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Steering Towards Low-Carbon Road Freight Transport Through Policies

The Case of Oslo

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Abstract

The primary purpose of this thesis is to assess policy measures promoting the uptake and use of low-carbon technologies in urban road freight transport (URFT) in Oslo, Norway. This sector has historically received little attention compared to passenger and public transport, but contribute to significant greenhouse gas (GHG) emissions, noise, and other negative health effects. Low-carbon vehicles in this research are referred to as electric and hydrogen vehicles, which could help mitigate these effects. To promote their uptake and use, policy measures must be implemented and synchronized with expectations from various stakeholders directly and indirectly impacting URFT. This is important to ensure effective results. Findings were collected through a literature review and semi-structured interviews with, among others, authorities, freight operators, original equipment manufacturers (OEM's), and research organisations. Findings suggest several policy measures are needed to promote the uptake and use of low-carbon freight vehicles, most urgently in the category of fiscal measures, and facilitation of low-carbon infrastructure. Also, toll roads, fuel taxes and various subsidy schemes were stressed as necessary to reduce high costs for low-carbon URFT vehicles, while zero/low-emission zones received overall high encouragement. Furthermore, green public procurements were generally considered positively among all interviewees to help create an early market. Stricter demands and prolonged tendering processes should be considered in these processes. In assessing individual policy measures towards the criteria of effort, effectiveness, and acceptability, areas for improvement were identified. For facilitation of low-carbon infrastructure, effectiveness was found to likely improve if financial contributions exceed current mandates, targeting early adopters in urban areas, and offering operational support. Other challenges in Oslo's URFT were linked to the need for authorities to clearly communicate what fuel propulsions are prioritised. Also, authorities should sometimes disregard the principle of technology neutrality, particularly relevant when supporting low-carbon technologies in an early phase. Further, the lack of delegating responsibility of URFT to a specific authority were identified as a drawback. Various levels and overlapping powers within political institutions ultimately begged the question of what specific body feel responsible for URFT. As such, creating a city logistics plan for Oslo should be the primary step, delegated to a specific agency or ministry both locally and nationally. Future research should focus on approaches between cities and best practices as to managing URFT. The sector is still in its infancy for what concerns political attention, on the backdrop of higher demand, emissions of GHG's, other harmful pollutants, and negative side-effects such as noise.

Keywords: Urban freight, low-carbon technologies, electric trucks, hydrogen trucks, policy measures

Executive Summary

Background and Problem Definition

Norway's capital Oslo is among the world's frontrunner cities in adopting targets to reduce greenhouse gas (GHG) emissions, which if to be achieved, require new transport solutions (Lind and Espegren, 2017). Movement of goods in urban road freight transport (URFT) is fundamental in urban economic and social development, thus making urban areas dependent on reliable road freight services to sustain it (Suksri, Raicu and Yue, 2012). However, urban freight is often associated with negative effects including GHG emissions and traffic safety, and have historically received little attention compared to other modes of transport (Suksri et. al., 2012). This is a challenge due to more than 60 % of GHG emissions in Oslo is caused by transport, in which 25 % can be attributed to road freight (The City Council of Oslo, 2016). Referred to as low-carbon propulsions in this study, battery electric and fuel-cell hydrogen vehicles could reduce GHG emissions significantly as compared to internal combustion engine vehicles (ICEV's). These propulsions could also mitigate negative effects such as noise. Regarding Oslo's quantitative targets of reducing GHG emission 50 % by 2020, and further 95 % by 2030 compared to the 1990 level, low-carbon freight vehicles will play a crucial role. To promote such vehicles, policy measures are needed to ensure their growth (Quak, Nesterova, Rooijen and Dong, 2016; Transport & Environment, 2017).

However, various stakeholders influence the outcome of policy measures. Literature suggests a discordance between stakeholders in URFT to determine what policy measures could promote low-carbon technologies in the sector (Taefi, Kreutzfeldt, Held and Fink, 2016). This is a problem due to the early stages of electric and hydrogen vehicles have led to high purchase costs. This is linked to factors such as individual orders, lack of critical masses and small-scale production (Pinchasik and Hovi, 2017). Thus, collaboration among the broad range of stakeholders have been suggested to craft policy measures (e.g. NHO et. al., 2016). This is easier said than done. URFT is often characterised as heterogenous, complex, and overall poorly understood by policymakers (Holguín-Veras, Leal and Seruya, 2017). Complexities are further strengthened in that URFT is governed by the decisions of numerous interdependent stakeholders (Ballantyne et. al., 2013) with often conflicting objectives (Suksri et. al., 2012).

Research Questions and Objective

This research seeks to understand what policy measures would most likely promote the uptake and use of low-carbon technologies. This is necessary to reduce GHG emissions from a carbon intensive sector, and to achieve national and local reduction targets in Norway. In doing so, other policy measures likely to reduce GHG emissions in URFT will be assessed, other than those promoting low-carbon technologies. This study also assesses the most important stakeholders in URFT, and most promising technical solutions, the latter being subject to rapid technological development.

Based on what has been described, the following research question (RQ) has been phrased:

RQ1: What policy measure(s) would most likely promote the uptake and use of low-carbon vehicles in urban road freight transport?

Complementing sub-questions (SQ's) include:

SQ1: What policy measures would most likely lead to GHG emission reduction in urban road freight transport?

SQ2: Who are the most important stakeholders in urban road freight transport?

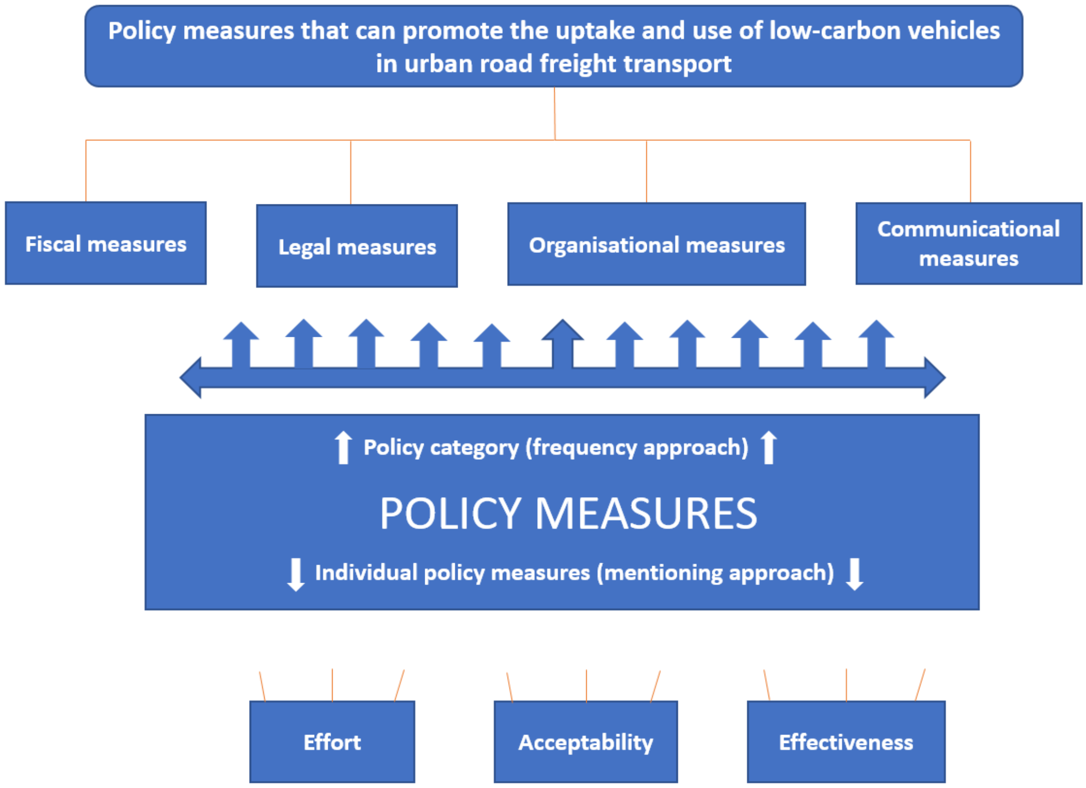
SQ3: What are the most promising technical solutions in urban road freight transport?

Research Design and Methodology

To arrive at the findings, this research applied an inductive qualitative research design, based on semi-structured interviews and a literature review. In the context of this study, the inductive approach means the coding and criteria for which policy measures were assessed towards. This allowed the researcher to immerse in the data for new insights to emerge (Hsieh and Shannon, 2005). Thus, both the process of coding policy measures and criteria for which they were assessed remained subject to change during the study.

For RQ1 and SQ1, evaluation of policy measures was based on two approaches, identifying the policy category[1] and individual policy measures most likely to promote low-carbon freight vehicles and reducing GHG's from URFT. To allow for this separation, policy measures were assessed based on a frequency approach to highlight most recommended policy category, and mentioning approach to highlight the most recommended individual policy measures. The latter approach based on mentioning does not reflect whether each interviewee mentioned single policy measures numerous times, but rather their mentioning at all. The most likely policy category was identified based on counting the number of times policy measures within each category were mentioned, across all interviewees. Further, a qualitative assessment of the most commonly suggested individual policy measures was assessed against three criteria, namely effort, effectiveness, and acceptability. While only RQ1 is listed in Figure 1, the figure illustrates the process for which both RQ1 and SQ1 were evaluated.

Figure 1: Framework for evaluating policy measures

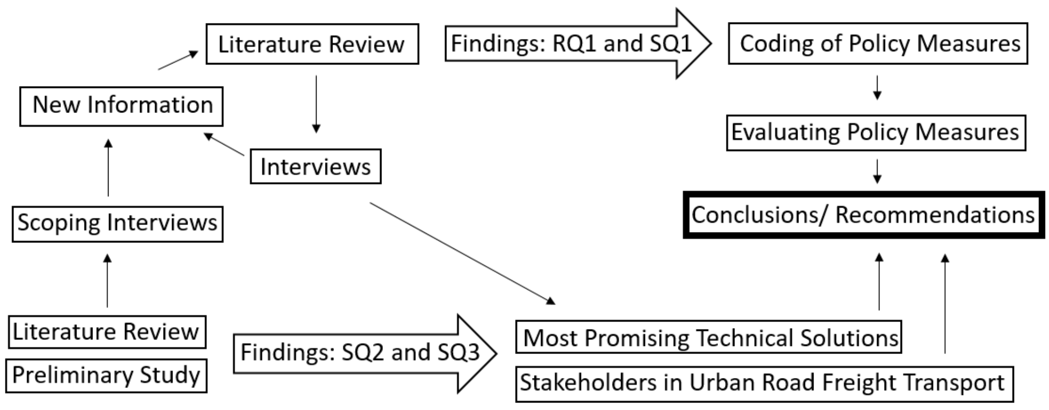


Source: Adapted from Suksri et al (2012).

[1] Fiscal, legal organisational and communicational measures

SQ2 were largely based on an extensive literature review to identify stakeholders in URFT. SQ3 were based on much of the same process to identify the most promising technical solutions, but also with inputs from interviews conducted in this study. Figure 2 illustrate how the research process was conducted.

Figure 2: The research process



Findings RQ1: **What policy measure(s) would most likely promote the uptake and use of low-carbon vehicles in urban road freight transport?**

Findings suggest facilitation of low-carbon infrastructure is the most commonly suggested, followed by zero/low-emission zones, green public procurements, Enova's subsidy schemes, toll roads, the national incentive scheme for electric vehicles, and adopting targets to reduce GHG emissions locally and nationally. The entire list of individual policy measures, also those applicable to SQ1 can be found in appendix 7.2, while an assessment against the criteria effectiveness, acceptability and effort is offered in section 5.1. Table 2 show the policy category with highest frequency were identified as fiscal measures, ahead of organisational measures.

Table 1: Individual policy measures based on mentioning

Individual policy measure	Most frequently mentioned policy measures
Facilitate low-carbon infrastructure development	6
Zero/low-emission zone	5
Green public procurement	5
Enova subsidy schemes	5
Tolled roads	4
Electric vehicles incentive scheme	4
National and municipal targets (GHG emissions)	4

Table 2: Policy categories based on theme frequency

Policy category	Overall theme frequency
Fiscal Measures	67
Legal Measures	22
Organisational Measures	54
Communicational Measures	3

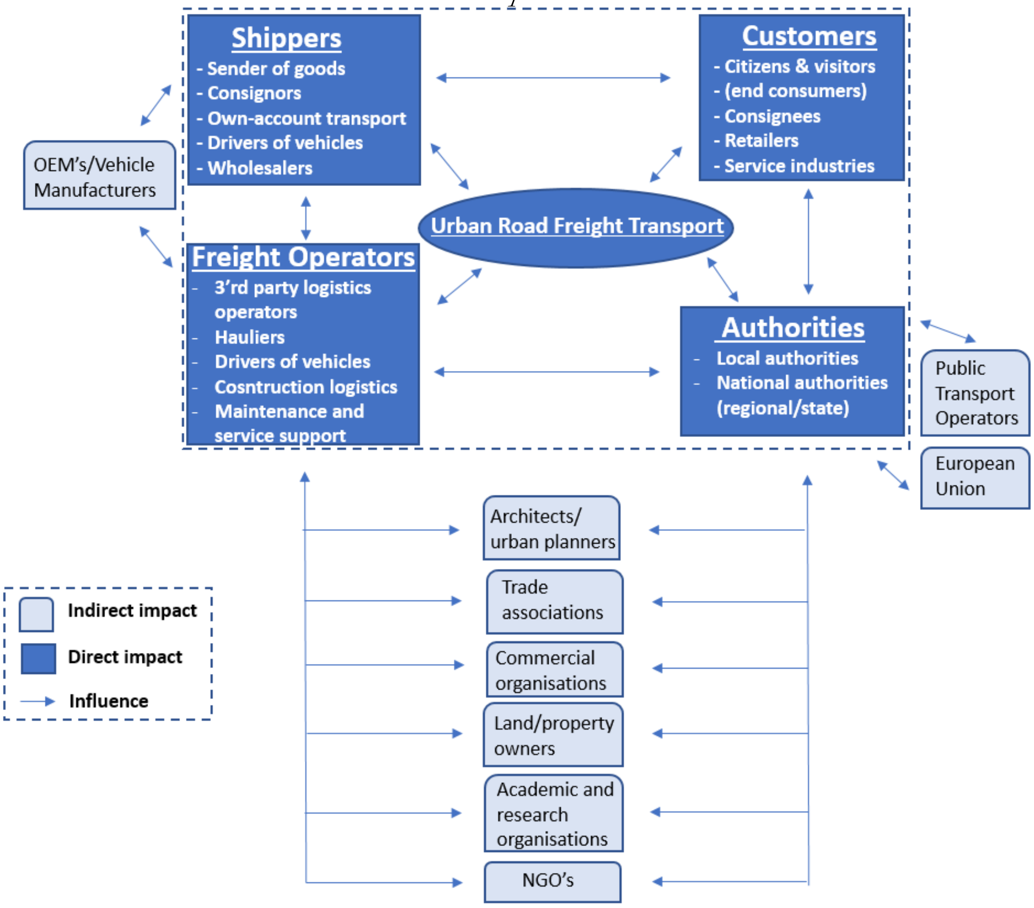
Findings SQ1: **What policy measures would most likely lead to GHG emission reduction in urban road freight transport?**

Implementing a consolidation centre[2], city logistics plans and adopting targets to reduce GHG emissions by local or national authorities were the most preferred individual policy measures for SQ1. Like RQ1, the study revealed policy measures scored different when analysed towards effectiveness, effort, and acceptability. That is, a consolidation centre seemed effective in reducing large freight vehicles in the city, but could prove less acceptable for freight operators potentially losing profit. Also, effort seemed high to successfully organise and operate a consolidation centre. Further, while a city logistics plan proved widely acceptable, effectiveness depends on the effort and knowledge to implement a viable and visionary plan. Lastly, targets to reduce GHG emissions could appear relevant to both RQ1 and SQ1. When analysed, this measure generally scored well on all criteria, but could appear less effective in the short-term due to unrealistic ambitions, particularly for targets adopted in Oslo for 2020.

Findings SQ2: **Who are the most important stakeholders in urban road freight transport?**

Figure 3 illustrate the most important stakeholders with a direct impact in URFT are shippers, customers, freight operators and authorities. Many stakeholders having an indirect impact are also relevant, and have an influence through their interest in the sector.

Figure 3: Stakeholders in URFT and their relationships



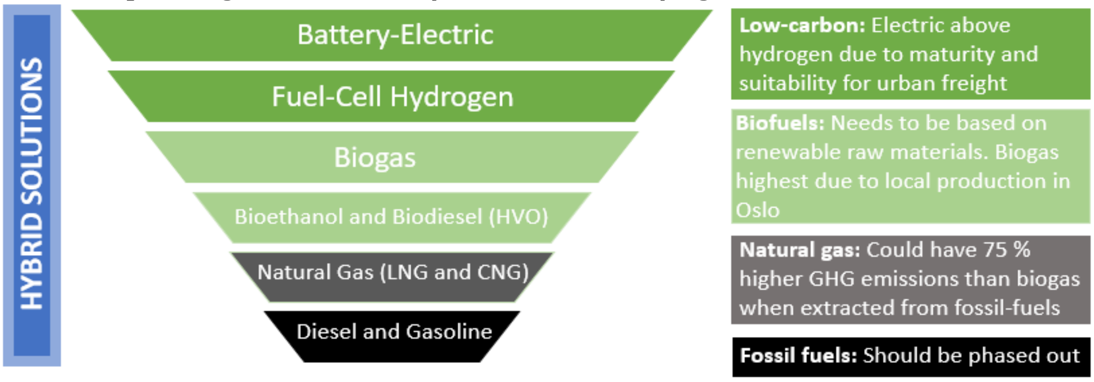
Source: Adapted from Ballantyne, Lindholm and Whiteing (2013).

[2] Consolidating goods from numerous freight operators for then to be delivered in a single shipment to several customers. Have been estimated to potentially reduce CO_2 emissions in the range of 18-90 % (Eidhammer and Andersen, 2015).

Findings SQ3: **What are the most promising technical solutions in urban road freight transport?**

Figure 4 illustrate the most promising technical solutions in a fuel propulsion hierarchy. This show battery electricity is the most promising propulsion, while diesel and gasoline are the least promising. It should be noted hybrid solutions are listed as viable alternative across the entire hierarchy. Brief comments as to justifying the ranking have been provided in the right columns, while a further elaboration is offered in section 3.3.2. and 4.4.1.

Figure 4: Most promising technical solutions for low-carbon urban freight vehicles



Conclusions

In conclusion, this thesis shows a variety of policy measures are needed to promote the uptake and use of low-carbon freight vehicles, most urgently facilitation of low-carbon infrastructure. Having the most common individual policy measures assessed towards the criteria of effort, effectiveness, and acceptability, no policy intervention appears flawless however. That is, facilitation of low-carbon infrastructure would seem more effective if financial contributions were broadened beyond current mandates to also offer operational support for suppliers. However, this appeared less acceptable primarily due to the principle of implementing technology neutral policy measures. Also, a zero-emission zone appeared effective in promoting low-carbon vehicles if bans on ICEV's were applied. Though, high effort and low-acceptability would likely have proved prominent barriers, unless being enacted as a commitment for future implementation. It was further found that green public procurements generally scored well on all three criteria. Yet, effectiveness could improve if stricter demands were set as a standard for these processes, and prolonged tenders could allow for increased likelihood that technological innovations and low-carbon solutions were fulfilled.

This research uncovered areas for improving the management of URFT within authorities, both in terms of clarity and delegating responsibility. For the latter, URFT should be delegated a specific body within national and local authorities to provide a sense of ownership, followed by an initial step to develop a city logistics plan. To improve clarity, ranking various fuel propulsions should be a first step, preferably through government enterprise Enova. Also, authorities should on occasion disregard the principle of technology neutral policy measures. This is particularly important to promote low-carbon technologies in an initial phase. In this context, operational support for suppliers of hydrogen infrastructure were recognised as vital.

Future research should seek to assess practices in URFT from a global perspective. Due to being a sector having historically received little attention compared to other modes of transport, and having been found poorly understood by policy makers, documentation of best practices from successful cities could prove of great value. This is an area further research is needed, to increase focus on a sector still in its infancy for what concerns political attention.

Table of Contents

List of Figures

List of Tables

Abbreviations

ARSCP - Applied Research in Sustainable Consumption and Production

BAT - Best Available Technology

CCS - Carbon Capture & Sequestration

CNG - Compressed Natural Gas

EFTA – European Free Trade Association

ESR - Effort Sharing Regulation

EU – European Union

EV - Electric Vehicle

FCEV – Fuel-Cell Electric Vehicle

GDP – Gross Domestic Product

GEE - Green Energy Economy

GHG – Greenhouse gases

HFT - Heavy Freight Truck

ICCT – International Council on Clean Transportation

ICEV - Internal Combustion Engine Vehicle

IEA – International Energy Agency

IFE – Institute of Energy Technology

LCA – Life-Cycle Assessment

LNG - Liquified Natural Gas

MFT - Medium Freight Truck

NGO – Non-governmental Organisation

NHO - Confederation of Norwegian Enterprise

NMBU – Norwegian University of Life Sciences

NLF - Norwegian Road Transport Association

NPRA – Norwegian Public Roads Administration

NWRED – Norwegian Water Resource Energy Directorate

OEM – Original Equipment Manufacturer

PFAD - Palm Fatty Acid Distillate

PHEV – Plug-in Hybrid Electric Vehicle

R&D – Research & Development

TCO - Total Cost Ownership

TØI – Institute of Transport Economics

URFT - Urban Road Freight Transport

1 Introduction

1.1 Background

Road freight transport is an important sector for distributing goods, keep economies efficient, and provide employment globally (Lindholm, 2013). In fact, we cannot do without these services, which creates both economic and social benefits (Arvidsson, Woxenius and Lammgård, 2013). However, the sector contributes to significant greenhouse gas (GHG) emissions[3] causing a threat to natural resources and human health. In addition, other negative impacts could include accidents, visual intrusion, barrier effects, lack of kerbside space, reduced traffic safety, local air pollution, vibrations, noise, and time lost in congestion (Kijewska, Johansen and Iwan, 2016; Arvidsson et. al., 2013; Quak et. al., 2016; Suksri et. al., 2012; MDS Transmodal Limited and CTL, 2012; Nordtømme, Bjerkan and Sund, 2015; Fu and Jenelius, 2017). As it stands by the year of 2017, transport is Europe's largest sector for emissions of GHG's (Transport & Environment, 2017). Discharge of GHG's from road freight in Nordic countries and the European Union (EU) are today above 1990 levels, having increased by 15 % from 1990 to 2014 (Transport & Environment, 2017). This development is projected to increase in the next decades, along with an increase in the overall volume of goods transported on trucks (Transport & Environment, 2017). This projection also holds true for Norway (Avinor, Kystverket, Jernbaneverket and Statens vegvesen, 2015; NAF, 2017).

Norwegian national authorities have committed to cutting GHG emissions 40 % up to the year of 2030 relative to 1990 level (Office of the Prime Minister, 2015). Further, Norway was among the first nations to ratify the Paris Agreement on climate change[4], and will likely be instructed to reduce GHG emissions 40 % in the EU's Effort Sharing Regulation[5] (ESR) compared to the 2005 level[6]. Transport represents the most polluting sector in the ESR[7], and 30 % of Norway's overall GHG emissions (Pinchasik and Hovi, 2017; ZERO, 2016; Ministry of Climate and Environment, 2017). As can be seen from selected Nordic countries in Table 3, most have more ambitious targets in the ESR compared to the EU average. To address this challenge, Norwegian national authorities adopted in June 2017 targets to reduce GHG emissions in transport by 35-40 % up to 2030, relative to the 2005 level (Ministry of Climate and Environment, 2017).

Table 3: GHG emission reduction targets in the ESR for Nordic countries

Nation	Effort Sharing Regulation targets by 2030 (vs 2005 level)
EU average	- 30 %
Norway	- 40 %
Sweden	- 40 %
Denmark	- 39 %
Finland	- 39 %

Source: Transport & Environment (2017).

[3] Primarily carbon dioxide (CO_2), but also smaller amounts of methane (CH_4) and nitrous oxide (N_2O).

[4] A global action plan working towards the objective of keeping the global average temperature to well below 2 degrees celsius (Ministry of Climate and Environment, 2016).

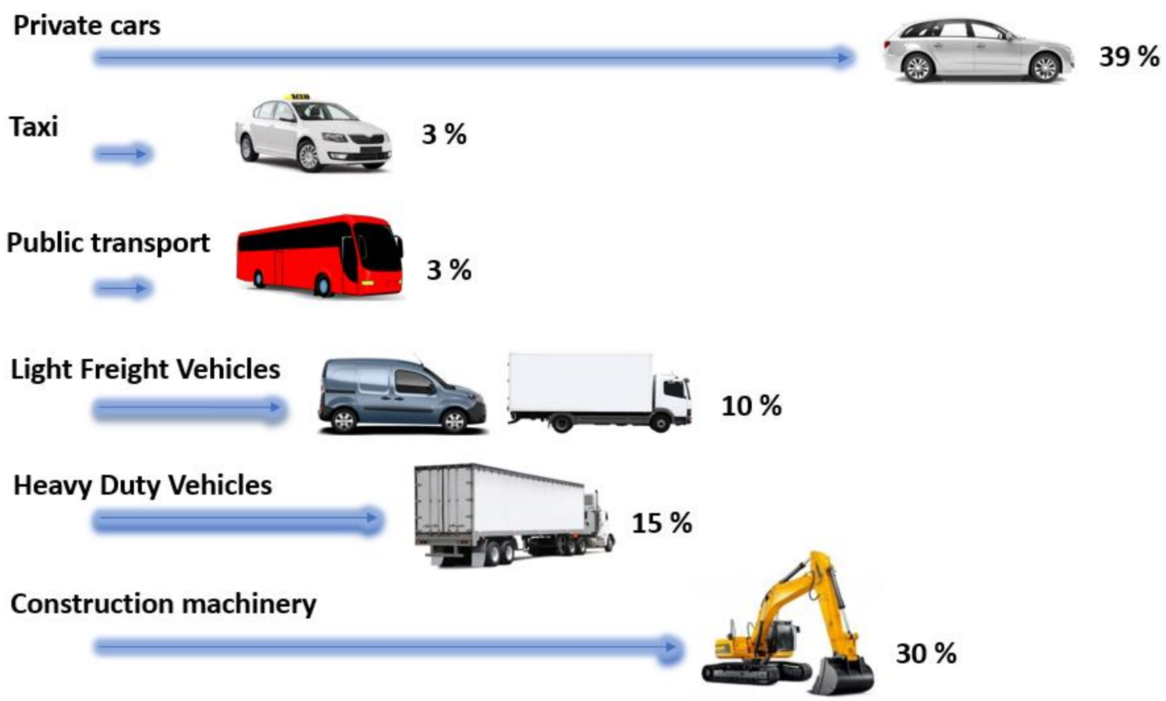
[5] Policy framework from the EU, covers sectors including transport, agriculture, buildings, waste, energy industries and industrial processes (Transport & Environment, 2014).

[6] As of September 2017, Norway is still discussing with EU the targets for their participation in the system.

[7] With exception. Electrically driven vehicles receive energy from power plants, the latter in which is not covered by the ESR.

For the capital and largest city in Norway, Oslo has launched an attempt to demonstrate how cities can take leadership in green transition (Lind and Espegren, 2017). Oslo is aiming to reduce GHG emissions 50 % by 2020, and 95 % by 2030 relative to the 1990 level (Nordic Energy Research and International Energy Agency, 2016; The City Council of Oslo, 2016). These are ambitions no other city can match (Peters, 2016). Transport will be important to reaching these targets as more than 60 % of Oslo's GHG emissions is caused by transport (The City Council of Oslo, 2016). Figure 5 illustrate approximately 25 % of GHG emissions is attributed to transportation of goods and services, not counting construction and machinery.

Figure 5: Distribution of GHG emissions from transport in Oslo, Norway



Source: Adapted from The City Council of Oslo (2016).

Apart from the large share of GHG emissions attributed to private cars, Figure 5 puts the focus on urban road freight transport (URFT). Compared to inter-urban distances, negative impacts of road freight transport are even more prevalent in cities and urban areas, both in terms of space contraints and environmental hazards such as noise and air pollutants (Eidhammer and Andersen, 2015; Taefi et. al., 2016). Further, projections towards 2050 suggest most of transported goods in Norway will take place on distances less than 300 km (Jordbakket et. al., 2017). This reinforce the importance of URFT in the context of achieving GHG reduction targets both nationally and locally in Oslo. While being a sector gradually gaining more attention politically, URFT has historically received little consideration compared to passenger, public and long-distance freight transport (Suksri et. al., 2012; Olsen, 2015; Muñuzuri, Larrañeta, Onieva, Cortés, 2005; Ballantyne et. al., 2013; Cherrett, Allen, Mcleod, Maynard, Hickford and Browne, 2012). For this study, Table 4 show what vehicle categories are considered to perform URFT.

Table 4: Vehicle categories in urban road freight transport

Vehicle category:	Vans	medium-freight truck (MFT)	heavy-freight truck (HFT)
Gross weight:	< 3.5 tonnes	3.5 tonnes – 18 tonnes	18 tonnes >

Source: Transport & Environment (2017). Nordic Energy Research and International Energy Agency (2016).

Given this overview, the research at hand seeks to primarily understand what are the most likely policy measures to promote the uptake and use of low-carbon vehicles in URFT, solutions capable of reducing GHG emissions. Furthermore, this study will identify other policy measures most likely to reduce GHG emissions in URFT by other means, what stakeholders are the most important in the sector, and the most promising technical solutions available.

1.2 Urban Road Freight Transport in Norway

There are nearly 80 000 heavy-freight truck's (HFT's) and approximately 450 000 vans and medium-freight trucsk (MFT's) in Norway (NHO et. al., 2016; Statistics Norway, 2017). Most of these vehicles are vans (Statistics Norway, 2017), many of which typically operate on short distances (Cherrett et. al., 2012; Lindholm, 2013). Scoping down, numbers show urban freight is highly concentrated in terms of geographical location. That is, every fifth kilometer of driving by vans is taking place in the capital city Oslo and nearby county Akershus, and one third of goods are transported between these two areas nationally (Statistics Norway, 2016). What's more, with approximately 74 million deliveries[8] being performed in Oslo and Akershus during the years of 2014/2015, more than 40 % of all national deliveries were performed in these areas (Statistics Norway, 2016).

In line with adopted targets, the City Council of Oslo have created initiatives to reduce GHG emissions through the so-called "Climate and Energy Strategy". This document includes initiatives to reduce GHG emissions from URFT specifically. Similarly, Norwegian national authorities have in the national transport plan[9] (NTP) adopted their own goals, while the EU have done the same. A comparison of these targets can be seen in Table 5.

Table 5: A selection of targets adopted by local and national authorities, and the EU

Vehicle category	The City Council of Oslo[10]	National authorities[11]	EU
Vans	All new vehicles shall be renewable or plug-in hybrids[12] from 2020	All new vehicles shall be zero-emission[13] in 2025	Essentially CO_2 free city logistics in major urban centres by 2030
Medium-freight trucks	20 % of existing fleet shall use renewable fuels[14] by 2020, and all on renewable fuels by 2030	All new vehicles shall be zero-emission within 2030	Essentially CO_2 free city logistics in major urban centres by 2030
Heavy-freight trucks	20 % of existing fleet shall use renewable fuels by 2020, and all on renewable fuels by 2030	50 % of new vehicles shall be zero-emission within 2030	Essentially CO_2 free city logistics in major urban centres by 2030

Source: The City Council of Oslo (2016). Ministry of Transport and Communications (2017). European Commission (2011).

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[8] Every stop to load and/or unload goods.

[9] Outlines how the government intends to prioritise resources for a 10 year period, within the transport sector.

[10] For the sake of this research and similarity, this study will interpret light freight vehicles as vans, and heavy duty vehicles as both MFT's and HFT's. These are translations to the original definitions by The City Council of Oslo (2016).

[11] For the sake of this research and similarity, this research will interpret light vans as vans, heavy duty vehicles as MFT's, and trucks as HFT's. These are translations to the original definitions by Ministry of Transport and Communications (2017).

[12] Hybrid means applying two fuel sources, for example both battery electricity and a conventional fuel (e.g. gasoline or diesel). Like this example, hybrids will be referred to in this study as plug-in-hybrid electric vehicles (PHEV's).

[13] Defined by national authorities to be either electric or hydrogen technology.

[14] Defined by the City Council of Oslo to be either biofuels or zero-emission solutions.

For targets in Oslo, researchers argue transport must undergo major changes if targets are to be met (Lind and Espegren, 2017). This is a challenge considering contemporary growth in global urban environments have resulted in growing demand for services and goods, all against a setting of increased demand (Cherrett. et. al., 2012; Cole, 2017). Only in Oslo, the city expects an additional 200 000 citizens, and 50 % increase in the transport of goods by 2030 (Spurkeland, 2016; Sund and Bjerkan, 2015). Other cities face similar challenges in the future following adoption of ambitious goals. Among others, Copenhagen wants to achieve carbon neutrality by 2025 (Nordic Energy Research and International Energy Agency, 2016), while London and Paris have said they will ban diesel cars by the year of 2020 (Garfield, 2017).

Considering the Nordic countries, cities are generally perceived to have more ambitious goals than national authorities (Nordic Energy Research and International Energy Agency, 2016). However, also targets adopted by Norwegian national authorities in Table 5 have been considered bold. In fact, based on the assumption hydrogen trucks will not be available before 2025, researchers from the Institute of Transport Economics (TØI) in Norway suggest 1300 hydrogen trucks would have to be sold annualy if targets are to be met, respectively 50 % zero-emission vehicles by 2030 (Fridstrøm and Østli, 2016). In conclusion, the researchers argue it remains an open question whether authorities have sufficiently strong policy measures to reach targets as set forth in Table 5 (Fridstrøm and Østli, 2016). Hovi and Pinchasik (2016) further argue the current state of policy measures as of 2016 will result in an increase from 9 to 10.6 million tonnes CO_2 in 2030 for business related transports[15], for which road transport represent the largest contributor.

This suggests policy measures are needed to promote the uptake and use of technologies capable of reducing GHG emissions from freight transport. That is, "sticks" and "carrots"[16] have been found vital to support both the usage of low-carbon technologies, and discourage the use of internal combustion engine vehicles (ICEV's) (Quak et. al., 2016). This is further justified by Transport & Environment, the European umbrella organisation for non-governmental organisations (NGO's) working with transport related matters. In a study from 2017, it was concluded that for trucks ranging from 3.5 tonnes and above (primarily MFT's and HFT's in this study), policy is needed on both EU, national and local level to expose the potential needed to achieve zero GHG emissions (Transport and Environment, 2017). Policy measures have also been found important to achieve not only Norway's, but Sweden's and Denmark's long-term ambition to become climate neutral by 2050 (Nordic Energy Research and International Energy Agency, 2016). In Norway specifically, the need for policy measures were supported by much of the Norwegian transport sector when they in 2016 conducted the "roadmap for industry and business transports"[17], emphasising the need for various policy measures to among others, accelerate the uptake of low-carbon technologies (NHO et. al., 2016). As of 2017 however, the Norwegian Automobile Federation argue incentives lack for transitioning towards low-carbon technologies for industry and business-related transports[18] (NAF, 2017).

1.3 Ways to Reduce GHG's from Urban Road Freight Transport

There are several ways to curb GHG emissions in land freight. Reducing demand for transport, optimising the logistics and fuel efficiency of truck operations, and implementing mandatory CO_2 or fuel efficiency standards for freight vehicles have been found possible solutions

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[15] Buses, trucks, light trucks, construction machinery, domestic shipping, and fisheries.

[16] Combination of policies offering both punishment (sticks) and rewards (carrots).

[17] Cooperation between 13 organizations, ranging from trade unions to an environmental organization, a contribution to the Norwegian government's work to determine emission targets for Norway with the EU.

[18] Referred to as "næringstransporter" in Norwegian. For this study, this means vehicles performing road freight.

(Transport & Environment, 2017; Thomas and Callan, 2010; Muncrief and Sharpe, 2015). Yet, many studies point to electricity[19], hydrogen[20], and biofuels[21] as the vision for sustainable transportation in the future (Connolly, Mathiesen and Ridjan, 2014; Bjartnes and Michelsen, 2016; Transport & Environment, 2017). While separate technologies, it's important to note both electric and hydrogen vehicles have an electric driveline and battery pack[22] (THEMA, VTT and Ecofys, 2016). To supplement these propulsions, biofuels will be particularly important in the short- to medium term. That is, while major freight operators including Norway's largest convenience wholesaler, ASKO, have signalled electricity and hydrogen as their long-term vision, biofuels are considered an important bridge technology based on current availability (Bentzrød, 2017). Lind and Espegren (2017) takes it one step further, arguing biofuels will be important in the long-term also, to decarbonise heavy freight trucks. Largely, the need for biofuels follow the current state of technological development for electric and hydrogen freight vehicles as of 2017. Among others, futures researcher at the Free University of Berlin, Erik Overland estimates only within a time perspective of 10 to 20 years, major breakthroughs can be expected for electric and hydrogen freight vehicles (NRKP1, 2017). In this context, cities offer a unique opportunity for an early market.

For the long-term perspective, local authorities in Oslo plan to replace petroleum based vehicles with electric and hydrogen technologies by 2030, not biofuels (The City Council of Oslo, 2016). Given both electric and hydrogen are currently immature technologies for heavier vehicles travelling inter-urban distances (Pinchasik and Hovi, 2017), this naturally suggests a focus on an urban setting. That is, urban areas have more technology options available and are more energy efficient, having charging infrastructure more easily available and driving distances typically being shorter (Lind and Espegren, 2017). Concrete examples demonstrate smaller electric freight vehicles have already proved a compelling case for reducing GHG emissions in urban areas. Studies conclude electric vans could reduce energy consumption by at most 76 %, and 57 % when also considering the stage of producing energy (Duarte, Rolim, Baptista, 2016). Overall however, high costs due to individual orders, small-scale production, lack of critical masses, limited charging infrastructure, and not yet sufficiently proven business case have proved prominent barriers for electric and hydrogen propulsions as of mid 2017 (Pinchasik and Hovi, 2017; Quak et. al., 2016).

Both electric and hydrogen technologies will be referred to as low-carbon, and not zero-emission vehicles, technologies, propulsions, or solutions in this study. This is primarily due to the various life cycle costs and impacts that needs to be accounted for in the entire lifespan. This definition alters from the one used by the Norwegian Ministry of Climate and Environment, which makes the distinction between categories of zero-emission technologies and low-carbon technologies, in which the former includes electricity and hydrogen, while the latter category is referred to as hybrid solutions (Ministry of Climate and Environment, 2017). The City Council of Oslo refers to the category of renewables as not only zero-emission being electric and hydrogen vehicles, but also the various alternatives of biofuels, leaving hybrid solutions in no specific category (Rambech, 2017). Furthermore, the four government agencies behind the NTP identifies zero-emission vehicles as fully electric or hydrogen based solutions (Avinor et. al., 2015).

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[19] Refers to battery electricity in this research. Electricity stored in a battery onboard the vehicle.

[20] Refers to vehicles producing electricity in a fuel-cell that can be stored onboard the vehicle.

[21] Including such as biogas, bioethanol, biodiesel and HVO.

[22] For hydrogen vehicles, electricity is first used to transform water into oxygen (O_2) and hydrogen (H). Hydrogen is then stored in a tank onboard the vehicle. This hydrogen gas can be burnt off in a fuel-cell for then to produce electric energy from hydrogen as an energy carrier, to accelerate the vehicle. Electric vehicles store electricity in a battery onboard the vehicle.

1.4 Research Gap

Preliminary research having led up to this project suggests a discordance between various URFT stakeholders in how to design supporting measures for low-carbon technologies, and that the scientific and political literature lacks a comprehensive discussion of what policy measures support such propulsions in the sector. (Taefi et. al., 2016). Given this foundation, complexities are increased due to URFT being characterised as heterogenous, complex, and often poorly understood by policymakers (Holguín-Veras et. al., 2017). This has led to the risk of policy measures with potentially poor outcomes (Holguín-Veras et. al., 2017). This factor is reinforced by studies suggesting authorities have traditionally only reacted to URFT in response to negative impacts through complaints from citizens and other stakeholders with regards to factors including access, safety, and noise (Ballantyne and Lindholm, 2013). This signify a vague interest in the sector historically. As such, findings from Ballantyne et al (2013) comes as no surprise, highlighting there are few examples where authorities have included private actors in transport planning. The lack of inclusion can be partly explained by the complexity of URFT, a sector characterised by numerous interdependent stakeholders (Ballantyne et. al., 2013) with often conflicting objectives to account for (Suksri et. al., 2012).

Thus, several studies highlight the need for enhanced collaboration and understanding between stakeholders involved in URFT, to among others achieve more sustainable practices and develop new propulsions (NHO et al., 2016; Taefi et. al., 2016; Ballantyne et al., 2013; Eidhammer and Andersen, 2015; Macharis, 2005; Suksri et. al., 2012; Nordtømme et. al., 2015). Low-carbon technologies represents such practices. In Norway, leading organisations in the Norwegian transport sector emphasised the necessity for a wide spectre of policy measures to reduce GHG emissions in the future, and to shift vehicles away from ICEV's towards low-carbon technologies (NHO et. al., 2016). Policy measures are numerous however, and studies underline the critical aspect of understanding the impacts of different interventions designed to reduce GHG emissions (Mundaca, Neij, Markandya, Hennicke, and Yan, 2016; Filippi, Nuzzolo, Comi and Site, 2010; Vierth, 2013). As such, authorities need to be informed and aware of impacts from the variety of policy measures available, to avoid negative effects and poor outcomes. Given no silver bullet can be applied and numerous stakeholders being involved, research is needed to evaluate what policy measures can enhance the uptake and use of low-carbon vehicles based on stakeholder perspectives. As literature argues URFT has historically received little attention compared to other modes of transport, understanding what other measures can reduce GHG emissions from URFT is also important, along with identifying the most promising technical solutions, and what stakeholders are the most important.

1.5 Research Objectives

1.5.1 Aim

The aim of this thesis is to determine what policy measure(s) are most recommended to promote uptake and use of low-cabon technologies in URFT. In doing so, the project will also seek to identify other policy measures capable of reducing GHG emissions other than promoting low-carbon technologies. Further, what are the most promising technical solutions available to decarbonise URFT, and who are the most important stakeholders in this sector will be assessed. The value of the findings is anticipated to have a practical nature. That is, supporting national and local policymakers to design policies, or policy packages for low-carbon technologies and reduced GHG emissions from URFT. The research will also serve to enhance knowledge of important stakeholders in the sector, and what technical solutions are the most promising.

1.5.2 Research Questions

Based on what has been described, the following RQ (research question) has been phrased:

RQ1:

- What policy measure(s) would most likely promote the uptake and use of low-carbon vehicles in urban road freight transport?

Complementing SQ's (sub-questions) include:

SQ1:

- What policy measures would most likely lead to GHG emission reduction in urban road freight transport?

SQ2:

- Who are the most important stakeholders in urban road freight transport?

SQ3:

- What are the most promising technical solutions in urban road freight transport?

1.6 Limitations and Scope

The limitations of this research include lack of time and thus availability of relevant stakeholder interviews. This thesis was scheduled for 4 months between May and September 2017, which made for limited time in conducting an in-depth analysis of a complex topic with several stakeholders and interested parties.

Thus, some stakeholders perceived important for URFT were not interviewed. These included such as transport buyers/customers and shippers of goods. Taking customers as an example, this was also due to the diversity of customers located in Oslo, and no prominent organisation that holistically represented the views of this group. This represents a limitation, due to freight operators are generally governed by criteria from customers (Tomasgard, Møller-Holst, Thomassen, Bull-Berg, Damman and Bjørkvoll, 2016; Norges Lastebileier-Forbund, 2016).

Further, whereas this research has covered extensive literature and have interviewed multiple stakeholders, the value of representation from individual interviews for a large stakeholder category should be interpreted with caution. That is, while the Ministry of Transport and Communications were interviewd as a representative of Norwegian national authorities, the numerous other ministries within national authorities were not. As such, the views of one ministry should not necessarily be interpreted as the views from all levels within national authorities.

Considering the methodology, the process for which policy measures were scoped, discussed, and later recommended could be seen as a drawback. That is, two distinct approaches were conducted to identify relevant policy measures and categories in this research. While the quantitative nature of these approaches was compensated by a qualitative analysis and discussion, similar studies may find alternative findings based on their selected approach to scope policy measures.

This study also acknowledge transport is a rapidly growing and mobile sector, a circumstance in which the need for up to date data is important. This is particularly important for capturing fluctuating expectations and announcements of future developments. Thus, a selection of non-peer-reviewed literature, or so called grey literature have been included to capture the most recent developments, data in which scientific research has yet to cover.

Lastly, as all interviews were conducted by mostly Norwegian, but also one Swedish interviewee, translations from Norwegian to English were conducted, which may be subject to alternative translations in literature. As such, translations in this research may not always reflect or represent alternative definitions on certain terms as found in literature.

1.7 Ethics

This study seeks to keep findings anomynous when requested, to respect all interviewees responses. For all except two interviews which were conducted over telephone and not recorded, the remaining interviewees were asked for permission to record the interviews. No direct quotations were used. Recording were exclusively used for academic purposes, and not shared with any third parties. For interviews that was recorded, a short summary was sent to each interviewee as an interpretation of the author's understanding of the interview. The interviewees were not referred to by name, but rather as a representative or employee at their respective company/organisation, to offer clarity for the reader.

The author closely communicated with one stakeholder group during the thesis period. TØI in Norway provided their profound experience and knowledge as a cooperating organisation for this research. While the author did not receive any financial benefits for the study process, TØI offered the author office space, access to databases, and interactions (both formal and informal) with their researchers. Despite the close contact with TØI, the author seeked objectiveness, and unbiased interpretation as much as possible.

1.8 Intended Audience

This study has a broad audience. Primarily, other cities at the forefront of developing urban freight systems, and policymakers at local and national level would have an interest in the outcome of this research. That is, this research may highlight for authorities that URFT have special requirenments, and assist in making better decisions when implementing policy measures having an impact on the sector, along with effects on vehicles performing within it. However, this research may also be of interest for businesses working with transport in Norway and abroad, to understand what direction the sector is transitioning and what stakeholders influence the development. Businesses such as freight operators are undoubtedly central in this context, to leverage the opportunities embedded in future technologies of transport. This group is an important audience due to their ultimate decision to invest in vehicles emitting less GHG's. Lastly, this research could also be of interest for research and academic institutions. URFT is a segment of transport that has traditionally received less attention compared to passenger transport. Thus, this research could serve as input into further work on making URFT more efficient and less polluting in cities.

1.9 Disposition

Chapter 1 provides a contextual background regarding emissions related to transport, and in Norway and Oslo specifically. It also introduces targets to reduce emissions not only at a national level, but also locally. This section further describe the importance of considering a shift in technology, and that reduced emissions from urban road freight could be achieved through numerous ways.

Chapter 2 clarify the logic behind the research design, including the overall methodology and the chosen methods to arrive at the findings. The research design is presented with as much detail as possible to show readers how the study was conducted and the process leading up to conclusions.

Chapter 3 covers a broad array of concepts and topics that fit into this research, based on a literature review. This includes the current state of electric and hydrogen vehicles, as well as limitations of these technologies, stakeholders and policies designed to promote their uptake, and alternative drivelines.

Chapter 4 presents the results from the interviews that were conducted. Most data are presented between each stakeholder group interviewed for this research, including recommended individual policy measures promoting low-carbon technologies and reduced GHG's, and most promising technical solutions.

Chapter 5 is the section for analysis and discussion. This section assesses information from the findings to argue how policy measures satisfy the criteria for this research, including analysis of efforts, effectiveness, and acceptability.

Chapter 6 presents the final conclusions in this research, and recommendations for future research.

2 Research Design

2.1 Methodology

2.1.1 Inductive Approach

This research applied an inductive qualitative research design, based on a literature review, and semi-structured interviews. In the context of this research, the inductive approach represents the coding and criteria for which policy measures were analysed towards, letting the researcher immerse in the data to allow new insights to emerge (Hsieh and Shannon, 2005). That is, both policy categories and criteria for which policy measures were assessed changed during the study. Also, a quantitative approach was applied to help identifying policy measures based on the interviews in this study.

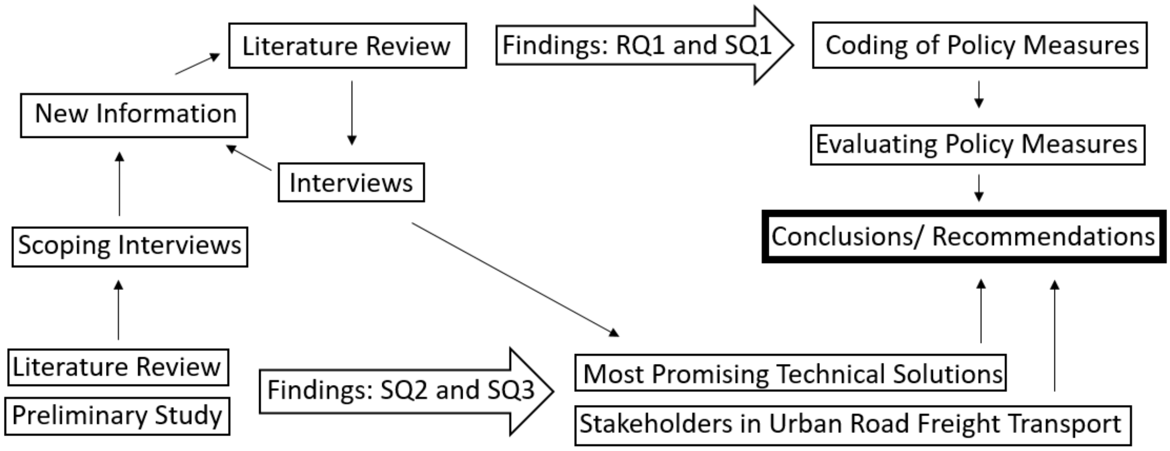
First, a review of available literature on policy measures both in Norway and current policy practices in cities globally were conducted. This work was largely done through a preliminary study in the Applied Research in Sustainable Consumption and Production (ARSCP) course at the IIIEE Lund University, and were continued throughout the course of this research. Sources were based on, among others scientific journals, academic reports, policy documents from governmental institutions and grey literature. The literature review process also served to identify not only relevant stakeholders in the URFT sector, but also relevant criteria and evaluation framework for policy measures. The identified stakeholders were approached for interviews based on their availability and significance to help answer the research question and sub-questions. Thus, some stakeholders were left out from the interview process, due to not being available. Qualitative primary data were obtained from semi-structured interviews with each stakeholder, for then to be coded, analysed, and interpreted for findings.

2.2 Methods

2.2.1 The Research Process

A literature review, and 11 semi-structured interviews were conducted for this research. While the literature review took place continuously during the thesis period, interviews were timely arranged prior to the start of the thesis period. These were all conducted during the month of June 2017. As new information emerged throughout the interview and interpretation process, it was added to the literature review. This is illustrated in Figure 6. As further illustrated in Figure 6, the literature review largely helped answer the two sub questions, namely identifying the most important stakeholders in urban road freight transport (SQ2), and the most promising technical solutions in the sector (SQ3). That is, while interviews also touched upon most promising technical solutions (SQ3), interviews primarily revolved around RQ1 and SQ1. Both RQ1 and SQ1 were largely answered through both a literature review and semi-structured interviews.

Figure 6: The research process



2.2.2 Literature Review

In selecting literature for this study, keywords in the process such as "urban road freight transport", "electric freight", "electric trucks", "hydrogen freight", "fuel-cell trucks", "urban transport Norway", "urban freight Oslo", "low-carbon freight transport", and "urban transport" were used to guide the sourcing of relevant material. This was primarily extracted from Lund University's library database, google scholar and ScienceDirect. In assessing the literature, each source was analysed separately and ranked based on its relevance to the research question. This was done based on looking at resemblance regarding keywords, year of publication, and reputation of the authors' organisation. The latter process included background searches on the internet and looking at factors such as number of citations. All literature was selected and sorted in a common document and ranked, to find back more easily to pertinent literature during writing.

Considering the research question and complementing sub-questions, searching for literature on future technologies in urban road freight, and road freight in general was the initial step. This process also served to recognising relevant stakeholders in URFT, and what policies had been enacted to stimulate growth in this segment of transport. In this process, focus on journal articles were key sources of information, but also grey literature from recent developments in the area. Grey literature was not always included as references due to primarily lack of peer-reviewing. Among Norwegian sources, both TØI, and SINTEF was used as key sources of information, the first being Norway's leading institution for multidisciplinary transport research, and the second being the largest independent research organisation in Scandinavia. Further, the Norwegian Road Transport Association (NLF), Norwegian Public Road Agency (NPRA), Norwegian Environment Agency, Institute of Energy Technology (IFE), Statistics Norway, various government reports and publications from the City Council of Oslo was used to focus the research specifically on urban road freight in Norway. In addition, sources from international journals was used to develop understanding on the research topic. This was focused on recent developments in urban freight, progressive technologies, and comparisons between cities.

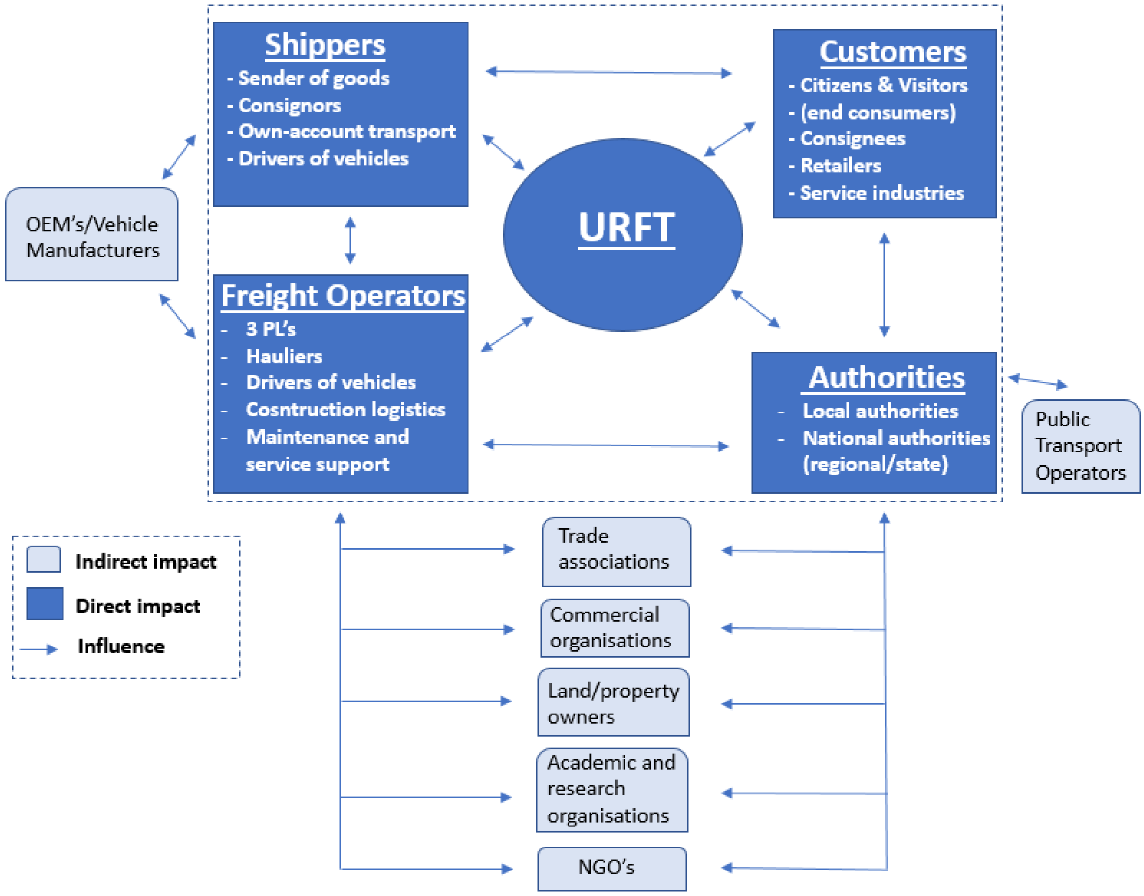
It must be stressed that predominant attention has been focused on literature from Norwegian sources, or research focused on Norway and Oslo specifically. This was partially due to the lack of literature from international journals relevant to the geographical context of this study. This made the application of Norwegian sources necessary. In addition, grey literature assisted in improving the author's understanding of the rapid development in the transport sector, yet to be discussed in literature from primarily scientific journals. The compilation of all literature reviewed also helped framing questions for the semi-structured interviews. This helped to create an interview guide as found in appendix 7.4, along with tailored questions for each interviewee.

2.2.3 Semi-Structured Interviews

Primary data was collected from 11 semi-structured interviews, whereof 9 were conducted in person, and two over telephone. To ensure homogeneity among interviewees, stakeholders preferably needed to fulfil the criteria of having in-depth knowledge of mobility, if possible in an urban context. Given the numerous stakeholders involved in URFT, an adapted framework from Ballantyne et al (2013) were applied to identify relevant stakeholders. These largely matched those identified from other relevant literature. Stakeholders were separated between those directly impacting, and those with an indirect impact on the sector. Those having a direct impact were defined as those having a direct influence on URFT, while those having an indirect impact were those having an interest in the sector (Ballantyne et. al., 2013).

Authorities, freight operators, shippers and customers were identified as having a direct impact on URFT. On the other hand, original equipment manufacturers (OEM's), public transport operators, trade associations, commercial organisations, and land/property owners were identified as having an indirect impact on the sector. Due to their prevalence in literature and importance to this research, both academic and research organisations, and NGO's were added to the original framework from Ballantyne et al (2013), as stakeholders having an indirect impact. Also, retailers and service industries were added as directly influencing stakeholders under the stakeholder group of customers. These were also additions to the original framework from Ballantyne et al (2013). Figure 7 illustrate this background, and Table 6 summarise what stakeholder groups were interviewed, and number of interviewees from each group.

Figure 7: Urban road freight transport stakeholders and their relationships



Source: Adapted from Ballantyne et. al (2013).

Table 6: Stakeholder groups and number of interviewees from each group

Stakeholder group	Organisation/interviewee	# of interviewees
National authorities	The Norwegian Ministry of Transport and Communications	1
Local authorities	Employee[23] at The City Council of Oslo's Agency for Climate	1
Freight operators	ASKO Norge AS, Posten Bring, and Norwegian Road Transport Association	3
Original equipment manufacturers	Volvo Trucks	1
Academic and research organisations	Institute of Transport Economics, Norwegian University of Life Sciences (NMBU), and SINTEF	3
NGO's	Bellona	1
Public agencies	Norwegian Public Road Administration	1

The interviews lasted for approximately 45-60 minutes. While a general interview guide was developed for all interviews, the study asked questions targeted at each stakeholder and their working context. That is, the interview guide was set up with a list of general questions being asked all interviewee's, while tailored questions were both prepared beforehand, and developed as the interview went on. This reinforce the semi-structured nature in which interviews were conducted. It should be noted the discussion in each interview was not limited to policy measures promoting only electric and hydrogen vehicles, but also measures to reduce GHG emissions from URFT, and other promising technical solutions such as biofuels.

Considering tailored questions, both national and local policymakers were asked questions including what factors were considered when designing policy measures, and reasoning behind implementing existing and considering potentially new measures. For freight operators, questions as to what factors determine type of vehicles they invested, and what influence both fiscal, and non-fiscal measures play in their investments were asked. For academia, NGO's and research organisations, questions as to what they believed had been the effect of existing policy measures, what policy measures should be considered implemented, and reflections of various fuel propulsions were areas of focus. Immediate notes during the interviews were taken, followed by a complete transcription and summary for which was sent to interviewees. A complete transcription was not conducted for the telephone interviews however, due to these not being recorded. Appendix 7.4 show the interview guide applied for this research.

2.2.4 Policy Evaluation and Interview Coding

Some stakeholders were merged into groups and evaluated together in the result section. These were merged due to representing similar interests, and the context for which they were interviewed in this study. For instance, the trade association "Norwegian Road Transport Association," representing a variety of freight operators, was evaluated together with the two other freight operators interviewed in this study, namely Posten Bring and ASKO. Similarly, the public agency NPRA was merged into the stakeholder group of academic and research

[23] The interviewee from local authorities spoke on behalf of himself and personal opinions, based on current position at the Agency for Climate. This agency is under the authority of the City Council of Oslo.

organisations. This was primarily due to the fact that NPRA was being interviewed in a research context for this study, one of several mandates for the agency. On the other hand, authorities were separated between national and local authorities. This was primarily due the important distinction of responsibilities between the two levels of authority. While both levels are important and have the mandate to also implement policy measures, local authorities (municipalities) are reasoned to have the most important role for a more environment, and climate friendly urban road freight distribution system (Dahl, 2015).

The weighting and scoring of policy measures was focused on a directed content analysis. Hsieh and Shannon (2005) highlight this as when interviews have been coded with the help of an initial framework based on categories that have been developed prior to conducting interviews. Policy measures were grouped into categories based on a framework from Hood and Margetts (2007), namely fiscal, legal, organisational, and communicational measures, illustrated in Table 7.

Table 7: Definition of policy categories

Fiscal measures	Legal measures	Organisational measures	Communicational measures
Reduces the total cost ownership (TCO)[24] of low-carbon vehicles or increasing TCO for conventional ICEV's	The government utilizes its authority to enable or prohibit certain activities, by examples of changing legislation or certification schemes	The government uses its own capacity and capability, including such as skills, people, infrastructure, and land	The government uses its "nodality" to collect and dispense information such as advantages, use case and TCO calculations

Source: Hood and Margetts (2007). Taefi et. al (2016).

Evaluation of policy measures was based on two approaches, identifying the policy category and individual policy measures most likely to promote low-carbon freight vehicles and reducing GHG's from URFT. To allow for this separation, policy measures were assessed based on a frequency approach to highlight most emphasised policy category, and mentioning approach to highlight most emphasised individual policy measures. The latter approach based on mentioning does not reflect whether each interviewee mentioned single policy measures numerous times, but rather their mentioning at all. Largely, this approach was chosen to address the research gap of a seemingly large discordance between stakeholders, and to recognise possible consensus between interviewees. For policymakers, this will assist in understanding what policy measures the industry and other stakeholders believe could best promote low-carbon vehicles, and measures that are broadly aligned by a range of industry actors. The approach of mentioning was also done to avoid the scenario for which a policy measure was mentioned multiple times in a context not applicable to promoting the uptake and use of low-carbon technologies.

To compensate this approach, the first approach of frequency counted the number of times policy measures within each category from Table 7 were mentioned, across all interviews. The sum of policy measures within each category was later added between all interviews to understand what policy category were the most emphasised throughout. This approach was applied to provide an overarching view among the myriad of policy options, and offer a baseline for policymakers of where to start.

To highlight the relative importance of individual stakeholders, it was further decided to assign a "weight" figure to the different stakeholders indicating their influence. This was incorporated in the frequency approach, identifying the most recommended policy category. That is, policy

[24] Purchase and other maintenance costs accounted.

measures mentioned by stakeholders directly impacting URFT was given a double counting, and single counting for those indirectly impacting the sector. Similar studies assessing policy measures in URFT justify the emphasis on weighing stakeholders. Among others, Taefi et al (2016) and Bakker and Trip (2013) assess policy measures based on selection of most relevant stakeholders, the first study considering only freight operators and local authorities in an online questionnaire, while the second study invited only local authorities in a focus group workshop.

For the approach based on mentioning of individual policy measures, findings mainly listed those measures most commonly mentioned throughout. However, also some individual policy measures being mentioned a fewer amount of times were incorporated based on emphasis in literature and interconnectedness with policy measures being mentioned the most. As an example, environmentally differentiated road charging, toll roads exemption and congestion charging have interconnections to the policy measure of tolled roads, which could be referred to in an overarching nature. For the analysis and discussion section, primarily those individual policy measures mentioned the most were emphasised, and assessed towards selected criteria in this research. Reinforcing the inductive nature of this study, criteria for which individual policy measures were assessed towards changed throughout the study. Policy measures were assessed primarily in the analysis and discussion section based on a criteria framework used by Taefi et al (2016). Descriptions of the criteria are also based on inputs from Mickwitz (2006), who's study focuses on environmental policy evaluation. Table 8 offer a further elaboration on descriptions of these criteria.

Table 8: Criteria for which policy measures were assessed towards

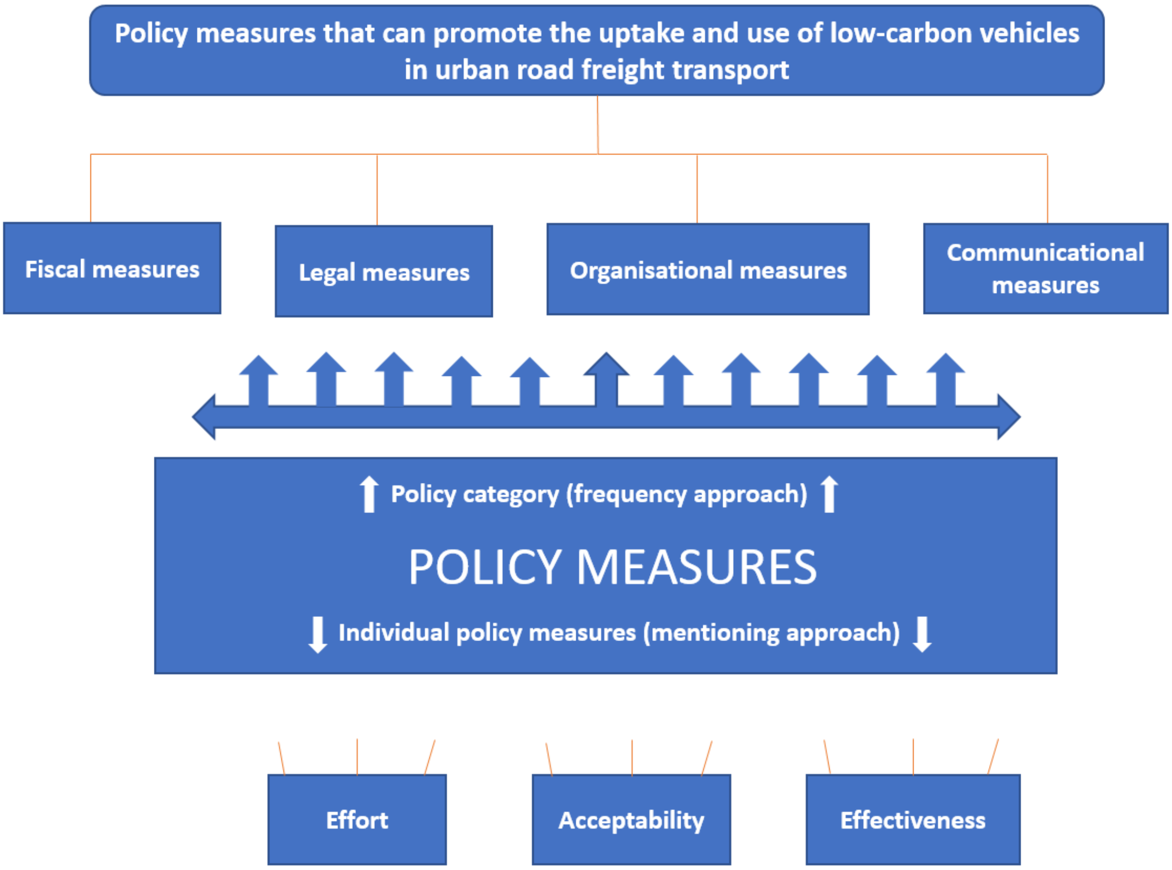
Criteria	Description
Effort	Denotes the personnel and monetary effort required to implement the policy
Acceptability	To what extent do individuals and organisations accept the policy
Effectiveness	To what degree do the achieved outcomes correspond to the intended goals of the policy?

Source: Taefi et al (2016). Mickwitz (2005).

2.2.5 Framework for Policy Evaluation

Assessing individual policy measures and policy categories were based on a multi-criteria decision analysis, based on a conceptual framework from Suksri et al (2012). A simplified illustration of this framework can be seen in Figure 8. Reinforcing the inductive nature of this study, policy categories and criteria was changed and deleted during the research process. As reflected in the frequency approach, policy measures from interviews were placed in separate categories and summed up between all interviews, for which the most emphasised policy category throughout were identified. As for the mentioning approach, primarily individual policy measures being mentioned most commonly by interviewees were assessed against the criteria effort, acceptability, and effectiveness in the analysis and discussion section. Recommendations of individual policy measures were based on the overall satisfaction against the criteria.

Figure 8: Framework for evaluating policy measures



Source: Adapted from Suksri et al (2012).

3 Literature Review

3.1 What Entails URFT?

The concept of urban road freight transport was coined as early as 1977 as “all journeys into, out of, and within a designated urban area by road vehicles specifically engaged in pick-up or delivery of goods (whether the vehicle be empty or not), with the exception of shopping trips” (Hicks, 1977, p. 101). Later however, the founder of the term “city logistics, Eiichi Taniguchi defined the topic as “City Logistics is the process for totally optimising the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy” (Taniguchi, Thompson, Yamada and Van Duin, 2001, p. 2). Later, the European Commission defined urban logistics in their 2011 White Paper on Transport as “the movement of goods, equipment and waste into, out from, or through an urban area” (European Commission, 2011).

While several definitions have been made later such as to include service vehicle movements and demolition/construction traffic, there is a consensus that urban road freight transport is a complex field to study (Ballantyne et.al., 2013). This is partly due to the variety of vehicle types as seen in Table 4, all capturing the extent to which URFT is considered, and the various purposes each vehicle trip could serve.

3.2 URFT Globally

While widely deemed an essential function to societies, URFT offers a great potential for reducing GHG emissions. This is partly due to representing a small portion of total freight activity among all transport modes, but accounting for a sizeable share (20 %) of total energy demand in Nordic urban areas (Nordic Energy Research and International Energy Agency, 2016). On average in European cities however, URFT represents 8-15 % traffic flow (MDS Transmodal Limited and CTL, 2012), and urban transport is causing 23 % of EU’s GHG emissions (Vis, 2017). Emissions of NO_x have also proved an issue[25], having studies from Germany suggesting 45 % of NO_x emissions are caused by MFT’s and HFT’s performing urban freight in the city of Hamburg (Taefi. et. al., 2016). These factors can be explained by numerous evidence, relating to URFT often being performed in inefficient ways, with the industry being particularly resistant to change (Arvidsson et. al., 2013).

Considering inefficiency, a french study (discussed by Small and van Dender, 2007) concludes that marginal external congestion costs of urban freight are up to 10 times higher than inter-urban traffic or long-distance transport. Studies have suggested this is largely a consequence of the frequency of stops and short trips for URFT vehicles (Filippi et al., 2010). Fu and Jenelius (2017) support this argument in a more recent study. They argue stop and go conditions on often congested streets, often performed by older vehicles make URFT vastly polluting. Also, URFT vehicles have a substantially higher energy intensity compared to other freight transport modes. Particularly vans and MFT’s are found to have high energy intensity compared to larger inter-urban freight vehicles (Nordic Energy Research and International Energy Agency, 2016).

In being resistant to change, studies have largely pointed to the sector’s lack of persistence to continue tests towards a steady state, following early pilot projects often financed through EU funds (Arvidsson et. al., 2013). Likewise, designers, building engineers, architects and owners of

[25] Compared to GHG’s such as CO_2 and CH_4 that contributes to global warming, nitrogen oxide (NO_x) and particulate matter (PM) primarily affect local air pollution negatively, not global warming. NO_x and PM is particularly a concern in cities.

commercial buildings have not facilitated improvements either. As an example, a study on Norwegian cities in 2008 found that areas for deliveries of goods were the last consideration in construction of new buildings (Rambøll Norge, 2008).

Also among policymakers, research suggests local authorities have only considered URFT as a reaction to harmful environmental impacts, often brought about through complaints from other road users or residents (Cherrett et. al., 2012; Ballantyne and Lindholm, 2013). Lack of time, resources, and expertise has historically made this segment of transport go rather unnoticed in planning processes among policymakers at local level (Ballantyne and Lindholm, 2013). In Oslo, it was noted authorities did not engaged much in the sector as compared to public transport until 2012. The increased emphasis took place during the now-ended research & development (R&D) project, Grønn bydistribusjon (Green city logistics) (Olsen, 2015). Internationally, studies also conclude that its only during the last two decades' the sector has gained more attention in both the research and political sphere (Ballantyne et. al., 2013; Cherett et.al., 2012; Muñuzuri et. al., 2005; Suksri et. al., 2012; Ballantyne and Lindholm, 2013). Still, research suggests that the challenges faced by the freight industry is still not fully understood, often performed by private stakeholders that lack dialogue with authorities (Ballantyne and Lindholm, 2013; Eidhammer and Andersen, 2015). EU has funded numerous project addressing this issue. Among others, the project CITYLAB brings together cities including Oslo, London, Southampton, Brussels, Rome, Paris, and Rotterdam to develop environmentally sound and efficient urban road freight, a project involving research institutions, local authorities and private market actors (Olsen, 2015).

Thus, enhanced collaboration among stakeholders have been a common recommendation to improve the efficiency of the sector (e.g. Ballantyne and Lindholm, 2013). This follows the recommendations from OECD's[26] working group on urban freight logistics back in 2003. It was highlighted "agreement among all stakeholders, especially support from the private sector, is necessary in developing a feasible and practical policy vision" (OECD, 2003, p 11). Another notable recommendation in research is a reevaluation of the possibilities for local authorities to include URFT as something equally important as passenger transport in their planning process, largely in terms of financial and strategic contributions (Ballantyne and Lindholm, 2013).

Globally, research suggests that challenges faced by local authorities regarding freight transport is not unique to specific countries or urban areas (Ballantyne et. al., 2013). Others suggest that individual characteristics of urban areas are case specific, and cannot necessarily be transferred to a different urban context (Suksri et. al., 2012). This has also been supported by other research making observations that policy implementation and what problems they are designed to address are different between cities (Eidhammer and Andersen, 2015). This difference is subject to factors including various design of cities, how policymakers manage freight within the city, and the level of incorporation of all stakeholders in the planning process. Studies from Chalmers University in Sweden reinforce these factors, claiming that different types of built environments, urban structures, and characteristics of receipients affect URFT in different cities (VREF, 2013).

For the future, cities are expected to expand and grow their peripheries, in which freight operators are projected to continuously consolidate their goods in hubs outside city centres (Vidyasekar, 2013). Due to increased urbanization[27], consolidation centres will likely be located closer to city centres in which freight operators will have more vans perform last mile deliveries,

[26] Organisation for Economic Co-operation and Development.

[27] Nearly 60 % of the world's population will live in cities by 2026, according to the UN.

optimised through increased telematics[28] (Deloitte, 2016). For the last mile delivery within city centres, studies suggest low-carbon vehicles is a solution for how to reduce negative impacts of noise and local air emissions, while maintaining the efficiency of the urban freight system (Quak et. al., 2016).

3.2.1 Oslo and Norway as Research Focus

Many cities have adopted ambitious commitments to promote cleaner urban freight vehicles. This was recognised in 2017 by the International Council on Clean Transportation (ICCT), arguing cities are those driving the change towards low-carbon vehicles, and are chiefly responsible for a gradual decline in diesel vehicles (Tietge and Díaz, 2017). Evidence as of mid-2017 points to the accuracy of this statement. Following high levels of local air pollution, European cities including Berlin, Madrid, London, Stuttgart, Liverpool, and Barcelona have enacted measures to limit or ban conventional diesel vehicles (Valle, 2017). The risk of heavy fines from the EU have stimulated legislative actions of this nature (Valle, 2017). Nordic countries are also taking part. Among others, Stockholm is considering the implementation of a low-emission zone allowing only electric, and Euro V or Euro VI vehicles[29] (Tietge and Díaz, 2017). Such zones with gradually more stringent entry requirements are being implemented in several cities today (Dodu, 2017).

Oslo has adopted a leadership role. The city is often referred to as an inspiring example following the major growth in the electric passenger vehicle market (Hockenos, 2017; Garfield, 2017). Together with Paris, the city was also the first to announce prohibition on the use of diesel cars locally in the wake of the "dieselgate"[30] scandal from 2015 (Nykvist, Suljada and Carlsen, 2017). Considering specific targets to reduce GHG emissions, no other city can refer to ambitions matching Oslo (Peters, 2016). As a parade of the movement towards a green transition, Oslo won the EGCA (European Green Capital Award) for 2019, an award that among others highlighted the city's strong commitment to reducing GHG emissions (European Green Capital, 2017). Building on the success in primarily the electric passenger vehicle segment, the focus is now on becoming a leader in commercial vehicles for purposes such as freight (The City Council of Oslo, 2016).

Nationally, Norway's clean energy source in hydropower has allowed for a rapid expansion of low-carbon technologies. Figenbaum (2015) pointed to the fact Norway had one of the highest fuel prices in Europe, combined with cheap electricity as a noteworthy incentive for electric vehicles already since the year of 1990. Based on gross electricity consumption, Table 9 indicate Norway is at the forefront in Europe for what concerns electricity produced from renewable sources[31]. The European Environment Agency have stressed the importance of this factor, stating electric vehicles are only as clean as their source of energy (Hockenos, 2017). For consumption however, it should be noted Norway is also an importer of fossil and nuclear based energy from other countries. That is, Norway export major shares of hydroelectricity to other countries having purchased a guarantee of origin for renewable energy (Vermes, 2016). In fact, numbers from the Norwegian Water Resource and Energy Directorate (NWRED) conclude only 14 % of Norwegian energy consumption comes from hydropower, while 64 %

[28] Realt time information on traffic, routes being dynamically optimized, truck uptime, empty journeys avoided and increased productivity.

[29] European standards for emissions in vehicles, primarily reducing NO_x and PM emissions, not CO_2 (Roland Berger Strategy Consultants, and Ruter, 2015). Euro VI is the most recent incarnation and have lowest emissions of NO_x and PM compared to Euro V vehicles and lower.

[30] Car manufacturer Volkswagen was found guilty of manipulating emissions testing for vehicles fueled by diesel.

[31] Referred to as hydro, wind, solar, geothermal and biomass/wastes (Eurostat, 2016).

comes from imported fossil fuels, and 21 % from nuclear energy (NVE, 2017). Thus, Table 9 could be viewed as misleading. The share of renewable electricity consumption will not increase unless a larger share of Norwegian energy consumers purchases a guarantee of origin (Brenna, 2017).

Table 9: Share of electricity from renewable sources based of gross consumption

Country	Share of renewable energy of gross consumption in 2015 (%)
EU average	28.8
Norway	106.4
Denmark	51.3
Sweden	65.8
Finland	32.5
Iceland	93.1

Source: Eurostat (2016).

Furthermore, pressure on existing power grids could see high maintenance and upgrading costs if the market for electric vehicles continue to expand. While the NWRED suggested the Norwegian power system could manage an increase to 1.5 million electric vehicles in 2030, local disturbances were mentioned as a factor. This resulted in the recommendation most charging should take place overnight (NVE, 2016). This is not always an option for urban road freight vehicles however, commonly faced with time contraints and larger batteries compared to passenger vehicles. Instead, they would likely require a sophisticated infrastructure of fast chargers, which could see enhanced pressure on existing power grids should the market expand.

Politically, promoting low-carbon technologies could be seen as a convenient growth segment in Oslo and Norway compared to other countries. Bjartnes and Michelsen (2016) underscore the debate is not subject to whether transport should decarbonise, but how and the pace for the transition. Convenience is also partly due to no established car or truck industry exist in Norway. This has also been argued a prominent factor in other European countries such as Switzerland (H2 Energy AG, 2015). This has reportedly given a higher acceptance among authorities to stimulate growth for low-carbon technologies, having no established industry trying to prevent new niches to develop (H2 Energy AG, 2015; Albrecht, 2017). Among others, IFE (2017) highlights there has been an enormous advantage that Norway has never had any large vehicle manufacturers domestically, having largely caused the success for passenger electric vehicles.

3.3 Ways to Reduce GHG's from URFT

3.3.1 Efficiency & Logistics

Reducing transport demand and improving fuel efficiency in trucks is found to be two of the most efficient ways to curb GHG emissions (Transport & Environment, 2017; Thomas and Callan, 2010). However, in their white paper on transport from 2011, the EU largely concluded curbing mobility was not an option (European Commission, 2011). This has lead to researchers suggest densification and urban planning could be viable alternatives to make walking, cycling, public transport, and shorter commutes more competitive (Fridstrøm, 2017). Considering Norway has the lowest number of travellers using public transport in Europe, and together with Portugal the highest amount of private passenger car usage (Fridstrøm, 2017), the potential for densification and urban planning would likely be high.

For fuel efficiency, studies show economic driving potentially supported by a fleet management system could reduce fuel consumption by 10 % (Norges Lastebileier-Forbund, 2016). Freight operators ASKO and Getru Bedrivjen in the Netherlands have demonstrated this in practice. The latter company have reduced fuel consumption by no less than 10 % through equipping 150 of their trucks with computer systems storing information from each ride (Logistiek010, 2017). Economic driving has also been mandatory in Swedish trucks driver education since 2008. Firms have increasingly started to monitor driver performance and incorporated incentives for drivers to improve fuel-efficiency (Vierth, 2013). Moreover, low resistance tyres, anti-idling devices, engine efficiency improvements and improved aerodynamic design is found to have significant potential to improve fuel efficiency further (Transport & Environment, 2017). Aerodynamic design has been taken to to its peak by the so-called teardrop trailer adopted by DHL and partner Ninatrans, reportedly having reduced fuel consumption by 5 - 10 % (Kilcarr, 2015). Combined, it is estimated implementing measures to improve fuel efficiency in trucks could reduce fuel consumption by as much as 30 % to 50 % from 2015 to 2020, compared to a 2010 baseline (Muncrief and Sharpe, 2015).

Improved logistics in the freight sector has also been discussed. Studies from the EU have suggested 23.2 % of vehicle-kilometers performed by European heavy-freight trucks run empty, and partially loaded vehicles are assumed to be very common (European Commission, 2014). Due to factors of being sparsely populated and having a well-developed infrastructure, Nordic countries have strongly advocated for the permission to use heavier and longer vehicles, or so-called modular trucks[32]. While not applicable to urban freight, the advantages range from a 25 % increase of truck loads per trip, reducing the need for road freight transport by 25 %, and potentially reducing CO_2 emissions 200 000 tonnes if 50 % of long-distance transport were transported on modular trucks (NHO et. al., 2016). Norges Lastebileier-Forbund (2016) further argue two modular trucks could replace 3 normal HFT's. On certain road networks only, Sweden is moving towards allowing 74 tonne trucks operating in freight transport (Nordic Logistics Association, 2017).

There has also been a growing call for CO_2 standards for trucks to be implemented in the EU. This is expected early to mid 2018, and has been strongly encouraged to disrupt the highly monopolised nature of European truck making, having only five manufacturers[33] accounting for nearly 100 % of the market (Transport & Environment, 2017). This goes back to the untapped potential in engine efficiency improvements. Among others, combustion optimization, engine friction reduction and waste heat recovery has been suggested areas a CO_2 standard could help trigger (Transport & Environment, 2017). In a 2050 perspective, Swedish truck manufacturer Scania projects efficiency improvements could at best lead to 20 % improvements compared to the 2017 level, primarily focusing on HFT's (Wästljung, 2017).

3.3.2 Biofuels and Other Technologies

Other fuel propulsions not considered low-carbon in this study could also reduce GHG emissions from road freight. These are numerous, and include not only the variety of biofuels, but also compressed natural gas (CNG), liquified natural gas (LNG) and hybrid solutions[34]. Using conventional diesel as a benchmark, Table 10 illustrate the comparison in environmental impacts and attributes in daily service, based on a study on behalf of the Norwegian Ministry of

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[32] Trucks with an average length of 25,25 metres, and weight of 60 tonnes. A standard heavy-freight truck is only 17,5 metres (Garathun, 2013).

[33] Volvo-Renault, Scania, IVECO, Daimler, and MAN (Transport & Environment, 2017).

[34] Referred to in this research as plug-in hybrid electric vehicle (PHEV). That is, vehicles combining gasoline/diesel and battery electricity.

Climate and Environment. For simplicity, only sustainable advanced biofuels[35], also referred to as 2nd generaion biofuels, and biogas were considered among the variety of biofuels in Table 10. A further elaboration is provided in subsequent sections however.

Table 10: Comparison of diesel to biofuels and other fuel propulsions

Propulsion	Environmental impacts		Attributes in daily service				
Fuel/Technology	**GHG emissions**	**NO_x and particulate matter**	**Range**	**Flexibility in driving pattern**	**Need for infrastructure**	**Fueling/ recharging time**	**Maturity**
Diesel	High	Low-High[36]	Normal	Normal	None	Normal	Mass-Production
Hybrid	Medium	Medium	Normal	Normal	Some	Medium	Implementation
Sustainable Advanced Biofuels	Low	High	Normal	Normal	None	Normal	Design
Biogas	Low	Medium	Less	Normal	Medium	More	Implementation
CNG	High	Medium	Less	Normal	Some	More	Implementation
LNG	High	Medium	Normal	Normal	Substantial	Normal	Pilot

Source: Adapted from THEMA (2015).

The Norwegian Environment Agency conclude the variety of biofuels will be important to reduce GHG emissions from transport (Miljødirektoratet, 2017). This is reflected in a more than doubling of the usage of biofuels between 2015 and 2016 in Norway (Statistics Norway, 2017). Norway has also a political ambition of a 20 % blending mandate[37] in 2020 (Ministry of Climate and Environment, 2017). The category of biofuels is broad however, ranging from biogas[38], bioethanol[39], biodiesel[40] and HVO[41]. Researchers have suggested supporting biodiesel is the most cost-efficient approach to adopt renewable fuel propulsions, but availability could be a challenge (Hovi and Pinchasik, 2016). Challenges beyond sufficient supply have proved prevalent also. Early 2017 saw a surge in prices of HVO. This fuel had reportedly cut 250 000 tonnes CO_2 from Norwegian road transport, more than total cuts from Norway's more than 80 000 electric passenger vehicles (Bentzrød and Strand, 2017). This was a consequence of a new classification of the raw material palm fatty acid distillate (PFAD), which had been found contributing to deforestation and global palm oil cultivation (Bentzrød and Strand, 2017). Instead, focus has shifted to sustainable advanced biofuels[42] rooting from waste and residue materials (Transport & Environment, 2017). Yet, only one percent of biofuels produced globally in 2017 were perceived being advanced (Hagman, Amundsen, Ranta and Nylund, 2017).

[35] Produced from feedstock that do not compete with food and feed crops directly (European Commission, 2012). That is, without the controversiers to land use such as ILUC (Indirect land use change). Raw materials are based on residues and wastes.

[36] Depending on Euro vehicle class. Euro VI engines have lower NO_x and PM emissions compared to Euro V and below.

[37] Biofuels will be blended into diesel and other fossil fuels.

[38] Produced from a variety of raw materials including oil seeds, straw, manures, wood, and organic waste. Norway typically produce biogas from a variety of waste fractions (Skedsmo commune, 2017).

[39] Produced from plants that contain sugar and starch, including corn, sugar crane, potatoes and more. Bioethanol is blended into normal gasoline. Could increase fuel consumption by 30 % compared to normal gasoline (Skedsmo kommune, 2017).

[40] Produced from vegetable fat or oils, including rapeseed, soya, palm oil. Biodiesel is blended into normal diesel (Skedsmo kommune, 2017).

[41] Hydrotreated Vegetale Oil. Usually referred to under the category of biodiesel.

[42] Without the controversiers to land use such as ILUC (Indirect land use change), based on residues and wastes.

Sustainable advanced biofuels are also projected to see substantial future demand from the aviation and shipping industries, potentially causing a shortage for what's left for road freight transport (Transport & Environment, 2017). Comparing the various biofuel alternatives, studies on behalf of public transport operator in Oslo and Akershus, Ruter suggested biogas, biodiesel and bioethanol could reach similar levels of CO_2 emissions depending on the feedstock used (Roland Berger Strategy Consultants and Ruter, 2015). While biofuels offer high energy density and few modifications from ICEV's (Kirkengen, 2017), Table 5 illustrate a clear preferenece from authorities towards electric and hydrogen technologies.

Natural gas has been considered another option. This propulsion could reduce GHG emissions 11 - 25 % compared to diesel vehicles (THEMA, 2015). When extracted from fossil fuel sources however, contribution to GHG emissions could be significant (Hagman et. al., 2017). That is, up to 75 % higher compared to biogas, HVO and bioethanol (Wästljung, 2017), and potentially higher than diesel if leakeges of methane would occur[43] (THEMA, 2015). For natural gas, CNG (compressed natural gas) and LNG (liquified natural gas) are potential alternatives. CNG is best suited for long transports, and LNG for shorter distances (Rambøll and Energigjenvinningsetaten, 2016). However, studies suggest these propulsions have 10 % lower efficiency compared to diesel, which have led to some researchers argue they will only reduce climate impacts when produced from sustainable biomethane[44], equivalent to upgraded biogas (Ricardo Energy & Environment, 2016). Oslo is well positioned in this manner. Studies conclude supply of biogas as of 2016 corresponds to 35 million litres of diesel, and a strong potential for further growth (Rambøll and Energigjenvinningsetaten, 2016). Internationally however, studies looking at EU countries stress concern regarding limited supply of sustainable biomethane to support a growing market (Ricardo Energy & Environment, 2016).

Also, hybridisation, a mix of conventional fossil fuels and electrification (in this study) have faced all between challenges, controversies, and promising projections. For heavier vehicles (MFT's and HFT's) electricity is found to support only a few kilometres before having to switch to a fossil driveline (Agency for Climate, 2017). For vans, no models are currently available in Norway as of 2017 (THEMA et. al., 2016). The potential application in urban road freight is promising however. Urban areas with numerous starts and stops have been found an ideal arena for hybridisation, capable of reducing diesel consumption by 30 % (Hagman et. al., 2017). Controversies have occurred however. The ICCT have found real emissions of GHG's from 2014 models of hybrid passenger cars were 40 % higher than the type approval suggested (Tietge et. al., 2016).

3.3.3 Low-carbon Technologies

Several Norwegian and international studies point to a mixture of technologies, including electricity, hydrogen, and biofuels for sustainable transportation in the future (Tomasgard et. al., 2016; Anandarajah, Mcdowall and Ekins, 2013; The City Council of Oslo, 2016; Bjartnes and Michelsen, 2016; Transport & Environment, 2017). Electricity and hydrogen have been considered the most efficient way to reduce GHG emissions from the transport sector (e.g. ZERO, 2017). Electricity has been found best suited to replace fossil-fuels in urban areas performed by light, and mid-duty vehicles, while hydrogen is often mentioned to have an even greater potential in long-distance freight transport with heavier vehicles (Nordic Energy Research and International Energy Agency, 2016; Quak et. al., 2016; IFE, 2017; National Research Council, 2015; Valmot, 2017). Connolly et al (2014) emphasise electricity should be

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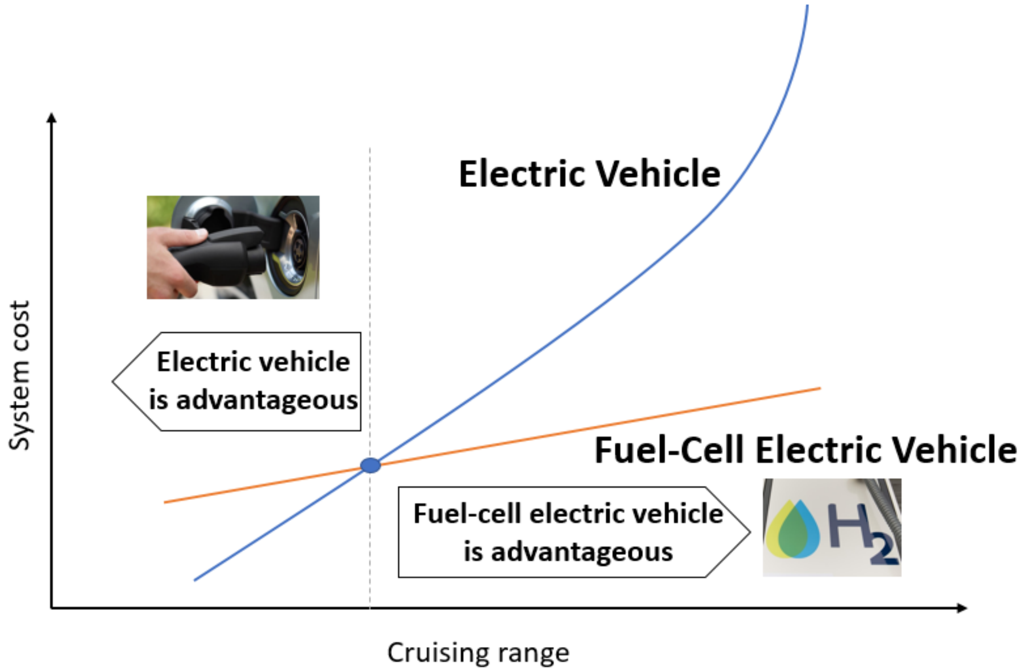
[43] Natural gas is primarily methane (CH_4). Methane contributes 34 times more GHG's compared to CO_2 in a period of 100 years (THEMA, 2015).

[44] Produced from removing impurities from biogas (Transport & Environment, 2017)

prioritised in short-distance transport due to higher efficiency compared to hydrogen. Electricity was also found the cheapest pathway, while hydrogen must be prioritised for long distance and heavy-duty transport (Connolly et. al., 2014). Driving patterns of frequent start and stops in urban areas also fit another attribute of battery electricity, in that the engine could feed back energy when braking (Canters, 2014). Toyota have illustrated the difference in range and cost potential between the two technologies in Figure 9, referring to electric and hydrogen vehicles as electric vehicle (EV) and fuel-cell electric vehicle (FCEV) respectively.

Figure 9: Toyota's assessment of technology potential for low-carbon technologies



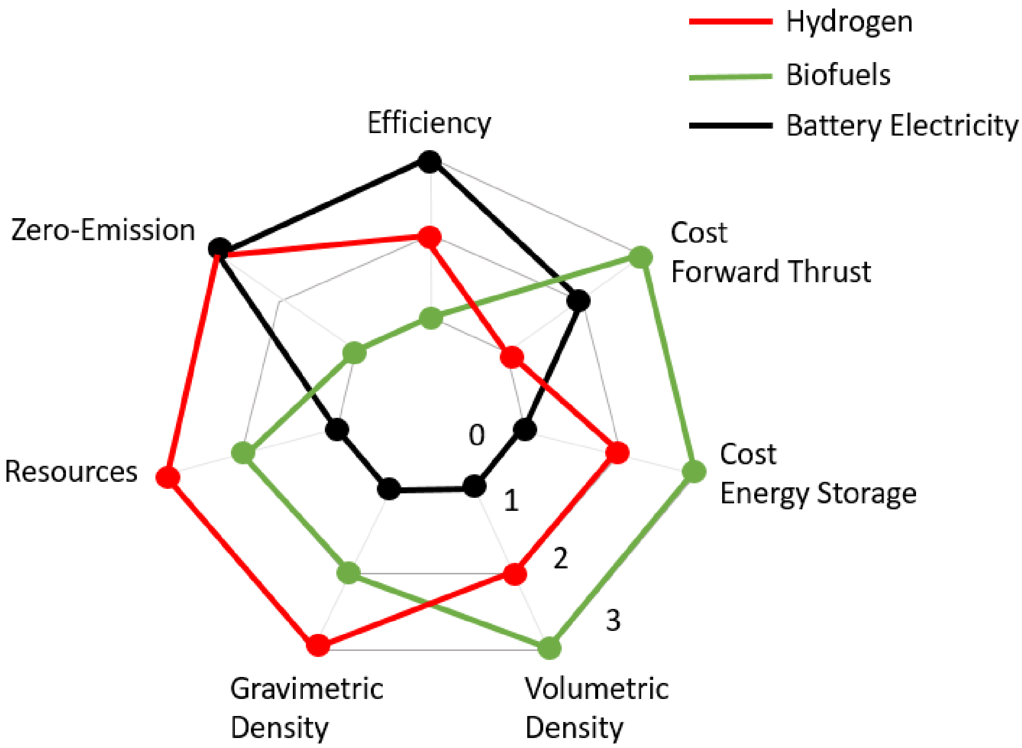
Source: Adapted from Tomasgard et al (2016).

However, deployment of both technologies has experienced limited market uptake (Anandarajah et. al., 2013). This has also been due to small-scale production from OEM's. Thus, some freight operators have imposed it on themselves to import, retrofit and produce vehicles on their own initiative (Taefi et. al., 2016).

Among others, international brewery company Heineken converted an electric Volvo truck for distributional services across several Dutch cities. The vehicle was constructed by company Ginaf on a chassis provided by Mercedes-Benz (Pink, 2015). The same largely holds true for hydrogen vehicles with numerous subcontractors involved. Considering costs, Switzerland's filling station operator Coop Mineralöl reported of a considerably higher purchase cost for their hydrogen heavy-freight truck (Barret, 2017). This was a similar experience shared by ASKO, who received a subsidy of nearly 20 million NOK, or US$ 2,4 million from government enterprise Enova. The money was attributed towards developing the company's own hydrogen infrastructure, 10 hydrogen forklifts, and 4 hydrogen HFT's together with manufacturer Scania (Enova, 2017). Put in perspective, ASKO received from Enova a subsidy of only 2,25 million NOK for a similar project, but for 3 battery electric HFT's (Enova, 2017). High costs have been pointed at the techno-economic disadvantage for low-carbon technologies compared to ICEV's. This is influenced by factors of individual small-scale production, sometimes performed manually, lack of a critical mass, and not yet sufficiently proven full-scale business case (Pinchasik and Hovi, 2017; Quak et. al., 2016; Anandarajah et. al., 2013). As such, biofuels and low-carbon technologies differ notably, in which the latter typically demand a new engine system, where some biofuels such as HVO can be applied in conventional ICEV's (Kirkengen, 2017).

On the other hand, various other factors have been found to determine the strengths and weaknesses of each technology. IFE (2017) have illustrated a handful of influences in Figure 10, in which the scale of 0-3 determine the score, 3 being the area of biggest strength, and level of maturity as of 2017. Likewise, Norwegian municipality, Skedsmo, have described in Table 11 the various strengths and weaknesses in their strategy report, "Strategy for fossil-free vehicles". The various strengths and weaknesses are awarded either + or ++ depending on their level of strength, and on the contrary - or - - depending on their level of weakness.

Figure 10: A comparison of characteristics between technologies



Source: Adapted from IFE (2017).

Table 11: Strengths and weaknesses of various fuel propulsions

	Hydrogen	Biofuels	Electricity
Strengths	++ High energy density per weight unit ++ Energy carrier with good ability to store energy ++ Unlimited access to raw materials ++ No local emissions	++ High energy density per volume + Low fuel cost + Low engine cost + Offer high engine effect + Some biofuels require no modification of engine + Can use existing infrastructure	++ High energy efficiency at production and use ++ No local emissions ++ Low operational costs
Weaknesses	- - High operational costs as of 2017 - Low energy efficiency during production and usage - Demand unique infrastructure	- - Low energy efficiency at production and use - Limited access to sustainable raw materials for many biofuels - Provide increase or small reduction of local emissions	- Low energy density per weight unit - Low energy density per volume unit

Source: Skedsmo kommune (2017).

As of mid-2017, electric freight vehicles are operating in Oslo, while hydrogen freight vehicles are being tested in pilot projects (NHO et. al., 2016). For hydrogen, passenger vehicles are just about to nudge its way into the global market with a few models available (Stølen, 2016; Fuel Cells Bulletin, 2016; ETauto, 2016; Casey, 2017). The early stages of both technologies for heavier freight vehicles have given uncertainties as to how the uptake might evolve. This is particularly prevalent for hydrogen that have limited production of passenger transport vehicles, and more imperative infrastructure shortages (Nordic Energy Research and International Energy Agency, 2016; Anandarajah et. al., 2013; Miljødirektoratet, 2015).

However, both technologies have been found necessary to decarbonise the entire transport sector (Lind and Espegren, 2017). There is a shared consensus that a combination of technologies is likely to lead to the most sustainable solution (Nykvist et. al., 2017). In fact, international research foundation IFE has found that if the strengths of both battery electricity and hydrogen are leveraged in a hybrid solution[45], one can achieve a better result compared to separate usage (IFE, 2017). This was also supported by Anandarajah et al (2013), highlighting the two technologies are complementary in a short and medium-term timeframe, but could emerge as competitors in the long-term when the sector has largely decarbonised.

As of mid-2017 however, a firm decarbonisation strategy for vehicles performing urban transport is not clear, largely due to heavier vehicles demand a substantial amount of energy compared to passenger cars. There is also less available research on sustainable transitions for the freight segment (Nykvist et. al., 2017). Therefore, multiple pilot tests and projects have focused on a variety of technologies. This includes the EU funded project TRANSrisk[46], developing scenarios for biofuels, electrification along with biofuels, and hydrogen fuel-cell solutions along with full-scale electrification. This project expects to help decision makers evaluate low-carbon technology options (TRANSrisk, 2015; Nykvist et. al., 2017). Others have a more specific approach, including ELinGO[47]. This project brings in a multidisciplinary range of partners, primarily focusing on inter-urban road freight electrification (Norwegian Public Roads Administration and SINTEF, 2016). For hydrogen, the project H2Share focus on running trials on multiple hydrogen heavy-freight trucks at 6 locations in Europe until 2020 (Van der Laak, 2017).

Projecting a mass market for low-carbon vehicles in urban transport have proved difficult. Yet, mobility researcher Birgit Gebhardt argue ICEV's will not play a large role in the future (Gebhardt, 2016). Instead two different scenarios, on the one hand electromobility, and the other hand hydrogen through fuel-cells is regarded the most viable options. She further argues electromobility could be a bridge towards the most preferable alternative in fuel-cells (Gebhardt, 2016). Yet, electromobility has been argued to be of utmost importance also in the future. This is mainly due to significant economic power in mass markets including China who are continuously embracing batteries, combined with the mass-market power to determine the direction of the market, for which the global industry must adopt and follow (Gebhardt, 2016).

3.4 Low-carbon Vehicles Compared to ICEV's

Based on a study for the Norwegian government in 2015, the various environmental impacts and attributes in daily service were compared for electric and hydrogen technologies. This is illustrated in Table 12, but modified according to research performed in this study as of 2017.

[45] While referred to as a mixture of battery electric and fuel-cell hydrogen in this context, hybrid propulsion in this study refer to the mixture of diesel/gasoline and battery electricity.

[46] Funded through EU Horizon 2020, focusing on low-carbon transition pathways.

[47] Norwegian R&D project performing a concept analysis on electrification of HFT's.

Generally, however, Table 12 reflects most of the same environmental impacts and attributes in daily service as conducted by THEMA (2015). A comparison was made against the baseline of diesel.

Table 12: Comparison of diesel and low-carbon technologies

Propulsion	Environmental impacts		Attributes in daily service					
Fuel/Technology	**GHG emissions**	**NO_x and particulate matter**	**Range**	**Flexibility in driving pattern**	**Need for infrastructure**	**Fueling/ recharging time**	**Maturity**
Diesel	High	Low-high[48]	Normal	Normal	None	Normal	Mass-production
Battery Electricity	None[49]	None	Less than half	Medium	Medium[50]	Very long	Implementation
Hydrogen Fuel-Cell (Electrolysis)	None[51]	None	Less	Normal	Substantial	Normal	Design

Source: Adapted from THEMA (2015).

Other than the factors mentioned in Table 12, battery electric vehicles have not only fewer components, but also fewer movable components[52]. This contribute to lower maintenance costs. Electric vehicles often have no need for a gearbox as well, compared to ICEV's (Valle, 2015; ZERO, 2017). In terms of efficiency[53], gasoline ICEV's are found losing up to 70 % efficiency[54], and diesel vehicles 50 % (Valle, 2015). While various numbers exist in literature, the electric engine is estimated at worst losing 40 % efficiency, while at best could operate on 85 % efficiency (Valle, 2015). For urban driving, efficiency above 90 % could also be achieved due to electric vehicles providing supreme effect throughout the entire range of driving patterns (ZERO, 2017). Comparing low-carbon technologies, battery electric vehicles are found at minimum three times more effective compared to hydrogen fuel-cell vehicles (Transport & Environment, 2017). A part of the reason is that hydrogen needs to be electrochemically transformed to electricity before being able to power the electric motor (Den Boer, Aarnink, Kleiner, Pagenkopf, 2013).

As a result, hydrogen vehicles lose a significant amount of energy in the fuel-cells (THEMA et. al., 2016). Studies suggest a fuel-cell is 50 % efficient in producing electricity (Transport & Environment, 2017). As compared to diesel and gasoline vehicles however, hydrogen fuel-cell trucks are found to have a higher efficiency through factors of avoiding friction, combustion, and thermal losses (Den Boer et. al., 2013). This is only considering a tank to wheel[55] perspective however, in which does not capture the overall efficiency of transport, storage, distribution and

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[48] Depending on Euro vehicle class. Euro VI have lower NO_x and PM emissions compared to Euro V and below.

[49] Depending on electricity mix and life-cycle assessment.

[50] For heavy freight vehicles, the need for "fast-chargers", and not basic charging could be higher than what's assessed here.

[51] Depending on electricity mix and life-cycle assessment.

[52] 20 movable compnents in electric against more than 2000 in internal combustion engines' (NHO et. al., 2016).

[53] How much of the energy being injected is maintained driving the vehicle ahead.

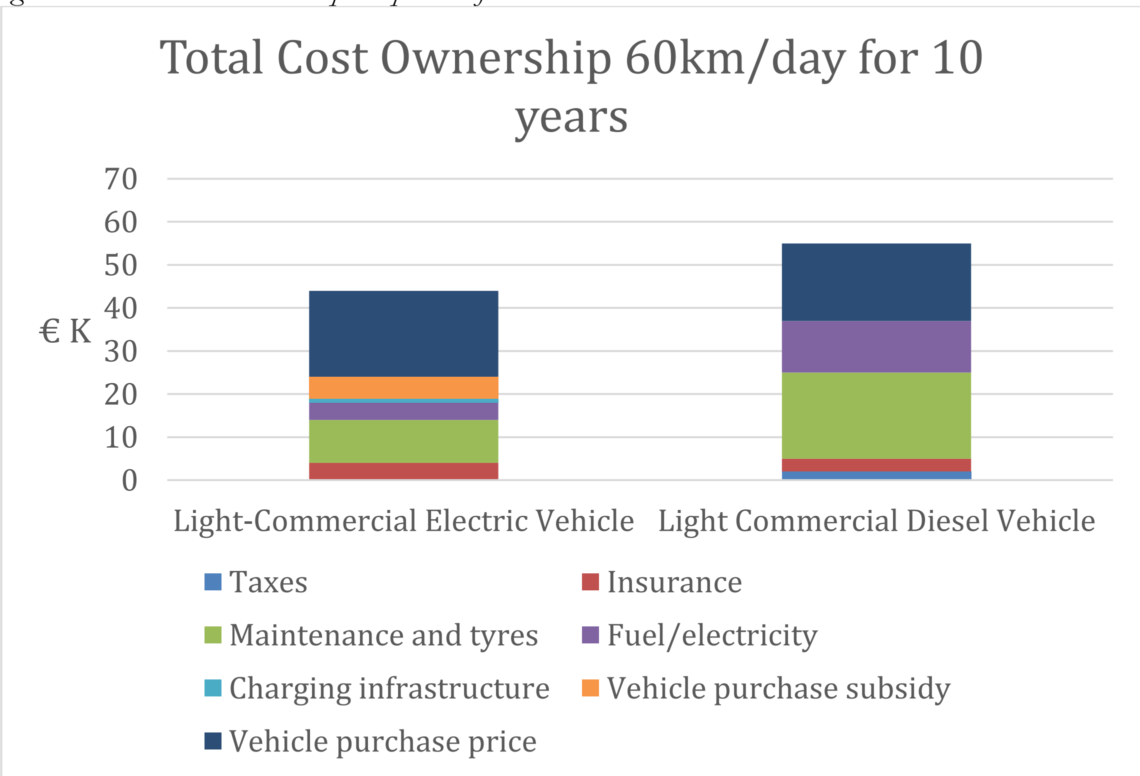
[54] Primarily in heat.

[55] Only considering tailpipe emissions (Transport & Environment, 2017).

in the case of hydrogen, electrolysis[56]. Adding a tank to wheel and well to tank[57] perspective, the overall efficiency of electric and hydrogen propulsions suggests battery electric vehicles achieve 73 % efficiency compared to 22 % for hydrogen (Transport & Environment, 2017).

Considering the business case as of 2017, studies on behalf of the Norwegian government suggested electric vans will not be competitive on price to ICEV's in a TCO (total cost ownership) perspective in the time leading up to 2030 (THEMA et. al., 2016). This has been contradicted by the now-ended EU project, FREVUE[58]. Findings suggested electric vans have a lower TCO compared to the equivalent diesel vehicle, based on average cost calculations across 8 European cities, including Oslo (Quak, 2017). Figure 11 illustrate this TCO comparison for what is referred to as light commercial vehicles, equivalent to vans in this study. The TCO comparison in Figure 11 suggest the variety of attributes related to the ownership makes an electric van cheaper in a 10-year perspective driving on average 60 km a day. The cost scale is measured in thousand (K) euro (€). Further, the factor of vehicle purchase subsidy in Figure 11 is added to include extra cost for authorities in providing subsidies. Under circumstances, the lower TCO comparison also held true for electric MFT's, while vehicles in the category of HFT's still had a higher TCO compared to diesel alternatives (Quak, 2017). As of 2017, no such studies have been conducted for hydrogen vehicles according to the literature reviewed in this research.

Figure 11: A total cost ownership comparison for vans



Source: Adapted from Quak (2017).

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[56] A process decomposing water into oxygen and hydrogen through an electric current being sent through the water. If applying renewable electricity in this process, hydrogen fuel-cell vehicles have the potential to have no exhaust of GHG emissions.

[57] Also considering upstream emissions. This includes extraction, refining and transport of fuels (Transport & Environment (2017).

[58] "Freight Electric Vehicles in Urban Europe". Norwegian company Posten Bring participated with 4 vans in Oslo.

Among others, not only lower maintenance and operational costs proved decisive for electric compared to ICEV's, but also lower fuel/electricity costs. Other studies suggest governmental support from larger time windows for delivery, zero/low emission-zones, and free parking have helped to further reduce the TCO for electric freight vehicles (Tretvik et. al., 2013; Hansvik, 2017). A shift towards low-carbon vehicles have also been found to potentially strengthen a firm's reputation towards customers and employees, and be a role model for others (Bjartnes and Michelsen, 2016; ZERO, 2016). This was not accounted for in Figure 11.

3.4.1 Battery Electric Vehicles

At the end of 2015, a total of 92 % of registered vans was fuelled by diesel, and 0.4 %, or 1808 applied electric engines, an increase of 80 percent from 2014 (NHO et. al., 2016; THEMA et. al., 2016). While still below one percent, this number went up in 2016, now representing 0.6 % or 2568 vehicles, a number closing to 3000 electric vans as of mid-2017 (Statistics Norway, 2017). Numbers appear slightly incoherent however, with some sources claiming the share of newly registered electric vans was at 2.1% in 2016 (NHO et. al., 2016), while the Ministry of Climate and Environment claimed the share of newly registered zero emission vehicles[59] was 1.8 % in 2016 (Ministry of Climate and Environment, 2017). Overall however, statistics show there is an overall increase of registered electric vans from 2015 to 2016, adding an additional 760 electric vans to the market in 2016 (Statistics Norway, 2017).

In conducting the "roadmap for industry and business transports", authors voiced their expectations for the entire market to represent 90 % electric vans in 2030[60], and electrification could remove 1.9 million tonnes of CO_2 leading up to 2030 (NHO. et. al., 2016). The growth of battery electricity is shared by studies on behalf of the Norwegian Ministry of Transport and Communications, an anticipation partly grounded in the Norwegian postal service company, Posten Bring's planned purchase of new electric vans and MFT's (THEMA et. al., 2016). The pioneering role of postal service companies have also been prominent in other countries such as Germany, where both independent post service provider, Hermes and postal service and international courier, Deutsche Post are making large investments for 2018 into electric vans and MFT's (Hawes, 2017; Edenhofer, 2017).

The development in electric vehicles in the freight segments have not experienced the same growth as in the passenger vehicle segment. This is not by chance. For electric passenger vehicles, full exemptions of major fees upon purchase have formed the baseline for a favourable economic business case. In fact, Norway has become a global forerunner referred to as the first mass market for electric passenger vehicles (Campbell and Sleire, 2017; Bjerkan, Nørbech and Nordtømme, 2016). The incentive scheme for electric vehicles in Norway is largely divided between national and local regulations, for which the latter is up to respective municipalities to decide whether should be continued or not. Table 13 illustrate the scope of the incentive scheme, which is also applicable to vehicles using hydrogen technology.

[59] The Ministry of Climate and Environment defines both electric and hydrogen vehicles as zero emission vehicles.

[60] It was not considered in this context whether electrification was battery electric or fuel-cell hydrogen propulsion.

Table 13: Incentives for electric passenger vehicles in Norway

Electric passenger vehicle incentive	National regulation	Local regulation
Exemption one-off registration tax[61]	Yes	No
Exemption VAT (value added tax)[62]	Yes	No
Half tax on company vehicles	Yes	No
Reduced annual motor vehicle tax	Yes	No
Exemption toll roads	No	Yes
Opportunity for free public parking	No	Yes
Bus lane access	No	Yes
Free ferry tickets	No	Yes
Free charging at public stations	No	Yes

Source: Bjerkan et al (2016). NAF (2017).

Economic incentives are not as prevalent for the freight segments however, mainly due to having a lower one-off registration tax and value added tax in the first place (Bjartnes and Michelsen, 2016; NHO et. al., 2016; THEMA et. al., 2016). For vans and MFT's between the weight of 3859kg[63] and 7500kg, the Norwegian Environment Agency emphasise only 22 % of the one-off registration tax is imposed on such vehicles, and no such fees exist for even heavier freight vehicles (Miljødirektoratet, 2015; THEMA et. al., 2016). This suggests savings can only be limited for purchasing low-carbon freight vehicles compared to low-carbon passenger vehicles (Miljødirektoratet, 2015). To stimulate growth in the freight segment, countries including Norway, the US, Japan, India, France, the Netherlands, and Spain have compensated by offering direct subsidies on purchase (Bjerkan et. al., 2016). In Norway, this has largely taken place through government enterprise Enova. Additionally, other than fiscal measures have proved decisive for low-carbon freight vehicles. Among others, Norwegian firm Sortimo highlighted the progressively increasing tolled roads in Oslo as an important factor for investing in electric vans (Arnesen, 2017). Another company, Veidekke, highlighted NOK 30 000 in annual operational cost savings per electric van as an important factor for their investment in electric vans (Aarhus, 2017).

For MFT's and particularly HFT's, predictions from the international research company HIS Markit highlights growth could reach 4 % of the EU and US market by 2025 (Behrmann, 2016). Prospects seem most promising for specific market applications at first however (Behrmann, 2016), for which cities are well suited in terms of extensive infrastructure network, and driving patterns that could be adapted to the specific needs of the user (THEMA et. al., 2016). This was also supported by truck manufacturer Scania who commented battery electric trucks will likely first penetrate in sensitive urban areas (ETAuto, 2016).

Various alternatives in the freight segments have emerged for electric vehicles, more so compared to the hydrogen market. Table 14 lists only a selected few models currently on the market or in planning. It should be noted that depending on the vehicle category used and weight, alternative studies may place separate vehicle models in other categories. The table further illustrate HFT's are making its entry, but are usually converted based on a chassis from

[61] Referred to as "engangsavgiften" in Norwegian, translation aquired from The Norwegian Tax Administration.

[62] Referred to as "moms" in Norwegian.

[63] Defined as an vans despite Table 2 in this study illustrating vans are only up to 3500kg.

large manufacturers such as MAN or Volvo (Pink, 2015). Notable exception from the retrofitting of existing vehicles seem on the rise however. This is evident not only with the upcoming Tesla Semi scheduled to be presented in November 2017. Also, truck manufacturer MAN has signalled serial production of electric trucks ranging from 12 to 26 tonnes starting from 2021 (MAN, 2017), and US manufacturer Cummins launched their all-electric HFT in August 2017 (Løvik, 2017).

Table 14: A selection of available and prospective electric vehicles

Model/developer	Category	Range in km (approximately)	Status of availability	Examples of application
Renault Kangoo Z.E.	Van	270	Now (upgrades in process)	University of Birmingham
Mercedes-Benz Vito E-CELL	Van	130	Now (upgrades in process)	Hermes Group
Nissan e-NV200	Van	170	Now	Extensive (e.g. AG Forster)
StreetScooter GmbH (several models)	Van	80-100	Now (upgrades in process)	Owned by Deutsche Post
Citroen Berlingo Electric L2	Van	170	Now (upgrades finished)	Extensive
Peugeot Partner Electric	Van	170	Now (upgrades finished	Extensive
Volkswagen e-Crafter	MFT	208 >	Early 2018	Unknown
Iveco Daily Electric	MFT	208 >	Summer 2017	Posten Bring
Renault Master Z.E.	MFT	200	End of 2017	Unknown
Mercedes-Benz electric Sprinter	MFT	200	Early 2018	Hermes Group
FUSO Canter E-Cell (Daimler)	MFT	100 >	First pilot in 2014	Stuttgart municipality, Enviro Waste
StreetScooter Work XL	MFT	80-200	Now (inidivdual orders)	Deutsche Post cooperation
LDV Ateco EV80	MFT	150 - 250	Trial stage (in Australia)	Courier companies
Hytruck (joint collaboration)	HFT	150	Available, converted truck	Heineken
Emoss Mobile Systems	HFT	200	Available, converted truck	ASKO, Transport Service Schelluinen
BMW Group and Terberg	HFT	80	Available, converted truck	BMW Group
PVI (Power Vehicle Innovations)	HFT	225	Available, converted truck	Sarpsborg municipality
Mercedes-Benz Urban eTruck	HFT	200	Trial, expected in 2020	Unknown
VDL ETS	HFT	100-120	Expected in 2017, converted DAF truck	Unknown
Cummins AEOS	HFT	160	Expected in 2019	Unknown
Tesla Semi	HFT	300-500	Launch September 2017	Unknown

Source: Author research

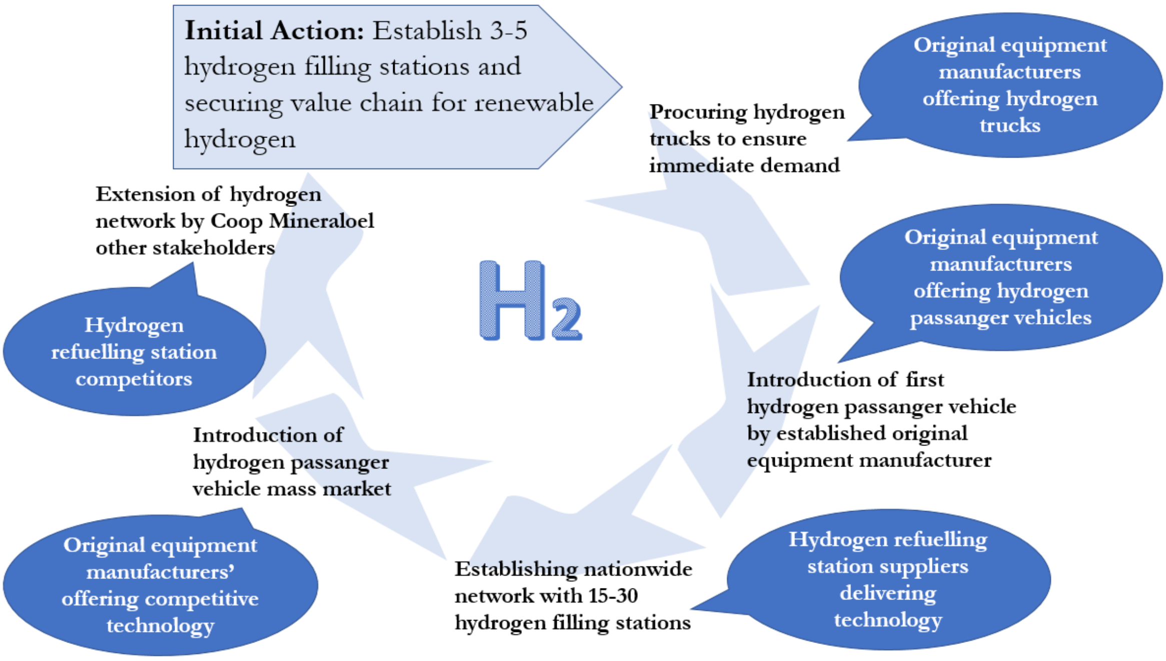
3.4.2 Fuel-cell Hydrogen Vehicles

While widely deemed a mature technology, only approximately 50 hydrogen vehicles existed in Norway as of 2017. These were mixed between two vehicle models both in the passenger vehicle segment (Brevik, 2017; THEMA et. al., 2016). In a study conducted by SINTEF on behalf of major Norwegian cities[64], it was highlighted it could take as much as 6 years from 2016 to have 340 hydrogen vehicles in Oslo, primarily in the passenger segment (Tomasgard et. al., 2016). This has led to studies in Norway suggesting hydrogen will not contribute significantly to reaching targets for GHG reductions by 2030 (THEMA et. al., 2016). To improve the business case and reduce costs, there has been focus on construction of hydrogen infrastructure. Globally, 224 stations existed in 2013, of which 43 % were in North and South America (Tomasgard et. al., 2016). While Denmark, Germany and United Kingdom have been the most active countries in Europe, national authorities in Norway have committed to building infrastructure for a total of 50 000 hydrogen vehicles in 2025 (Agency for Climate, 2017). This is a major investment considering only 5 hydrogen stations existed in Norway as of July 2017 (Norsk hydrogenforum, 2017).

Infrastructure for hydrogen have proved costly however, also for operations. Thus, direct subsidies, early operational support and feed-in-tariffs have been suggested to ensure a viable business case for hydrogen suppliers (Tomasgard et. al., 2016). Figure 12 illustrate Swiss filling station operator Coop Mineralöl's strategy for creating a hydrogen market. According to Coop, the key initial steps include upfront establishment of 3-5 hydrogen stations, for then to procure the company's own hydrogen trucks to ensure immediate demand. A key element is linked to third party engagement however. This include OEM's offering serial produced hydrogen trucks and passenger vehicles, and other suppliers further developing an extensive refuelling network of 15-30 hydrogen stations nationwide. Eventually, a mass market could emerge given proper engagement from third party stakeholders and the frontrunner role of Coop. While Coop Mineralöl's broad business segments allow the company to develop both filling stations and procure vehicles, few operators could likely take this role in Norway. This signify collaboration is needed. The Norwegian city Bergen has confirmed such an intention, receiving government funding from Enova equivalent to 20 million NOK for two hydrogen stations (Enova, 2017). Subsequent plans include for the local taxi company, Bergen municipality and Hordaland county council to procure 5 hydrogen vehicles combined (Enova, 2017). The latter process ensures an immediate demand.

[64] Oslo, Bergen, Stavanger and Trondheim.

Figure 12: Implementation plan for hydrogen technology in Switzerland



Source: Adapted from H2 Energy AG (2015).

While experiencing gradual market penetration and incentives similar to battery electric vehicles in Norway, the International Energy Agency (IEA) concluded in 2015 that most fuel cell and hydrogen technologies are still at an early stage. High costs were pointed out as the main reason for lack of competitiveness (IEA, 2015). Yet, this has not prevented Hyundai, Honda, and Toyota in developing hydrogen passenger vehicles ready for mass production (IFE, 2017). Moreover, together with only a handful of other operators globally including Coop Mineralöl, Norway's convenience wholesaler ASKO is developing one of Europe's very first hydrogen heavy-freight trucks. The first vehicle is scheduled to enter operations in 2018 (Scania, 2016). NHO et al (2016) highlights hydrogen has an enormous potential in the transport sector, and Norway has some favourable conditions in pioneering this technology. Table 15 describe some of these conditions. Competence in Carbon Capture & Sequestration (CCS) has been found vital in the scenario for which hydrogen is produced from natural gas, and not renewable electricity.

Table 15: Favourable prerequisites and examples in a Norwegian context

Favorable prerequisites in Norway	Examples of organisations
Private sector with vast knowledge	Hexagon and NEL
Strong R&D environment	SINTEF, IFE and TØI
Access to energy from renewable sources	N/A
Amplified access to natural gas	N/A
Competence in CCS	ZEG Power and Reinertsen
Strong Fiancial Resources	Enova, Innovation Norway, and Norwegian Research Council

Source: NHO et al (2016). IFE (2017).

In the future, studies suggest hydrogen could mature significantly after 2025 (THEMA et. al., 2016). For national targets, the Institute of Transport Economics suggest Norway needs close to 7000 hydrogen HFT's within 2030 to reach the goal as put forward by national authorities (Fridstrøm and Østli, 2016). That is, 50 % of heavy-freight trucks being zero-emission within 2030[65] (Ministry of Transport and Communications, 2017). The Norwegian Road Transport Association (NLF) highlighted the target could be feasible, but under conditions of significant incentives from national authorities (Stølen, 2017).

To further stimulate hydrogen, Norwegian research organisation SINTEF found the lack of a national hydrogen strategy as a drawback for further investment in hydrogen, and authorities not emphasising hydrogen as a key focus area in the public debate (Tomasgard, 2016). The high investment cost in both infrastructure and vehicles have increased focus on government enterprise Enova to further stimulate hydrogen through various subsidy schemes. However, studies have found some stakeholders perceiving Enova unclear in their opinion on hydrogen (Tomasgard, 2016). Others have called for Enova to make a clearer stance by ranking various fuel propulsions, to communicate the priorities and direction of the market more clearly (IFE, 2017).

Compared to the market for electric URFT vehicles, availability of hydrogen vehicles is lower both for the passenger and freight segment. This is shown in Table 16. Notable exceptions of retrofitting also exist for hydrogen however. Toyota have launched their very own hydrogen heavy-freight truck in California, US. Also, Norwegian operators Tine, Tenden and VT Gruppen have ordered the Nikola One model equipped with a hydrogen fuel-cell technology, estimated for arrival in 2019 (Arnesen, 2016).

Table 16: A selection of available and prospective hydrogen vehicles

Model/developer	Category	Range in km (approximately)	Status of availability	Examples of application
Renault Kangoo Z.E.	Van	300	Now, converted by Symbio	Braley, Skedsmo Municipality, and DHL
Nissan EV-200 H2	Van	600	2018, converted by Symbio	Taxi Parisien
UPS fuel cell truck	MFT	Unknown	Prototype end 2017	UPS
Scania	HFT	500	Pilot late 2018	ASKO, Norway
ESORO (joint collaboration)	HFT	375-400	Now, converted by ESORO and others	Coop Mineralöl, Switzerland
VDL ETS	HFT	Unknown	Pilot late 2018. A converted DAF	Unknown
Kenworth T680	HFT	Unknown	Testing end 2017	Los Angeles Seaport
Toyota – «Project Portal»	HFT	320	Current pilot project	Unknown
Nikola One	HFT	1900 >	2019 and onwards	Tine, VT-gruppen and Tenden, Norway

Source: Author research

3.4.3 CO_2 Emissions Throughout the Life Cycle

In his book "Achieving Sustainable Mobility" from 2007, Erling Holden highlights while alternative fuel sources reduce environmental impacts in one category, they could likely increase

[65] For the sake of this research and similarity, this research will interpret light vans as vans, heavy duty vehicles as MFT's, and trucks as HFT's, as translations to the original definitions by Ministry of Transport and Communications (2017).

environmental impacts in another category, thus "it is not very likely that the use of alternative fuels will reduce overall total environmental impacts" (Holden, 2007, p. 181). Given the strong market penetration of battery electric vehicles in Norway and elsewhere, questions have emerged as to GHG emissions during the vehicles entire life-cycle. A life-cycle assessment[66] (LCA) is a valuable tool to make such an analysis. Due to its larger market penetration compared to hydrogen, most literature have only considered battery electric vehicles in a life-cycle context. Table 17 highlights conclusion from some available studies.

Table 17: A selection of studies considering the life cycle of battery electric vehicles

Source	General conclusion on life cycle emissions
Lee, Thomas, and Brown (2013)	• Study focused in the US in urban areas • 42-61 % less GHG's from battery electric compared to diesel • Number fluctuates depending on numerous variables including electricity mix
Sen, Ercan and Tatari (2017)	• Study focused in the US on long-distance transport • Potentially 63 % less GHG's from battery electric HFT's compared to diesel HFT's • Number fluctuates depending on electricity mix
Romare and Dahllöf (2017)	• Study based in Sweden, not considering use phase, focused on vans • Data currently not transparent enough to draw conclusions on a battery's GHG emissions in production
Zhao, Onat, Kucukvar and Tatari (2016)	• Study focused in the US on urban areas • Electric trucks have higher GHG's and energy consumption than other trucks • Electric vehicles could have lower GHG's depending on regional electricity mix of cleaner energy

Other than the importance of the electricity mix, Ellingsen et al (2013) highlight the manufacturing of battery cells are the most impact intensive in the life cycle chain. For increasing battery electric vehicles competitiveness towards ICEV's, the same study underlined policymakers and the industry must increase emphasis on R&D resources, cleaner electricity sources in manufacturing of batteries, increasing battery lifetime, and closing material loops by recycling (Ellingsen et. al., 2013).

In a more recent study, the production phase was once again stated as the most intensive in terms of GHG emissions (Ellingsen, Hung and Strømman, 2017). However, the scientific community were referred to as still not able to give a unified answer of GHG emissions related to the production phase, and research gaps were prevalent in that few studies had so far considered the use phase and end of life treatment of batteries (Ellingsen et. al., 2017). Building on the GHG emissions from the production phase, Norway's leading engineering magazine concluded producing electric vehicles generate twice the amount of CO_2 compared to fossil-fuel vehicles (Tonstad, 2017). This was primarily due to battery production, where the extraction of cobalt, nickel and lithium demanded high energy usage, and were extracted from countries in primarily in South America (Tonstad, 2017). However, the same study also concluded during the entire life-cycle, electric vehicles on a petroleum energy mix would lead to a 24 % reduction in GHG's compared to an ICEV, and up to 64 % on a renewable energy mix (Tonstad, 2017).

[66] Assessing the environmental impacts of a product's entire life cycle, from raw material extraction to disposal.

On the other side, having assessed future technologies and manufacturing processes, German mobility research Birgit Gebhardt highlighted the best ecological long-term solution would be the hydrogen fuel-cell technology as compared to battery electricity. This was justified by referring to the recycling and weight of the batteries, including unsustainable extraction of lightweight materials (Gebhardt, 2016). As such, it was concluded much of the current research had calculated life-cycle emissions for battery electric vehicles in a very beneficial way (Gebhardt, 2016).

While the hydrogen fuel-cell technology has encountered less attention compared to battery electric life cycle assessments, platinum extraction for fuel-cell production has been identified as a potential challenge. Whereas platinum is both expensive and rare, researchers from Chalmers University in Sweden and the Technical University of Denmark have discovered a new type of nanocatalyst that could potentially reduce the need for platinum in the production phase (Palmgren, 2017). Considering the rapid technological development as experienced in the transport sector in 2017, Norwegian NGO, ZERO claimed new technology would likely replace the need for raw materials such as lithium in the future (Tonstad, 2017).

From an overarching perspective, research is continuously shifting attention towards risks and impacts associated with technology choices, including new resource dependencies (e.g. cobalt and lithium for batteries) (Nykvist et. al., 2017). On the other side, technology is continuously progressing to improve energy density in batteries. Ramoni and Zhang (2013) argue this factor has increased the residual value and made batteries more attractive after they can no longer be used in vehicles, claiming a battery has approximately 80 % capacity left. Thus, not only the recycling of valuable and limited raw materials are central elements in the future of low-carbon propulsions, but also electricity mixes as reflected in Table 17. Concerning the public stand politically as of 2017, The Norwegian Ministry of Climate and Environment argue there is a clear tendency electric vehicle is more climate and environmentally friendly compared to ICEV's (Ministry of Climate and Environment, 2017)

3.5 Stakeholders

Various stakeholders are engaged in urban road freight transport in Oslo and elsewhere. Stathopoulos, Valeri and Marcucci (2012) highlights that whereas traditional studies have focused on some single stakeholders in their research, a wider perspective is needed to not only understand complex interactions, but also improve urban freight planning and improve policies. Suksri et al (2012) reinforce this statement stressing the need for a comprehensive approach incorporating several stakeholder insights and different criteria in the assessment process. This was argued to likely increase the probability of accepting the proposed solution. Thus, the framework for this study as seen in Figure 7 could be deemed representative in terms of incorporating various stakeholder perceptions. However, literature suggests a few modifications to the original framework adapted from Ballantyne et al (2013), primarily regarding who stakeholders should be.

There is a broad consensus that both freight operators and authorities (national and local) are two of the key stakeholders directly impacting URFT. However, research from Transport & Environment (2017) suggests authorities should be expanded to the EU level, given their influence on member states including Norway in the framework of the European Free Trade Association (EFTA) membership. As reflected in Figure 7, Ballantyne et al (2013) also include customers and shippers as stakeholders having a direct impact on urban freight. Among other studies suggesting stakeholders directly impacting URFT, Kijewska et al (2016) makes the case for wholesalers, carriers, and handling service companies, which is largely covered in the category of freight operators in Figure 7.

Furthermore, Nordtømme et al (2015) highlight the most relevant stakeholders in the urban distribution chain as local authorities, freight operators and end-receivers. This is a similar approach to Stathopoulos et al (2011) who also include customers and inhabitants of the city, reflecting the broad category of customers seen in Figure 7. Tanaguchi et al (2001) expands the scope to include four key stakeholders with large subdivisions, namely freight carriers (warehouse companies and transporters), residents (consumers), shippers (retailers, wholesalers, and manufacturers), and administrators (city, state, and national level).

Further expanding on the stakeholders in Figure 7, architects have been included in a study primarily focused on loading and unloading zones for freight vehicles in Norwegian cities (Rambøll Norge, 2008). This view was shared in more recent time by Spurkeland (2016), underlining the need to include, among others, both architects, property owners and receivers of goods to improve efficiency. As such, while most stakeholders in Figure 7 reflect what's found in literature, architects seem to be a missing stakeholder in this framework, along with expanding the scope of authorities to also include the EU. An updated framework is presented in the result section.

3.5.1 Assessing Roles

The Norwegian government is central in determining political priorities for any sector, also in transport. Having committed to targets of reducing GHG emission through international agreements such as the EU's ESR, the government has created an overarching political direction for the future of transport (Bjartnes and Michelsen, 2016). While the Norwegian Ministry of Transport and Communications are responsible for GHG emissions in road transport, various ministries have a mandate affecting road freight in an urban context. This include the Ministry of Trade, Industry and Fisheries sorting technology export, and the Ministry of Petroleum and Energy focusing on national emissions. They also have the ownership of government enterprise Enova (IFE, 2017). In addition, the Ministry of Climate and Environment are responsible for biofuels, while the Ministry of Finance make final priorities as to several fiscal rates including tax rates on fuels (IFE, 2017).

Local authorities in Oslo is another key stakeholder with direct influence, perhaps the most decisive considering their ability to directly influence developments within their legal boundaries. In fact, research has suggested cities are able to be even more influential than nations in reducing GHG emissions (Jordan et. al., 2015). Like national authorities, responsibilities for URFT is dispersed internally, but mainly within the City Council for Environment and Transport[67]. At the agency level, the Agency for Climate, Agency of Urban Environment[68], and Agency for Improvement and Development[69] are some of the agencies affecting freight operations in the city. The latter agency is under a separate council, namely the City Council for Finance[70]. While the list goes on, examples include the Agency for Climate's role in coordinating environmental and climate efforts, the Agency of Urban Environment's role of conducting a concept study for a low-emission zone, and the Agency for Improvement and Development's role of managing criteria for public procurements.

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[67] Referred to in Norwegian as "Byrådsavdeling for miljø- og samferdsel".

[68] Referred to in Norwegian as «Bymiljøetaten».

[69] Referred to in Norwegian as "Utviklings- og kompetanseetaten».

[70] Referred to in Norwegian as "Byrådsavdeling for finans".

Freight operators have a direct impact through ultimately purchasing low-carbon vehicles. They also oversee technical specifications of the lorry (Liimatainen et. al., 2014). Among the operators in Oslo, ASKO and Posten Bring already use electric vehicles in their urban distribution fleet. Smaller operators have purchased primarily electric vans. Also, shippers have a direct impact on URFT. At times, this stakeholder group not only perform their own transport operations, but also have their own needs and requirements for each transport. Liimatainen et al (2014) argue decisions made by shippers could enable or disable the prospects to decarbonise road freight.

Customers are also directly making an impact. By establishing criteria towards freight operators, NLF argue customers and buyers of transport could affect the development of truck transport in a more sustainable direction (Norges Lastebileier-Forbund, 2016). This could include demanding only electric vehicles in their orders (Norges Lastebileier-Forbund, 2016). NLF have adopted the program Fair Transport, to among others educate and make easier for transport buyers to choose sustainable freight operators, also in terms of social conditions (Stølen, 2017).

Having an indirect impact on the urban road freight sector, commercial organisations and trade associations often provide inputs to authorities. For trade associations, Ballantyne and Lindholm (2013) argue freight associations in various countries often have the primary contact with authorities speaking for their members. NGO's are also having an indirect impact, working to get foothold for their views politically. Norwegian NGO's including ZERO and Bellona have for long advocated for, facilitated workshops, and lobbied to enhance the uptake and use of electric and hydrogen vehicles in Norway. Among others, ZERO have established a forum for renewable transport to enhance stakeholder collaboration. These include shippers, freight operators, customers/buyers of transport, and authorities (ZERO, 2017).

Academic and research organisations such as TØI have a broad working context, and have an indirect impact. They create predictions and calculations on themes such as market trends for low-carbon technologies and potential impacts of policy measures. Among others, TØI have previously conducted calculations of a potentially new tax system for road use duty on fuels[71] (NAF, 2017). As such, they not only provide inputs to policy makers nationally and locally, but also steer the public conversation. While having numerous roles in Norway, the public agency NPRA also have a key role in URFT, prominently through coordinating R&D projects such as Bylogistikk[72].

OEM's and vehicle manufacturers also have an indirect impact on the sector. Serial production of low-carbon freight vehicles could create lower purchase costs, more extensive service support, send strong market signals, and contribute towards economies of scale. As an example, current retrofitting of low-carbon freight vehicles demonstrates drawbacks in that numerous subcontractors are involved, purchasing separate components such as chassis, fuel-cells, and engines from various suppliers. This is a complex process often resulting in high costs and substantial resources for the freight operator. Thus, public transport operator in Oslo, Ruter will likely play a role in developing a market for heavier low-carbon vehicles such as buses based on OEM models. This could help motivate the market and send a strong signal to authorities of the feasibility of adopting low-carbon technologies for heavier vehicles. Among others, Ruter has the objective to use only renewable energy sources for their current fleet of more than 1100 buses in 2020. This include battery electric and hydrogen fuel-cell propulsions (Roland Berger Strategy Consultants and Ruter, 2015).

[71] Referred to in Norwegian as "veiavgiften" or "bensinavgiften". Levied on the content of fuels.

[72] R&D project between 2016 and 2021 to enhance knowledge of freight and other transport modes in urban areas.

3.6 Policy Measures

In discussing the transition towards a green energy economy[73] (GEE), of which battery electric vehicles is entailed, research has suggested there is an overabundance of policies and low-carbon technologies at current disposal (Mundaca et. al., 2016). Leading organisations in the Norwegian transport sector argue not only sticks such as taxes is the way to go, but also carrots including direct subsidies (NHO et. al., 2016). This indicate both financial and non-financial measures are necessary to stimulate low-carbon technologies. Quak et al (2016) argue non-financial incentives are of vast importance as they provide freight operators a long-term competitive advantage.

Policy measures in URFT are often numerous and difficult to predict the outcome of (Macharis, 2005). This follows observations that the sector is found heterogenous, complex, and often poorly understood by policymakers (Holguín-Veras et. al., 2017). Eidhammer and Andersen (2015) argue the effect of policy measures are usually not properly documented, and are often based on simple calculations. This factor is important due to studies suggesting comprehensive policy assessments could help mitigate unintended outcomes in the future (Mundaca et. al., 2016). Despite requiring intensive use of resources and being complex, policy assessment could offer continuous learning opportunities for policymakers and other stakeholders, also bridging the gap between policymaking and science (Mundaca et. al., 2016).

For the variety of policy measures, some studies have made clusters of categories. Cherrett et al (2012) and studies on behalf of the European Commission apply a broad categorisation including regulatory, market-based, land use planning, infrastructure, new technologies and management and other measures (MDS Transmodal Limited and CTL, 2012). Stathopoulos et al (2012) use a similar method, including market based measures, regulatory measures, land use planning, infrastructural measures, new technologies and management measures. McKinnon (2003) have a more overarching nature. These include fiscal measures, financial incentives, regulations, infrastructure and land-use planning, and advice and incentives. Filippi et al (2010) also limit the number of categories, separating measures into freight traffic regulation, physical infrastructure, Intelligent Transportation Systems (ITS), and loading units and vehicles.

To further narrow it down, Green, Skerlos, and Winebrake (2014) apply only three categories. These include R&D, investments in charging infrastructure and service equipment, and vehicle tax credits or rebates. Lindholm (2013) also apply three categories only, namely infrastructure, restrictions, and consolidation. Furthermore, studies performed on behalf of the Norwegian Ministry of Transport and Communications consider fiscal incentives, regulatory measures, facilitation of infrastructure and information sharing (THEMA et. al., 2016). For the study at hand, the overarching categorisation from Hood and Margetts (2007) cover many of the options presented in literature, namely fiscal, legal, organisational, and communicational measures.

Salama et al (2014) discuss the legal measure of privileged loading and unloading bays for low-carbon technology vehicles, while Taefi et al (2016) specifically apply policy measures from all four categories provided by Hood and Margetts (2007). It should be noted however, many studies including Muñuzuri et al (2005) discuss both individual policy measures, and overarching categories. Referring to section 2.2.4, this study adopts a similar approach.

Based on preliminary research in the ARSCP course, and literature review for this study, a list of policy measures has been developed connected to the primary research question and first

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[73] Defined as the scientific and policy subject area that focuses on how the expansion of resource efficient and low-carbon energy technology systems , markets and services can bring together economic, environmental, social and security aspects. A key focus of GEE is policies and strategies that are designed to foster the rapid transition towards sustainable energy economy systems (Mundaca et. al., 2016).

sub-question (SQ1). The list contains policy measures that could promote the uptake and use of low-carbon technologies, and reduce GHG emissions in URFT by other means. This can be found in appendix 7.1. Table 18, and Table 19 lists some of the key policy measures currently in place as of 2017, separated between local authorities in Oslo and national authorities in Norway. It also lists policy measures having been proposed. This is not to indicate the entire range of implemented and proposed policy measures are all accounted for, but rather some of the most important from literature. To align these policy measures with the dynamic nature of their implementation, both tables also include a "Phase" section, ranging from A, B, C, and D.

A: The policy measure has already been analysed and created a strategy for.
B: The policy measure is currently in or past pilot project stage.
C: The policy measure has been implemented based on arrangement to further reduce GHG's
D: The policy measure is being modified after implementation to further reduce GHG's.

Table 18: Key existing and projected measures for low-carbon freight by national authorities, Norway

Selection of current policy measures	Description	Phase
CO_2 tax	Paid as part of the fuel price. Main purpose to charge for CO_2 emissions	A, B, C, D[74]
Road use duty on fuels	Paid as part of the fuel price. Charge road users for external costs of using roads	A, B, C, D[75]
Toll roads charges	E.g: Full exemption or environmentally differentiated tolled roads charging	A, B, C, D
Annual weight-based motor vehicle tax	Applicable to vehicles at least 7500 kg. Lower charges based on highest Euro (I – VI) standard	N/A[76]
Green public procurements	Increased emphasis on procuring low-carbon propulsions	A, C[77]
Enova subsidy (technology)	Offer subsidies for additional costs for electric and hydrogen freight vehicles	N/A
Enova subsidy (infrastructure)	Offer subsidies for additional costs for infrastructure for electric and hydrogen	N/A
Enova subsidy (others)	Offer subsidies for additional costs for fullscale energy- and climate technology projects	N/A
Proposed new policy measures	**Description**	**Status**
Establishing CO_2 fund	For business related transport[78]. Elaborated on in later section	A
Increased scrapping subsidy	Receiving scrapping subsidy up to 13 000 NOK to invest in low-carbon freight vans, possibly up to 50 000 NOK[79]	A
Prolong toll roads and other incentives for low-carbon freight vehicles	Reference to Table 13. A commitment for toll roads exemption and bus lane access for low-carbon freight vehicles until 2025	A

Source: Agency for Climate (2017). THEMA et al (2016).

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[74] Is already implemented. The tax rate is continuously debated.

[75] Same as the CO_2 tax. A "distance-based" model of this tax has been proposed (THEMA et. al., 2016).

[76] Not aplicable. Could vary in the long-term perspective.

[77] New criteria for a more strict focus has been enacted as of early 2017 (Hagelien, 2017).

[78] Final segments yet to be determined, but likely to include buses, trucks, light trucks, construction machinery, domestic shipping, and fisheries.

[79] Service and trading company, Bertel O. Steen have increased the subsidy making it a total of 50 000 (Abrahamsem, 2017).

Table 19: Key existing and projected measures for low-carbon freight by local authorities, Oslo

Selection of current policy measures	Description	Phase
Environmentally differentiated toll roads and congestion charging	Higher charges for vehicles emitting more GHG's, NO_x and PM	A, C
Green public procurements	The City Council of Oslo develops a procurement strategy with key focus on climate	A, C
Establishing energy stations (passenger vehicles and vans)	Stations offering fuel propulsions including electric, hydrogen and biofuels to strenghten the market for supply	A, C
Establishing energy station at Alnabru, Oslo (vans and heavier freight vehicles)	«Lighhouse project». Same as energy stations, but specifically for heavier freight vehicles.	A, B
Construct charging infrastructure	Primarily basic charging infrastructure for battery electric vehicles, partly in cooperation with private actors	A, C
Considering a consolidation centre[80]	Improve logistics and reduce freight vehicles in city centre	A
Establishing low-emission zones	Primarily reducing NO_x emissions and PM, not GHG's	A, B, C
Push for improved national policy measures	Continuous process. Include among others increased differentiation of taxes, and inputs to various political processes	C
Shared hydrogen strategy with Akershus County Council	Strategy aimed to be a global leading region for hydrogen in transport. Wants to develop fleet of vehicles and infrastructure	A
Proposed new policy measures	**Description**	**Status**
Low-emission waste collection vehicles	Targeted for waste transport between waste facilities only, not pickup from households	A
Double the amount of charging stations for battery electric vehicles	The current goal as of 2017 is 200 new charging points annually. A doubling is proposed	A
Enhanced marketing of Enova subsidy schemes	In 2016, Enova invested a total of 2,3 billion NOK in energy and climate projects (Enova, 2017)	A

Source: Agency for Climate (2017). Mordt, Jonassen and Martinsen (2017).

It should be noted both Table 18 and Table 19 supplement several of the incentives already enacted for low-carbon vehicles from Table 13. That is, fee exemptions upon purchase and other incentives such as bus-lane access for low-carbon vehicles, administered at both national and local level. Furthermore, several of the policy measures are placed under more than a single letter in the "Phase" section, reflecting the policy measure is either being continuously assessed, or currently being in one or more phases. Some policy measures have also been considered difficult to place within a specific phase, reflecting the phrasing of not applicable (N/A). Apart from a few external sources, identified policy measures and the phase section was largely based on research from local authorities in Oslo, more specifically the Agency for Climate. Thus, the "Phase" section in Table 18 for what concerns national authorities should be interpreted with caution, and may not be fully aligned with current status as of mid-2017.

3.6.1 Fiscal Measures

Fiscal measures are defined as to reduce the TCO of low-carbon vehicles or increasing TCO for conventional ICEV's (Taefi et. al., 2016). A global study from the ICCT suggests fiscal measures could be powerful to reduce the TCO for low-carbon vehicles (Mock and Yang, 2014). This is reinforced by global studies focusing on road freight, claiming purchasing decisions are nearly exclusively rational and based on economic considerations only (Deloitte, 2016).

[80] Estimated to be implemented earliest in 2019 (Agency for Climate).

Thus, subsidy schemes are relevant in this context. In Norway, government enterprise Enova has seen a progressively larger mandate in their work to transition Norway into a low-carbon society (Enova, 2017). Repeatedly, the Norwegian government have stressed the importance of Enova in supporting both electric and hydrogen vehicles in all segments, including for road freight and infrastructure (Ministry of Climate and Environment, 2017). The government has also voiced its intentions to cooperate with the Confederation of Norwegian Enterprise (NHO) to establish a CO_2 fund[81] (Ministry of Climate and Environment, 2017). As should be noted however, research have identified potential bottlenecks in that financial contributions don't fully reduce the price of low-carbon vehicles compared to ICEV's, and the risk of manufacturers inflating their price according to the subsidy (Bakker and Trip, 2013; Green et. al., 2014).

Further, studies highlight green public procurements could stimulate low-carbon technologies. This policy measure is designed to make purchases reducing the environmental impact across a service or products life cycle (Rainville, 2016). In Norway, the public sector annually purchases goods and services equal to 15 % of Norway's gross domestic product (GDP) (Statistics Norway, 2016). New and more strict regulations for public procurements were presented in 2017, emphasising promotion of climate friendly solutions where possible (Hagelien, 2017). A similar approach has also been a focus for local authorities in Oslo (Agency for Climate, 2017).

Other fiscal measures include a variety of subcategories under toll roads. Among others, these include environmentally differentiated road charging, congestion charging, toll roads exemption, and reduced rates in the tolled roads. The Norwegian government have previously identified the tax system as the most important policy measure in climate policy (Melgård, 2016). However, the minister of climate and environment emphasised higher CO_2 taxes on conventional fuels would not necessarily lead to reduced traffic (Melgård, 2016). Studies on behalf of the Ministry of Transport and Communications underscore the complexity of this matter, arguing while vehicle operators put more emphasis on purchase rather than operation costs, an increased CO_2 tax of 25-50 % is recommended, and would not lead to socioeconomic losses (THEMA et. al., 2016). Other taxes being widely discussed in literature include environmentally differentiated road charging, a measure set to come into effect during the fall of 2017 in Oslo (Juven, 2017). Table 20 illustrate only a selection of fiscal policy measures from literature, and a variety of sources emphasising their importance. This is based on the complete overview of policy measures from literature in appendix 7.1.

Table 20: A selection of fiscal measures based on literature review

Policy measure	**Selection of sources**
Green public procurement in public tenders	The City Council of Oslo, 2016; NHO et. al., 2016; Quak et. al., 2016; THEMA et.al., 2016; IFE 2017; Norges Lastebileier-Forbund, 2016
Subsidy schemes	NHO et. al., 2016; Tretvik et. al., 2013; THEMA et.al.,2016; Bjartnes and Michelsen, 2016
Increased CO_2 tax on conventional fuels	NHO et. al., 2016; Tretvik et. al., 2013; Fridstrøm and Østli, 2016; THEMA et.al., 2016; Bjartnes and Michelsen, 2016
Environmentally differentiated road charging	The City Council of Oslo, 2016; NHO et. al., 2016; Tretvik et. al., 2013; MDS Transmodal Limited and CTL, 2012
Toll roads (reduced or full exemptions)	Bakker and Trip, 2013; Suksri et. al, 2012; MDS Transmodal Limited and CTL, 2012; Bjartnes and Michelsen, 2016

[81] For business related transport. Based on a concept to use the CO_2 tax to stimulate and invest in technologies reducing GHG and other emissions from transport.

3.6.2 Legal Mesures

Legal measures are defined as when the government utilise its authority to enable or prohibit certain activities, by examples of changing legislation or certification schemes (Taefi et. al., 2016). Among the various measures in this category, Bakker and Trip (2013) finds a compelling aspect in that several legal measures have less impact on national or municipal budgets. As a measure incorporated in the incentive scheme for electric vehicles, access to bus lanes for road freight vehicles have been found to save one hour daily for postal service company Posten Bring (Sagplass, 2017). On the other side, the entry of electric vehicles in bus lanes have reportedly created negative side effects including congestion. Public transport operator in Oslo and Akershus, Ruter, have previously made strong complaints on this matter (Bråthen, 2015). While only applicable for low-carbon freight vehicles as of 2017, researchers have suggested permitting all freight vehicles in bus lanes could reduce quieing cost of up to 59 % on one of the most heavily trafficated roads in Oslo (Caspersen and Hovi, 2016). Representing most of the freight operators in Norway, NLF have also advocated for the economic savings if freight vehicles were allowed in bus-lanes, regardeless of their fuel propulsion (Norges Lastebileier-Forbund, 2016).

Free or privileged parking for low-carbon vehicles have also been discussed in literature as a legal measure. Studies have found this measure being less acceptable among policymakers (Taefi et. al., 2016). On the contrary, Salama et al (2014) argue reduced TCO could be the outcome, while also improving efficiency of low-carbon vehicles. Among the participants in the EU funded FREVUE project, Amsterdam reported positive experiences in granting electric vehicles access to such as parking in restricted zones, and enter certain pedestrian areas. These were factors freight operators found to make a more viable business case for investing in low-carbon vehicles (Pink, 2017). On the other hand, Bakker and Trip (2013) highlight resentment from drivers of ICEV's could be a drawback. In Oslo, the project "Bilfritt byliv" has the ambition to remove not only parking areas, but also vehicles within the city, potentially capable of increasing the access for urban goods deliveries (Agency for Climate, 2017).

Furthermore, low-emission zones are another prevalent legal measure in literature. For Oslo however, the proposed zone is not designed strict enough to promote the uptake and use of low-carbon vehicles, but rather higher classes of the Euro standards (THEMA et. al., 2016). As an alternative, zero-emission zones could permit only low-carbon vehicles to enter zones within the city, as have been suggested for London in 2025 (Roberts, 2017). Among the controversies for implementing either a zero or low-emission zone, THEMA et al (2016) stress the potential negative effect of increased competitiveness for shopping centres outside cities. This would subsequently make shops within city centres less economically viable.

Certification of transport companies is another legal measure authorities could implement. Among others, the city of Parma in Italy has given only freight operators with a certification allowance to deliver in the city centre. Taefi et al (2016) argue freight operators could use certification schemes as a marketing tool when promoting their services to customers. Also, London have implemented the Fleet Operator Recognition Scheme (FORS), designed to offer a bronze to gold accreditation based on implementing best practices to reduce road risks, GHG's and other emissions (FORS, 2017). The scheme has been successful, and surveys revealed sub-contractors performing freight are increasingly requested to have a FORS accreditation to participate in tenders (Druce, 2017). Table 21 illustrate a selection of legal policy measures from literature.

Table 21: A selection of legal measures based on literature review

Policy measure	Selection of sources
Access to bus lane	The City Council of Oslo, 2016; Bakker and Trip, 2013; THEMA et. al., 2016; Spurkeland, 2016; Caspersen and Hovi, 2016
Free and/or priviliged parking for low-emission URFT vehicles	Bakker and Trip, 2013; Kijewska et. al., 2016; Cherrett et. al., 2016
Zero/low-emission zones	The City Council of Oslo, 2016; Eidhammer and Andersen, 2015; NHO et. al., 2016; MDS Transmodal Limited and CTL, 2012; THEMA et.al., 2016; Bjartnes and Michelsen, 2016
Certify transport companies with low-emission fleets/other reward scheme	Taefi et. al., 2016; NHO et. al., 2016; Bjartnes and Michelsen, 2016; Eidhammer and Andersen, 2015; Fu and Jenelius, 2017; FORS, 2017

3.6.3 Organisational Measures

Organisational measures are defined as actions where the government uses its own capacity and capability, including such as skills, people, infrastructure, and land (Taefi et. al., 2016). Consolidation centres have been identified as a measure capable of reducing the amount of freight vehicles in cities, that could also be combined with a demand to only use low-carbon vehicles in last-mile delivery from the consolidation centre (Eidhammer and Andersen, 2015). Challenges have mainly discussed added costs for buyers of transport if a consolidation centre were to be implemented, and difficulities of establishing a viable business case (VREF, 2013).

Internally, authorities could lead by example by purchasing low-carbon vehicles. Among others, the city of Rotterdam is planning to have 50 % electric vehicles within 2018, a strategy that has also been adopted by government body "Transport for London" in the UK, voicing the intention of requiring the government to incentivise uptake of zero-emission vehicles (Roberts, 2017). Other organisational measures include facilitation of low-carbon infrastructure through strategic ownership of favourable urban locations, direct subsidies for investment or operational support. Further, a review from the now ended EU project, FREVUE highlighted lack of service support and repair was a major challenge during testing of electric freight vehicles (Quak et. al., 2016). This was echoed by a Norwegian study considering low-carbon vans specifically, stressing service and support for electric compared to petroleum vans required more time, costs and service operators lacked sufficient knowledge (THEMA, 2014). As such, reliable repair and maintenance support is essential for freight operators using low-carbon vehicles in URFT, for which authorities could help establish (Taefi et. al., 2016). Table 22 illustrate a selection of organisational policy measures from literature.

Table 22: A selection of organisational measures based on literature review

Policy measure	Selection of sources
Consolidation centre (supplemented by vehicle technology demand)	Eidhammer and Andersen, 2015; NHO et. al., 2016; Cherrett et. al., 2012; Filippi et. al., 2010; Nordtømme et. al., 2015
Electric and hydrogen vehicles in municipal fleets	Bakker and Trip, 2013; Eidhammer and Andersen, 2015; Tretvik et. al., 2013; Bjartnes and Michelsen, 2016
National and municipal targets (GHG emissions)	Albrecht, 2017; Bjartnes and Michelsen, 2017; NHO et. al., 2016
Facilitate low-carbon infrastructure development	The City Council of Oslo, 2016; Bakker and Trip, 2013; Quak et. al., 2016; MDS Transmodal Limited and CTL, 2012
Repair and service support	Taefi et. al., 2016; Quak et. al., 2016; THEMA et.al., 2016

3.6.4 Communicational Measures

Communicational measures are when the government uses its "nodality" to collect and dispense information such as advantages, and TCO calculations (Taefi et. al., 2016). The same study largely concluded one measure sufficed for this category due to more than one aspect of low-carbon technologies were usually communicated at information centres or websites. In assessing the potential for low-carbon vehicles in Norway however, THEMA et al (2016) also stress the importance of communicational measures by means of informational campaigns, to make visible for stakeholders why they should adopt low-carbon propulsions. For electric vehicles, Bakker and Trip (2013) stress the importance of various levels of government taking part in this process, to provide information in a more coherent manner regarding the prospectives and consequences of ownership. The same study also suggested authorities should take responsibility for creating one main arena for such information in a virtual or physical office (Bakker and Trip, 2013).

Based on their proposed "plan of action" to the City Council of Oslo, the Agency for Climate recommended clearer communication and marketing of Enova's subsidy schemes. This was suggested considering stakeholders in Oslo extracted only 4 % of subsidies made available for transport related projects in 2016, equivalent to 836 million NOK (Agency for Climate, 2017). While deemed an organisational measure in this study, cooperation fora/groups/ networks could play a vital role for authorities to initiate enhanced marketing of available subsidy schemes. Among others, the cooperation network "Næring for klima" were suggested as a platform for which national subsidy schemes such as Enova became more visible among private stakeholders (Agency for Climate, 2017). Also at national level, the Ministry of Climate and Environment strive in their certification scheme, Miljøfyrtårn to promote environmental challenges in small- and medium sized enterprises (THEMA et. al., 2016). Table 23 illustrate numerous sources from literature emphasising communicational policy measures being important.

Table 23: A selection of communicational measures based on literature review

Policy measure	Selection of sources
Virtual (webpage) or physical (e.g. conferences) information from authorities on topics including costs, state funding, advantages, TCO and availability.	Taefi et al., 2016; Bakker and Trip, 2013; NHO et. al., 2016; THEMA et.al., 2016; Bjartnes and Michelsen, 2016; Norges Lastebileier-Forbund, 2016
Promote marketing of Enova subsidy schemes	Agency for Climate, 2017

4 Results

The result section focuses largely on stakeholder policy evaluation, assessed towards the criteria from Table 8, namely effort, effectiveness, and acceptability. An evaluation based on these criteria are offered in greater detail in the analysis and discussion section, while only briefly discussed as part of the result section. Referring to the research process in Figure 6, results are mainly based on the research question to identify policy measures promoting the uptake and use of low-carbon vehicles in urban road freight transport (URFT), and sub-question of what policy measures can lead to GHG emission reductions in this sector by other means. The two other sub-questions[82] are discussed in the end of the result section. For the evaluation process, some stakeholders were merged into groups and evaluated together in the results, as described in section 2.2.4.

Two approaches were applied in the evaluation process. Referring to section 2.2.4, this process included both the most preferred policy category[83] and individual policy measures. Policy categories were assessed based on a frequency approach, counting the number of times policy measures within each category were mentioned, across all interviews. The sum of policy measures within each category were then added between all interviews. Referring to the variety of policy measures and categories in section 3.6, this approach was useful to highlight not only the most important category based on frequency, but also understand whether fiscal considerations were exclusively the most vital consideration for investing in low-carbon vehicles, as argued by Deloitte (2016). Referring to Figure 7, the relative importance of individual stakeholders was considered for this approach, weighting policy categories based on interviewees' impact in the sector[84]. That is, stakeholders having a direct impact was given a double counting based on the frequency approach.

The most preferred individual policy measures are also identified in the result section. This approach did not reflect whether separate interviewees mentioned a policy measure several times, but rather their mentioning at all. Individual policy measures were then added across all interview groups based on mentioning, in a combined number. Similar to the approach for policy category, this also allowed to understand possible consensus between interviewees, and challenge the conclusions from Taefi et al (2016), arguing discordances between groups of stakeholders could be large. In a myriad of policy options, this process also helped to filter the most preferred policy measures, helping decision makers understand what are the most important individual policy measures. Referring to section 2.2.4, the discussion and analysis section focus primarily on individual policy measures most commonly mentioned by interviewees.

4.1 Stakeholders with Direct Influence

4.1.1 Authorities

Table 24 show the individual policy measures mentioned during the interview with the Ministry of Transport and Communications, and the category for which they fit. Table 25 display the same for the interviewee working at the Agency for Climate, under the City Council of Oslo. It should be noted the latter interviewee expressed his own personal opinions based on current position at the agency. Some of the policy measures, including the electric vehicles incentive

[82] The most important stakeholders in urban road freight transport, and the most promising technical solutions
[83] Fiscal, legal, organisational and communicational,

[84] Those having a direct impact can be defined as those having a direct influence on the sector, while those having an indirect impact are those having an interest in the urban road freight sector (Ballantyne et. al., 2013).

scheme involves both the fiscal measure of tax exemptions, and legal measure of access to bus lanes.

Table 24: Policy measures mentioned by national authority

Individual policy measure	Suggested policy category(s)
CO_2 tax	Fiscal
Road use duty on fuels	Fiscal
Environmentally differentiated road charging	Fiscal
Toll roads	Fiscal
Congestion charging	Fiscal
Enova subsidy schemes	Fiscal
Electric vehicles incentive scheme[85]	Fiscal and legal
NTP (national transport plan)[86]	Fiscal and organisational
Zero/low-emission zones	Legal
Facilitate low-carbon infrastructure development	Organisational

Table 25: Policy measures mentioned by local authority

Individual policy measure	Suggested policy category(s)
Green public procurements	Fiscal
Toll roads	Fiscal
Enova subsidy scheme	Fiscal
Hydrogen taxi subsidy scheme	Fiscal
Electric vehicles incentive scheme	Fiscal and legal
NTP (national transport plan)	Fiscal and organisational
Zero/low-emission zones	Legal
City logistics plans	Organisational
Use of cargo bikes	Organisational
Consolidation centres	Organisational
Facilitate low-carbon infrastructure development	Organisational
Finance and develop infrastructure (basic electric charging infrastructure)	Organisational
Cooperation fora/groups/networks	Organisational
National and municipal targets (GHG emissions)	Organisational

National authorities explicitly emphasised the CO_2 tax[87] was the most effective policy measure, allowing the market to facilitate developments based on the given rate as determined by the

[85] Referred to as the combination of policy measures from Table 13.

[86] Outlines how the government intends to prioritise resources for a 10 year period, within the transport sector.

[87] A tax levied on the content of fuels, putting a price on the emissions of CO_2. In Norway referred to as CO_2 avgiften.

Ministry of Finance. In terms of the effort criteria applied in this research, the CO_2 tax require minimal efforts considering the outcome was highlighted as largely up to the market to determine. The road use duty on fuels[88] was also highlighted as a central tax, but a specific case was highlighted for which the road use duty on fuels could prove less acceptable, another criterion in this research. That is, a suggested increase of 0.15 NOK per liter of diesel in 2016 was used as an example, having created strong opposition. It was noted a distance-based road charging had been previously considered as an alternative to the road use duty on fuels. For local authorities, it was noted both sticks and carrots were needed to promote low-carbon technologies. Numerous policy measures were incorporated in "klimabudsjettet[89]". Delegating responsibility of these measures were strived for however. That is, the Agency for Climate wanted to delegate policy initiative to different businesses/agencies internally that had a sense of "ownership" to the activities of each policy measure.

Both national and local authorities stated authorities should focus on neutral measures[90] to stimulate low-carbon technologies. The incentive scheme for electric vehicles (also applicable for hydrogen, Table 13) was stated as an exception. While considered to be effective, annual costs up to 3-4 billion NOK had raised questions as to the continued acceptability from the perspective of national authorities. Exceptions had also been made from local authorities by financing and constructing basic charging infrastructure for electric vehicles, and having a subsidy scheme for the first 50 hydrogen taxi's in the city. To achieve Oslo's GHG reduction targets however, a continuation of national authorities' incentive scheme for electric vehicles were stressed. Thus, the emphasis from both levels of authorities suggest a high satisfaction of the criteria effectiveness for this scheme.

Local authorities mentioned cooperation with national authorities likely occurred when needed, but noted the municipality likely had a more ambitious climate policy than at national level. National authorities noted municipalities were often active in areas they didn't have authority. An example was highlighted in municipalities often wanting to implement strict low-emission zones[91] to counteract local air pollution. Whereas permission to implement temporary increases in toll roads and congestion charging had been granted instead, municipalities had not always made use of these options. A disagreement seemingly rooted in acceptability. Still, local authorities noted cooperation in terms of taxes and tolls had been achieved, including such as environmentally differentiated road charging, incorporated in Oslopakke 3[92].

A notable distinction between local and national authorities were the emphasis on green public procurements. Purchasing goods and services for 26 billion NOK annually, the municipality in Oslo emphasised increased focus on criteria for environmental performance and low GHG emissions in their procurements. For low-carbon infrastructure, local authorities emphasised this should be upfront. National authorities further noted it was also up to the market contributing private risk and capital, a collective understanding also shared locally. In dense areas such as Oslo, the opportunity for a commercial market was noted as likely, and creating a market would be more difficult if the government offered infrastructure for free. Local

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[88] A tax that is imposed for the use of infrastructure and external costs for use of vehicle. In Norway referred to as "bensinavgiften or veibruksavgiften".

[89] Referred to as priority areas with a list of concrete measures to achieve GHG reduction goals as adopted by Oslo. Puts a number on expected GHG reductions from each measure, and expected costs.

[90] Not having authorities offer favourable incentives for specific technologies.

[91] Meaning largely a shift from petrol to diesel, and a shift from Euro V to Euro VI trucks, reducing the impact of NO_x and PM's, while leaving CO_2 largely unchanged.

[92] An overarching plan for construction and financing of roads and public transport in Oslo and Akershus, Norway. Also includes cooperation with national authorities' due to a state financial grant.

authorities revealed they could facilitate development through purchase and previous ownership of strategic locations. From there, private actors preferably needed to come in and develop Energy stations[93]. Both national and local authorities referred to Enova and R&D projects to help cover investment costs, and grow an early market.

Table 26 show fiscal measures being the most recurring policy category among national and local authorities combined.

Table 26: Policy categories and frequency in interview with authorities'

Policy category	Theme frequency (double counting[94])
Fiscal Measures	29
Legal Measures	8
Organisational Measures	19
Communicational Measures	0

4.1.2 Freight Operators

Generally, fiscal measures including the CO_2 tax, road use duty on fuels, toll road exemption, congestion charging and environmentally differentiated road charging were important policy measures for freight operators. As reflected in Table 27, several policy measures were considered important by this stakeholder group to stimulate low-carbon technologies.

[93] Described as a station with fuel infrastructure for zero-emission and renewable fuels (The City Council of Oslo, 2016).

[94] Based on having direct impact in urban road freight transport.

Table 27: Policy measures mentioned by freight operators

Individual policy measure	Suggested policy category(s)
Toll roads	Fiscal
Annual motor vehicle tax	Fiscal
CO_2 tax	Fiscal
Road use duty on fuels	Fiscal
Environmentally differentiated road charging	Fiscal
Enova subsidy schemes	Fiscal
Green public procurement	Fiscal
Scrapping subsidy, also diesel vehicle scrappage fund	Fiscal
CO_2 fund	Fiscal
Congestion charging	Fiscal
Electric vehicles incentive scheme	Fiscal and legal
NTP (national transport plan)	Fiscal and organisational
Bypakker (City Packages)[95]	Fiscal and organisational
R&D projects	Fiscal and organisational
Zero/low-emission zone	Legal
Harmonisation of taxes nationally/internationally	Legal
Standards for CO_2 emissions	Legal
National and municipal targets (GHG emissions)	Organisational
Facilitate low-carbon infrastructure development	Organisational
City logistics plan	Organisational
Cooperation fora/groups/networks	Organisational
Consolidation centre	Organisational
Low-carbon vehicles in municipal fleets	Organisational
Access to information/information sharing	Communicational

Operator Posten Bring stressed the electric vehicle incentive scheme made electric freight vehicles more effective due to reduced rates on toll roads and access to bus lanes. This signify broad acceptability across directly impacting stakeholders, also referring to the interviews from authorities. Operator ASKO further argued a cut or full exemption in toll road rates for biogas and bioethanol vehicles should be considered. NLF (Norwegian Road Transport Association) highlighted toll roads were the most important consideration for their members. Rather than electric and biofuel vehicles however, the discussion on environmentally differentiated toll roads was primarily focused on favourable attributes of the Euro VI technology. Among charges on fuels, NLF highlighted they perceived the CO_2 tax as sufficient for achieving national obligations adopted in the Paris climate accord, and should not be increased. This echoed the sensitivity aspect of increasing fuel prices as noted by national authorities. NLF also stated that while a

[95] Among others a plan for spatial and transport policy in individual cities. Have a time perspective of 20 years, and have several large investment projects incorporated.

variation of tolls and taxes was inevitable, due note should be given and harmonisation between cities should be strived for.

Regarding the possible implementation of low-emission zones in Oslo, it was noted this could help charge those contributing most to air pollution and traffic within the city. While all operators supported such a zone, it was highlighted technology needed to be available and allow the opportunity for operators staying ahead of the stick. Concerning other fiscal measures, green public procurements were generally perceived positively among freight operators, and stricter demands in these processes should be considered.

Both ASKO and Posten Bring stressed the importance of Enova to cover additional costs for electric and hydrogen vehicles. Yet, additional costs were still high after subsidies, a factor noted as having possibly caused hesitation in the market. As an initiative from the industry, the ongoing discussions of implementing a CO_2 fund were generally supported among freight operators to provide further financial incentives to deploy low-carbon vehicles. On the other hand, NLF noted a fund should not be paid for from an increased CO_2 tax, but rather the existing rate. Again, these factors underscore a seeminly low acceptability for increased tolls, charges, and taxes of fiscal nature from stakeholders having direct impact.

Regarding low-carbon infrastructure, freight operators noted fuel infrastructure was not their core competence, despite ASKO and Posten Bring having invested in HVO infrastructure. ASKO raised the question as to whom should be responsible for infrastructure development for both electric, hydrogen and various biofuels. It was noted a previous attempt to work with energy companies had largely failed due to disagreements on making a long-term commitment to a single fuel supplier. Posten Bring noted they could not demand subcontractors using electric, hydrogen and biofuels without technology or infrastructure being in place.

Following the same path as authorities, freight operators also primarily discussed fiscal measures, as reflected in Table 28.

Table 28: Policy categories and frequency in interview with freight operators

Policy Category	Theme Frequency (double counting)
Fiscal Measures	26
Legal Measures	8
Organisational Measures	18
Communicational Measures	2

4.2 Stakeholders with Indirect Influence

4.2.1 Manufacturers

From the manufacturers perspective, Volvo Trucks stated policy measures should strive to be long-term, set demands and be technology neutral. Implementing effective measures was not always easy from the perspective of authorities however. An example was given in the scenario of replacing diesel vehicles with hydrogen, for which would require a large systematic transition, making it difficult to govern. Table 29 lists measures mentioned from the interview.

Table 29: Policy measures mentioned by OEM's

Individual policy measure	Suggested policy category(s)
Green public procurement	Fiscal
R&D projects	Fiscal and organisational
Zero/low-emission zone	Legal
Harmonisation of taxes and tolls nationally/policy framework for fuel propulsions internationally	Legal
Facilitate low-carbon infrastructure development	Organisational
Cooperation fora/groups/networks	Organisational
Repair and service workshop	Organisational

Discussing growth for low-carbon technologies, facilitation of infrastructure was stated as an important measure. It was noted authorities working with a plan and strategy for infrastructure, subsequently contributing to cooperation could be positive. Volvo mentioned working with customers to understand their interests was important, and cooperation with energy companies to discuss the possibility of delivering fuels not currently widespread. Service support and assistance was particularly important for OEM's when establishing in new markets. Considering the criteria of effort, this signify both the monetary and personnel required for a transition towards low-carbon fuel propulsions could be substantial from a manufacturers perspective.

Cooperation to harmonise legislation across cities and nations was also discussed. Bergen and Oslo was described as an example where policy measures should strive to be harmonised to the same standards and demands. This echoed the argument from the freight operators' perspective, highlighting fragmentation of toll road rates between cities should be avoided. The same issue of harmonisation was also mentioned in an international context, in the work towards fuel standards in both Europe and the US, in which the example of taxes and charges on biofuels were highlighted. Contrary to directly impacting stakeholders, Table 30 reflect highest representation of organisational measures.

Table 30: Policy categories and frequency in interview with OEM

Policy category	Theme frequency (single counting)
Fiscal Measures	2
Legal Measures	2
Organisational Measures	4
Communicational Measures	0

4.2.2 Public Agencies, Academic and Research Organisations

While the interview with Institute of Transport Economics (TØI) and the Norwegian Public Roads Administration (NPRA) predominately focused on measures to improve efficiency of URFT, the representative from the Norwegian University of Life Sciences (NMBU) emphasised largely land use and urban development, and SINTEF the ongoing project ELinGO (electrification of heavy freight transport). Table 31 lists the variety of policy measures mentioned during the interviews.

Table 31: Policy measures mentioned by public agency, academic and research organisations

Individual policy measure	Suggested policy category(s)
Enova subsidy schemes	Fiscal
Toll roads	Fiscal
Congestion charging	Fiscal
Green public procurement	Fiscal
R&D projects	Fiscal and organisational
Dedicated truck lanes	Legal
Zero/low-emission zones	Legal
Certify transport companies with low-emission fleets/other reward scheme	Legal
Low-carbon vehicles in municipal fleets	Organisational
Consolidation centres	Organisational
City logistics plans	Organisational
National and municipal targets (GHG emissions)	Organisational
Cooperation fora/groups/networks	Organisational
Facilitate low-carbon infrastructure development	Organisational
Access to information/information sharing	Communicational

Predominant focus was on policy measures to reduced GHG's from URFT, not promote low-carbon technologies. Implementing consolidation centres, creating a city logistics plan and authorities adopting targets to reduce GHG's were key focuses in the interviews.

Consolidation centres was a recurring topic to potentially reduce GHG emissions. A drawback was highlighted in presenting a viable business model, and whether authorities should contribute financial support and strategic locations in the city for such centres. TØI stated the private sector was often capable of developing solutions to improve logistics in cities, but a viable business case often proved a challenge. Thus, while the effectiveness of such measures was largely not disputed, acceptability was, primarily regarding responsible parties and roles for implementation.

A city logistics plan was discussed in the context of improving how local authorities purchased goods, and took account of URFT in municipal planning and desging of new areas. This was again echoed from the interview with local authorities, noting this should be an area of greater focus at political level. Networking groups and cooperation fora were other measures frequently recommended. While it was noted this could be a platform to share concerns and better understand the consequences of implementing policy measures, the NPRA and TØI stressed the risk of only the largest freight operators taking part, not smaller. London's "Freight Quality Partnerships" were featured as a forum that had likely worked well to enhance knowledge between freight operators and local authorities.

Table 32 shows organisational measures being the most recurrent category. This largely reflected frequent discussions of how the URFT sector could be made more efficient, requiring initiatives internally from authorities and cooperation with the entire range of stakeholders to be achieved. Communicational measures were also mentioned however. Lack of knowledge of URFT and educating the public and politicians on the sector made the lack of knowledge for urban road freight a notable observation among the interviewees.

Table 32: Policy categories and frequency in interviews with public agency, academic and research organisations

Policy category	Theme frequency (single counting)
Fiscal Measures	5
Legal Measures	3
Organisational Measures	10
Communicational Measures	1

4.2.3 Policy Interventions (NGO's)

The focus on national policy measures, both the electric vehicle incentive scheme and government Enterprise Enova's subsidy schemes were important considerations from the Norwegian NGO, Bellona's perspective. As reflected in Table 33, fiscal measures were the most recurrent.

Table 33: Policy measures mentioned by NGO

Individual policy measure	Suggested policy category(s)
Green public procurements	Fiscal
Scrapping subsidy, also diesel vehicle scrappage fund	Fiscal
CO_2 fund	Fiscal
Enova subsidy scheme	Fiscal
Electric vehicles incentive scheme	Fiscal and legal
Low-carbon vehicles in municipal fleets	Organisational
Facilitate low-carbon infrastructure development	Organisational
National and municipal targets (GHG emissions)	Organisational

The incentive scheme for electric vehicles were emphasised as important, reinforcing a broad understanding of the effectiveness and acceptability of this scheme. While the most decisive fee exemptions were decided by national authorities, the interviewee were critical to local authorities being given the authority to decide other incentives in the scheme including access to bus lanes, free parking, and ferry tickets.

The possible implementation of a CO_2 fund and various existing Enova subsidy schemes were highlighted as policy measures that could also promote low-carbon technologies. Infrastructure for such technologies should be upfront, in which Enova had a central role. However, examples from the maritime sector was highlighted as an area the subsidies were not effectively distributed. That is, instead of Enova offering infrastructure subsidies in tenders designed to pick winners based on the quality of the application, strategic locations should be preferred, preferably in ports located in the largest cities with most traffic.

Further, green public procurements could have an extended procurement process to improve technological solutions. While stating policy measures should be technology neutral, the interviewee mentioned this should not lead to other than the best available technology (BAT) being chosen, and policy measures should be designed thereof. Table 34 reinforce the emphasis on fiscal measures overall.

Table 34: Policy categories and frequency in interview with NGO

Policy category	Theme frequency (single counting)
Fiscal Measures	5
Legal Measures	1
Organisational Measures	3
Communicational Measures	0

4.3 Summary Policy Measures

Table 35 show faciliatation of low-carbon infrastructure were mentioned most. This signify a broad consensus among stakeholders in this research, both directly and indirectly affecting URFT, that infrastructure is vital and should be upfront to promote the uptake and use of low-carbon technologies. However, the variety of policy measures suggest a combination of measures are needed. One example was the strong support among stakeholders having a direct impact, for the variety of policy measures within the incentive scheme for electric vehicles. Freight operators referring to this scheme stated the combination of toll roads exemption and bus-lane access made low-carbon vehicles effective. In an urban context, zero/low-emission zones were also frequently discussed by stakeholders having direct impact, and disagreements were noted as to the strictness of such zones. Furthermore, apart from the broad support for stricter criteria and prolonged tenders in green public procurements, and Enova's key role through financial subsidies, toll roads[96] seemed not only the most sensitive, but also the most important for freight operators. Lastly, targets to reduce GHG emissions from both local and national level were generally received with approval. This was particularly prevalent for stakeholders with indirect influence and freight operators, praising the predictability and long-term market stability this provided. Appendix 7.2. show the full spectre of policy measures mentioned across all interview groups, while Table 35 show only those mentioned 4 times or more.

Table 35: Individual policy measures based on mentioning

Individual policy measure	Most frequently mentioned policy measures
Facilitate low-carbon infrastructure development	6
Zero/low-emission zones	5
Green public procurements	5
Enova subsidy schemes	5
Toll roads	4
Electric vehicles incentive scheme	4
National and municipal targets (GHG emissions)	4

The top scoring measures in Table 35 does not reflect Table 36 suggesting fiscal measures being the most frequent policy category. That is, a zero/low emission zone is considered a legal

[96] While not explicitly, toll roads were often discussed in the context of congestion, and environmentally differentiated road charging.

measure in this study, while facilitation of low-carbon infrastructure is deemed organisational. The latter could also be considered fiscal and not only organisational however. This were prominent when referred to regarding the incentive scheme from Enova, supporting infrastructure investment in a distinct subsidy program. However, both levels of authority stressed the need for private risk and capital, suggesting infrastructure should largely take place organisationally through facilitation and other stimulus, not solely financing. This aligns well with the principle of technology neutrality, which were explicitly emphasised as a principle from both levels of authority. Also, while referred to in Table 35 as an individual policy measure, the full spectre of toll roads is likely more complex. That is, both complete toll road exemption, congestion charging, and environmentally differentiated charging were often incorporated in the discussion involving toll roads, suggesting fiscal measures is perhaps not fully accounted for in Table 35.

Table 36: Policy categories based on theme frequency

Policy category	Overall theme frequency
Fiscal Measures	67
Legal Measures	22
Organisational Measures	54
Communicational Measures	3

4.4 Technical Solutions and Most Important Stakeholders

4.4.1 Most Promising Technical Solutions

Among the most promising technical solutions, several propulsions were mentioned in interviews. However, electric and hydrogen solutions were widely deemed the future in a 10 to 15-year perspective. This was mainly due to low local emissions of NO_x, PM, and GHG's. Volvo Trucks emphasised a problem for the development of low-carbon technologies in that conventional fuels such as diesel still made a profit. It was further noted local conditions were key determinants for what fuel propulsions should be pursued, a possible reason for why hydrogen was a major subject in Norway, more so than other countries according to Volvo.

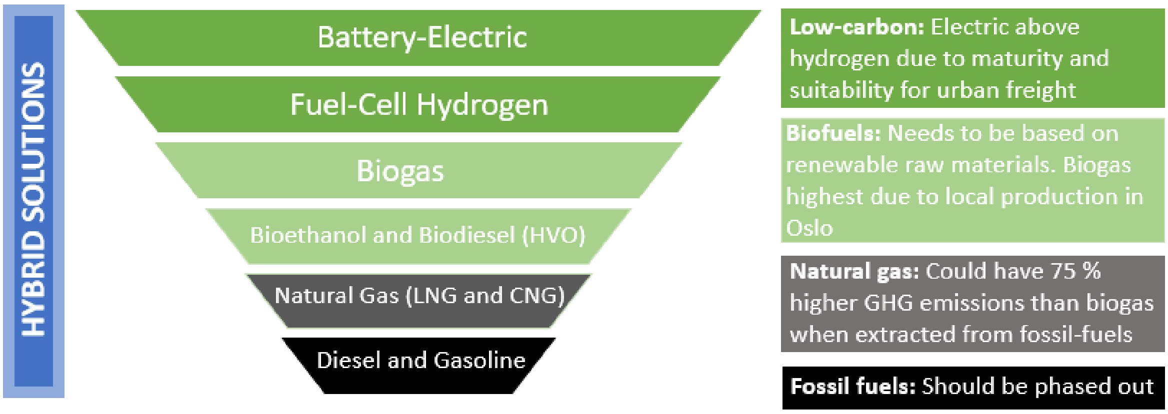
From the OEM perspective however, the need for a global solution were emphasised, as few if any would develop hydrogen specifically for Norway. Volvo highlighted that while hydrogen was not ruled out as a potential fuel for future development, the technology had also been tested about 20 years ago, and current developments saw this technology still having challenges. High energy demand was also highlighted as a drawback, not always produced in a sustainable manner through electrolysis based on renewable energy, according to NGO, Bellona. Other interviewees noted hydrogen could be complementary to electricity, where hydrogen has the largest potential for heavier long-distance transport, while electricity is most suited for lighter vehicles over shorter distances. Also for longer distances, hybrid solutions were emphasised as potentially viable options.

Biofuels were widely deemed necessary in the short- to medium term. There was also optimism there could be sufficient supply of sustainable advanced biofuels globally if market demanded this. Concerns were mentioned however in that biofuels could potentially stagnate development of electric or other technologies for heavier vehicles if sufficiently incentivised, an argument echoed also echoed from literature (e.g. Anandarajah et. al., 2013). While still expensive as of 2017, biogas was mentioned as having high efficiency and a priority in Oslo due to being produced locally. HVO was also listed as having prospects for growth. However, limited supply had caused some stagnation in the market, along with a significant increase in prices following new classification of raw material, PFAD in early 2017. Access to raw materials and ILUC[97] was also highligted as a potential limiting factor for biofuels in general. Bellona highlighted biofuels could have a role, but preferably for sectors that had no option other than this driveline, in which heavy road freight vehicles was listed as an example.

Among freight operators, Posten Bring highlighted the likely usage of electricity, HVO and biogas towards 2025, for then to phase out HVO gradually due to the likely demand from more energy intensive sectors. ASKO also highlighted various biofuels including bioethanol and HVO as important in the short to medium term, due to current availability, and building knowledge for the future. Overall, the long-term ambition stressed fully adopting low-carbon technologies, and technological maturity was stated as the drawback at current state.

Combined with the literature review from primarily section 3.3.2, Figure 13 illustrate the most promising technical solutions in a fuel propulsion hierarchy. This illustrate battery electricity being the most promising, while diesel and gasoline the least promising. As further suggested from section 3.4.3, the electricity mix seem of vast importance to the overall environmental performance of battery electric vehicles, which in the case of Norway would be low given vast production of hydropower. It should be noted increased number of electric and hydrogen vehicles, particularly for larger freight vehicles could create path dependencies towards unsustainable extraction of limited raw materials however. This is further elaborated on in section 3.4.3. Lastly, it should also be noted hybrid solutions are listed as viable alternative across the entire hierarchy. Brief comments as to justifying the ranking have been provided in the right columns.

Figure 13: Most promising technical solutions for low-carbon urabn freight vehicles



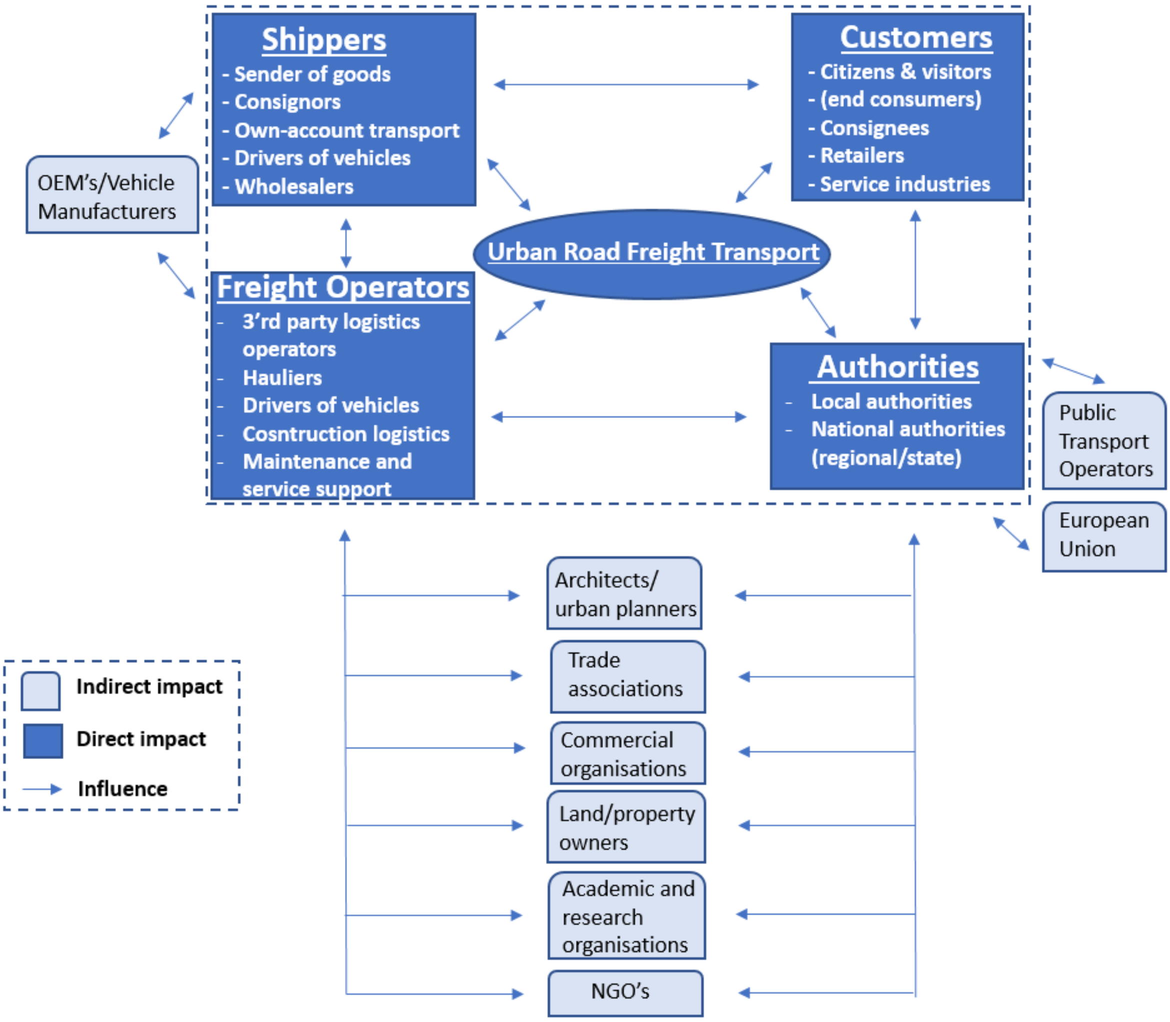
4.4.2 Most Important Stakeholders

Based on primarily a literature review, Figure 14 illustrate the stakeholders deemed most important in URFT. As a notable addition to the original framework from Figure 7, architects/urban planners, and the European Union have been included. Based on the section of 3.5.1 of assessing stakeholders, the EU was identified a key determinant to guide member states, also Norway in adopting targets to reduce GHG emissions. This is reflected in Table 3, in which Norway has been given a higher target to reduce GHG emissions compared to the EU average, namely 40 % in the Effort Sharing Regulation (ESR) sectors. Given their overarching role, the EU could also implement standards to reduce CO_2 emissions from freight vehicles, like

[97] Indirect land use change.

the successful Euro standard classification, and thus make an important impact on URFT in Oslo as well. Referring to the same section of 3.5.1, literature also suggest architects and urban planners should be included, due to their role in facilitating both loading and unloading bays for freight vehicles, and the opportunity to help design cities to improve efficiency of URFT. This was also noted from the interview with academic institution, Norwegian University of Life Sciences (NMBU). The interviewee emphasised focus on spatial planning as a measure to reduce distances in Oslo, thus the number of kilometres driven by freight vehicles. Overall however, sections 2.2.3, and 3.5.1 suggests the most important stakeholder groups include shippers, customers, freight operators and authorities. Figure 14 also indicate various sub-categories exist under these overarching stakeholder groups.

Figure 14: Most important stakeholders in URFT



Source: Adapted from Ballantyne et al (2013).

5 Analysis and Discussion

Referred to in section 2.2.4, the discussion and analysis focus predominantely on individual policy measures being mentioned most commonly. These policy measures are showed in Table 35. However, some individual policy measures being mentioned less are also incorporated based on emphasis in literature, and explicit weight among directly impacting stakeholders. This is also due to the close connection to policy measures being mentioned the most. Returning to the main research question - what policy measures may promote low-carbon vehicles in URFT, we can find an example in the variety of fuel charges and toll roads that will be discussed in a wider context, including such as environmentally differentiated road charging, and the CO_2 tax. This is mainly due to their prevalence among directly impacting stakeholders, often referring to the importance of fiscal measures such as toll roads in an overarching context.

Also, due the low representation of policy measures connected to SQ1[98] in Table 35, the most mentioned in this category will be given explicit attention. The compilation of all policy measures in appendix 7.1 illustrate the important distinction between SQ1 and RQ1, in that some reduce GHG emissions, but don't promote uptake of low-carbon vehicles. Similar studies from Taefi et al (2016) and Bakker and Trip (2013) demonstrate this division. The latter study found only six of the top ten measures promoting uptake of electric freight vehicles, while the remaining four reduced GHG emissions by other means. Thus, the most mentioned policy measures in SQ1 will be analysed and discussed, namely consolidation centres, city logistics plans, and national/municipal targets to reduce GHG emissions. It should be noted the latter could also be deemed a policy measure also leading to increased uptake and use of low-carbon technologies, which also goes for consolidation centre if implemented accordingly. That is, demanding low-carbon vehicles performing laste-mile deliveries.

Most policy measures correspond to RQ1 however, promoting the uptake and use of low-carbon technologies. Facilitation of low-carbon infrastructure was the individual policy measure mentioned by most interviewees, and is given explicit attention in the subsequent section. A separate section has also been dedicated for other fiscal measures of high emphasis including toll roads, taxes, and green public procurements. The analysis and discussion has also devoted explicit attention to zero/low emission zones, due to not only number of mentions, but also its flexibility and seemingly dispute between authorities as to level of strictness. Also, the variety of Enova subsidy schemes will be discussed more thoroughly due to its general applicability for low-carbon investments, which will also be the case for the electric vehicle incentive scheme. Based on criteria for this research in Table 8, both effort, effectiveness and acceptability separate what measures can best promote the uptake and use of low-carbon technologies.

5.1 Policy Measures Promoting Uptake and Use of Low-carbon Vehicles

5.1.1 Facilitation of Low-carbon Infrastructure Development

Most interviewees mentioned facilitation of low-carbon infrastructure should be upfront, referring to both strategic facilitation through properties, and government enterprise Enova subsidising this development. Based on findings from this study, financial contributions would seem necessary. As an alternative to the current practice of Enova tendering subsidies for only parts of the investment cost however, operational support should be considered too. This would

[98] What policy measures would most likely lead to GHG emission reduction in URFT by other means.

be particularly relevant for hydrogen stations to make the business case more affordable through early market development. In fact, due to being economically unprofitable during initial market growth, the German Environment Agency suggested public support was reasonable for operational expenses of hydrogen stations (Umweltbundesamt., 2016). Feed-in-tarrifs could address the cost of operations in this context, covering operational costs when the volume of hydrogen has increased, but operational costs are still too high to cover a positive business case. Feed-in-tarrifs could also reduce risk for investors through predetermined payments. This was raised by Tomasgard et al (2016) as a critical aspect in attracting more private capital, a financial flow emphasised by authorities in this study as necessary to create a commercial market.

From the perspective of national authorities however, broadening financial contributions could prove less viable regarding the criteria of acceptability. Budget constraints and an already favourable incentive scheme for low-carbon vehicles' through fee exemptions could appear as sufficient policy incentives already, the latter referred to in the interview with national authorities as a costly consideration. Thus, Taefi et al (2016) argue local budgets may have to supplement national funding in some cases. This could seem both reasonable and effective given local authorities often govern and have first-hand knowledge of activities in their cities, an aquintance likely providing a strong sense of ownership to local infrastructure initiatives.

For the criteria of effectiveness, this could further improve if facilitation of infrastructure targeted early adopters.[99] Green et al (2014) argue early adopters are the most likely to accept trade-offs between cost and environmental benefits. ASKO demonstrate this in practice, referring to their owner's environmental engagement for investing in more expensive low-carbon URFT vehicles, and biofuel infrastructure. Authorities could take a more active role in this process. Studies on the uptake of electric urban freight vehicles show one of the top ranked non-fiscal policy measures among authorities and freight operators was setting up infrastructure on the compunds of companies (Taefi et. al., 2016). Among others, this has proved successful by German postal operator Deutche Post DHL, receiving funds from the federal German ministry of environment for charging infrastructure (Canters, 2014). As evidence for the effective aspect of targeting early adopters, Deutche Post have commited to selling their expanding fleet of electric freight vehicles to third parties (Lambert, 2017). To further ensure the effectiveness of targeting early adopters, authorities should identify a cost that is acceptable for operators, which may differ notably from current or prospective incentive schemes, according to Green et al (2014).

As an extension of targeting early adopters, THEMA et al (2015) argue urban areas should be a priority at first. This is in line with not only arguments from interviews in this research, but also research on hydrogen prospects from SINTEF, advocating for a rapid and geographically concentrated growth in the use of hydrogen in Norway (Tomasgard et, al., 2016). From interviews, Bellona highlighted Enova should target infrastructure in Norway's largest seaports to ensure effective expansion of the market, referred to when discussing shorepower for the maritime sector. This should be replicated in urban road freight. To further ensure widespread access for low-carbon infrastructure within geographically strategic locations such as cities, facilitation through strategic property ownership would be an essential involvement from local authorities in this context. This was indicated as an acceptable contribution from local authorities during the interview.

Again, acceptability could prove a challenge however. By favouring early adopters in urban areas, rural policymakers and citizens could protest. It should also be noted the role of an early adopter is not applicable to all. Thus, some operators could be given an arbitrary competitive

[99] Considered frontrunners of adopting new technologies.

advantage. The interview with NLF (Norwegian Road Transport Association) emphasised the transport sector have small profit margins, and many have enough just to get by. It should also be noted early adopters usually have finances and resources at their disposal to enter complex application processes for subsidy funding. The interview with the representative from the Agency for Climate further strengthened this claim when discussing the low number of applicants from Oslo receiving funding from Enova. It was noted the complicated application process was an area for which Enova could improve, a factor emphasised as likely having made smaller operators deem Enova subsidy schemes somehow inaccessible.

Thus, facilitation of low-carbon infrastructure indicates high effectiveness overall, particularly when targeting early adopters in urban areas. Also, this policy measure would likely require only administrative working tasks regarding the criteria of effort. On the other hand, acceptability to broaden financial support towards operational costs would likely be low beyond current mandates from Enova and a potential CO_2 fund. Furthermore, acceptability could also possibly be low if authorities target geographically concentrated locations and early adopters. However, succesfull examples from Germany demonstrate the political acceptability of targeting early adopters. If not however, facilitation through strategic property ownership would seem ever more important to eastablish energy stations[100], a role primarily for local authorities to manage. Overall, given the overall high emphasis and urgent need to develop a market, facilitating low-carbon infrastructure is the policy measure most likely to promote the uptake and use of low-carbon freight vehicles.

5.1.2 Zero/Low-Emission Zones

A zero/low emission zone would promote vehicles having low emissions, or vehicles other than ICEV's through high charges or bans. However, only a zero-emission zone would likely be effective in enhancing low-carbon vehicles (Roberts, 2017). This would be due to only permitting entry for zero-emission vehicles, referred to as low-carbon vehicles in this research. The proposal for a low-emission zone as presented in Oslo would not reduce GHG emissions[101], but rather promote a shift from Euro V to Euro VI vehicles, according to the interviewee working at the Agency for Climate. As such, the effectiveness criteria may prove disappointing for what concerns promoting low-carbon vehicles, and reduce GHG emissions. It should be noted Euro VI freight vehicles reduce NO_x and particulate matter (PM) emissions substantially however, resulting in improved health effects for residents in Oslo. That is, the Norwegian Institute of Public Health (NIPH) concluded 185 individuals died early in 2013 following high levels of particulate matter, a problem a low-emission zone could help address (Berg, 2017).

While the criteria of effectiveness would be better satisfied in a zero-emission zone, effort from local level necessary to enforce it, along with acceptability could prove challenging. Table 14 and 16 showing current low-carbon vehicles, along with literature from this study (e.g. Anandarajah et. al., 2013) reveal there is limited availability and high purchase costs for low-carbon URFT vehicles as of 2017. As such, a zero-emission zone would likely create low acceptability both politically and from the industry at large, left with limited and expensive alternatives if ICEV's were banned within selected city zones. Opposition would likely also prove strong from another stakeholder group having direct impact as identified in Figure 7 for this study, namely customers. That is, more expensive freight zones in the city would likely result

[100] A station with fuel infrastructure for zero-emission and renewable fuels (The City Council of Oslo, 2016).

[101] In Oslo, a low-emission zone would primarily stimulate a shift towards Euro VI vehicles, not electric and hydrogen vehicles.

in higher prices for shop owners and city residents, thus making shopping centres outside cities more convenient and affordable in a business case perspective.

Effort is another consideration in this context. As laid out for Oslo, the Norwegian think tank Civita claims the proposed low-emission zone would cost 40 million NOK to implement, along with somewhere in between 160 and 500 million NOK to operate (Riekeles, 2017). This adds to additional factors suggesting high effort is required, considering both the likely need for creating a new toll tag[102] system and areas for which these could be purchased. Enforcement is another aspect potentially resulting in high effort too. That is, given the historically low emphasis on URFT compared to passenger and public transport among policy makers, its an open question wether authorities have the monetary and personell required to enforce strict provisions for vehicle entries within certain city zones.

Alternatively, a future political commitment to implement a zero-emission zone could promote effective deployment of low-carbon vehicles in the years leading up to implementation, while also offering authorities sufficient time to prepare such a system practically. The latter aspect would likely reduce the immediate effort required. Examples from London introducing a zero-emission zone in 2025 illustrate the political acceptability of this approach as well (Roberts, 2017). However, effectiveness dwell on successful cooperation and agreement between local and national authorities' due to the latter's statutory authority. IFE (2017) refers to the discussion of a low-emission zone in Oslo as slow and potentially conflict driven, echoed by the interview with national authorities in this study, mentioning local authorities are sometimes active in areas they don't have authority. Therefore, more freedom should be considered delegated local authorities for more effective implementation, in line with recommendations from Bjartnes and Michelsen (2016).

Thus, a zero-emission zone would likely be the only design to promote low-carbon vehicles effectively. Further, a commitment to implement such a zone in the future would seem the most convenient, and perhaps only way of satisfying the criteria of acceptability, effort, and effectiveness, the latter criteria in the context of uptake and use of low-carbon freight vehicles.

5.1.3 Other Fiscal Measures

Green public procurements, toll roads and taxes were fiscal policy measures mentioned frequently by interviewees. Among tolls and taxes, complete toll road exemptions, environmentally differentiated road charging and congestion charging were important considerations under the category of toll roads, along with the CO_2 tax and road use duty on fuels. As argued by NAF (2017), the Norwegian political climate as of 2017 is in a phase where tolls and taxes are increasingly applied to transit vehicle fleets towards low-carbon vehicles. This signify the potential acceptability and effectiveness of such measures.

Compared to faciliatation of low-carbon infrastructure however, toll roads and taxes would have lower effectiveness promoting low-carbon vehicles, mainly due to the obvious risk of operating such vehicles before infrastructure is in place. The same disadvantage holds true when comparing to the possible future implementation of a zero-emission zone, due to increased toll roads and taxes would likely have more impact on the passenger car market, not freight vehicles in urban areas. That is, making passenger car ICEV's more expensive could move the population towards other viable alternatives such as biking or public transport, options that are not viable for freight transport. Making urban freight transport more expensive would rather impose higher costs on customers and citizens eventually. This goes back to arguments from Arvidsson

[102] Can be referred to in Norwegian as «bompengebrikke».

et al (2013) stating we cannot do without transport services from URFT vehicles. This suggests higher tolls and taxes on urban road freight would primarily have an impact in making transport services more expensive, rather than effective promotion of the limited and expensive selection of low-carbon vehicles.

Nevertheless, increased toll road and tax rates could be effective in selected circumstances. That is, while THEMA et al (2016) argue vehicle purchasers are more concerned with purchase rather than operating costs, a potential doubling of the CO_2 tax could prove too big to ignore. This could make ICEV's less economically viable as compared to low-carbon vehicles, as already demonstrated in a TCO perspective from Figure 11. Further, while smaller operators would likely deem a major increase in tolls and taxes less acceptable, larger operators may perceive this differently. Among others, ASKO have mentioned they are not directly opposed to higher road charges, mainly due to their growing fleet of low-carbon and biofuel vehicles (Klette, 2017). As such, increased tolls, and taxes on ICEV's could help establish a widespread market of low-carbon vehicles among early adopters, gradually reducing the market price while also making biofuels more competitive. If reduced biofuel prices hold true, this would likely make it more acceptable for smaller operators who can apply biofuels in several of their conventional ICEV's.

However, the interview with national authorities revealed higher fuel charges and taxes are sensitive, thus likely not acceptable if raised by the double, or even four times as suggested by NGO, ZERO (Melgård, 2016). Further, studies looking at the uptake of electric urban freight vehicles show an increased CO_2 tax is perceived as ineffective among local authorities and freight operators in German cities (Taefi et. al., 2016). On the other hand, timing could hardly be more convenient to increase the CO_2 tax. That is, Nordic Energy Research and International Energy Agency. (2016) argue authorities could exploit current low oil prices to increase fuel charges above current levels. Combined with a continuation of the favourable incentive scheme for low-carbon vehicles, this could effectively stimulate modifications in the system towards biofuels and low-carbon technologies, while requiring minor administrative efforts.

Among the various fiscal measures however, green public procurements best satisfy all criteria of effort, effectiveness, and acceptability. This is not without exceptions however. Referring to the bus sector, research from TØI offer valuable inputs also for green public procurements in the freight sector. That is, while municipalities and county councils were found to have economic opportunities to prioritise climate and environmentally friendly solutions in procurement processes, knowledge of the best solutions are currently a limiting factor (Hagman et. al., 2017). This suggests effort may be the criteria for which is least satisfied, and would require a high collective effort across the public sector to aquire knowledge of the most sustainable solutions in the low-carbon freight segment. This argument is strengthened from the fact urban freight has historically earned low emphasis compared to passenger and public transport. Succesful examples of green public procurements have showed promising steps however, which signify not only effort, but also acceptability is not necessarily a widespread barrier across the public sector. Sarpsborg municipality outside Oslo has garnered national attention for procuring two electric waste collection trucks (Dalløkken, 2017). This demonstrate weighing environment and quality above price in procurement processes is acceptable. This also indicate that the knowledge effort already exists in selected Norwegian municipalities to leverage green public procurements adopting low-carbon vehicles. Likewise, apart from being effective in the primary goal of reducing GHG emissions, inspiring others ensures green public procurements could have a broad effect within and outside its intended target area. That is, based on procurement of hydrogen vehicles in Skedsmo, another municipality near Oslo, many have suggested the City Council of Oslo should adopt similar procurement strategies within their own agencies (e.g. H2BLOG, 2016). Stricter demands and prolonged tendering should be considered for green public procurements in future work on this policy measure.

5.2 Policy Measures Reducing GHG Emissions in URFT

Other than establishing national and municipal targets to reduce GHG emissions, findings from this study suggests a consolidation centre and a city logistics plan were the most mentioned policy measures capable of reducing GHG emissions by other means than low-carbon vehicles. This corresponds to SQ1 in this study, and will be assessed towards the criteria of effectiveness, effort and acceptability.

5.2.1 National and Municipal Targets to Reduce GHG Emissions

National and local authorities adopting targets to reduce GHG emissions could promote both low-carbon technologies and reduce GHG emissions. Most interviewees praised the adoption of long-term targets, recurrently calling for stability and predictability in political decision making. Thus, this measure is both effective in offering urban freight stakeholders long-term certainty, and require minimal effort from authorities to adopt. On the other hand, evidence suggest acceptability in terms of achievement has been a challenge.

Futures researcher Erik Overland argues climate targets in Oslo[103] are perhaps overly ambitious to reach in 2020, but not in a 2030 perspective due to the rapid development in technology for transport (NRKP1, 2017). As such, while deemed unrealistic in the short-term towards 2020, this demonstrate politically bold GHG reduction targets are acceptable at the cost of realistic assumptions. Consequently, this indicate a mixed outcome of the effectiveness criteria. That is, while effectiveness is likely broad in the sense of determining the overall direction of the market, targets in Oslo, particularly in the short-term may prove ineffective in achieving its goals.

This argument is reinforced when comparing Oslo's target to reduce 50 % GHG emissions within 2020, compared to more moderate ambitions from other major Norwegian cities. That is, Trondheim targets a 25 % reduction of GHG emissions in the year of 2020, while Bergen looks to 30 % and Stavanger 20 % (NAF, 2017). Towards 2030 however, Oslo's 95 % GHG reduction target not only levels, but is also surpassed by Bergen who targets being completely free from fossil fuels (NAF, 2017).

5.2.2 City Logistics Plans

Considering a city logistics plan, Eidhammer and Andersen (2015) emphasise this should be a collaboration with inputs from numerous stakeholders, based on a goal to make URFT more effective with concrete policy measures as to how. While not explicitly for city logistics, a similar request for a hydrogen plan in Norway could draw parallel lessons as to authorities' underestimation of strategic plans, also for city logistics. That is, research from SINTEF argue a hydrogen strategy could be a measure to make visible the priorities for hydrogen to an international audience, and attract manufacturers developing low-carbon vehicles to the Norwegian market (Tomasgard et. al., 2016). Similarly, a city logistics plan could expand the vehicle models offered to freight operators in Oslo's URFT, based on a visible exernal communication. Consequently, effectiveness of a city logistics plan could be substantial. Moreover, satisfying RQ1 of promoting low-carbon freight vehicles could be an additional outcome.

More than anything however, the need for clarity in what concerns urban road freight drives the need for a city logistics plan. In terms of criteria applied in this study, acceptability appears to be the criterion for which is most satisfied. Among others, the interviewee working at the Agency for Climate acknowledged a city logistics plan should be an area of greater focus. What's more, in a hearing consultation to national authorities, NLF stated their members miss a

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[103] 50 % reduction in GHG emissions within 2020, and 95 % within 2030.

stronger focus in the national transport plan (NTP) on freight transport's role in cities (Norges Lastebileier-Forbund, 2016). This signify broad acceptability across directly impacting stakeholders. This can be interpreted as a need for clarity from operators to authorities for their long-term vision of the sector, and how this vision is intended to be achieved. Effectiveness depend on unpredictable factors however. This is mainly due to URFT being a complex and difficult sector to work with, and limited knowledge exist among policy makers as compared to other segments of transport (e.g. Ballantyne and Lindholm, 2013). Similar to green public procurements, this signify a potentially high effort to aquire knowledge to develop an overarching and visionary city logistics plan.

5.2.3 Consolidation Centres

Considering implementation of a consolidation centre, consolidating goods for last-mile deliveries could increase the payload of freight vehicles making deliveries, thus potentially reducing the number of freight vehicles in the city. While a seemingly effective measure, interviews with TØI and the NPRA raised some concerns. One factor was the potential reluctance from operators that could risk losing market shares, and the extra cost and time by adding one step in their delivery chain. Hence, the effort of convincing the vast number of smaller operators to accept using a consolidation centre appear high, changing the conventional model for how URFT is performed. Consequently, acceptability could also prove a barrier, but more likely for freight operators as compared to authorities. That is, the latter's interest in reducing GHG emissions from the city is likely not shared equally by freight operators, that would likely consider current market operations of several unconsolidated deliveries as optimal from a business perspective. Thus, a prerequisite is therefore not only agreements, but also cooperation among all stakeholders for being effectively implemented, and acceptable.

Moreover, the interview with TØI revealed another uncertainty in achieving a viable business case. This was connected to the role of authorities that could potentially offer either or both financial support and strategic locations in urban proximity for a consolidation centre. For financial support, Andersen and Presttun (2013) highlight experiences from other cities often demonstrate initial investment support is necessary, occasionally supplemented with early operational support to establish a viable business case. In terms of offering strategic locations, effectiveness of a consolidation centre seems largely dependent on authorities taking the role of providing locations, which would otherwise prove difficult. That is, Presttun (2017) argue centres for logistics activities are typically not desired from the local community, while finding space and high market prices are other prominent barriers for their implementation.

Further indication suggest poor experiences from other cities question the effectiveness of a consolidation centre. While the representative from TØI highlighted Paris, Brussels and Rotterdam were cities having operational consolidation centres, others had problems making a business case. This could affect acceptability among not only freight operators and other stakeholders, but also authorities. That is, acceptability largely hinges on authorities' acceptance to finance a consolidation centre in early stages, while freight operators must overcome the reluctance to risk lose profit from an extra step in the delivery chain.

While potentially difficult to coordinate, the interview with NPRA stated the probable most effective design of a consolidation centre were if transport buyers set their address to the centre. From there, the last mile delivery was for the centre and transport buyer to solve only. As such, if local authorities contributed a strategic location for a consolidation centre, along with initial financial investment and operational support, this model would likely yield the most successful contribution towards Oslo's targets of drastic GHG emission cuts. Lastly, it should be noted that while a low-emission zone in Oslo would likely increase the attractiveness of a consolidation centre, a demand to only allow low-carbon vehicles to operate from the centre would likely make an effective contribution towards RQ1 in this study as well.

5.3 Reflections

This study has listed numerous policy measures able to promote low-carbon technologies and reduce GHG's from URFT. The literature review, interviews, and assessment against criteria show there are room for improvement however, particularly for what concerns focus on URFT as a sector. Both at local and national level, findings suggest responsibility and implementation of policy measures can be fragmented for what concerns delegation of responsibility for URFT within various level of authorities, and unclear. As a result, this could reduce effectiveness of policy measures designed to promote low-carbon technologies, and reduce GHG emissions from the sector. This section reflects on these challenges.

5.3.1 Clearer Priorities

Using hydrogen as an example, a survey conducted by Tomasgard et al (2016) stress stakeholders in the private sector consider the dialogue fragmented politically, with low predicatability as to future innovation uptake of this low-carbon propulsion. This seem to be largely caused by not only the early stage of the market, but also a lack of clarity from authorithies, likely connected to the principle of implementing technology neutral policy measures. Addressing this factor, IFE (2017) argue national authorities, preferably through Enova should dare to rank various fuel propulsions to provide predictability for the private market. Having garnered widespread attention, ASKO have developed their own fuel hierarchy as illustrated in appendix 7.3, not much unlike the one in Figure 13 for this study. This indicate a clear direction towards electric and hydrogen from a private operator, consequently assisting other operators in making decisions upon their next investment, based on the most sustainable solution available. With respect to the regime of technology neural policy measures as emphasised by authorities in this study, some, including research institution SINTEF argue the principle should be disregarded in some instances (Tomasgard et, al., 2016). This argument is supported by findings from this study, based on the need for active participation from authorities in establishing initial markets for low-carbon freight vehicles. A ranking of fuel propulsions for improved clarity should be an initial step in this context, preferably from Enova. Also, enhanced focused on communicational policy measures to market the advantages of the highest ranked fuels should be a priority, a policy category vastly underestimated from findings in this research.

The uptake and use of low-carbon vehicles would likely be further promoted if a joint statement was created between various levels of authorities. The shared hydrogen strategy between Oslo and Akershus county council could be viewed a rolemodel in this context, making clear the priorities of the region. This helps to not only harmonise a strategy for deployment of hydrogen vehicles for a large geographical area, but also indicate towards vehicle manufacturers hydrogen is a political priority in Norway, and Oslo and Akershus specifically. This should be encouraged regionally between municipalities, major cities and between national and local authorities as well, to enhance clarity in the transition towards low-carbon technologies. Again, this reinforce more focus on communicational measures should be considered, along with efforts to harmonise standards across cities and regions, recommended in interviews by freight operators and OEM's in this study.

5.3.2 Delegating Responsibilities

A finding from this study was no specific body appeared directly responsible for the the URFT sector nationally or locally. This could be perceived as a problem due to various levels of authority and internal departments therein affect URFT through various individual policy measures. This follows arguments from Ballantyne and Lindholm (2013), stating collaboration between internal departments of local authorities regarding freight transport appear generally missing. As such, loacal authorities should delegate responsibility of URFT to a specific body, followed by an initial step to develop a city logistics plan. This will ensure not only enhanced knowledge, but also much needed ownership of URFT delegated to a specific body. The Agency for Climate, or Agency of Urban Environment apper likely alternatives in this context for Oslo. That is, through their coordinating role, the Agency for Climate could be vital in preventing fragmentation among local authorities working with the URFT sector. Also, the Agency of Urban Environment appear relevant due to their role of working on conceptual studies for both a consolidation centre and low-emission zone in Oslo, areas already affecting URFT.

The challenge appears similar on national level. The Norwegian research foundation IFE has imposed the role of making visible the differences in attitutudes and spot synergies between national ministries working on similar tasks (IFE, 2017). Among others, while the Ministry of Climate and Environment manage biofuels, the Ministry of Transport and Communications is responsible for overall GHG emissions in road transport, and final priorities are decided by the Ministry of Finance. What's more, government enterprise Enova, who is working towards Norway's transition towards a low-carbon society (Enova, 2017), is owned by the Ministry of Petroleum and Energy. Similar to local authorities, this ultimately begs the question as to who feels responsible for URFT among the variety of overlapping powers.

As such, it should be no surprise Spurkeland (2016) questions what ministry is responsible for urban road freight logistics, mentioning both the Ministry of Transport and Communications and the Ministry of Trade, Industry and Fisheries as potential candidates. Due to primarily being a local matter, enhanced autonomy delegated from national to local authorities in directly regulating policy measures affecting URFT could help cities assume a larger sense of ownership to the sector. This follows recommendations from climate researchers Bjartnes and Michelsen. (2016), and alignes well with arguments from the Stockholm Environment Institute. Among others, the institute suggest national authorities could in several cases encourage action by cities through removing restrictions on their authority, particularly relevant for areas where cities ideal role is implementers and polic leads (Broekhoff, Erickson and Lee, 2015). Urban road freight should be considered such an area.

This is further reflected in findings from this study, showing a perceivingly ineffective implementation process of zero/low emission zones in Oslo. The statutory authority from national authorities on this matter provides little room for effective policy interventions at local level. On the contrary, local authorities have been given the mandate to regulate access to bus-lanes for low-carbon vehicles, as shown in Table 13. IFE (2017) argue this has helped to avoid unecesarry conflicts and achieve a desired dynamic. For Oslo to achieve targets reducing GHG emissions, a successful interdependent relationship with national authorities seem necessary however. In studying incentives for electric passenger vehicles as found in Table 13, Figenbaum et al (2015) finds national incentives to outperform local and regional incentives. Other research also argues efforts by subnational governments where they have limited influence have proved not successful, except for when closely collaborating with national authorities (Broekhoff et. al., 2015).

As such, while numerous policy measures are found capable of promoting the uptake and use of low-carbon technologies, the potential for improvement is notable. Initially, the various components of URFT needs to be delegated a specific department, agency, or ministry at local and national level. While overlapping responsibilities affecting URFT is inevitable, the development of a city logistics plan, delegated to a specific body within authorities likely gives a clear sense of ownership. This could further ensure progress and understanding for a complex, but important sector. Eventually, the unpredictable future for electric and hydrogen vehicles in urban freight can be counteracted by authorities being rolemodels taking bold actions. This can be done through a policy measure seldom touched upon in this study, namely adopting increased numbers of low-emission vehicles in municipal fleets.

6 Conclusion

The research question and complementing sub-questions guiding this research from the start was the following:

RQ1:

- What policy measure(s) would most likely promote the uptake and use of low-carbon vehicles in urban road freight transport?

Results indicate that fiscal measures are the most recommended policy category, while organisational mesures rank second. For individual policy measures, a variety of policy measures appear necessary to promote the uptake and use of low-carbon vehicles, and no single measure would suffice. However, findings suggest facilitation of low-carbon infrastructure is the most important, followed by zero/low-emission zones, green public procurements, Enova's subsidy schemes, toll roads, the national incentive scheme for electric vehicles, and adopting targets to reduce GHG emissions locally and nationally. Communicational measures for promoting low-carbon freight vehicles appear underestimated however. This is connected to enhanced clarity from authorities to rank various fuel propulsions, and promote advantages and TCO calculations for low-carbon freight vehicles. This mandate could be delegated a specific body within both levels of authority, who's responsibility for URFT needs to be made clear.

Having the most common individual policy measures assessed towards the criteria of effort, effectiveness, and acceptability, no policy intervention appears flawless. That is, facilitation of low-carbon infrastructure would seem more effective if financial contributions were broadened beyond current mandates to also offer operational support for suppliers. However, this appeared less acceptable primarily due to the principle of implementing technology neutral policy measures. Also, a zero-emission zone appeard effective in promoting low-carbon vehicles if bans on ICEV's were applied. However, high effort and low-accetability would likely have proved prominent barriers, unless being enacted as a commitment for future implementation. It was further found that green public procurements generally scored well on all tree criteria. Yet, effectiveness could improve if stricter demands were set as a standard for these processes, and prolonged tenders could allow for increased likelihood that technological innovations and low-carbon solutions were fulfilled.

SQ1:

- What policy measures would most likely lead to GHG emission reduction in urban road freight transport?

Implementing a consolidation centre, creating a city logistics plan, and adopting targets to reduce GHG emissions from local and national authorities proved the most preferred individual policy measures. Similar to RQ1, the study revealed policy measures scored different when analysed towards criteria of effort, effectiveness and acceptability. In this context, a consolidation centre seemed effective in reducing freight vehicles in the city, but less acceptable for freight operators potentially losing profit from an extra step in the delivery chain. Also, effort seemed high to successfully organise and operate a consolidation centre. Further, while a city logistics plan seemed as having a widespread acceptance, effectiveness largely hinged on the knowledge and effort to implement a viable and visionary plan. Lastly, targets to reduce emissions could also be seen as relevant to RQ1. When analysed, it appeared this measure generally scored well on all criteria, but could appear less effective in the short-term due to unrealistic objectives, particularly for targets in Oslo towards the year of 2020.

SQ2:

- Who are the most important stakeholders in urban road freight transport?

As shown in Figure 14, authorities, freight operators, customers and shippers are deemed most important stakeholder groups in the URFT sector, having direct impact on the sector. As should be noted, each of these stakeholders also have several sub-segments of stakeholders under each group. Also, numerous stakeholders were found to have an indirect impact on URFT. These include OEM's, public transport operatiors, the EU, architects/urban planners, trade associations, commercial organisations, land/property owners, academic and research organisations, and NGO's. This follows findings from the literature review, suggesting URFT is characterised as a sector of numerous interdependent stakeholders with often conflicting objectives to account for.

SQ3:

- What are the most promising technical solutions in urban road freight transport?

From Figure 13, a battery electric fuel propulsion was identified as the most promising technical solution in URFT, ahead of fuel-cell hydrogen. Battery electricity were ranked the highest due to applicability in urban transport with short distances, frequency of time where vehicles spend idling, and significantly reducing tailpipe emissions of GHG's. As further suggested from section 3.4.3, the electricity mix is of vast importance to the overall environmental performance of battery electric vehicles. To the extent Norway utilise renewable energy from domestic hydropower production, negative environmental impacts would be low in a life-cycle perspective. Further, biogas was ranked above other biofuels mainly due to local production in Oslo, thus making biogas a political priority, also with low GHG emissions. Lastly, the variety of natural gas (CNG and LNG) ranked above diesel and gasoline, the latter for which were deemed as should be phased out.

In conclusion, this thesis shows a variety of policy measures are needed to promte the uptake and use of low-carbon freight vehicles. Most urgently however, facilitation of low-carbon infrastructure is needed to promote low-carbon freight vehicles. It should also be noted this research uncovered areas for improvement in managing URFT among authorities. Among others, this is needed in terms of improved clarity to occasionally disregard the principle of implementing technology neutral policy measures. In this context, operational support for hydrogen infrastructure, and ranking of various fuel propulsions should be key steps, preferably through government enterprise, Enova. Improvements were also identified in delegating responsibilities for uran road freight. That is, URFT should be delegated a specific body within national and local authorities to provide a sense of ownership, followed by the initial step of developing a city logistics plan.

Future research should seek to further assess practices in a global perspective regarding URFT. Due to being a sector having historically received little attention compared to other modes of transport, and having been found poorly understood by policy makers, documentation of best practices from successful cities could prove of great value. This is an area further research is needed, to increase focus on a sector still in its infancy for what concerns political attention. Interviews from this study suggest Gøteborg, Sweden, and Rotterdam, Netherlands could be fronterunner cities on these matters.

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7 Appendix

7.1 Policy measures identified from literature

Category	Policy Measure	Source
Communication	Virtual (webpage) or physical (e.g. conferences) information on low-carbon vehicles. Provided by authorities on topics including costs, state funding, advantages, total cost of ownership and availability.	(Taefi et al., 2016: Bakker and Trip, 2013; NHO et. al., 2016; THEMA et.al., 2016; Sagplass interview, 2017; Bjartnes and Michelsen, 2016)
Legal	Access to bus lanes	(The City Council of Oslo, 2016: Bakker and Trip, 2013; THEMA et. al., 2016; Spurkeland, 2016)
Legal	Free and/or privileged parking	(Bakker and Trip, 2013; Kijewska et. al., 2016; Cherrett et. al., 2012)
Legal	Low-emission freight vehicles can use privileged loading and unloading zones in inner city. (or construction of these)	(Salama et al., 2014; Eidhammer and Andersen, 2015; Cherrett et. al., 2012; MDS Transmodal Limited and CTL, 2012; Kijewska et. al., 2016; Spurkeland, 2016)
Legal	Establish low/zero-emission zone(s)	(The City Council of Oslo, 2016; Eidhammer and Andersen, 2015; NHO et. al., 2016; MDS Transmodal Limited and CTL, 2012; THEMA et.al., 2016; Bjartnes and Michelsen, 2016)
Legal	Certify transport companies with low-emission fleets/other reward scheme	(Taefi et. al., 2016; NHO et. al., 2016; Bjartnes and Michelsen, 2016; Eidhammer and Andersen, 2015; Fu and Jenelius, 2017)
Legal	Lobby for harmonisation of charging infrastructure/standard for charging plugs	(Nordic Energy Research and International Energy Agency, 2016; Bakker and Trip, 2013)
Organisational	Create a consolidation centre (can be supplemented in demanding low-carbon technologies)	(Suksri et. al., 2012; Eidhammer and Andersen, 2015; NHO et. al., 2016; Cherrett et. al., 2012; Filippi et. al., 2010; MDS Transmodal Limited and CTL, 2012; Nordtømme et. al., 2015)
Organisational	Electric and hydrogen vehicles in municipal fleets	(Bakker and Trip, 2013; Eidhammer and Andersen, 2015; Tretvik et. al., 2013; Bjartnes and Michelsen, 2016)
Organisational	Facilitate low-carbon infrastructure development	(The City Council of Oslo, 2016; Bakker and Trip, 2013; Quak et. al., 2016; NHO et. al., 2016; Tretvik et. al., 2013; MDS Transmodal Limited and CTL, 2012)
Organisational	Finance and construct energy stations	(NHO et. al., 2016; The City Council of Oslo, 2016; Råstad Interview, 2017)
Organisational	Repair and service support	Taefi et. al., 2016; Quak et. al., 2016; THEMA et.al., 2016)
Fiscal	Green public procurement in public tenders	(The City Council of Oslo, 2016; NHO et. al., 2016; Quak et. al., 2016; THEMA et.al., 2016; Bjartnes and Michelsen, 2016; IFE, 2017)
Fiscal	Subsidy schemes	(NHO et. al., 2016; Tretvik et. al., 2013; THEMA et.al.,2016; Bjartnes and Michelsen, 2016)
Fiscal	CO_2 tax on ICEV's and higher fuel surcharge	(NHO et. al., 2016; Tretvik et. al., 2013; Fridstrøm and Østli, 2016; THEMA et.al., 2016; Bjartnes and Michelsen, 2016)

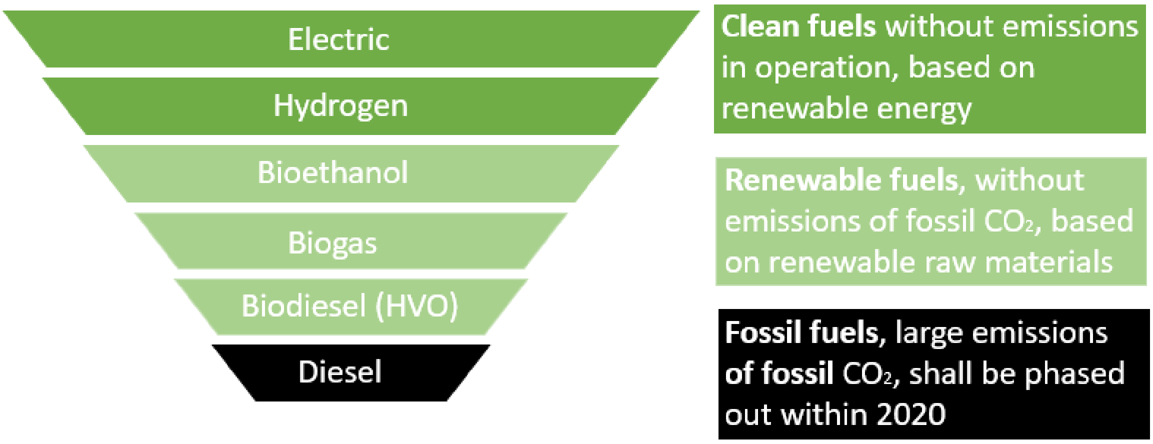
Fiscal	Electronic road charging/environmentally differentiated road charging	(The City Council of Oslo, 2016; NHO et. al., 2016; Tretvik et. al., 2013; MDS Transmodal Limited and CTL, 2012)
Fiscal	CO_2 fund	(Pinchasik and Hovi, 2017; NHO et. al., 2016)
Fiscal	Exemption from toll roads/city toll charges	(Bakker and Trip, 2013; Suksri et. al, 2012; MDS Transmodal Limited and CTL, 2012; Bjartnes and Michelsen, 2016)
Fiscal	Congestion pricing	
Fiscal	Scrapping subsidy, also diesel vehicle scrappage fund	(THEMA et. al., 2016; Bjartnes and Michelsen, 2016; Ministry of Climate and Environment, 2017; Cole, 2017)

7.2 Mentioning of policy measures across interviews

Policy Measure	Theme Frequency
Facilitate low-carbon infrastructure development	6
Zero/low-emission zone	5
Green public procurements	5
Enova subsidy scheme	5
Toll roads	4
Electric vehicles incentive scheme	4
National and municipal targets (GHG emissions)	4
City logistics plans	3
Consolidation centres	3
Congestion charging	3
Environmentally differentiated road charging	3
NTP (national transport plan)	3
R&D projects	3
Low-carbon vehicles in municipal fleets	3
Cooperation fora/groups/networks	3
CO_2 fund	2
Road use duty on fuels	2
Scrapping subsidy, also diesel vehicle scrappage fund	2
Access to information/information sharing	2
Harmonisation of toll roads	2
CO_2 tax	2

Annual motor vehicle tax	1
Hydrogen taxi subsidy scheme	1
Dedicated truck lanes	1
Finance and develop infrastructure (basic electric charging infrastructure)	1
Bypakker (City Packages)	1
Standards for CO_2 emissions	1
Certify transport companies with low-emission fleets/other reward scheme	1

7.3 ASKO's fuel hierarchy



Source: Adapted from Bjartnes and Michelsen (2016).

7.4 Semi-structured interview guide

Interview guide for discussions with stakeholders

Prospective heading for research:

Steering Towards Low-Carbon Road Freight Transport Through Policies

The Case of Oslo

1) **Personlige detaljer:**

- Navn:
- Institusjon:
- Stilling:
- Intervju kategori:

2) **Introduksjon og formaliteter/Introduction and formalities:**

- Tusen takk for at jeg fikk komme, hvem jeg er, hvor jeg kommer fra og hva jeg driver med……………….: hvordan politiske virkemidler påvirker opptak av lav- eller nullutslippsteknologier for nyttekjøretøy, mer spesifikt elektrisitet og hydrogen.
- Om konfidensialitet, opptak, og at han/hun svarer på det han/hun vil. Dersom jeg bruker noe som kan tilbakeføres til deg, blir du selvfølgelig forelagt dette.

3) **Intervjuguide og notater/Interview guide and notes**

Generelle spørsmål som vil bli stilt alle intervjuobjekt/general questions for all interviews:

- Kan du først si litt om din stilling og hvordan du evt har arbeidet/arbeider med transport?
- Norge og Oslo skal kutte klimagassutslipp betraktelig de neste årene (2020, 2030 og 2050 mål), hvilken rolle ser du for deg transport ha i denne prosessen med å kutte klimagassutslipp?
- Norge er av mange kjent som et foregangsland i lav- eller nullutslipps personbiler (primært elektrisitet), hva tenker du om vekstmuligheter for lav- eller nullutslipps nyttekjøretøy, som sett i personbilmarkedet?
- Hvordan vurderer du ulike alternativer i teknologi av lav- eller nullutslipps nyttekjøretøy? (elektrisk/hydrogen/biodrivstoff/hybrid)
- (Om det ikke kommer opp – følg opp med spørsmål om tanker rundt elektrisitet og hydrogen)
- Hvordan mener du myndighetene best kan legge til rette for en omlegging i kjøretøyparken for lav- eller nullutslipps nyttekjøretøy?
- Hvilke politiske virkemidler mener du er best egnet til å drive overgangen til elektriske eller hydrogendrevne nyttekjøretøy? Hvorfor disse?
- Ser du noen barrierer ved innføringen av disse virkemidlene eller ved null- eller lavutslipps nyttekjøretøy?
- Hvem burde ta ansvar for tilrettelegging for lav- nullutslipps infrastruktur?
- Avsluttende kommentarer?

Deretter gå inn på skreddersydde spørsmål for hvert intervjuobjekt/tailored questions for each interviewee:

Til sist, husk å forhøre deg om det er mulig å kontakte ved senere anledning, om flere spørsmål skulle komme opp.