not available for use by the public because the data is there, but no one estimates and give in-depths. It might be that too many apps are made on looking at available data and try to push something else instead of saying what will be the benefits for people for instance. But I think there are a lot of possibilities starting from looking about what can be done for citizens and then finding out that there are a lot of open data that can help. Maybe there is some latent data in between but there are quite a lot of purposes in people's daily life. So, there is a huge possibility to do something that can make a difference. But it has to start with the customers and citizens, what you can do for them instead of just starting with the available data and make something that tries to push. Something that people don't understand what they need.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now? Can you rate from 1 to 5?

R: Not very much. One of the reasons is that when you have elections, you elect people to represent you according to a program but very often you see that they do whatever they like afterwards, not looking at what was the program they had for the election. And there is quite a lot of horse trading between the different parties. So, in my view, one way of engaging citizens

would be to do as Switzerland, where people are actually voting directly on the issues, not electing representatives to do whatever they like on their behalf. It is working in Switzerland. The big thing here could be to let people vote on their mobile phone, just as you do with the European song contest, where people are voting on their mobile phones. It is quite possible if you know you are going to do something in the neighborhood. Why not let people in the neighborhood vote? It is technically feasible. The ones who don't like it is the politicians, because they lose power. But you can let everyone vote or you can limit it to people within a certain age or a certain neighborhood, there are a lot of technical possibilities. And of course, if you do then you would make the people care more about the details, because they are part of the solutions in the moment. They are not because the municipality board doing a lot of things that nobody really cares about. Very often people don't like the consequences what they do. There is a lot of the political power. And if you want to really have every or most of the citizens participate, you should let them be able to vote, let them be part of the decision. Normally people would say that 'OK. I am in minority, but I am able to vote' then it's ok rather than when you have politicians decide things and the majority of people have no ways of saying anything. Then that's a different problem.

I: If you are to rate the present circumstance of driving supporting knowledge on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: I think traffic overall is quite good or acceptable. It changed a lot 3-4 years ago when the petroleum price went down because before that there was a lot of traffic jam. Because there were a lot more people living here. What happened when the oil price went down was not that a lot of people got unemployed but quite a lot of foreigners working in the petroleum industry left. So, let's guess the traffic on average went down 20-30% and then suddenly the need of cars versus the capacity of the road was more in balance.

I: But like the present circumstances about the knowledge you can get about the traffic jam somewhere or the information of the parking lot?

R: I can get the traffic jam easily, but I cannot that easily get knowledge about the parking lot. But very often you can drive to see. Once you are close to your goal, you can try to check out if there is any available space. It is not that many days during the year everything is built up. It might be on business time of the day before Christmas when people go out to buy something or it is when you have big parade like 17th of May. It's said 10-15 days during the year that everything is packed up. So, the overall picture is that there is enough parking space, especially if people can accept to work several hundred meters. If people say that you need to park within 15 meters, then it causes a problem.

I: So how do you scale it from 1 to 5?

R: I would say the general situation is quite good. So, 4 or something like that.

Theme: Motivating and mobilizing

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: I use Apple map

I: How do they work to help you achieve the traffic efficiency?

R: The app pictures quite well what is happening in the traffic. What you don't get from these is if there have been some kinds of accidents within the last half hour or something like that. But there is some time after the accident, then you can see what is going on, if the traffic is jamming up.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: I think it would be a nice idea to have an app that can show everything concerning the traffic and also some single issue that the apps are doing today. I would rate 5 for having app showing all the parts concerning the traffic, not only a single part.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: For the daily use, the best would be to show the pattern of traffic jam, then comes the parking lot, and then comes the third emission, and then other circumstances.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: I would say the least impact in my daily situation is the emission side. But you can also add more than you mentioned, for instance where can you find public toilet, petrol stations, public charging for electric cars. And other information people would like to know where the nearest shopping mall is. There is app for shopping mall, app for parking but it is nice to combine them.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: What you do is that you will be more exact for the time you need to travel. When you don't have that type of app, then you don't know where to find parking lot and so on. Then it adds some purpose time because you need to go in advance, you don't know how long it will take.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: It would be 5. It's nice to have everything on 1 place rather than many places.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: I think I would like to include the weather because when it is raining, people are less inclined to walk a long distance. So, you want to park close to the area if it is raining. Who usually accepts to walk a long distance if suddenly the weather is not good?

I: What are your expectations for the municipality to serve you better?

R: I am not sure what to answer because it depends on what you do and when you do it. But when you need things from public offices, it would be nice to have opening time so you can do that when you are not working. It would be nice to have some more flexibility. And availability could be also a thing for your app. When you need to have some kind of applicants to public offices. It would be nice to know when they have opening are available. It is easy now to say that OK we go there in your lunch hour but then it's closed because they have a lunch hour. We go there after work and then they close because they have gone home. It is a problem for people who have to collect kids from school or kindergarten when they also have to go to public offices sometimes. Then it's a collision with the available time of the offices.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: I don't see a problem with that.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: I think that could be a nice thing that you are able to see whose car it is, to see what kind of car it is in your neighborhood but not identify the exact car. Because then you go into personal data and then you have the regulations regarding personal data. You can have the type of car in the region or the general average amount of CO_2 in your neighborhood, so it's a nice possibility to compare.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the other people?

R: Yes.

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: Yes.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: I don't have problem interacting with the municipality, but it depends on what kind of interaction we are talking about. Having a dialog about what can be done is nice. For example, if you see there's some issues on the street, you can let the municipality know but then you expect they will fix it. If not, that's negative information. But quite often, people tell the municipality about a lot of things, and they have to see what the lowest immediate kind of danger is now and then they go finding ways. But then there might be a long list of things that people say could be done in other ways but it's not like any danger, so we leave. It is like when it comes to clearing snow when it's snowing, they start from the most important roads where there is public transport. You cannot have capacity to do everything at once.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app? Can you rate it from 1 to 5?

R: Probably 3. If you get real time information available and you know that you can have an impact, then you will feel better and more active in the society. If you can't get the information and you think that you don't have an impact, then you will feel less inclined to engage. I think it is quite unrealistic to reduce 80% but would be nice to see 10-15% can be reduced by people. If you want to have bigger impact, then you have to go back to the crew ship and airport. Really if people care about CO_2 much, people shouldn't take airplane.

I: What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

R: Depends on what you mean by 'green'. But there is a huge possibility that Stavanger can improve, also Sandnes and Sola and the other parts of the region. It is to let go of using one-time plastic, let go of having different types of pollution. It can reduce CO_2 a lot with the stoves which produce a lot of CO_2 in the winter. And of course, the traffic is one easy area to approach because everyone is travelling in different ways. I have a colleague living in the wooden house area in Stavanger sentrum. He takes a bike to work. He lives in the center, so everything is very close to him. He only uses car to visit his relatives. So, it is hard for him to reduce even more. I think people who use cars more often are those who live in the area without much public transport.

Interviewee: 8.2

Interviewer: Abdur Rehman

Date of interview: May 14, 2019

Location of interview: Forus, Stavanger.

List of acronyms: I=Interviewer, R=Respondent / Interviewee

General:

Age: 50

Gender: Male

Number of dependent children: 0

Interview:

I: How many cars? Which type of cars? (gas, diesel, hybrid?)

R: 1 - Diesel

I: Where do you live?

R: Gausel

I: Do you often travel to the city center?

R: 4 times a week

I: Which problems of driving you are facing now in Stavanger?

R: It is mostly finding the free parking that's the only major issue. Secondly the toll stations, but this is something I cannot avoid. So, as a result, I prefer to travel by bus to Stavanger. But if I must travel by car to city center then I just don't travel in rush hours and also at the same time I avoid peak hour toll fee.

I: How much are you aware of the level of CO_2 emission your car is emitting?

R: I have no idea.

I: What do you think about the importance of CO_2 emission target of the municipality?

R: Well, I understand that municipality has made it an important target I am not sure if this is the most important target to have. But the fact is that at least they have some target about the environment, so it is good, and I support this target.

I: How can you relate the municipality's CO_2 goal to your personal life?

R: Even without knowing that this is a strong target for the municipality, I reduce the car emission by taking the bus. Although, my primary motivation was not the emission but the financial reasons that I did not want to pay for toll, but I assume that these toll stations are implemented by keeping in mind the environment issues. So, I reacted in a right way that I stopped using car and preferred bus.

I: How interested you are in knowing how much CO_2 your car is emitting and compared with other cars of the same vehicle model?

R: I will be interested in knowing CO_2 level of my car. Knowing CO_2 level of other cars would not be my primary need but getting knowledge of it would be interesting.

I: How often do you take your car to the EU control?

R: Every 2nd year.

I: Do you know that CO_2 emission is subject to the EU control condition?

R: I didn't know.

I: Do you think it is a good indicator of a systematic flaw and a warrant follow-up testing?

R: I don't really know enough about the cars that what CO_2 is consequence of. But if I am made understand that this means car is not working properly then it is a good indicator.

I: How do you know how much you pay for the toll? Is it real time?

R: Well, that is a major issue. I receive a bill and then I must do some research to get the details, it is a bit obscure.

I: Do you have any trouble with the transparency of the toll?

R: I used to get bill every six months. But recently I had no bill. So, I have to trace my last six months to see where I have travelled, and it is really hard to keep track of my travelling for last six months. To me it is a very obscure system.

I: How do you know where there is a toll station?

R: There are 2 ways: 1) you see it, when it is too late and I am under it, 2) there is the website where I check the locations of toll stations.

I: In which way are you designing your route to have less toll fee?

R: The way where they are placed on the road does not allow you to avoid them. But if I want to avoid them then I have to make a detour, which cost more time, more fuel so generally it is just better to travel under it.

I: If you want to park somewhere, how do you find an available spot in a parking lot?

R: The places where I regularly travel, I know where I would likely to get free parking space with free parking. But if I travel some place new then I look for the sign board in parking lots and sometimes I follow my intuitions that this kind of parking lot will have free parking space. I don't mind parking my car far from destination even if I have to walk.

I: How do you know if there is traffic jam somewhere?

R: Google maps.

I: How do you know about the speed limit of the street?

R: Follow the signs.

What do you think about the open data on the website of the municipality in terms of transportation (parking lot, walking and cycle paths, roads with speed limit?)

R: I have no idea.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now?

R: I'm not engaged in active manner but in passive manner, since I implement what they ask us to implement.

I: If you are to rate the present circumstance of knowledge about Stavanger traffic on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 2.

I: Which mobile apps are you using to get information about transportation? (Traffic jam, parking, maintenance, etc.)?

R: Google maps.

I: How do they work to help you achieve the traffic efficiency?

R: Just by helping me in anticipating that there is going to be a traffic jam but sometimes the accuracy is not good.

I: If there is an app that can show you how much CO_2 your car is emitting, how much toll you have paid and suggest which route you should take to make it more environmentally-friendly and more cost-saving, signals for maintenance, speed limit, traffic jam, parking lot, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: 4.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like best?

R: Parking lot, Cost saving and environment friendly.

I: Of all the features of the app (CO_2 measurement, toll payment, speed limit, traffic jam, parking lot), which feature do you like least?

R: Speed limit.

I: How can you relate the municipality's CO_2 goal to your personal life if you can exploit this app?

R: If this app become useable, it shows that municipality really cares about the environment and it is very positive. It will engage all the citizens to be more conscious about the driving and environment. This is how municipality can show that they are doing something for environment, and I would support them.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 4.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: You can put a cost comparison between running an electric car to fuel car. This will motivate people to go for electric car.

I: What are your expectations for the municipality to serve you better?

R: When you come from a Latin country, you don't trust your municipality but in Norway I have learned that there is lot of work has been done for the well-being of people. But there is also a very strong interference from big industries that can completely take your good goals off the route.

I: Do you feel comfortable sharing your CO_2 emission with the municipality open data?

R: Yes.

I: Do you feel comfortable sharing your CO_2 emission with other people?

R: Yes.

I: Do you want to see other people's CO_2 emission and compare it to your own?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the municipality open data?

R: Yes.

I: Do you want to share the type of your cars and the type of fuel you are using with the other people?

R: Yes.

I: Do you want to see other people's type of cars and the type of fuel they are using?

R: Yes.

I: Do you want to interact with the municipality directly via this platform? (report an accident, report traffic jam, report errors)

R: Yes, this will be good.

I: Do you feel more engaged to the municipality's activities or policies if you can exploit the app?

R: Yes, it raises the concerns and it is not a negative concern it is positive one.

I: What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

R: To answer this question, I need to measure the impact of this app and its features. I might say that it might have 10% - 15% positive impact for the city to be less polluted.

4. Interview with the municipality

Interviewee: Municipality 1

Interviewer: Kim Ngan

Date of interview: May 23, 2019

Location of interview: Stavanger Sentrum

List of acronyms: I=Interviewer, R=Respondent / Interviewee

I: What is your role within the organization?

R: I am working in the Environmental office. Office for environmental and climate, which was approved last autumn by politicians. I am working on mobility and business mind. It is more like motivating people to take bicycle or by foot instead of cars. So, I am a project leader of the yearly event for mobility. One week each year and it's car free days. It happens in city center, we close city center for cars and we fill it with other companies and organization doing great mobility, going on bicycles and electric mobility and everything. It is a big day which happens on 8th of September between 12:00 and 16:00. It is a family day, we invite whole city, the buses and train will be free, so people can come free. We convince them to commute on bicycle, by foot, bus, electric vehicles. We provide them with information about electric bike, they can try and see if this is something for them. This is my main job topic.

I also have the charging strategy of Stavanger kommune. Manage the charging stations around the city and making it easier for the people living and travelling. With hope that there will be more electric cars in the future. So, I am coordinator of this job. These are some of my main job topics.

I: Which problems you are facing now in terms of managing CO_2 emitted from cars in Stavanger?

R: We do not have real-time CO_2; we contact statistic office of Norway and get numbers from them. There is problem that we always get the data 2 years later. So, now we have the data of 2017. We had project where we were counting cars travelling on highway. We did not had information about CO_2, but we had the rough idea. We could make the average of cars driving around the Stavanger. And then it was related to (name of website I didn't understand) where people can go to website to check when was it was lot of cars or low CO_2. But it was not real-time.

I: with talking to Gunnar, he mentioned that there are 3 big stations to measure inside Stavanger kommune and some small sensors, do you know about this?

R: I didn't know about that but, we relate to the statistics because we are making plans and actions related to emissions and climate.

I: How important the CO_2 target is to the municipality?

R: It is very important. We are working a lot on this plan for 2 years. We got it back from politicians and it was a big project. We had to put it down to the people, we had to answer people having questions. My colleague she is working with climate issue. She received a lot of calls from inhabitants and we had to answer every one of them, and we had to put it in a plan. It took us 2 years and finally politicians decided it even higher the target. This is a big engagement here in municipality, politicians as well. We are working on it and people are taking it seriously. We want to make it happen.

I: What is the plan of the municipality to reduce CO_2 from cars?

R: My other colleague, each year we have a CO_2 and climate report. We just finished the report of last year and year before to that. I think we are going a bit down. We have to work harder if we want to reach our goal by 2030. But I think the challenging strategy will help us to reduce CO_2 emission.

I: beside the increasing charging facility around the city, do you have any other plan to reduce CO_2?

R: Beside mobility, we have very nice action plan over 100 concrete things we need to do not related to mobility and transport but related to electricity we have action plans by the end of 2022 and then we will make new plans. And we put the responsibility for each task, so everybody knows what they have to do by the year 2022 we have to reach that target. Last week on Wednesday we had big meeting here with all the officers talking about how it is going. And then we really use the opportunity to get money from governmental environmental department, if we ask for it. We wrote 15 different aliments to the department and everything has to do with climate, to reduce climate, to do with transport, electricity etc. so we had this meeting, my colleague had the report.

I: What kinds of transportation data is available on the open data?

R: We have measured the bicycles, information about people going to city center. People going on hiking or going to lake. And I know kolumbus is working to be on open data nowadays. Soon they want to publish it. We had meeting. This is to raise awareness.

I: beside environmental Sunday, do you have other campaigns to raise awareness? Some other campaigns, but I don't have any campaigns now. But we try to do all the tasks to cover the plan. Communication on Facebook.

I: How can the municipality engage citizens in the CO_2 target?

R: We conduct measures to provide awareness, as mentioned above 8th September, campaigns, such environmental Sundays, etc. raise awareness in different ways like Facebook etc.

I: do you have any current dashboard to manage CO_2?

R: We don't have dashboard. You can talk to my colleague; he is in the mobility and can explain you better. I think, maybe Kolumbuus is trying to do something like this in Sandnes, sola, Stavanger and Randeberg and we will maybe a part of it.

I: How interested the municipality is in knowing how much CO_2 is emitted from cars in real time?

R: We have to be sure that this something we can rely on; technology and everything. So, we have big stations but for real time we have to do something proper.

I: How the municipality gets the information of which place is having traffic congestion?

R: We don't have any information.

I: Do you feel normal citizens are engaged to the municipality's activities or policies now?

R: I don't know, we don't have any measurements about that. I think, more than before people are engaged. Climate is not our, but the youth, the pupils going on the street trying to demonstrate and everything so there is some engagement. There was lot of information on newspaper when politicians set the goal last year, so I think they are engaged but we don't have any measurement. But when people come for environmental Sunday, gladmat etc. so we think that they are engaged.

I: If you are to rate the present circumstance of the municipality providing supporting knowledge to citizens on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: I don't prefer to answer this because Smart city group may rate this as 5 and I may rate it 3. So, I cannot answer this. But maybe 3 from me.

I: If you are to rate the present circumstance of the collaboration between the municipality and citizens on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: 3.

Because of toll stations, not everybody is understanding why we are doing this.

I: If there is an app that can show you how much CO_2 cars is emitting, how much toll has been paid and suggest which route citizens should take to make it more environmentally-friendly and more cost-saving, how much do you like it on the scale from 1 to 5 (1 is least, 5 is most)?

R: I don't know.

Theme: Working together

I: What are the advantages of installing a CO_2 sensor at some toll stations?

R: It will help to raise some awareness.

I: What are the challenges of installing a CO_2 sensor at some toll stations?

R: We have to use this not just waste money on it. Use it properly is a challenge.

I: Do you have any other suggestions to make the app better? (easy to use, free, etc.)

R: Make it more visible even to those people who don't use the app like old citizens. Like having big screens on highway or city center where everybody can see their information would be more interested.

I: If citizens can exploit the app, how much impact do you think they are contributing to the CO_2 target?

R: It will raise awareness to it is an important tool too. It is about not taking the car so I think it will have impact.

I: Do you want to interact with citizens directly via this platform? (see an accident, report traffic jam, report errors)

R: We already have one platform for this. It is not chat box or email, but it is a form available on the website of municipality. You fill out the form and then it goes to concerning department. Mostly we had complaints related to garbage and we try to fix it and we have good feedback.

I: do you think it would be fine to have another platform for citizens to contact municipality? Yes, it would be better to combine both.

I: if you can have a dashboard to manage it, what do you think it should look like? How do you set the target of CO_2 reduction for cars in the municipality?

R: This is more something like internal for the leaders to see; they can see that we must do more efforts when it is red. If something is wrong with the garbage cans, then we must put more efforts to garbage cans. The usage and indicators should be better internally.

I: do you have target for CO_2 generated from cars?

R: No.

I: If you are to rate the potential of driving supporting knowledge from the app on a scale from 1 to 5 (1 is the worst, 5 is the best), what will you rate?

R: I don't know.

I: Which role could the municipality take if the app exists? (regulator, funder or coordinator)?

R: We do not have any prior app. But probably we would be funder.

Interviewee: Municipality 2

Interviewer: Kim Ngan

Date of email receipt: May 23, 2019

This interview is conducted by emails.

1. Which problems you are facing now in terms of managing CO_2 emitted from cars in Stavanger?

Difficult to answer.

2. What do you think should be done differently to better handle CO_2 from cars in the future?

Difficult to answer.

3. Do you have a strategy or a target? please explain the purpose and expectations?

Stavanger's Climate and Environmental Plan 2018-2030 was adopted by the city council in November 2018. The plan, along with a separate action plan, describes the major environmental challenges, objectives and actions to reduce the impact on climate and environment.

The main objectives of the climate and environmental plan are:

- to cut greenhouse gases by 80 per cent by 2030 compared with 2015, and to be a fossil-free municipality by 2040
- to ensure it is safe to eat fish and seafood from all marine areas in Stavanger by 2030
- to ensure clean air for all residents
- to protect the living conditions of plants and animal life, and increase biodiversity

For more information:

https://www.stavanger.kommune.no/en/waste-and-environment/technical-services/#climate-and-environmental-plan-2018-2030.

4. Is this strategy or target consistent with country's inter/national obligations?

All municipal planning will be based on the Sustainable Development Goals. The measures in the Climate and Environmental Plan are a contribution, in the local community and/ or other places in the world. The plan refers also both to the Paris-agreement and the Norwegian "Klimaforliket".

5. How do you set the target of CO_2 reduction for cars in the municipality?

Cutting direct GHG emissions from the transport sector by 80 per cent by 2030 and by 100 per cent by 2040.

6. What is the plan of the municipality to reduce CO_2 from cars?

- facilitate more cycling routes and pedestrian routes, and properly maintain them

- collaborate with the county authority on improving public transport in the region, including the Busway (Bussveien)
- expand opportunities for charging electric cars and electric lorries, especially in co-ownerships and housing cooperatives
- contribute to the work on cutting emissions from ships that call at Stavanger.

For more details see the Action Plan (2018-22), pages 5-15:
https://www.stavanger.kommune.no/siteassets/renovasjon-og-miljo/miljo-og-klima/climate-and-environmental-action-plan--stavanger-2018-2022---final-version.pdf

7. Please list the main parameters that may influence the reduction of CO_2 emissions

- facilitate more cycling routes and pedestrian routes, and properly maintain them
- collaborate with the county authority on improving public transport in the region, including the Busway (Bussveien)
- expand opportunities for charging electric cars and electric lorries, especially in co-ownerships and housing cooperatives
- contribute to the work on cutting emissions from ships that call at Stavanger.

8. What is the current tool to track CO_2 emission from cars?

- Statistics for GHG emissions in Stavanger from light and heavy vehicles
- Number of charging points for electric cars available to the public
- Development of the vehicle fleet and its composition
- Number of people who are members of car sharing schemes
- Means of travel distribution for passenger transport and by journey purpose
- Means of travel distribution for long journeys
- Indicators for land use and parking, detailed in the city growth agreement and travel habits survey
- Traffic index for road traffic (vehicles), bike traffic and pedestrian traffic based in counts from permanent registration points and municipal counting points
- Statistics for renting city bikes and kilometers ridden
- Counting public transport journeys
- Number of calls by cruise ships that get an environmental discount (Environmental Port Index)
- Number of households that do not own their own car

9. Which technology do you think can be applicable to the municipality to manage CO_2 from cars?

- Statistics for GHG emissions in Stavanger from light and heavy vehicles
- Number of charging points for electric cars available to the public
- Development of the vehicle fleet and its composition
- Number of people who are members of car sharing schemes
- Means of travel distribution for passenger transport and by journey purpose
- Means of travel distribution for long journeys
- Indicators for land use and parking, detailed in the city growth agreement and travel habits survey
- Traffic index for road traffic (vehicles), bike traffic and pedestrian traffic based in counts from permanent registration points and municipal counting points
- Statistics for renting city bikes and kilometers ridden
- Counting public transport journeys
- Number of calls by cruise ships that get an environmental discount (Environmental Port Index)
- Number of households that do not own their own car

10. How can the municipality engage citizens in the CO_2 target?

- facilitating meeting places, dialogues with residents and resident participation (f.ex. Miljøsøndag in September)
- communicating opportunities, solutions and good stories that improve the residents' quality of life while providing climate and environmental benefits (f.ex. on the website and other social media like Facebook and Twitter)
- cooperating on resident-oriented activities and communication related to the climate and environment with other municipalities and public authorities, as well as organizations, the business sector, and research and educational institutions
- actively participating in a regional climate and environmental forum with the aim of learning more, exchanging experiences and conducting joint activities (national and regional forums)
- specially facilitating practical training in the climate and environment for kindergartens and schools (using programs like Green flag and Eco-lighthouse, go to school-campaign)

11. How interested the municipality is in knowing how much CO_2 is emitted from cars in real time?

We do not have any market analysis and cannot answer to this question.

12. What kind of procedure/approach do you use to collect the real-time data?

We suggest you get in touch with the operator Ferde.

13. Who is in charge of the toll system in the municipality?

This is part of Bymiljøpakken, Bymiljøpakken

14. Where is the data of toll fee stored?

We suggest you get in touch with the operator Ferde

15. Is such statistical data be made available for the citizen?

To some degree through Bymiljøpakken

16. Is the toll fee managed by the municipality as well?

No

17. What do you think if the toll data is made open on the municipality website?

Difficult to answer.

18. How the municipality gets the information of which place is having traffic congestion?

Stavanger Municipality works with neighboring municipalities, the county authority and road authorities to ensure that fewer people are exposed to hazardous airborne dust. An action plan for better quality air in the city has been adopted. The municipality and Norwegian Public Roads Administration take measures to reduce airborne dust from road wear when necessary. n 2018, a new air quality measuring station was established in Schancheholen, in addition to the existing ones in Kannik and Våland. A new measuring station in Forus/ Godeset is also being considered.

19. Does the municipality manage the data regarding speed limit of the street?

No, only as part of planning for action in certain streets.

20. Does the municipality manage the data regarding speed that cars are reaching at every camera station?

No

21. What do you think if the speed data is made open on the municipality website?

Difficult to answer.

22. What do you think about the citizen utilization of open data on the website of the municipality (parking lot, walking and cycle paths, roads with speed limit?)

Difficult to answer.

23. Do you feel normal citizens are engaged to the municipality's activities or policies now?

Not everybody. But the people have to face municipality`s activities each day in terms of f.ex. waste handling, toll fees, cycle routes, public electric charging, parking and other activities affecting the climate and environment. We have the service "VOF" (Varsle om feil – Alert on

problems) where the inhabitants can report errors in the system. And VOF is used very frequently which indicates that people feel that it is worth it reporting problems. That problems are fixed quickly – and that they get a respond from the municipality.

24. Does the municipality own or support any app to help citizens get better information about transportation (Traffic jam, parking, maintenance, etc.)?

No, we haven't.

25. How do they work to help citizens achieve the traffic efficiency?

We try to avoid traffic jams by participating in HjemJobbHjem as an employer and facilitate so that the employees can cycle, go or take the buss/train to work.

26. Have you implemented any instrument/sensor(s) for CO_2 emission from transport?

I don't know.

27. What are the advantages of installing a CO_2 sensor at some toll stations?

Today we get the CO_2-statistics from SSB two years later. If there would be a reliable CO_2-sensor (corresponding to national standards) at some toll stations we could measure real time CO_2 which could contribute to sensitize the awareness of our inhabitants. We could f.ex. show the measurements on a big screen in the city and / or on our website.

28. What are the challenges of installing a CO_2 sensor at some toll stations?

The sensors have to correspond to national standards. We do not know any doing that per today.

29. How do you want to manage CO_2 from cars if that app can provide such information in real time? (content of the dashboard, graph, target?)

We could contribute to sensitize the awareness of our inhabitants.

30. What can you imagine how 'green' Stavanger will be in the next 5 years if people start using the app?

Difficult to answer.

31. To what extent you think this idea is possible to sustain the benefits for citizens in the long term?

Difficult to answer.

5. Categories of Personal Data collected from toll booths

Source: (AutoPASS, 2019)

In total, 23 categories of personal data are processed by the toll collection systems. For each person, we only process data in those categories in which we hold information and which are necessary.

1. Name (First name/Given name, Middle name, Surname/Family name)
2. Address information (street address/PO box, postcode, city)
3. Contact information (telephone, e-mail address)
4. ID number (national insurance no. / b. date, D number)
5. Customer number / Agreement number
6. Customer's role (in the organisation)
7. Employer and workplace
8. Tag number (PAN)
9. Licence plate / country (vehicle)
10. Vehicle description (colour, size, model, environmental ratings etc.)
11. Photo / video (of vehicle)
12. Time and location of transit
13. Parking permits for people with reduced mobility*
14. Other reasons for discount and exemption (one of the reasons in tariff decision)
15. Notes and received documentation in relation to users' contact with the toll road operator (free text field)
16. Account information
17. Invoice information (transit information, amount, due date, address information, etc.)
18. Payment rules (direct debit, paper invoice, in advance, etc.)
19. Invoice and payment history (accounting history)
20. Reason code for decision to stop seeking payment
21. Registration code (codes from toll plaza)
22. Status code (for customer, vehicle and contract)

23. Request ID for each search in MyPage

6. List of database parameters with descriptions from EDAR system

Source: (Sjödin, et al., 2018)

DATABASE PARAMETER NAME	PARAMETER DESCRIPTION
VehiclePassageID	Filled in automatically when data are imported into the database
PassageTime	Time of vehicle passages according to the RSD
SessionID	Filled in automatically when sessions are registered in the database via the website interface
VehicleCategoryID	Vehicle category code according to the "Lists" spreadsheet in the database Excel upload form
VehicleCategory	Filled in automatically when VehicleCategoryID is inserted
FuelTypeID	Fuel type code according to the "Lists" spreadsheet in the database Excel upload form
FuelType	Filled in automatically when FuelTypeID is inserted
EmissionStandardID	Emission standard code according to the "Lists" spreadsheet in the database Excel upload form
EmissionStandard	Filled in automatically when EmissionStandardID is inserted
AbatementTechID	Abatement technology code according to the "Lists" spreadsheet in the database Excel upload form
AbatementTech	Filled in automatically when AbatementTechID is inserted
VehicleMakeCodeID	Vehicle make code according to the "Lists" spreadsheet in the database Excel upload form
VehicleMake	Filled in automatically when AbatementTechID is inserted
S/A flag	RSD speed and acceleration measurement valid flag (V=valid, x= unvalid)
Speed mph	Measured vehicle speed by the RSD - in miles per hour
Accel mphpersec	Measured vehicle acceleration by the RSD - in miles per hour per second
Speed kph	Measured vehicle speed by the RSD - in miles per hour
Accel kphpersec	Measured vehicle acceleration by the RSD - in miles per hour per second
VSP	Vehicle specific power caclulated by the RSD from speed and acceleration and US default data

VSPStatus	VSP valid flag (V=valid, x=unvalid)
ValidPlumePoints	Number of valid CO_2 measurements by the RSD in the exhaust plume
Average_CO2	The average column density for CO2 along the RSD beam during the measurement
Max_CO2	The maximum column density for CO2 along the RSD beam during the measurement
Percent_CO	Tailpipe concentration of CO in volume percent derived from the RSD measurements
Percent_CO2	Tailpipe concentration of CO_2 in volume percent derived from the RSD measurements
PPM_HC_Propane	Tailpipe concentration of HC expressed in ppm propane units derived from the RSD measurements
PPM_HC_Hexane	Tailpipe concentration of HC expressed in ppm hexane units derived from the RSD measurements
PPM_NO	Tailpipe concentration of NO in ppm derived from the RSD measurements
PPM_NO2	Tailpipe concentration of NO2 in ppm derived from the RSD measurements
PPM_NH3	Tailpipe concentration of NH3 in ppm derived from the RSD measurements
UV_Smoke	Tailpipe concentration of smoke derived from the RSD measurements in the UV range
IR_Smoke	Tailpipe concentration of smoke derived from the RSD measurements in the IR range
Ratio_CO_CO2	CO/CO_2-ratio by volume derived from the RSD measurements
Ratio_HC_CO2	HC/CO_2-ratio by volume derived from the RSD measurements
Ratio_NO_CO2	NO/CO_2-ratio by volume derived from the RSD measurements
Ratio_NO2_CO2	$NO2/CO_2$-ratio by volume derived from the RSD measurements
Ratio_NH3_CO2	$NH3/CO_2$-ratio by volume derived from the RSD measurements
AmbientTemperature	Air temperature as measured by the RSD
BarometricPressure	Air barometric pressure as measured by the RSD
Humidity	Air humidity temperature as measured by the RSD
CO_gpkg	CO emission in grams per kg fuel burned
CO2_gpkg	CO_2 emission in grams per kg fuel burned

HC_gpkg	HC emission in grams per kg fuel burned
NO_gpkg	NO emission in grams per kg fuel burned (as NO_2)
NO2_gpkg	NO2 emission in grams per kg fuel burned
NOx_gpkg	NOx emission in grams per kg fuel burned (as NO_2)
NH3_gpkg	NH3 emission in grams per kg fuel burned
UV_Smoke_gpkg	Smoke (PM) emission in grams per kg fuel burned according to the RSD measurements in the UV range
IR_Smoke_gpkg	Smoke (PM) emission in grams per kg fuel burned according to the RSD measurements in the IR range
E_VSP_kW/t	Vehicle specific power in kW per tonne calculated from the RSD measurements by means of the CONOX methodology
E_FuelRate_g/s	Vehicle fuel rate in grams per second calculated from the measurements by means of the CONOX methodology
E_CO2_g/s	CO2 mass emissions in grams per second calculated from the RSD measurements by means of the CONOX methodology
E_CO_g/s	CO mass emissions in grams per second calculated from the RSD measurements by means of the CONOX methodology
E_HC_g/s	HC mass emissions in grams per second calculated from the RSD measurements by means of the CONOX methodology
E_NO_as NO2_g/s	NO mass emissions in grams per second as NO_2 calculated from the RSD measurements by means of the CONOX methodology
E_NO2_g/s	NO_2 mass emissions in grams per second calculated from the RSD measurements by means of the CONOX methodology
E_PM_g/s	PM mass emissions in grams per second calculated from the RSD measurements by means of the CONOX methodology
CalFactor_CO	RSD calibration factor for CO
CalFactor_CO2	RSD calibration factor for CO_2
CalFactor_HC	RSD calibration factor for HC

ValidPlumePoints_CO	Number of valid CO measurements by the RSD in the exhaust plume
ValidPlumePoints_HC	Number of valid HC measurements by the RSD in the exhaust plume
ValidPlumePoints_NO	Number of valid NO measurements by the RSD in the exhaust plume
ValidPlumePoints_NO2	Number of valid NO2 measurements by the RSD in the exhaust plume
ValidPlumePoints_NH3	Number of valid NH3 measurements by the RSD in the exhaust plume
CO_Valid	RSD CO measurement valid flag (V=valid, x= unvalid)
CO2_Valid	RSD CO2 measurement valid flag (V=valid, x= unvalid)
IR_HC_Valid	RSD HC measurement valid flag (V=valid, x= unvalid)
NO_Valid	RSD NO measurement valid flag (V=valid, x= unvalid)
NO2_Valid	RSD NO2 measurement valid flag (V=valid, x= unvalid)
NH3_Valid	RSD NH3 measurement valid flag (V=valid, x= unvalid)
UV_Smoke_Valid	RSD UV smoke measurement valid flag (V=valid, x= unvalid)
NO2 measured or estimated	Filled in automatically when campaign or session is registered in the database (1=measured, 2=estimated)
LICENCE	The license plate number of the measured vehicle
VIN/CHASSIS NUMBER	Vehicle identification number - in Sweden also called chassis number
GROUP NUMBER	Number code which relates to the make, model and model year of the vehicle - we might omit this from the DB
MODEL NAME	EU vehicle classification - M1, N1, N2, N3, etc.
VEHICLE DESCRIPTION	Parameter in the Swedish national vehicle register giving the make of the vehicle and sometimes also the model
TRADE DESIGNATION	Parameter in the Swedish national vehicle register giving the model of the vehicle and sometimes also the make
MODEL YEAR	Model year of the vehicle
MONTH OF MANUFACTURE	Year and month of manufacture of the vehicle
DATE OF REGISTRATION	Date when the vehicle was registered in the vehicle register
DISPLACEMENT_cm3	Engine displacement volume in cm3
CURB WEIGHT_kg	Curb weight of the vehicle in kg

TOTAL WEIGHT_kg	Total weight (maximum allowed weight) of the vehicle in kg
POWER_FUEL1_kW	Engine power of the vehicle in kW
WIDTH_mm	Vehicle width in mm
HEIGHT_mm	Vehicle height in mm
LENGTH_mm	Vehicle length in mm
CERT_CO2_gkm_MIXED	Certified CO2 emission in grams per km in mixed driving - value often (always?) lacking in the Swedish vehicle register
CERT_CO2_gkm_RURALMOTORWAY	Certified CO2 emission in grams per km in rural or motorway driving - value often (always?) lacking in the Swedish vehicle register
CERT_CO2_gkm_URBAN	Certified CO2 emission in grams per km in urban driving - value often (always?) lacking in the Swedish vehicle register
CERT_FUELCONSUMPTION_MIXED_lp100km	Certified fuel consumption emission in grams per km in mixed driving
CERT_FUELCONSUMPTION_RURALMOTORWAY_lp100km	Certified fuel consumption emission in grams per km in rural or motorway driving - value often (always?) lacking in the Swedish vehicle register
CERT_FUELCONSUMPTION_URBAN_lp100km	Certified fuel consumption emission in grams per km in urban driving - value often (always?) lacking in the Swedish vehicle register
CO2_FUELCONSUMPTION_DrivingcycleID	Driving cycle ID - value often/always lacking in the Swedish vehicle register
VehicleInformation Date	Date when the vehicle register was updated
Mileage_km	Odometer reading of the vehicle in km when the vehicle was last inspected at an inspection station
Inspection date	Date when the vehicle was last inspected at an inspection station
VehiclePassageComments	Comments during vehicle passage in the RSD measurements
Segment	Vehicle segment according to ICCT segmentation
On-road mass	On-road mass according to CONOX definition
FF_R0_N/t	Parameter to be inserted into the fuel flow equation developed by Stefan Hausberger
FF_R1_(Ns/m)/t	Parameter to be inserted into the fuel flow equation developed by Stefan Hausberger
FF_cw*A_m2/t	Parameter to be inserted into the fuel flow equation developed by Stefan Hausberger
FF_coeff_A	Parameter to be inserted into the fuel flow equation developed by Stefan Hausberger

FF_coeff_B	Parameter to be inserted into the fuel flow equation developed by Stefan Hausberger
FF_coeff_C	Parameter to be inserted into the fuel flow equation developed by Stefan Hausberger
FF_flag	Valid flag for fuel flow (V=valid, x=unvalid)