TØI Report 1503/2016

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Pathways to Sustainable Transport among Norwegian Crafts and Service Workers

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Sammendrag:

Rapporten fremlegger resultater fra en studie av norske håndverk -og service bedrifter (H&S) som har tatt i bruk elektriske kjøretøy og mobilstyringsapplikasjoner (MA). Sistnevnte påvirker i stor grad virksomhetenes kjøremønster, men potensialet for å redusere reiseomfanget er usikkert. Andelen H&S virksomheter som har tatt i bruk el-biler er så langt begrenset, men det er sterk interesse for å ta dette i bruk i større skala. Analyser av kjøremønster blant et utvalg H&S-bedrifter viser at 37 % av kjøretøyene relativt lett kan erstattes av el-biler, noe som tilsier 13% av det totale transportarbeidet. En økning i rekkevidden for el-biler med 50%, eller ladning i løpet av dagen, vil hver for seg kunne øke antall utskiftbare kjøretøyer til 64%. Dette vil i så fall resulterer i 41% reduksjon i utslipp av klimagasser fra hele H&S sektoren.

Summary:

This report documents results from a study of Norwegian crafts -and service companies (C&S) that have adopted electric utility vehicles (EUVs) and/or mobile management applications (MAs). Results show that MAs largely affects the travel patterns in the enterprises, but the potential to reduce the amount of travel is uncertain. Analyses of driving patterns among a sample of C&S enterprises shows that a potential replacement of diesel vehicles with EUVs be relatively easily done for 37% of the vehicles, representing 13% of the total transport work. An increase in the range of electric vehicles by 50%, or charging of the cars during the day, could increase the number of changeable vehicles to 64%. This would then result in a 41% reduction in greenhouse gas emissions from all vehicles in the C&S sector.

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Preface

This report present results from the research project Crafttrans (Innovating for more efficient and sustainable transportation among Norwegian craftsmen). Two other TØI-reports have formerly been published as a part of this project, TØI-report 1326 and 1336. The work has been conducted with financial support from the Norwegian Research Council, as well as the Norwegian Road Authority, the Municipality of Oslo, Ruter and Renault Norway. Project manager has been Jon Martin Denstadli (2013-14) and Tom Erik Julsrud (2014-16). In addition, the project team have included Liva Vågane, Erik Figenbaum, Susanne Nordbakke (all TØI) and Hans Tilset (NTNU). Parts of the work has been done in collaboration with Asbjørn Wethal at Statistics Norway (SSB). Associate professor Tim Schwanen (University of Oxford) and Professor Per Morten Schiefloe (NTNU) have been scientific advisors for the project.

The work has been conducted in collaboration with a reference group including Toril Presttun (Statens Vegvesen), Helge Jenssen (Oslo kommune), Jan Traaseth (Renault), Nina Solli (NHO), Kristin Brandt (Håndverksforeningen), Tony Gundersen and Daniel Hillarøy (GSGroup).

The project addresses a vote of thanks to the crafts- and service enterprises that opened their doors and generously shared of their experiences with us.

Oslo, July 2016
Institute of Transport Economics

Gunnar Lindberg	*Frode Longva*
Managing Director	*Research Director*

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Summary

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This report documents results from a study of Norwegian crafts -and service companies (C&S) that have adopted electric utility vehicles (EUVs) and/or mobile management applications (MAs)-two technologies that are believed to be of crucial importance for the development of more efficient and sustainable mobility among such enterprises in the future urban landscapes. Currently, adoption of EUVs among C&S enterprises in Norway is low, but there seems to be a strong interest for a wider use in the future. For the smaller craft enterprises today's financial incentives are particularly important for their motivation to adopt electric vehicles, while for the somewhat larger service enterprises benefits related to environmental issues and greener company images are of greater importance. Mobile Management Applications largely affects the travel patterns in the enterprises, but the potential to reduce the amount of travel is currently uncertain. Analyses of driving patterns among a sample of C&S enterprises shows that a replacement of diesel vehicles with electric cars be relatively easily done for 37% of the vehicles, representing 13% of the total transport work. However, an increase in the range of electric vehicles by 50%, or charging of the cars during the day, could increase the number of replaceable vehicles to 64% and the transport work carried out with EUVs to 41%. This would then result in a 41% reduction in greenhouse gas emissions from all vehicles in the C& S sector.

Case studies of EUVs

Qualitative interviews with EUV users in the C&S sector have shown that there is significant variation among C&S industries in their motives for adopting EUVs. The smaller, traditional craft enterprises – painters (decorators), bricklayers, carpenters and roofing workers –are driven mainly by economic benefits, particularly in relation to cheaper fuels and tax reduction. For enterprises in the service sector – cleaners, caretaker services, home care and security – environmental benefits are more important. Decisions to implement EUVs in this latter sector was often related to green certification schemes.

Economic benefits are important when decisions are being made to adopt EUVs, as are issues in relation to organizational *identity* and image, this most clearly spelt out by craft managers.

Implementation in smaller craft enterprises is usually informal through small-scale testing. In the service enterprises, however, EUVs are thoroughly evaluated before being fully implemented. In all cases, substantial informal and formal learning take place. The innovative technology is usually actively introduced and promoted by a particular person, usually a manager with an interest in cars, new technologies and/or environmental issues.

Despite much resistance, electric cars and vans are usually evaluated positively. In craft enterprises, EUVs are used mostly in combination with traditional diesel vans, while in service enterprises they replace all cars.

Battery capacity is a major challenge, particularly for traditional craft businesses. In general, crafts enterprises have more ad hoc oriented travel patterns, which means that limited battery capacity can be problematic, particularly if the company caters for customers located over a wide geographic area. Service enterprises tend to have more predefined mobility patterns where limited battery capacity is more manageable.

Crafts workers are generally enthusiastic about EUVs and nurture a hope that improved models will soon be available. At the time of the interviews (i.e late 2015) general opinion was that the current models were only useful in combination with traditional diesel and petrol cars. EUVs, however, were generally seen as good enough to meet the basic needs of service workers, even though more cargo capacity and driving range would be highly welcome.

Case studies of MMA users

Handyman (HM) is a central supplier of MMA for C&S workers. Interviews were therefore conducted with users in a number of enterprises in order to get more insight on implementation and use of these tools. Implementation is highly dependent on there being entrepreneurs who can push this through in the crafts industry, usually a young person with an interest in technology. Younger craftsmen are generally more used to new technologies, and their working routines are not as strongly internalized as those of older craftsmen. They therefore adjust more readily to the use of HM.

The major motive behind adoption of HM is in relation to potential increased efficiency of billing and registration of man-hours, i.e. by a reduction in the amount of paperwork for both manager and craftsman. Another important reason in most companies was that HM made the management and distribution of assignments/jobs from office to craftsmen easier. Only two of the companies (Plumbing 1 and Electric 2) had an explicit focus on the potential of reduced driving among craftsmen as the reason for implementing HM.

Most companies believed HM would reduce the amount of driving among craftsmen owing to new opportunities for direct re-assignment of work tasks. For example, the craftsmen didn't always have to go into the office every morning to get their assignments or to report hours used in the field, and there was also the potential for sharing of information between crafts workers. Many craftsmen work alone on assignments, and before the introduction of HM they had to visit the office to consult with their colleagues and managers.

Still, trying to measure reduced travel resulting from use of HM was difficult. The one company that had done so during the course of the years before and after the introduction of HM could not find any reduction in driving (measured by the number of kilometres). Most of our interviewees believed that there was potential for reducing the number of trips to the wholesaler for instance, but few companies reported having realized it.

One side effect of the technology mentioned by several firms was a lower frequency of social meetings. The introduction of HM had made trips into the office in the morning redundant, and records of man-hours (on paper before the HM) once a day/once a week were no longer necessary. Thus some expressed concern for a long-term impact on organizational climate and learning.

Crafts and service workers' attitudes to EUV

A web-based survey was conducted among managers in small and medium-sized enterprises in seven key crafts industries to get more information about uses of EUVs, and to find out what interest there was for future adoption. A net sample of 264 crafts respondents was recruited among members of local craftsmen enterprises in Oslo, Bergen, Trondheim and Stavanger. The sample included craft enterprises within the building -and construction segment.

As expected, there was relatively little interest in the adoption of EVs, with approximately only 5% owning or having access to an electric car on a daily basis. The EUV users in our survey were spread across different business areas, although 6 out of 14 were electrical installation firms.

Although there are not many EUV users in this part of the crafts industry, there is a strong likelihood of electric vans being adopted in the near future. Looking two years ahead, about one in four of today's non-users say that it is likely, or very likely, their company will adopt EUVs. Of those who said adoption was unlikely during the following two years, over 27% believed it would be relevant during the next five years. Fifty-one percent of the informants said it was likely their company would adopt EUVs in the coming two to five years.

As mentioned in section two, the current incentives might persuade C&S and service workers into using EUVs. In general, these seem to be having a significant impact on current EUV use, the most attractive being toll-free roads and free parking.

Based on an exploratory factor analysis, we found three distinct groups of attitudes to EUVs: the first including positive attitudes to the practical benefits of using an EUV and a preference for speed and reliability; the second, expressing doubt about the usefulness of EUVs and the risk of investing in them; the third, expressing positive attitudes to EUVs, based on a good image developed among customers and vendors.

There are significant attitudinal differences between enterprises that have already adopted EUVs and those that haven't. The most prominent feature of current users is that they have a good understanding of the mobility benefits, and of aspects related to a positive and environmentally friendly image and economic benefits. For those planning to adopt EUVs in the coming two years, image and economy are more important than the current benefits. Risk-related attitudes are prominent among those who have a long-term horizon on adoption and those reluctant to adopt in general.

Potential for EUVs based on electronic travel diaries

Crafttrans gathered data logs of the transport activity of seven craftsmen companies in order to get a better understanding of how craftsmen travel. The dataset was obtained from the Guard Systems electronic travel log database (TRAVELLOG). TØI and Guard Systems were given permission from these seven companies to access GPS data for their vehicles, data already stored in and retrieved from Guard Systems' operative database of logged travel. The seven companies operated with 115 vehicles and data were obtained for two weeks.

A natural sample of the daily trips of craftsmen with traditional vans was used to estimate the potential for replacement with EUVs based on travel behaviour.

The potential range of diesel vehicles to be replaced depends on the daily travel distance. In general, vehicles covering less than 51 km per day are readily replaced, and in most cases also those in the range 51–80 km. In the case of vehicles driven 80–120 km, there is potential for vans being replaced on the basis of driving style, temperature, cargo, etc., but at over 120 km replacement is not possible without a charging stop during the day.

Therefore, with a limit of 80 km driving on the maximum day of travel, 41% of vehicles can be replaced but only 13% of the transport work. If all transport could be replaced with EUVs on days of travel less than 80 km, 42% of the transport work would be replaced. A 50% increase in range, achievable in a 5-year timeframe, would result in a much higher substitution of transport work. The share of vehicles would then be 68% and the transport work share 41%.

The potential for replacing transport work may be greater if the transport activities of companies can be redistributed so that electric vehicles are used on the short distance trips they are capable of. Redistributing vehicles would also allow EUVs to be used more in summer, when range is longer than in winter, and is straightforward in theory but in practice can be challenging. The vehicle is also the "personal tool box" of many craftsmen who may be reluctant to change vehicles from one day to the next.

Vans covering short trips are those most likely to be replaced, although they generate little transport work. The potential of diesel utility vehicles being replaced by EUVs includes 23% of vehicles that travel up to only 50 km per day and are 100% replaceable by EUVs. However, they account for only 5% of the transport work of the logged vehicles. Approximately 14% of the total are driven occasionally in the 50–80 km interval and account for 8% of the transport work. It is likely that most of these, too, are readily replaceable by EUVs. The base potential is thus up to 37% of vehicles and 13% of the total transport work. Technical development of EUVs resulting in the winter range being extended to 120 km, which could happen with the next generation of vehicles or by charging shorter range vehicles during the day, will increase the number of vehicles that can be EUVs from 42 to potentially 73, covering 41% of the total transport work of the 115 logged vehicles.

Charging during the day has the advantage of expanding the range the vehicle can cover over the workday. On average, the real winter range (corresponds to all year range) can be expanded by some 40 km on average, i.e. 50% more if the range is 80 km.

Measures to initiate rapid transition to green mobility

All in all, the situation is promising for further growth in use, although a faster transition will require initiatives and continued efforts along several dimensions.

By combining factors on multiple levels, a momentum for change could be developed and help to spur the development of greener mobility among C&S enterprises.

Changes on a landscape level, such as oil prices and global climate, will clearly impact on any transition towards non-fossil fueled mobility systems. In this discussion, however, we focus mainly on the meso and micro-level, where it is reasonable to think that changes may be initiated in a Norwegian context.

Currently, there is strong pressure on a policy level to implement measures that could help to reduce emissions from diesel-engined cars in urban regions. At this level, certain crucial preconditions need to be pursued to sustain and improve the transition process. There is need for *new EUV models* that cater better for the needs of craftsmen; the *incentive system* for purchase and use of EUVs needs to be continued and further developed, and the current *restrictions on ICE vans* in urban areas need to be strengthened.

On a micro level, *continued niche experimentation* among C&S industries is necessary, but these experiments need to be increased in number, scope and diversity if a stronger impact is to be achieved. Better incentive systems may help to make this type of small-scale experimentation attractive for C&S managers. In addition, a more diverse set of technologies should be implemented, involving not only alternative energy systems but also various ICT-based mobility technologies. Thus, systems for low energy mobility among professional users should be integrated with new ideas for smart urban mobility involving systems that can help manage mobility resources more efficiently. There is also need to enhance learning and create larger "networks of niches" that can learn from each other and thus have much stronger impact and exposure.

To stimulate "network effects", it is crucial to expose experiments and ideas on a wide scale along multiple channels. Highly relevant and innovative cases should represent lighthouse cases that can inspire other enterprises and decision-makers. It is also necessary to demonstrate the implication of new technologies more rigidly through longitudinal field studies and research based experiments.

Potential environmental gains

For the purpose of this analysis the assumption is that greenhouse gas emissions and local pollution are nullified 100% when diesel utility vehicles are replaced by EUVs. The effect on emissions from the enterprise within a city and for Norway as a whole is therefore calculated from the annual number of kilometres of travel with EUVs that would otherwise have been diesel utility vehicles.

A categorization of enterprise vehicles based on maximum driven distance in data from the data-loggers shows that 37% of vehicles covered less than 80 km on all days, accounting for only 13% of transport work. Replacing vehicles doing less than 80 km would thus potentially reduce transport emissions from C&S enterprises by 13%. If vehicle travel can be redistributed between vehicles, the potential can be substantially increased.

A theoretical experiment showed that for one of the companies the share of vehicle replaceable could increase from 54% to 84% and the share of transport work from 20% to 47% by optimizing travel with only a few vehicles doing the long-distance trips. In the interviews, users stated that planning trips at this level would be challenging. Those who had successfully implemented EUVs, however, stated that the ability to plan trips better was part of the success story.

New technology increasing range by 50%, or users charging-up during the day, could increase the number of vehicles replaceable to 64% and transport work by EUVs to 41% of C&S enterprises' total transport work, resulting in 41% reduction of emissions. The share of vehicles driven over 10,000 km per year also increases substantially, making the potential easier to realize by increasing the economic gain of users. If range of EUVs could increase to cover all days of transport up to 200 km, then the logger data and opinions of the interviewed C&S enterprises both support the entire C&S enterprise sector's transportation needs potentially covered by EUVs, leading to a 100% reduction of emissions and local pollution.

Sammendrag

Strategier for bærekraftig transport blant Norske håndverks -og servicebedrifter

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Forfattere: Tom Julsrud, Erik Figenbaum, Susanne Nordbakke, Jon Martin Denstadli, Hans Tilset, Per Morten Schiefloe
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Denne rapporten fremlegger resultater fra en studie av norske håndverk -og service bedrifter (H&S) som har tatt i bruk av elektriske kjøretøy og mobilstyringsapplikasjoner (MA), to teknologier som antas å være spesielt viktige for utvikling av effektiv og bærekraftig mobilitet blant H&S-bedrifter i fremtidens byregioner. Foreløpig er andelen virksomheter som har tatt dette i bruk begrenset, med det er sterk interesse for å ta dette i bruk i større skala i fremtiden. For de mindre håndverksbedriftene er dagens økonomiske insentiver særlig viktige for motivasjonen til å ta i bruk el-biler, mens for de noe større servicebedriftene er miljøsertifisering og profilering av større betydning for bruk av el-biler. Mobilstyringsapplikasjoner påvirker i stor grad virksomhetenes kjøremønster, men teknologiens potensial for å redusere reiseomfanget er foreløpig usikkert. Analyser av kjøremønster viser at potensialet for å erstatte dieselbiler med el-biler i dag relativt lett kan gjøres for 37% av kjøretøyene, noe som tilsier 13% av det totale transportarbeidet. En økning i rekkevidden for el-biler med 50%, eller ladning i løpet av dagen, vil hver for seg kunne øke antall utskiftbare kjøretøyer til 64% og transportarbeid gjennomført med el-biler til 41%. Dette vil i så fall resulterer i 41% reduksjon i utslipp av klimagasser fra hele H&S sektoren.

Casestudier av el-bilbrukere

Kvalitative intervjuer med El-bilbrukere innenfor H&S-sektoren avdekker betydelig variasjon på tvers av næringer når det gjelder motiver for å ta i bruk denne teknologien. De mer tradisjonelle håndverksbedriftene - malere, murere, snekkere og taktekkere - er hovedsakelig motivert av økonomiske fordeler, spesielt knyttet til billigere drivstoff og lavere avgifter. For bedrifter i tjenestesektoren - rengjøringsfirmaer, vaktmesterselskap, hjemmehjelpstjenester og sikkerhetsselskap – er miljømessige fordeler like viktig. En viktig årsak er at disse selskapene oftere har tatt i bruk grønne sertifiseringsordninger som gjør det nødvendig å implementere miljøtiltak.

Økonomiske fordeler er likevel viktig for alle selskaper når beslutningene om å ta i bruk el-biler blir fattet. I tillegg er forhold knyttet til organisasjonsidentitet, profilering og omdømme ofte viktige. El-biler anses i denne sammenheng som et virkemiddel som kan gi virksomhetene et grønnere image og bedre omdømme.

Implementering av el-biler i mindre håndverksbedrifter foregår vanligvis gjennom uformell småskala-testing. I service-bedriftene blir dette i større grad grundig evaluert før teknologien tas i bruk i en større skala. I alle tilfeller foregår betydelig uformell og formell læring, spesielt i virksomheter som lykkes med implementeringen. Vilje til å endre reisevaner og planlegge turene bedre fremsto som en viktig faktor for å lykkes.

Til tross for en del motstand, blir el-biler og el-varebiler vanligvis vurdert som positivt. I håndverksbedrifter brukes bilene mest i kombinasjon med tradisjonelle dieselbiler, mens i de større tjenesteytende virksomheter erstatter de i flere tilfeller hele bilparken. Innenfor håndverkerbedriftene er elektrikere et unntak, der vi finner en også eksempler på fullskala implementering.

Batterikapasitet er en stor utfordring, spesielt for tradisjonelle håndverksbedrifter. Generelt har disse et mer ad hoc-preget reisemønster, noe som betyr planlegging av turer og begrenset batterikapasitet er mer problematisk. Dette gjelder i særlig grad dersom bedriften henvender til kunder som befinner seg på et stort geografisk område. Service-bedrifter har derimot en tendens til å ha mer forhåndsdefinerte bevegelsesmønstre, noe som gjør begrenset batterikapasitet mer håndterlig.

Representanter for håndverksbedriftene er generelt begeistret over el-bilene og de gir uttrykk for et håp om at bedre modeller snart kommer på markedet, bedre tilpasset deres behov. På undersøkelsestidspunktet var den generelle oppfatningen at dagens modeller kun var nyttige som et supplement til tradisjonelle diesel- og bensinbiler. Innenfor service-virksomhetene ble el-bilene generelt vurdert som gode nok til å dekke de grunnleggende deres behov for ansattes daglige mobilitet, selv om mer lastekapasitet og bedre batterikapasitet ville økt nytteverdien ytterligere.

Casestudier av MA-brukere

Intervjuer ble gjennomført med brukere av mobilstyringsapplikasjonen (MA) Handyman i en et utvalg håndverks -og servicebedrifter for å få innsikt i adopsjon, bruk og eventuelle effekter på reiseatferd. Selve adopsjonen er svært avhengig av at det er entreprenører i virksomhetene som kan presse dette gjennom, vanligvis en ung person med interesse for teknologi. Yngre håndverkere er generelt mer vant til nye teknologier, og deres arbeidsrutiner er ikke like sterkt internalisert som de eldre håndverkere. De tilpasser seg derfor lettere bruken av denne applikasjonen.

Det viktigste motivet bak innføringen av Handyman er muligheter for økt effektivitet i faktureringsprosesser, raskere og mer pålitelig registrering av arbeidstimer. Systemet har et potensial for å gi en reduksjon i mengden av papirarbeid for både ledere og håndverkere ute i felten. Et annen viktig motiv var mulighetene for en enklere fordeling av arbeidsoppgaver og oppdrag fra kontoret til håndverkerne. Bare to av selskapene – en rørlegger og en elektriker - hadde et eksplisitt fokus på potensialet for redusert bilkjøringen ved hjelp av applikasjonen.

De fleste bedriftene mente likevel at applikasjonen over tid ville redusere bilkjøringen blant håndverkere på grunn av økte muligheter for mer koordinert tildeling av arbeidsoppgaver, basert på hvor de ulike håndverkerne til enhver tid befant seg. Systemet hadde medført at håndverkerne sjeldnere behøvde å reise inn til hovedkontoret hver morgen for å få tildelt oppgaver, eller å rapportere timebruk. Det var også eksempler på at systemet ble benyttet til deling av informasjon mellom håndverk uten at de møttes ansikt-til-ansikt. Mange håndverkere arbeider alene på oppdrag, og før innføringen av Handyman møttes de på kontoret for å rådføre seg med kolleger og ledere.

Forsøk på en systematisk og valid måling av redusert reisetid og/eller reiseavstand som følge av applikasjonen var vanskelig. Den ene selskapet som hadde gjort dette i løpet av årene før og etter innføringen av Handyman kunne ikke finne noen reduksjon i kjøringen med firmabilene (målt i antall kilometer). De fleste av våre informanter mente at det var betydelige muligheter for å redusere antall turer til byggevarehus o.l., men få virksomheter rapporterte å ha realisert eller registrert et slikt potensial.

En utilsiktet effekt av teknologien, som ble nevnt av flere informanter, var færre uformelle møter på hovedkontoret. Reiser inn til kontoret for å skrive og levere arbeidstimer (daglig eller ukentlig) var ikke lenger nødvendig, og noen uttrykte bekymring for at dette kunne ha en langsiktig negativ innvirkning på det sosiale miljøet og mulighetene for felles læring i virksomheten.

Håndverk- og service arbeidernes holdninger til el-biler

En spørreundersøkelse ble gjennomført blant ledere i et utvalg håndverks- og servicebedrifter for å få mer kunnskap om bruk av el-biler, holdninger til teknologien og interessen for fremtidig bruk. Et nettoutvalg på 264 respondentene ble rekruttert blant håndverks- og servicebedrifter i Oslo, Bergen, Trondheim og Stavanger.

Totalt var det 5% av virksomhetene i utvalget som eide eller hadde daglig tilgang til en el-bil/el-varebil. El-bil brukerne var spredt på ulike virksomhetsområder, men et knapt flertall jobbet innenfor elektrisk installasjon. Til tross for at det i dag ikke er mange el-bil, ser det ut til å være stor sannsynlighet for at bruken vil øke i nær fremtid. Om lag én av fire ledere i virksomheter som i dag ikke bruker denne teknologien oppgir at det er sannsynlig/svært sannsynlig, at de vil gå til anskaffelse av el-biler de nærmeste to årene. Av de som mente at en anskaffelse var usannsynlig i løpet av de neste to årene, anga over 27% et dette ville være aktuelt i løpet av de neste fem årene. Vel halvparten av lederne sa det var sannsynlig at deres bedrift ville implementere el-biler i løpet av de neste fem årene.

Flere av dagens insentiver for el-biler later til å ha en positivt effekt på H&S- bedriftenes interesse for å bytte til el-bil. Dette gjelder spesielt avgiftsfritak, fritak fra betaling av bompenger og gratis parkering. Basert på en utforskende faktoranalyse, ble det avdekket tre forskjellige holdninger til teknologien i vårt utvalg. For de første, en faktor der praktiske fordelene og insentivene ved daglig bruk av el-bil ble fremhevet; for der andre, en mer tvilende holdning til nytten av el-biler med fokus på en økt risikoen ved å investere i disse; for det tredje, en positiv holdning til el-biler basert på muligheten for å utvikle en sterkere miljøprofil og image blant kunder og leverandører.

Det er betydelige holdningsforskjeller mellom bedrifter som allerede har tatt i bruk el-biler og de som ikke har det. El-bilbrukerne har en sterk forståelse av de økonomiske fordelene og av forhold knyttet til et positiv og miljøvennlig image. For de som planlegger å anskaffe el-bil i løpet av de neste to årene, er holdninger relatert til image og økonomi mer fremtredende. Risiko-aspekter ved å investere i el-biler er særlig fremtredende blant ledere som ikke er interessert i å anskaffe el-biler.

Analyser av el-bilers kjøremønster basert på elektroniske reisedagbøker

Innenfor Crafttrans-prosjektet har det blitt samlet inn data fra elektroniske kjøredagbøker i syv håndverk- og servicebedrifter for å få en økt forståelse for daglig og ukentlig reisemønster, og anslå potensialet for å erstatte dagens kjøretøy med el-biler Anonymiserte data ble hentet via elektroniske kjørebøker i Guard System sin database. Det ferdige datasettet omfattet all kjøring i syv selskaper i Oslo og Akershus, total med 115 biler, over en to-ukersperiode.

Mulighetene for å erstatte dieselbiler med el-biler avhenger i stor grad av bilenes daglige kjørelengde. Generelt kan kjøretøy som reiser mindre enn 51 km pr dag lett skiftes ut, og dette gjelder også for de som har kjørelengder på 51-80 km. Når det gjelder kjøretøy som går 80-120 km, er det et potensial for å bytte til el-bil, men dette avhenger i stor grad av kjørestil, temperatur, last, etc. Kjøretøy med en reiselengde på over 120 km vil ikke kunne erstattes av el-biler uten ladning i løpet av dagen. I vårt utvalg betyr det at innenfor en grense på 80 km per dag er det 41% av kjøretøyene som kan erstattes, tilsvarende 13% av det totale transportarbeidet. Hvis all transport under 80 km erstattes, vil 42% av transportarbeidet kunne erstattes av el-biler. En 50% økning i rekkevidde for el-biler kan anses som realistisk innenfor en 5-års tidsramme. Dette vil i så fall tilsi i at andelen 68% av bilene kan erstattes, og 41% av transportarbeidet.

Potensialet for å erstatte transportarbeid kan også økes ved at transportvirksomheten i bedriftene omfordeles slik at elektriske biler blir prioritert på de korte distansene. En omfordeling av bilene vil også gjøre at el-bilene kan bli brukt mer i sommerhalvåret når rekkevidden er lengre enn om vinteren. I praksis kan likevel dette bli utfordrende. Bilen er for mange håndverkere også en "personlig verktøykasse" som kan være vanskelig å bytte fra dag til dag.

Varebiler som har korte turer er enklest å erstatte med el-biler, men det er også disse som genererer minst transportarbeid. Diesel-kjøretøyer som kjører maksimum 50 km per dag og er 100% utskiftbare omfatter 23% av kjøretøyene i utvalget, men de utfører kun 5% av transportarbeidet. Omtrent 14% av den totale bilparken kjører av og til i intervallet 50-80 km og disse utfører 8% av transportarbeidet. Det er sannsynlig at de fleste av disse også er lett utskiftbare, og dette gjør at potensialet for utskiftbare kjøretøy kan økes til 37%, og 13% av det totale transportarbeidet.

En økning i batterikapasiteten til 120 km om vinteren, eller ved å lade dagens kjøretøyer i løpet av dagen, vil øke antall utskiftbare dieselbiler fra 42 til 73 %, noe som tilsvarer 41% av det totale transportarbeidet. Ladning i løpet av dagen kan utvide den reelle rekkevidden med rundt 40 km i gjennomsnitt for vinterhalvåret, dvs. 50% mer innenfor grensen på 80 km.

Tiltak for å initiere raskere overgang til grønn mobilitet blant håndverk- og servicebedrifter

Sett under ett er situasjonen lovende for en fortsatt vekst i bruk av el-biler innenfor H&S bedriftene. En hurtigere overgang kreve imidlertid aktivering av et bredt sett med tiltak og en kontinuerlig innsats på flere områder.

Rapporten analyser mulighetene for å initiere en raskere endringstakt på dette feltet med støtte i *sosio-teknisk innovasjonsteori* og nettverksteori. I lys av disse perspektivene kan store teknologirelaterte endringer i samfunnet anses som resultater av utviklinger på ulike nivåer, som på ulike vis interagerer med hverandre. Mye av endringene initieres imidlertid på et nisjenivå, dvs. blant mindre grupper av aktive brukere som eksperimenterer med nye teknologiske løsninger. I lys av nettverksteorier for innovasjon er det videre et poeng at relativt små endringer i et system kan generere hurtige forandringer, når de når visse terskelverdier. Dette rammeverket indikerer at ved å kombinere faktorer på flere nivåer, kan det utvikles et taktskifte i omstillingene mot mer miljøvennlig mobilitet blant H&S. Det er imidlertid spesielt på et meso- og mikronivå at det er mulig å initiere aktive tiltak som kan forventes å få betydning, og en styrking av aktiviteter på et mikronivå (nisjer) bør vies ekstra oppmerksomhet.

Det er på den ene side visse *forutsetninger* som bør være på plass for å opprettholde og forbedre overgangsprosessen. Dette dreier seg blant annet om følgende: Det bør utvikles nye el-bil modeller som i større grad kan dekke behovene til håndverkere f.eks når det gjelder lastekapasitet; dagens belønningssystemet for kjøp og bruk av el-biler må videreføres og videreutvikles; gjeldende restriksjoner på diesel og bensindrevne varebiler i urbane områder må styrkes, og; avskrivingsreglene for el-biler bør gjøres mer fordelaktige. Foreløpig er det et tiltagende press fra politisk hold om å iverksette tiltak som kan bidra til å redusere utslippene fra dieseldrevne biler i urbane områder. Denne typen tiltak vil være avgjørende pådrivere for å fremdrive hurtigere endringer i bruk av miljøriktig mobilitetsteknologi blant H&S bedrifter i byene, ettersom dehar en stor del av sine turer i bykjernen. Likeledes vil et sterkere fokus på å også anse daglig transport som en del av grønne sertifiseringsordninger være viktig. Dette bør tillegges større vekt f.eks ved innkjøp av tjenester fra H&S virksomheter innen offentlig sektor.

På den annen side er det behov for nye *aktive tiltak* for å ytterligere stimulere til endringer innenfor H&S segmentet. Dette omfatter blant annet en sterkere grad av pilotering og utprøving med ny teknologi på mikro-nivå. Disse forsøkene må økes i antall, omfang og mangfold hvis en sterkere effekt skal oppnås. Bedre insentivsystemer for små virksomheter innenfor H&S sektoren bør utvikles som også kan bidra til å gjøre småskala utprøvinger attraktiv i de aktuelle bransjene. Det er behov for tiltak som kan forbedre læringseffekter og legge til rette for kunnskapsnettverk for å utveksle erfaring brukere, tjenestetilbydere og myndigheter. I tillegg bør et mer variert sett med teknologier tas i bruk, herunder ulike IKT-baserte applikasjoner som kan understøtte grønnere mobilitet. Løsninger for lavenergi-mobilitet blant profesjonelle brukere i byområder må sees i sammenheng med nye konsepter for smart mobilitet i byene, med fokus på mer effektiv koordinering og administrasjon av mobilitetsressursene.

For å stimulere til "nettverkseffekter", er det avgjørende å eksponere eksperimenter og ideer på en bred skala langs flere kanaler. Svært relevante og innovative tilfeller kan representere «fyrtårn» som kan inspirere andre bedrifter og beslutningstakere. Det er også nødvendig med mer systematisk demonstrasjon av effekter av nye teknologier gjennom longitudinelle feltstudier og forskningsbaserte eksperimenter.

Potensielle miljøgevinster

En kan generelt sett anta at utslippene av klimagasser og lokal forurensing går mot 100% når alle dagens dieselnyttekjøretøyer innenfor H&S sektoren blir erstattet av el-biler. Effekten av utslipp fra virksomheter i en by (og for Norge som helhet) er derfor beregnet ut fra årlig antall kilometer med el-biler, gitt at disse ellers ville ha vært gjennomført med dieselkjøretøyer.

Analysene av de elektroniske kjøredagbøkene vise at 37% av kjøretøyene i utvalget kjørte mindre enn 80 km og sto for 13% av transportarbeidet. Et bytte av disse kjøretøyene vil derfor potensielt redusere transportutslippene fra H&S bedriftene med 13%.Dersom bilparken i virksomhetene omfordeles i forhold til oppdragenes lengde, kan imidlertid potensialet økes betydelig. Et teoretisk eksperiment viste at for ett av selskapene kunne andelen kjøretøy som erstattes øke fra 54% til 84%, og dermed andelen av transportarbeidet fra 20% til 47%. I intervjuene med el-bilbrukerne ble det gitt uttrykk for at en slik planlegging av reisene i mange tilfeller vil være utfordrende. De virksomhetene som hadde greid å implementere el-biler i en større skala uttalt imidlertid at evnen til å planlegge turene i forhold til biltypene var avgjørende.

En økning i rekkevidden for el-biler med 50%, eller ladning av kjøretøyene i løpet av dagen, vil hver for seg kunne øke antall utskiftbare kjøretøyer til 64% og transportarbeid gjennomført med el-biler til 41%. Dette vil i så fall resulterer i 41% reduksjon av utslipp fra H&S sektoren. Andelen biler som kjører over 10.000 km per år øker betraktelig og dette tilsier at det vil være lettere å realisere den økonomiske gevinsten flere brukerne. Hvis el-bilenes rekkevidde øker slik at alle reiser opptil 200 km kan gjennomføres med el-bil, indikerer våre data at transportbehovet til hele H&S sektoren vil kunne gjennomføres ved hjelp av el-biler, og dermed fører til en 100% reduksjon i utslipp og lokal forurensning.

1 Introduction

The challenges that the world's large urban areas face today are massive, one of the most urgent being pollution and emissions from fossil-fuelled cars and vans. To avoid the impacts of global warming it is urgent, on a global level, to curb CO_2 emissions where fossil fuels are a main source.

In 2012, mobile sources in Norway emitted an estimated 17.4 million tonnes of CO_2 equivalents of greenhouse gasses (GHG). Between 1990 and 2012, transport emissions rose by 27% (SSB, 2014). On a local and regional level, fossil-fuelled emission from combustion engines is the cause of severe health-related problems (asthma, cancer, etc.) and increased mortality rates. Growing car traffic is causing traffic jams, accidents and inefficient urban land-use (Whitelegg 1997, Chapman 2007). Roads and parking spaces are increasingly occupying valuable urban space. A central issue in most transport policy programmes is therefore to make urban transport systems both more efficient and less dependent on fossil-fuelled cars.

The duality of developing transport systems that are both efficient and green is at the heart of a more sustainable urban transport paradigm[1], and the Crafttrans project addresses both these challenges. The focus for the project is investigation of new technological innovation that can improve urban transport. This includes, first, *electric utility vehicles* (EUVs). The second research area is *mobile management applications* (MMAs), i.e. smartphone-based applications that help companies and drivers to develop more efficient travel patterns. While EUVs bear the promise of mobility with limited or no emissions of GHG, MMAs address the issue of smarter and more efficient mobility.

The project explores the usefulness of these technologies in the context of urban transport conducted by craftsmen and service workers. Although these groups generate a significant number of trips in most urban areas, up until now they have been largely neglected in transport research. According to an earlier analysis in the Crafttrans project, craftsmen transport constitutes 11% of all the vehicles passing through toll gates in Oslo on an average working day, 15% in Bergen and 5% in Trondheim (Denstadli, Vågane and Wethal 2014).

During the project we found it necessary to extend the scope, which originally focused on craftsmen alone, so that we included public and private service workers. In the public sector this involved employees in the supply of utilities, such as water and electricity, as well as providers of home-based health services[2]. Relevant private businesses are providers of security and facility management services. The reason for extending the scope was because the number of EUV users in the crafts industry was found to be very low, and because many of the early users and "niches" were found in the service sector.

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[1] The term 'sustainable mobility' has been defined by the World Business Council for Sustainable Development as; "the ability to meet the needs of society to move freely, gain access, communicate, trade, and establish relationships without sacrificing other essential human or ecological values today or in the future" (WBCSD 2004).

[2] http://www.dictionary.com/browse/service

1.1 Definitions

Crafts industries: This refers to a wide set of professions, and a precise demarcation of this concept tends to be difficult. On the one hand the term is used to describes work related activities that is non-industrial, based on individual skills and knowledge. Thus it may be defined as "work usually done by hand that exhibits artistry and individuality" (Merriam-Webster: 2015). Following this approach it is seen as a type of creative work, typically including graphical workers, weavers and knitters, glass and ceramics makers, goldsmiths, etc. (TBR 2013). On the other hand it is used to describe manual and practical work conducted with the help of specialized tools and machines. As stated in this definition used in Norwegian statistics: "Craftsmen use their knowledge and skills in the areas of construction, design, customization, maintenance and repairing of machinery equipment or tools, calibration of machine tools, graphic work, processing of food and manufacture of textiles or wood, metal and other articles" (SSB 1998). In this more extended use, craftsman industries include carpenters, butchers, electricians, mechanics, etc. The general categories used by Norwegian statistics includes the following sectors:

- Stonework, construction work
- Metalwork, machine work, electricians,
- Precision work, design and graphic work
- Other crafts- and skilled work.

While the first seems to be common in English/American literature and documents, the latter is in accordance with the mainstream Norwegian understanding[3]. In this report we will follow the wider understanding of the concept, focusing on selected professions that fall within this broad term. As will be clarified the emphasis in this report are on craft workers operating within the building -and construction segment.

Service industries: This refer to companies that primarily earn revenue through providing intangible products and services[4]. The service sector is among the largest and fastest growing in Norway, as in most modern economies. Employees working in the public and private sectors of 1) trade, hotels, restaurants, 2) health and social services, and 3) service providing, represented over 60% of the workforce in Norway in 2015.[5] The proportion involved in related mobile services is unknown, but it may be assumed it is a significant number.

Sustainable mobility: There is today a strong interest to develop urban regions that are less dependent on fossil fueled transport and that to a greater extent exploits opportunities embedded in new communication technologies and alternative energy systems. Sustainable mobility has been outlined as a new approach within which to investigate the complexity of cities, and to strengthen the links between land use and transport. According to Banister (2008) four key actions is central: 1) Reducing the need to travel by use of communication technologies; 2) development of transport policy measures to stimulate to modal shifts; 3) land-use policy measures to reduce distances, and; 4) technological innovation to increase efficiency increase. The work in the Crafttrans project contributes in particular to the later dimension of the sustainable mobility paradigm. Efficiency here relates reduction in levels of noise and emissions as well as systems that can reduce unnecessary driving.

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[3] The Norwegian understanding may bear resemblance with the English term «workmen».

[4] Business dictionary (www.businessdictionary.com)

[5] Statistics Norway (https://www.ssb.no/arbeid-og-lonn/statistikker/regsys/aar/2016-05-27?fane=tabell&sort=nummer&tabell=267368)

1.2 Mobility in crafts- and service industries

Workers in crafts and service industries conduct significant shares of their work outside enterprises offices or premises, and as such they can be expected to have high level mobility during the day. From the perspective of transportation, craftsmen are a particularly challenging group of mobile workers, since their job requires carrying tools, materials and other equipment necessitating car transportation. According to figures from Statistics Norway (SSB), the crafts industry employs some 250,000 people in Norway, corresponding to 10% of the workforce[6]. These groups provide vital products and services for their local communities. Unlike "white collar" professionals, who can use public transport or even non-motorized modes of travel when moving between clients (in urban areas), craftsmen have few alternatives to the car. Their travel therefore amounts to a considerable number of trips in urban areas on week days.

The point of departure for the Crafttrans project was the idea that there were potential benefits to transformation of C&S workers' travel patterns in urban areas if they started using electric vehicles and more efficient tools for transportation planning. Successful adoption and application of emerging new technologies, such as EUVs and MMAs, may contribute to the harvesting of these benefits and spur the development of more sustainable urban transport patterns. Work already conducted in the project has strengthened our expectations concerning the potential that is inherent in these technologies. In this report, we provide information and empirically based knowledge that documents this, and also discuss how this potential may be exploited.

Earlier work in the project has documented volumes of crafts workers' travel in four of the largest urban regions in Norway, while drawing on different data and methodologies (Denstadli et al., 2014). An extensive review of relevant theoretical approaches to studying innovations in this area has also been accomplished (Julsrud et al., 2015). The current report is dedicated to an in-depth analysis of implementation and use of EUVs and MMAs in the C&S sector in Norway, based on multiple data sources. We are concerned with the actual use of these key technologies, the perceived drivers and barriers experienced among the early users, as well as the potential for further implementation and use. Based on these different sources we suggest policy measures that could stimulate the adoption and use of these innovations and contribute to the ongoing research on socio-technical transition processes in the area of transportation.

To achieve the desired outcomes of more sustainable urban transportation systems, travel behaviour needs to change on a large scale, both professional and private. This, then, addresses questions of how innovation in the transport sector can be up-scaled to forge wider changes in the transport system. Theoretical stepping stones to understanding and possibly explaining how innovations may cause such changes can be found in the economic innovation literature as well as in works on social change and sociological system theories. Some key approaches within this project have been discussed in earlier work (Julsrud et al., 2014). Recently, a synthesis of several streams of research has come together in so-called "transition theories". In this approach, innovation is seen mainly as emerging from local "pockets" of users experimenting with innovative tools or practices. Transitions have been studied in different fields; transitions towards sustainable energy systems, organic food supply, shipping and more (Kemp et al., 2011; (Nykvist and Whitmarsh 2008). Although scattered, the terms *socio-technical transition theory* (STT) and *multi-level perspectives* (MLPs) are

[6] ssb.no/emner/06/01/yrkeaku/ttab-2012-04-26-01.html

frequently used as umbrella terms for these studies (Geels 2012, Grin, Rotmans and Schot 2010, Kemp, Avelino and Bressers 2011). Here we follow Geels et al. and use their description of MLP as a point of departure, although we supplement with some other relevant theoretical approaches.

1.3 The multi-level perspective (MLP)

The point of departure for the multi-level perspective is that transitions are non-linear processes from the interplay of multiple developments at three analytical levels (Rip and Kemp 1998, Geels 2002, Geels 2012). At the micro-level, *niches* refers to small groups of entrepreneurs and early adopters experimenting with innovations at a very early stage. These may (probably) be considered a kind of "communities of practice" in which meaning is in the process of being developed, but where it still stands out as improvised and experimental. Three processes are believed to be of particular importance for the activities in niches: Learning processes on various dimensions; the articulation of expectations or visions; and the building of social networks and enrolment of more actors (Geels 2012).

At a meso-level, there are *socio-technical regimes*, where technologies have been segmented into more permanent structures and configurations. The importance of certain types of technology and associated practices is backed-up relationships with other groups and social institutions. Key actors in sustaining a regime are usually firms and the activities of engineers, along with social groups such as users, policy-makers, special-interest groups and civil society actors. Geels (2002) claims that the regimes include cognitive, regulative and normative rules. So it is not just technology that is involved, but also certain shared beliefs, values and cultures. In existing regimes, innovation is mostly incremental because of lock-in mechanisms and path dependence. In the transport domain there are multiple regimes related to different transport-related practices (i.e. biking, walking and so on). Geels (2012) argues that these transport modes can be called *subaltern regimes*, in contrast to the dominant auto-mobility regime.

At the highest (macro-) level there are *landscapes* in which technologies have become a fundamental part of our understanding and worldview. This constitutes the external context which actors within niches or socio-technical regimes largely have to take for granted. In general, this will include spatial structures, political ideologies, societal values, beliefs, concerns, the media landscape and macro-economic trends.

It is emphasized that the changes the multi-level perspective is concerned with are both large scale and long term. Transitions that have been investigated are typically used on technology-driven transitions over several decades.

A central feature of niches is that they provide "shielded spaces" where the new innovations can grow and hopefully find their new form (Geels 2012). This involves a form of "nurturing" of the innovation so that it can take the form of a configuration that may compete in the in the general business environment outside the shielded niches. This is what Smith and Raven (2012) label as a *fit and conform strategy*. Another way is to try to undermine incumbent regimes and transmit niche-derived institutional reforms into re-structured regimes. This represent an more external and offensive strategy is labelled as *stretch end transform* (Smith and Raven 2012). In the processes of negotiating the innovations in the public arena these different ways of empowering niches tends to follow different paths, where the first argue for the profitability of the innovation in the current business environment, the other that there are needs for wider changes in the political or economic system.

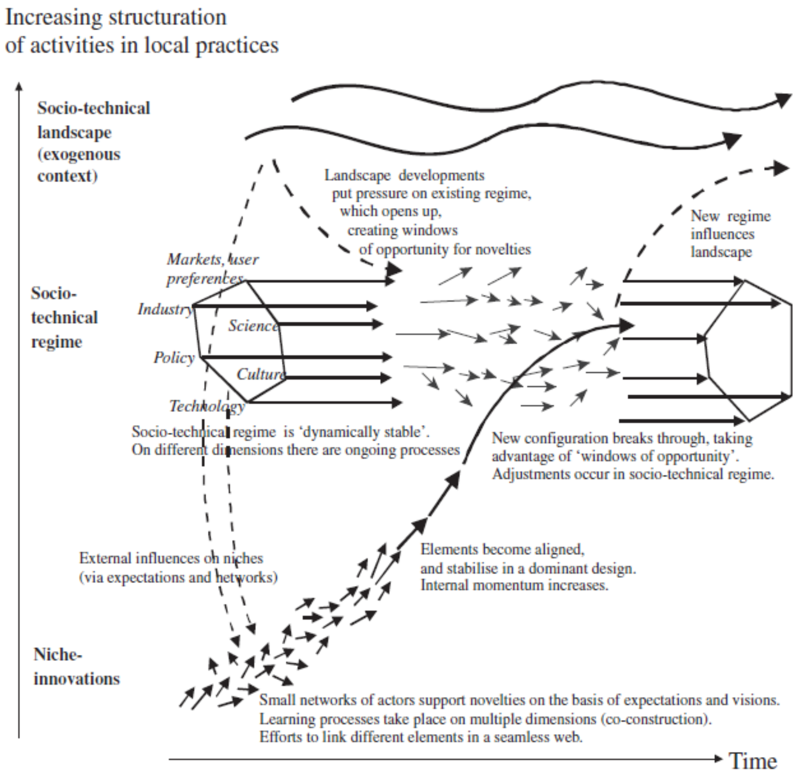

Figure 1.1: The multi-level perspective on transitions (from Geels, 2002, p. 1263).

The ideal-typical representation of how the three analytical levels interact dynamically is illustrated in Figure 1.1. Transitions come about through the interaction between processes at different levels. Niche-level innovations build up internal momentum and interact with forces at the regime level. However, changes at the landscape level may create pressure on the regime, destabilisation of which creates windows of opportunity for new niches.

Geels and Schot (2007) have outlined four general (and ideal-typical) *transition pathways* based on this general model: (1) technological substitution, in which niche innovations emerge and replace existing regimes; (2) reconfiguration, in which niche innovations are adopted within the existing system/regime and subsequently led to changes in the system architecture; (3) transformation, in which incumbent actors change regime elements (beliefs, search heuristics, investment patterns, regulations, etc.) to solve problems and accommodate external pressures; and (4) dealignment/realignment, where changes in the landscape led to regime breakdown (de-alignment), followed by a prolonged period of niche experimentation with multiple novelties.

In the overarching framework proposed by MLP, small networks of actors (niches) are constantly experimenting with new technologies and practices. These activities are seen as particularly important because they are outside what is defined in the dominant socio-technical regimes. Such niches can be of different dimensions and often of long duration. In situations where there is turbulence within the technical regimes, however, they can win a bigger foothold, but the degree to which an innovation in a niche is actually a winner depends largely on how it fits within the existing regimes and landscapes. Innovations can come into conflict with the existing regimes. Often, however, changes in society's basic assumptions force changes to the current socio-technical regimes and expose them to ideas from technical niches. Some niches come together and form stronger constellations that challenge existing regimes.

Clearly, the technology itself may put constraints on how the niches operate and perform over a longer term. While some innovations may be relatively similar to the incumbents, others may be radically different. The terms, 'sustaining' and 'disruptive' technologies, are frequently applied to denote the differences (Christensen 1997). While *sustaining innovations* are characterized by having the capacity to improve the performance of established products that mainstream customers have historically valued, *disruptive innovations* bring to the market a markedly different value proposition than had been available previously, and in this have the power ultimately to precipitate the failure of incumbent firms. The sustaining technologies may cause regimes to reorganize and change, but only disruptive technologies cause large-scale transitions (Dijk, Wells and Kemp 2016). Over time, sustaining technologies are readily adopted within the existing system/regime.

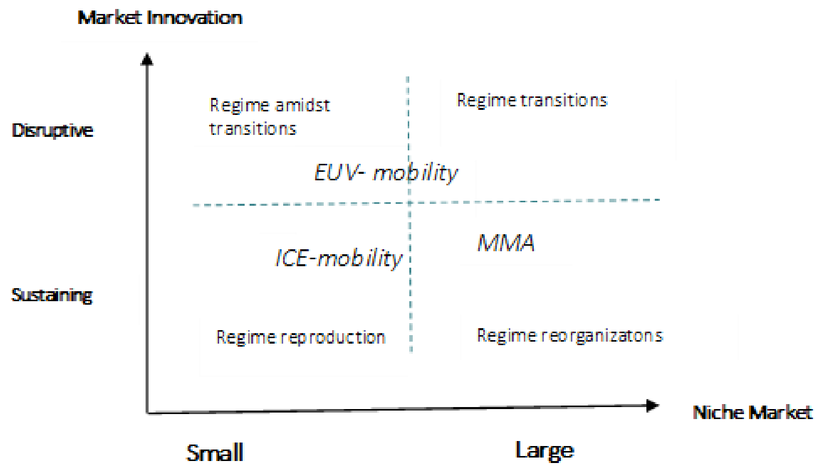

Figure 1.2: Regime evolution framework (based on Dijk et al., 2016).

In the Crafttrans project, enterprises that have been "experimenting" with the use of MMA and EUV technologies are analysed, EUV seen by several authors (including Frank Geels) as having clear disruptive potential. Mobility management tools today are to different degree part of the current ICE-based mobility regime, and in this setting may have less disruptive potential (Dijk et al. 2016). Even though applications like Handyman make it easy for craft enterprises to improve their internal communication, logistics routines and transport routing, it still builds on established business practices related to implementation of ICT-based office systems. This is illustrated in Figure 1.2.

1.4 Radical and incremental changes

Within the framework of transition theories, "niche actors" are seen as key drivers in the innovation process. To some extent it could be argued that electric vehicles have moved beyond the niche stage as the technology has gradually been adopted in the population. So far, however, this has not been the case for EUVs in the segments of professional users. We therefore argue that crafts workers experimenting with EUVs may be considered as part of a niche. Mobility experiments involving information and communication technologies, such as ITS applications and teleworking, are also described as niches (Geels, 2012).

Theoretically and empirically, the niche dynamics is understood in different ways (Nykvist and Whitmarsh 2008, Smith and Raven 2012). Based on Geels (2012: 427), we consider niches as “small networks of actors that support novelties on the basis of expectation and vision”. This then includes technologies as well as the development of new practices related to their use. Central activities include informal experimentation, development of a common understanding of the usefulness of the new technology and evaluation of appropriateness of technology for the purpose of the group and organization.

Ideally, niches may represent social arenas where the role of the new tools tried out in real-life settings and informal learning takes place. Actors within the niches may also provide feedback to new technological development, acting as communities for user-driven innovations (Hippel 1988). Yet, several factors may short-cut such processes; for example, low competence, lack of trust and confidence in managers or limited resources with which to accomplish the testing. The outcome of niche activities is therefore always open and uncertain.

The term *transition arenas* is used to described as a specific “network of frontrunners” that create new conditions for upscaling of the innovation (Rotmans and Loorbach 2010). Following an action oriented transition management approach, Rotmans and Loorbach suggest that such informal networks play a key role in initiating transitions. Based on case studies of transition processes they outline four important type of gouvernance activities:

- Strategic: activities at the level of a societal system that tale into account long time horizon, relate to structuring a complex societal problem and creating alternative futures
- Tactical: activities at the level of subsystems that related to build up and break down system structures
- Operational: activities that relates to shrt-term and everyday decisions and actions, where actors either recreate system structures or choose to restructure/change them
- Reflexive: activities that relate to evaluation of the existing situation at the various level and their interrelation of misfit.

In all these activities *networks of forerunners* are critical to initiate and sustain transition movements. At this point there is close connection to studies in the field of social change and social network dynamics social network dynamics where it is has been documented show a few small but powerful actors may have a big impact on the diffusion of ideas and practices in different fields. Epidemic diseases, ideas and practices for example can follow slow take-up rates for periods, and then rise dramatically (Barabási 2003). In many large social systems there seem to be critical thresholds, and when these are reached the uptake of innovations takes on another momentum (Gladwell 2000, Whitelegg 1997, Valente 1999). In a world that is increasingly connected through a web of communication media, diffusion of ideas and new practices spreads rapidly, and the context for transition is constantly changing. Insights on tipping points underscore that states of equilibrium may become destabilized quickly[7]. This means, for instance, that when a sufficient number of people are convinced about climate change, changes in climate-related technologies can take on another momentum.

[7] The point has been further developed in the interdisciplinary field of complexity theory Dennis, K. & J. Urry. 2009. *After the car*. Cambridge: Polity Press.

1.5 A framework for transitions to greener mobility practices in the crafts and service industry

The multi-level approach leads to an overarching understanding of how large-scale innovations take place, but also to how they may be stimulated. To some extent it may be used as a guideline for promotion and governance of mobility transitions (Rotmans and Loorbach 2010, Nill and Kemp 2009).

Transition to a more sustainable transport system in the C&S sector means that multiple measures have to be addressed and, in general, may be oriented towards changes at different levels. Landscape-level policies could be attitudes and values stimulating the growth of green transport solutions among craft enterprise services and contributing to strengthened political awareness of green mobility initiatives. Action aimed at regime level could focus on areas important for initiatives influencing current mobility practices among C&S workers. Finally, at a niche level the focus could be on initiating and promoting scale experimentations with technologies.

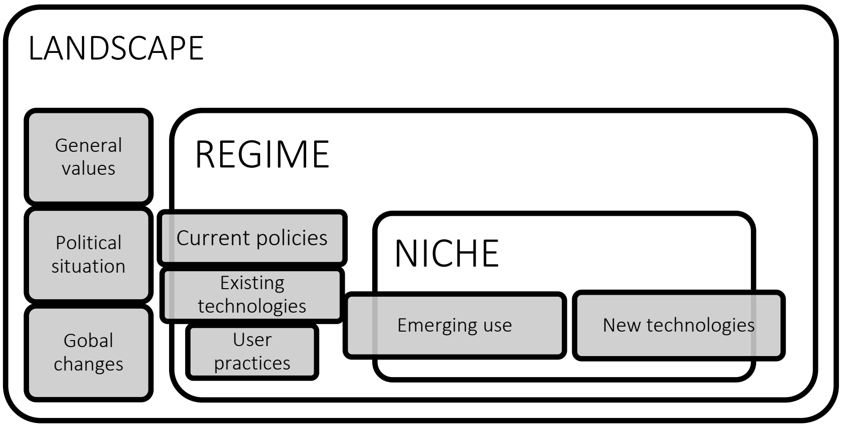

Figure 1.3: Overview of some key elements in the multi-level perspective (MLP) approach.

As mentioned above, the transition to new technologies and practices cannot be expected to be stable and predictable, however. Transition can come to an end as a result of unexpected circumstances, competing systems or changes in the wider socio-technical and political systems. At the same time, "network effects" may rapidly take-off and dramatic shifts take place in the pace of uptake of innovation as certain thresholds of adoption within a population are reached (Watts 2004, Gladwell 2000). All this relates to the nature of the innovation, the exposure in social rooms and global media, as well as emerging changes in a global context. The adoption of fax machines, home computers, text messages and social media was slow at first, before suddenly becoming a radical stage of quick adoption (Dennis and Urry 2009). These elements are further discussed and elaborated in the last section.

The boundaries between niches and the overarching regime are rarely absolute. Niche actors and groups are continuously in contact with a given regime, and so their commitment to a new mobility regime will differ over time and within different contexts. As new mobility practice wins a foothold in the larger society, the boundary of a niche may dissolve altogether. As mentioned, EUVs represent more radical innovative technologies, and their boundaries to the dominant regime may be stronger than for the MMAs.

The following section is an overview of the key characteristics of EUVs and MMAs, as well as their current position in the market. The next two levels are from case studies of early users of EUV and MMA. To a certain degree these enterprises may be considered as niches experimenting with new mobility technologies. As case studies they are particularly useful as sources of information on drivers and barriers for implementation and daily use of EUVs and MMA, as well as for their impact on travel behaviour and routines. Section five is an overview of the general interest of C&S workers in the use of EUVs, with a focus on users in three large urban regions in Norway. MMA was not part of this study. In the sixth section, we analyse electronic travel diaries in C&S enterprises for information on travel routines during a time span of 10 days. This gives additional data on the potential for a wider adoption of EUV in the future. In the final section we discuss all findings and propose actions and pathways that may stimulate faster adoption of EUVs among C&S enterprises in Norway.

1.6 Methodological approach

The research is based on combination of quantitative and qualitative methodological approaches (Figure 1.4). In chapter 3 and 4 we use qualitative case studies to investigate adoption processes in crafts and service enterprises. These studies are of an inductive character where the objective is to generate new concepts and theoretical understanding on the basis of new empirical evidence. The case studies inform the survey of EUV-users reported in chapter 5 as well as the analysis of driving patterns (mobility tracking) based on GPS-logs in chapter 6. The findings are drawn together in the last chapter of this report (chapter 7). Note that the theoretical overview and a study of craft workers travel volumes in Oslo, Bergen and Trondheim has been conducted previous of this report.

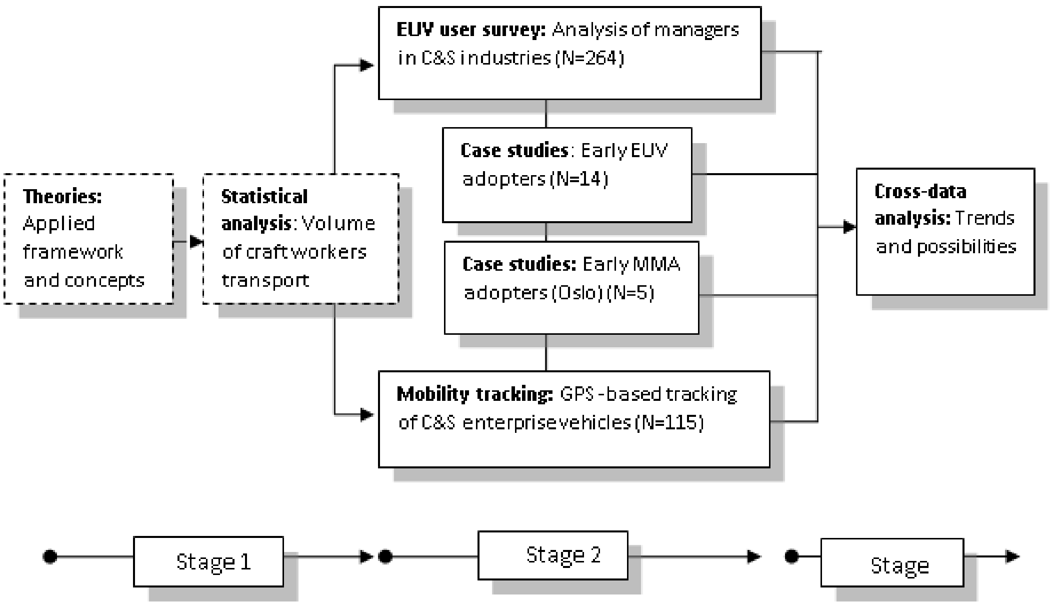

Figure 1.4: Key methodologies and research progress (dotted boxes = earlier works).

2 Electric utility vehicles (EUVs) and mobile management applications (MMAs) – an overview

Development of smarter and more environmentally friendly transport in urban regions will establish measures to mitigate emissions, two of which are particularly important in the development of more sustainable mobility in the crafts industry. On the one hand, *electric utility vehicles* (EUVs) that can help to reduce the overall emissions of CO_2 from local travel and, on the other, *mobile management applications* (MMAs) that can help to reduce unnecessary travel. In the Crafttrans project, the potential impact of these two innovations is investigated based on triangulation of quantitative and qualitative data sources. These are introduced in this section along with their current level of diffusion.

2.1.1 Electric utility vehicles

According to Statistics Norway (SSB, 2015), small vans were driven on average 14,837 km/year in 2014 and large vans 17,172 km; vehicles in the provinces of Oslo and Akershus were driven slightly above the national average. Passenger vehicles had an average mileage of 12,305 km in 2014 (ibid.). Average age at scrappage was 15.6 years for vans in 2014 (average of small and large vans) compared with 18.5 years for passenger vehicles (SSB, 2015b).

The shorter life of vans is an advantage, as electric vehicle battery life for current vehicle models is likely to be less than the average scrappage age of passenger vehicles.

2.1.2 EUV models

Four small electric vans are available in the Norwegian market (Nissan E-NV200, Renault Kangoo, Peugeot Partner and Citroën Berlingo) (Figure 2.1) ranging in price from NOK 199,900 to 216,000. Electric vans are exempted from all procurement and investment taxes.

Figure 2.1: Electric vans in the Norwegian market, left to right: Renault Kangoo, Nissan E-NV200, Peugeot Partner, Citroën Berlingo. Source: Manufacturers' web pages.

Nissan and Renault vehicles are available in several versions. Nominal range is 170 km and battery warranty is 5 years/100,000 km. Characteristics of the vehicles are presented in Table 2.1 along with comparable diesel versions.

Table 2.1: Characteristics and price (2015) of EUVs and their ICE counterparts. Source: Importers web sites.

	Peugeot Partner	Peugeot Partner	Citroën Berlingo	Citroën Berlingo	Nissan E-NV200	Nissan NV200	Renault Kangoo Z.E.		Renault Kangoo
	Electric	Diesel 1.6 Blue HDI 75 hp	Electric	Diesel 1.6 Blue HDI 75 hp	Electric	Diesel 110 hp	Electric	Electric	Diesel 1.5 dCi 75 hk
Price excl. vat incl. reg. tax	215800	139900	209900	139900	209900	150879	207900	199900	157168
Reg. tax	0	17311	0	17312	0	23469	0	0	18241
VAT (if appl.)	0	30638	0	30647	0	34458	0	0	34732
Max load	695 kg	785 kg	695 kg		588 kg	677 kg	595 kg	625 kg	595 kg
Seats	3	3	3	3	2	2	2-3	2-3	2-3
Range	170 km		170 km		170 km		170 km	170 km	
Charge time	6-11 hours		7-15 hours		7-12 hours		6-8 hours	6-8 hours	
Fast charge	Yes		Yes		Yes				
Heating system	Electric		Electric		Electric		Diesel	Diesel	
Battery warranty	5 y /100' km		5 y /100' km		5 y /100' km		5 y /100' km	5 y /100' km	
Battery size	22.5 kWh		22.5 kWh		24 kWh		22 kWh	22 kWh	
CO_2 g/km		112		112		130			112
Energy consumption		4,3 l/100 km			130 Wh/km	4,9 /100 km	155 Wh/km	155 Wh/km	5.2 l/100 km
Average annual tax 2016-2020	1400	3060	1400	3060	1400	3060	1400	1400	3060

2.1.3 Utility of electric vans under Norwegian conditions

Electric vehicles generally have a range that is highly variable, as can be seen in Figure 2.2 and in the list of variables influencing range.

The real world experienced range is a function of several factors:

1. Theoretical range
2. Weight of the vehicle
3. Number of people in the vehicle
4. Weight of equipment + materials
5. Topography
6. Temperature
7. Weather conditions
8. Use of climate controls
9. Type of precipitation
10. Road surface
11. Number of stops (cabin reheat)
12. Types of tyres (summer, winter)
13. The speed of travel
14. The place of travel
15. The driving style
16. The traffic conditions (fluid, etc.)

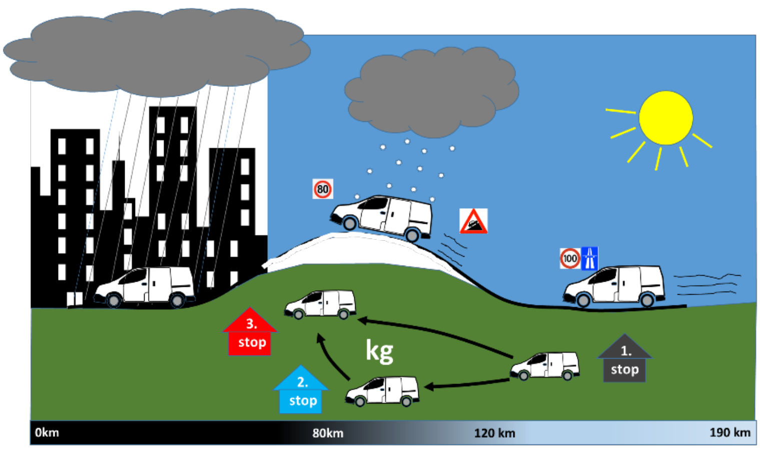

Figure 2.2: Factors influencing range of electric vehicles. Adapted from: Figenbaum and Kolbenstvedt, 2015.

Some additional aspects come into play in the case of vans used in commercial applications:

1. Private consumers have several options when range is too short on their BEV. They can rent or borrow a vehicle, use public transport, use another vehicle in the household or choose to forego a trip. The only option open to commercial companies is swapping vehicles, as the vehicle is the workhorse of the craftsman, storing his equipment and materials. Even swapping vehicles may be difficult if the tools of each different craftsman are in the vehicle.
2. If range is too short for an EV to be used on a trip, consumers normally lose time as the main alternative is public transport, which is slower . A craftsman, on the other hand, would lose income in not being able to serve customers. Range is thus of much greater importance for this user group.
3. Cold weather is a problem for craftsmen, who have many more stops during the day than the average private motorist. After each stop, the cabin will need to be reheated because the volume to heat ratio is much greater in a van than in a passenger vehicle. Passenger vehicles are normally also better insulated.
4. The vehicle may be used as a "warming hut" when the driver is having a break in winter, further depleting the range of vehicle batteries when heating is purely electric.

These factors led Renault in Norway to develop a selection diagram for when electric vans could be an option – the use of green, yellow and red colour coding (source: Renault 2014). A translated and modified diagram is shown in Table 2.2. Renault equips its EUVs with diesel heaters, so that the effect on range of energy used to heat the cabin is eliminated. For vehicles without diesel heaters, another safety margin is a limit of 50 km, as in Crafttrans, where one can be 100% sure that vehicles are capable all year round of fulfilling the driving requirements of Craftsmen. The interval 51 to 80 km is probably compatible and in Renault's case the diesel heater makes the Renault Kangoo compatible too. These limits have been used in the current analysis.

Table 2.2: Daily driving, compatibility with electric utility vehicle capability in the Norwegian climate. Adapted from Renault Norway by splitting those driving below 80 km into two categories.

Daily driving distance			
Less than 51 km	51-80 km	80-120 km	Over 120 km
Yes, fully compatible	Yes, most probably compatible	Potentially compatible Additional questions: • Type of road • Driving style and speed • Cargo weight • Topography • Temperature	Not compatible, unless charging possible during the day

2.1.4 Potential to extend range or increase use

EUV range can be extended if the batteries are charged during the day and usable applications can be extended if vehicle fleet owners plan the mileage of their vehicles better, or redistribute their use. The latter means that EUVs are used as to the limit on short distances and diesel vans on long distances. Both these themes were explored in the interviews with current EUV owners, as well as the real need for cargo space and range.

2.1.5 Incentives for electric vans

The electric vehicle market in Norway is heavily incentivized, as can be seen in Table 2.3.

Table 2.3: Electric vehicle incentives in Norway, adapted from Figenbaum and Kolbenstvedt, 2015.

Incentive	Introduced	Benefit for passenger BEV buyer, relative advantage	Future of the incentive[8]	Effect on electric vans
Fiscal incentives Reduction of purchase price/yearly cost gives competitive prices				
Exemption from registration tax	1990/1996	The tax is based on emission and weight and makes ICE vehicles more expensive. Example of ICEV taxes: VW Up €3000. VW Golf: €6000-9000.	Continued until 2020. Will be compared against the achievement of the Norwegian climate policy goals for 2020 and 2030. For ICE vehicles the registration tax will be further tuned to reduce emissions.	Reduced tax compared with passenger vehicles because the tax rates are lower. Typical tax for small diesel van is around €2000-2500.
VAT exemption	2001	Vehicles competing with BEVs are levied a VAT of 25% on sales price minus registration tax.	Unchanged through the end of 2017. Will consider replacing it with a subsidy scheme, initially at the level of the VAT exemption and slowly ramped down.	Most Craftsmen buyers have full refund of VAT and no advantage of this incentive.
Reduced annual vehicle licence fee	1996/2004	BEVs and hydrogen vehicles €52 (2014 figures). Diesel rate: €360-420with/without particulate filter.	Half rate of ICE vehicles to be introduced 01.01.2018 and full rate from 2020, i.e. the incentive will be removed from that year.	Same rates apply as for passenger vehicles.
Reduced company-car tax	2000	The company-car tax is lower but BEVs are not usually company cars.	This incentive may be removed from 2018.	Not relevant.
Direct subsidies to users – reducing usage costs and range challenges				
Free toll roads	1997	In the Oslo area the saved costs are €600-1000 per year for commuters. Some places in excess of €2500/year	The government will appraise the environmental effects of introducing differentiated fees for toll roads (main roads and toll rings around cities) and ferries based on the environmental characteristics of vehicles as well as a low rate for BEVs and FCEVs.	Potentially greater effect on vans as they drive more trips during the day.
Reduced fares on ferries	2009	Similar to toll roads saving money for those using car ferries.		Same or larger effect than for passenger vehicles.
Financial support for charging stations	2009	Reduce the economic risk for investors in charging stations, reduce range anxiety and expand usage options.		Most charge onsite, not needing public stations.
Financial support for fast charge stations	2011	More fast-charging stations become available, increases BEV miles driven and market.		Make it possible to reach customers further away, but not economic due to loss of income while waiting.
Reduction of time costs and giving relative advantages				
Access to bus lanes	2003/2005	BEV users save time driving to work in the bus lane during rush hours. High value to user in regions with large rush-hour delays.	Local authorities may be given the possibility to introduce restrictions in their jurisdictional district if zero emission vehicles hinder the bus's ability to navigate the bus lanes.	Greater effect because time saved can be sold at a higher price than the average time cost of commuters.
Free parking	1999	Users get a parking space where these are scarce or expensive and save time looking for a space.	Local authorities will be given the authority to decide whether this incentive is to continue in their jurisdictional district.	Less effect, must park where the work is, and time constraint an issue.[6]
Free charging		Not regulated in national laws, but is often bundled with free parking.	Local authorities will be given the authority to decide whether this incentive is to continue.	Most have free electricity available at work site.

[8] As presented in the government's revised budget for 2015 (May 2015) and subsequent decision in parliament.

2.1.6 Economics of EUV use in Norway

The cost gap between electric and diesel vans is between NOK 45,000 and NOK 75,000 when registration tax is included and VAT excluded, and NOK 60,000 and NOK 85,000 when all taxes are excluded. When all taxes in Norway are factored in, the difference is between NOK 0 and NOK 20,000, as diesel vehicles are heavily taxed.

When adding the annual tax, fuel/electricity cost, financial cost and an annual oil change on diesel vehicles, the total costs of ownership over 5 years are evened out when VAT is excluded from the calculation, as shown in the figure. Companies are eligible for a 100% VAT refund.

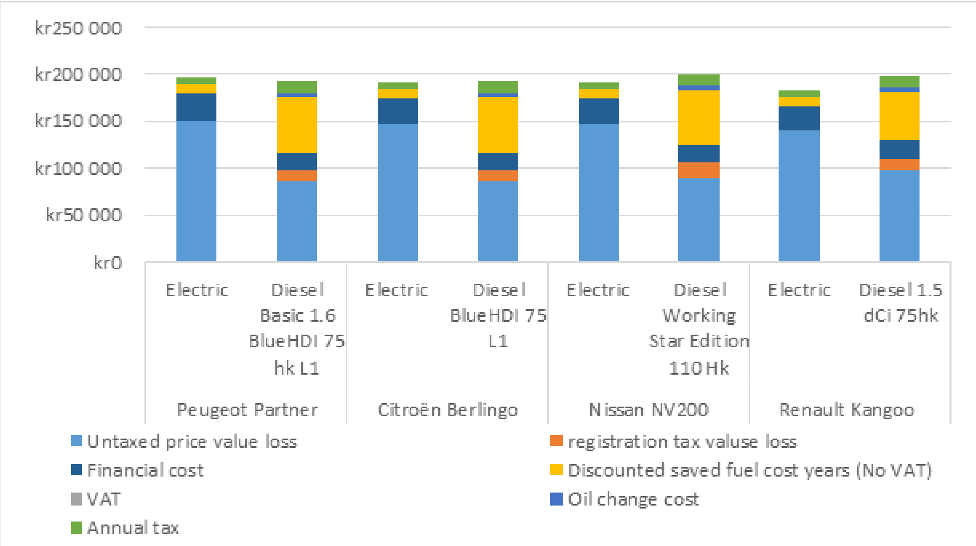

Figure 2.3: Economics of electric vans in 2015–2016. Total cost of ownership over five years.

Cost of service is slightly lower on electric vehicles due to the simplicity of the electric drive, but it is not transparent for buyers and thus unlikely to have any influence on the decision to purchase. It has been assumed that the difference in service equates with the oil change costs of NOK 1,000 per year for diesel vehicles (as included in Figure 2.3). In both cases the value loss of the vehicle has been set to 70% over 5 years. In reality, it is likely that battery electric vans will have a higher value loss, as this is new technology with uncertain residual value.

The life of the battery is crucial. Modern electric vehicles now typically have an 8-year 70% remaining battery capacity warranty on batteries. It is thus likely that batteries for vans may last more than 10 years, taking into consideration that vehicle manufacturers provide warranty on the expectation that batteries will last longer than 8 years for the majority of vehicles.

2.1.7 Diffusion of EUVs

There are about 400,000 vans in Norway, 330,000 of them with a payload less than 1,000 kg. The number of vans and small lorries driven by craftsmen and others is growing (http://www.ssb.no/vis/emner/10/12/20/transpsg/main.html) and contributing to increased congestion and emissions. Although Norway has experienced a booming electric vehicle market in recent years, the number of electric vans (EUVs) is still curtailed, partly due to limited availability and high costs, and partly to lacking technology (limited range).

However, technology is improving exponentially, with studies suggesting sales of diesel vans outpacing electric vans (e.g., Myklebust and Steen, 2012).

The electric van market was very small up until 2014 (as seen in Figure 2.4), but since then has been stable at around 2% of the entire van market. This is in contrast to the electric passenger vehicle market, which took off in 2013 and in the first half of 2015 had a market share of 18%. Electric passenger vehicle buyers, however, have more incentives than van buyers (see the table above).

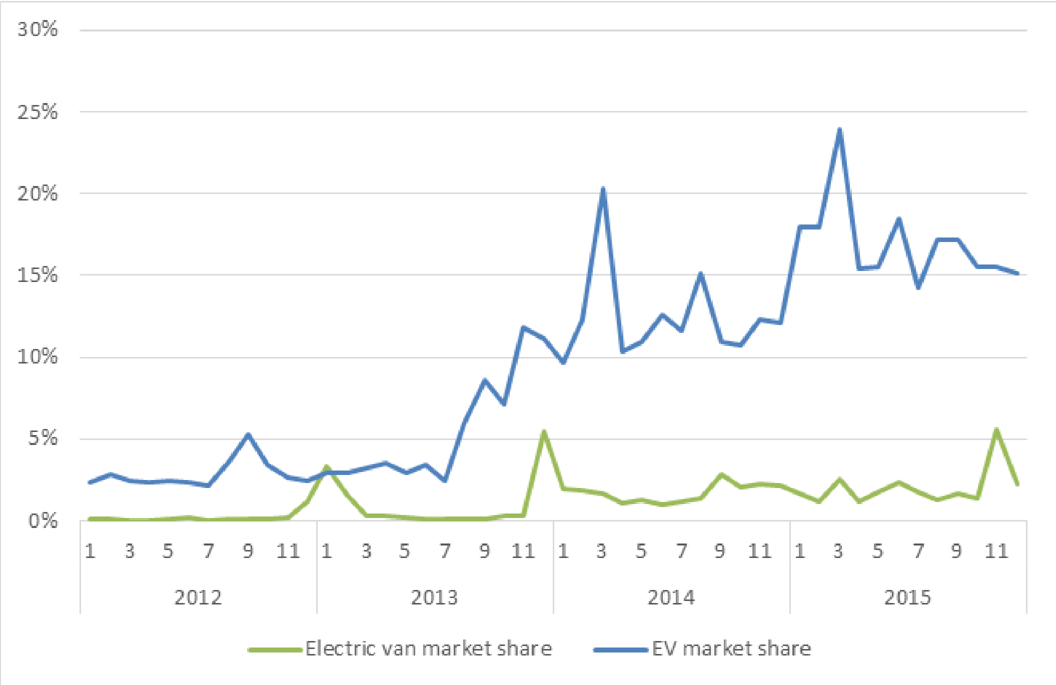

Figure 2.4: Electric vans and passenger vehicles: market shares in the Norwegian market. Source: OFVAS.

2.2 Mobile management applications

In recent years, the concept of the *smart city* has been widely discussed, with academics and public and private companies developing a strong interest in the issue. Although there is no clear definition, it usually includes a combination of measures involving economic growth, environmental sustainability and inclusiveness (Garau, Masala and Pinna 2015). In all of this, Information Communication Technology (ICT) tools are crucial in enabling smart cities to 'economize time, improve individual mobility, facilitate access to information and services, save energy and resources, and participate in urban decision-making processes' (Kunzmann 2014)12)

A new generation of mobile applications based on wireless broadband networks is fundamental in the development of smart cities with more efficient and sustainable transport systems. In transportation research, these are usually seen as elements in Intelligent Transport Systems (ITS). Mobile ICT has the potential to improve the coordination of activities for enterprises with mobile workers. In particular, redesigning the operations within the value chain to produce goods and services using fewer resources and increasing the efficiency of production may be important innovation for many SMEs (Klewitz and Hansen 2013). The term "mobility management systems" or "fleet management" is much used to describe dedicated technical systems to organize and coordinate mobility of persons or personal vehicles. The uptake of systems for mobility/ fleet management is difficult to estimate as there are no clear definitions of these terms in the literature. Some studies indicate, however, that the number of active fleet management systems deployed in commercial vehicle fleets in Europe is about 5.3 million[9]

There are a large number of mobile management applications on the market dedicated to mobile workers in the C&S industry. In the Norwegian market, the main operators are Handyman, Speedycraft, SmartDok, Tripeltex and Cordel. In this project, we investigated users of the *Handyman (HM*) application, which is one of the most comprehensive systems available. During the past year, this software has been integrated within the ePocket group, which has about 35,000 users daily and 1,700 firms as customers in the whole of Europe[10].

The main elements of HM are a system for automatic order handling and invoicing[11]. Running on a mobile smart device, the system can be integrated with other invoicing and document handling systems in addition to regular smart device functions. It contains functions for using various check-lists, ordering materials and parts, checking availability of materials in wholesalers' stocks; systems for documentation of work processes; and use of navigation and maps for way-finding and better coordination.

For electric vehicles with limited battery capacity, routing and efficient way-finding have emerged as critical where new mobile applications have an untapped potential to support operations of green vehicles (Margaritis et al. 2016).

[9] Berg Insight (2015). Newsletter. http://www.berginsight.com/ShowReport.aspx?m_m=3&Id=235

[10] Information derived from e-mail exchange with ePocket group, Norway.

[11] For more information, see: http://guardsystems.com/handyman-no/files/2015/05/hm-flyer-mobile.pdf

3 Case study insights: Mobile management applications (MMAs)

3.1 The cases

Despite its wide uptake in the business market, there is currently very little knowledge about how mobility management applications are affecting on transport related behaviour in enterprises. To gain better insight in the potential for more sustainable travel patterns the project carried out a series of case studies in selected crafts – and service enterprises in Oslo. Very few studies has been done in this area earlier and an explorative approach was applied to get new insights and build understanding.

3.1.1 Objectives

The objective of the work was twofold: first to understand how if MMA had influenced on the transport activities in the enterprises and, if so, in what way. Second, we wanted to know how this technology had been adopted in the firms, and understand more about the various organizational dynamics that had either stimulated or curbed the innovation processes. Our theoretical point of departure was concepts and key ideas elaborated by in sociotechnical innovation theory (MLP) (chapter 1). Personal interviews were carried out with representatives of five craftsmen companies in order to get more detailed information about what and who triggered the companies into implementing mobility management applications (MMA). How did this new technology potentially change working and driving practices in companies?

3.1.2 Selection

The selection of the enterprises was strategic, i.e. based on relevance for the questions addressed in the project (Flyvbjerg 2006). The purpose of the study was not to get insight from a representative sample of enterprises, but develop context sensitive knowledge related to everyday use of a new type of mobility management technology. Thus, rather than trying to get representative cases, we wanted to get relevant cases – small craft enterprises that had experience from using the technology for a period of time.

Through a provider of a particular MMA-system – Handyman- we got access to a list of enterprises that had implemented this technology and on the basis of this we selected a random group of craft enterprises in the wider Oslo-region that had applied Handyman (HM). Three were working in installation and maintenance of electricity and two in plumbing systems. In all companies, representatives from management were interviewed and, with the exception of only one case, had initiated the introduction of MMA in the company. In one company, an interview was carried out with a representative of the management together with an employee working as a plumber.

Of four companies that have used HM for more than five years, only one craftsman employed in one company uses it, although he does use the office device of HM (for easier billing, etc.). In the other three companies, all craftsmen, or all those who are employed (not apprentices), have their own HM, either on their telephone or on a tablet. In the fifth company, only a third of craftsmen have their own HM and they usually work together in teams whose heads will have it. An overview of characteristics of the five companies interviewed is given in Table 3.1.

Table 3.1: Characteristics of the five companies interviewed.

Type of company	Plumbing company 1	Plumbing company 2	Electro company 1*	Electro company 2**	Electro company 3***
No. of years since adoption of HM	1 year	6-7 years	10 years	5-6 years	12 years
No. of craftsmen	34	13-14 (some part-time)	50	(44 in total) X craftsmen	17
No. of craftsmen with HM	All	1	All	14	15
No. of craftsmen with a company car	21	All	All the employed craftsmen, not the apprentices.	15	15

* In this company, we interviewed a leader and an electrician.
** This company does not distribute service-car, free mobile phone, HM, etc., to all craftsmen. When they believe that a person is willing to stay, they often offer him these benefits (all at the same time). Those who have HM also have greater access to potential jobs and projects.
*** This company started in 2003 to use the forerunner of HM, "Husky".

3.2 The adoption process

3.2.1 The entrepreneur

Common among all the companies interviewed, the adoption of HM was initiated by one person within management, someone typically relatively young and interested in technology. In two of the companies, the people interviewed had not been involved in the adoption phase and therefore could refer only to what they had heard about the process. In most of the companies, the process had first started with an offer from a supplier working in mobile management applications who came on a visit and introduced the product and its potential benefits (usually in terms of economic efficiency).

Most of the companies stress that they did not want to implement a product that was not ready, in the sense that they did not want to be part of a test project that would involve learning and testing. One company stands out as having the longest experience with Handyman and its forerunner, Husky. The person who initiated the process was working as an electrician in addition to helping out with billings when one of the mobile management application companies introduced them to Husky. He points out that he knew the amount of work billing entailed and that he "fell for [the] system right away". At that time, during the early 1990s, they did not know of anyone else applying this kind of management product (Electricity company 3). In addition, he stresses that back then you had to be a bit of a "nerd" to understand how it worked, because it was much more complicated than it is now. At the time, the device (Husky) was not well received among electricians.

3.2.2 Reception of HM among craftsmen

There is a strong age dimension related to how new technology is received among craftsmen. The younger ones are used to new technologies. Their working routines are not as strongly internalized as among the older men, and so they adjust more easily to the use of HM. In companies with a younger work force, the reception of HM has gone more smoothly than in companies with an older work force.

Companies still experience some craftsmen forgetting to synchronize their hours and registration of materials, which in the second round delays the billing process at the office.

3.2.3 Motives for adoption

The major reason for a company adopting HM was the potential it afforded for increased efficiency of billing and registration of man-hours by reducing the amount of paper work for the manager and the craftsmen. As one interviewee put it:

"It was related to the amount of papers … When you have 38 electricians, who jump from one assignment to another, then there will be a lot of paperwork. And this should be hand written, which takes time. The lists (billings from one assignment) come in to the office, they had to be split, archived, registered in the system here at the office. It was OK to get rid of that … That was the background for it (adopting the HM). We saw the potential to avoid a lot of manual work."

(Electro company 2)

Before the introduction of HM, craftsmen had to register their hours on paper and they had to get the order for a project (on a paper) at the office. The office had to do the billing on paper and in most cases had to wait for the registered hours before billing could be completed for a project. The companies had different routines for how often the craftsmen had to come in to the office and register their hours, some each day, some once a week and some twice a month. As for the orders, the craftsmen had to go into the office every day to get their assignments. With the HM, all of these registrations are synchronized and no paper is needed between craftsmen and the office. However, in some companies they still meet at the office to get their assignments for the day.

Another important reason for the HM being implemented in most companies was that it made management and distribution of assignments/jobs from the office to the craftsmen easier. The office registers the order and craftsmen get their assignments/jobs via HM, with address and content of the order. This was an expected result of implementation of the HM, which was sold into the companies as a benefit. An additional benefit was improvements in communication between the customer, the office and the craftsmen, as one administrator put it:

"And not least (about why they introduced HM) the communication between customer and craftsmen, when an administrator at the office communicates with a customer about an order, they put the craftsman in the copy-field and he gets the whole communication about the order. Then I (the administrator) just say to the craftsman: "See mail".And then he can go through the mail and see what we have agreed upon with the customer. Otherwise, we use the phone as well, but now we can communicate on several levels."

(Electro company 1)

One company stresses that the new technology has improved quality of life at work for craftsmen, as it reduces the need to come into the office every day.

Another benefit, one that was expected, is that HM makes it easier to discuss technical issues and challenges with the office, e.g. pictures can be taken when there is a problem and sent to the office. In addition, the risk of losing information with HM is less than it used to be. For example, pictures taken when a problem occurs are saved directly into the file of an assignment/job in the central system. As illustrated by the example of one administrator:

"Take yesterday as an example. I sent out a plumber who was not too experienced with sprinkler systems. And evidently, if you meet centrals and different solutions for a sprinkler and you are inexperienced with them, you might not know what to do. Then you take a picture and you send it to me. Off course, you could do that with a smart phone as well, but the advantage here is that the picture will be saved directly to the file of a given order. Then, later, if someone else is going there he (the administrator) does not have to search in his archives. And he does not have to archive the picture because then it (the picture) is already in the system (saved and archived). And we try to take pictures before and after for documentation."

(Plumber company 1)

In one company they saw a potential economic gain. Craftsmen could register the items and hours used when in situ of the assignment instead of later. By completing billing at the location of the assignment, the employer was paying for the time used for billing.

Only two of the companies (Plumbing 1 and Electric 2) focused explicitly on the potential for reduced driving among their craftsmen as a reason for implementation of HM. In contrast to the other companies interviewed, they have few or no private customers. They serve larger companies and they are both medium sized (34–45 employees). In one of them, potential cost-savings from reduced driving were used as an argument to get the manager of the company to invest in HM. The explanation for why companies that serve larger companies have "reduced driving" as a motive for implementing HM, while those that mainly serve private customers did not, might relate to differences in opportunities for long-term planning. It is likely that those serving larger companies have larger and more long-term contracts than those that serve mainly private customers.

The positive gain of reduced driving in these companies is primarily time-saving, as one company representative put it: "Time gained on fewer trips equals more time for work on projects".

3.3 Changes in driving routines?

Although most companies had not measured the effect, they believe that there are several reasons why use of HM has reduced driving among craftsmen:

- In three of the five companies, work is directly assigned to the craftsmen through HM. There is therefore no need for them to go into the office every morning, but instead go directly to the location of the assignment.
- Companies used to have different practices for registering man-hours and use of materials. Someone would come into the office each day or once a week to do this. In companies with larger assignments, the head of the project would come into the office and deliver the man-hours and register material for his "team" (once a week). With HM, no one needs to go into the office any more, as the hours and materials can be plotted directly in HM (which then has to be synchronized).

- When difficulties with an assignment are encountered, and the office has to be consulted, the possibility to take a picture of the problem and send it to the office (to discuss it over the telephone) is also mentioned as a factor that has reduced the number of trips among craftsmen, at least in a couple of companies. Many craftsmen work alone on assignments, and before the introduction of HM had to go into the office to consult with their colleagues and managers.
- One company applies a function on HM that allows them to order material straight from the wholesaler and to have it delivered direct to the location of the assignment. For example, the material is ordered a day ahead and it is delivered the next day. This function has reduced the number of trips needed to wholesalers. It is probably easier to use on long-term assignments, where the work can be planned ahead. Companies applying this function usually have larger and more long-term projects compared to companies that use HM to order material which they pick up themselves. In many cases, however, craftsmen prefer to telephone the wholesaler (this is explored in the next section).

Only one company had measured the amount of driving before and after the introduction of HM. In this case, the economic gains of reduced driving had been used as an argument (by one of the managers) to persuade the head of the office to introduce HM. In this company, they could not find any reduction in driving (measuring number of kilometres) from before to after the introduction of HM, which the management found surprising. However, the interviewee stressed that in their calculations they had not controlled for potential changes in the number of cars in the company and potential effects of changes in the demand of assignments.

In one company, they don't believe that HM has changed the driving routines of the craftsmen (Plumbing company 2), only one of whom applies HM fully. In this company, the craftsmen still meet at the office every morning and are given assignments for the day on paper. The company has experienced a range of problems with HM and communication between the office and hand devices.

4 Case study insights: Electric Utility Vehicles (EUVs)

4.1 The cases

In order to understand the possibilities and implications of innovative technologies, it is interesting to analyse the experiences particularly of early users. In accordance with the framework proposed by transition management theory (MLP), enterprises that are experimenting with new transport technology may represent "niches". These actors are keys to achieving larger scale transformations and are particularly interesting to analyse in-depth. They may be considered as a group of innovators or early adopters (Rogers 1995).

4.1.1 Objective

In this chapter we look further into the way EUVs are implemented among C&S workers, and how this has affected everyday travel. As for the case studies of MMA enterprises, the objective is to develop context sensitive understanding of the use of EUVs among craft workers. The idea behind these studies was not to test hypotheses, but rather to build a better and richer understanding of the way this new technology was used in the enterprises, using concepts and key ideas elaborated by in sociotechnical innovation theory (MLP) (chapter 1).

The objective of the work was twofold: first to understand how if EUVs had influenced on the transport-related activities in the enterprises and, if so, in what way. Second, we wanted to know how this technology had been adopted in the firms, and the organizational dynamics that had either stimulated or curbed the innovation processes.

4.1.2 Selection

Sampling of cases was based on finding those that are theoretically relevant, even though not representative of a larger universe of possible users. As documented above, the number of craft enterprises that have implemented EUVs in Norway is currently limited, especially compared to the use of regular EVs. Yet, these early adopters represent important sources for learning about how EUVs are used in the daily lives of mobile workers, and the factors strengthening or curbing the adoption of such cars. A sampling strategy based on strategy, finding "paradigmatic cases" – i.e. cases that has a certain prototypical value and can be used to (Flyvbjerg 2006).

By contacting leading providers of EUVs we got a list of enterprises that has bought vehicles over the last years. The list was used to select 14 enterprises in craft-industry in the wider Oslo region that had purchased one or more EUVs during the previous 1–3 years. The first group consisted of a number of traditional craft industries, included carpenters, electricians, bricklayers, painters and roofing enterprises. As the project decided to widen the scope a handful enterprises in service-related industries came to be included – cleaning, security, home care and caretaker services (Table 4.1).

All these cases were workplaces where most employees were manual workers and where a high level of daily mobility was required. They were all involved in different types of professional travel within the two city centres. Tasks carried out in the service enterprises may be on the "periphery" of what are usually considered craft work. However, inclusion of these enterprises is beneficial because it ensures a certain amount of diversity across cases. While the craft enterprises were usually at an early stage in the adoption process, many service enterprises had had several years of experience. Service enterprises can therefore function as points of reference for craft businesses. It should be noted, however, that there are some key differences between C&S industries in this sample: The craft businesses were typically small-scale Norwegian SMEs with 3–20 employees. The service enterprises were mostly larger businesses, while two (10,11) were sub-units to public sector institutions.

Table 4.1: The cases of early adopters.

No.	Company (code)	Business	Sector	Location	Employees	No. of EUVs	Experience (months)
1	CA1	Carpenter	Craft	Oslo	1	1	18
2	CA2	Carpenter	Craft	Oslo	9	2	24
3	CA3	Carpenter	Craft	Trondheim	7	1	24
4	EL1	Electrician	Craft	Oslo	40	4	17
5	BL1	Bricklayer	Craft	Oslo	14	6	24
6	PA1	Painter	Craft	Trondheim	28	1	15
7	RO1	Roofing	Craft	Trondheim	17	2	24
8	SE1	Security	Service	Oslo	200	6	24
9	SE2	Security	Service	Oslo	70	7	42
10	CL1	Cleaning	Service	Trondheim	150	3	30
11	CL2	Cleaning	Service	Trondheim	300	5	36
12	JA1	Caretaker	Service	Oslo	40	3	24
13	JA2	Caretaker/post	Service	Trondheim	22	13	36
14	HC1	Home care services	Service	Trondheim	5000	60	44

* Interview included employees.

All cases were located in the larger urban areas of Oslo and Trondheim and interviews were conducted on the premises of the enterprises. Informants were mostly managers. The cases were recruited from three of the largest distributors of EUVs to the Norwegian market – Renault, Peugeot and Nissan – and from the national register of EUV owners.

4.2 Motives and the decision to adopt

EUVs can deliver an environmentally friendly form of transport and at the same time contribute to a process in which transport is less dependent on fossil fuels. To stimulate the adoption of electric vehicles in Norway, a broad set of incentives implemented by the government included: reduced annual vehicle tax, exemption from road tolls and from parking fees on municipally owned parking facilities, reduced company car taxes and exemption from vehicle registration tax and VAT as well as access to bus lanes (Figenbaum et al., 2015a).

The positive environmental benefits were important for almost all enterprises in our sample, and, for a few, crucial in the decision to invest in an electric van. This was most salient among the larger service enterprises, where a majority had implemented environmental certification schemes[12] with a pledge to record transport activities and reduce emissions.

"We are ISO certified on environment, and that's an important motive. We need to document that we launch measures to reduce our impact on the external environment. But, clearly, we have also looked at the economic aspects, and we had a lot of diesel cars driving around in the city centre earlier, cars that were involved in car jams, parking, toll fees and everything. And that generated a lot of costs on fuel …" (10).

In total, half of all enterprises had implemented green certification schemes, which seems to have had a significant effect on the motivation to adopt EUVs. The motive for implementing green certificates was in positively contributing to the environment, but also in improving their credibility in bidding rounds, where the certificates were considered a competitive advantage.

For smaller craft enterprises, the economic incentives were undoubtedly the most important, particularly potential benefits related to cheaper fuels and tax reduction. Although one of the smaller craft enterprises (7) had also implemented a green certification scheme, the economic benefits were emphasized much more strongly. Six out of seven craft enterprises held economic benefits as the most important motivation for their buying EUVs, and it was the lower tax rates and expected lower expenditure on fuel that were decisive. The environmental gains were not neglected, but they were secondary to the economic incentives. As mentioned by one of the carpenters:

"For us the economy was most important, but the environmental aspect was also involved. And that this was new and exciting. It is trendy to think about the environment as it gives a signal externally that we think is good. If this had worked optimally we [would have] used it big time in our marketing campaigns …" (6)

As reflected in the statement, EUVs were also recognized as one way to a greener public image. In one security enterprise (9), the initial motive was to develop a more environmentally friendly image so that it would stand out from other players in the market. Later it realized that there was a significant economic benefit in using the EUVs, according to the manager. Similarly, a manager in an electric company (4) described their EUVs as "mobile advertising boards" and their most important way of promoting the business in urban areas.

For the manager in the bricklayer enterprise, time-saving was highlighted as an important motive behind the purchase of an EUV. The main office is in Asker, a municipality west of Oslo (where the manager lived), where the main road into the city is one of the most congested in the region. With his EUV he could use the bus lanes for public transport and save time travelling to the work site and to where the company had its outlet. This, however, could also be considered a kind of economic benefit.

While the decision process in crafts enterprises was usually very quick, informal and (sometimes) even spontaneous, the service enterprises relied on procedures that were more bureaucratic. Decisions to invest in green cars were often founded on overarching longer-term objectives, where reduced emissions of greenhouse gases were central.

[12] There are different certification schemes available: *Eco-Lighthouse* (Miljøfyrtårn) is Norway's most widely used certification scheme for enterprises seeking to document their environmental efforts and demonstrate social responsibility (http://eco-lighthouse.org/). The ISO 14001 is an international standard for environmental management governed by Standard Norway (http://www.standard.no/).

The reasons for these companies buying an EUV are similar to consumers' reasons for buying a passenger electric vehicle – economy, environment and an interest in technology (Figenbaum et al., 2014). However, consumers place much greater emphasis on local incentives such as free toll roads and access to bus lanes (ibid.).

4.3 The implementation process

The uptake of EUVs in traditional craft enterprises has been slow and although there is great interest, few businesses have very much experience using electric vehicles. In many of our cases they described the adoption process up to that point as an "experiment" or a "test" to see whether it could actually work for them (6,3). In the service sector, however, the EUVs had been used for longer.

The initial suggestion about buying an EUV was introduced in some cases by a car dealer (6,7), in others at the recommendation of other enterprises (5,10) or simply through a leaflet in the mailbox (2). However, a common characteristic of them all was that the innovative technology had been actively introduced and promoted by a particular person, usually a manager with an interest in cars, new technologies and/or environmental issues. In several cases it was a manager who owned an electric car privately. One manager in a cleaning company said:

"I consider myself as an "e-car guy", I have been driving electric cars for years. Long before they looked like cars. So I was a driving force behind this, and just after I started in the job I initiated this project …" (11).

Thus, an enthusiastic manager is clearly important in getting the innovation over the first barriers in the diffusion process. In most of the enterprises there were many stories of resistance, doubt and rejection among employees.

The resistance seemed to come for different reasons. In one of the larger service companies the implementation process was described as having a "top-down form", where decisions were made in the managerial group with weak support among employees. This caused frustration among employees who were forced to use EUVs. In other cases, employees had negative experiences from earlier generations of electric cars. This was the case in one of the security firms:

"I was part of a project when I worked in (company name) during the 80s, when we bought two electric cars. We bought the Kewet, which was the only one available at the time. But nobody wanted to drive them (…) One of the cars actually went on fire, and two guys had to be picked up by an ambulance because they had inhaled PVC gas, or such a gas, and ended up in hospital. After that everything was put on hold. So that was my experience before this started, it was all negative really …" (9).

The smaller electric cars (i.e. Buddy, Kewet, Think) were described as too small and unsafe, while the newer EUVs were perceived as much better and more reliable. Enterprises with earlier experiences of these cars tended initially to be critical. In most enterprises, however, the resistance turned positive (in some cases) after some weeks of use. In some of the enterprises minor improvements were made, including upgrading of batteries and installation of new and better chargers outside the workplace.

Implementation in the smaller craft enterprises was usually informal, with one or two of the staff trying out the vehicle for a period to see how it worked. Often the process stopped there if the car was not as they had expected it to be (6,7). In the service enterprises, however, the EUVs were evaluated more thoroughly before being fully implemented. In some cases this included programmes for education of the intended drivers. The largest security company (8) had conducted a one-year pilot project followed by a course in "eco-driving".

Several companies initially experienced insufficient range when they took EUVs into their fleet. Learning to drive and charge the vehicle efficiently thus became an important element in the implementation process. In the craft enterprises, learning usually took on a more informal character, with the workers sharing stories and talking about their experiences. In some cases (13, 9) this led to informal competition among drivers trying to save as much battery power as possible. The manager in the caretaking company at the university (who was responsible for the distribution of mail) explained how the employees worked to save power:

"… at the time that we started, during the first weeks, we had two post cars that were exchanged, they drove a few miles and we could hardly manage to get around the route. The cars ran out of power. The discussion then went; what are we going to do? So we took a turn with economic driving, how to save energy from more careful driving, reduced heating, and so on. And there was competition among our drivers to see how far you actually could get. So from having to charge every day, during lunch, one could after a while manage with charging perhaps only twice a week" (13).

Half the companies had installed dedicated charging outlets outside their premises to facilitate efficient charging. A municipal cleaning company (11) put chargers outside some of the buildings they clean in order to extend the range of their vehicles. One company experienced their electric vehicles leading to more careful driving styles and consequently to fewer of their cars being damaged. The manager of a department at a university responsible for various caretaker services believed that the reduction in car accidents and damage was due to the use of electric cars. This point was also mentioned by the manager of one of the other security enterprises (9).

4.4 Patterns of use

EUVs have limited capacity for transporting heavy and sizeable goods, which is to some extent a challenge for crafts workers who often need to carry heavy tools and building materials with them. Yet, in most larger work sites building materials and machines are transported on large trucks in advance. So the need for cargo capacity is less of a problem than one might expect. Most craft enterprises had both EUVs and traditional diesel vans at their disposal. The typical pattern among crafts enterprises was then to use the electric vehicle for transporting personnel doing inspections and field support tasks, while the regular cars were used when there was need for transporting heavy tools. Managers in the bricklayer enterprise and the painting/decorator firm explained that:

"Cargo capacity is no real problem for us. We don't carry heavy stuff. Usually we just take along some painting boxes and floor covering. The big pallets are transported directly from the suppliers. …" (6)

For two of the carpenters, as well as the painting/decorator firm, the EUVs were used mainly by the administration to visit work sites and to travel to meetings. In the other carpentry firm the EUV was used by one employee to travel between work sites, to fetch minor goods at the warehouse and as a regular commuting car. In the service enterprises the transportation of goods was limited; the cars were used to transport employees between different assignments. For the security enterprise, for instance, the typical transport was to drive officers between a number of buildings where they could carry out regular security checks. Caretakers used the car to get between a limited set of buildings within a local district.

Travel distance is of course important when it comes to the possibility of using EUVs – limited battery capacity being the issue. Driving distance for the EUVs used in the case enterprises varied significantly, with a maximum of approximately 150–200 km per day for one security company and the bricklayers. For these enterprises, charging and range anxiety were important issues. Asking the customer for power to recharge was an option, but to be avoided as this was seen as unprofessional. About half the companies see the need for and stated that they charge their vehicles during the day, either at their main office or in the field. Electricians (4) stated the advantage of being able to make available electricity for charging at work sites. Some stated that the public charging infrastructure in their area was inadequate (1, 6).

As important as distance, however, was the irregularity of their trips. In many of the crafts enterprises this was seen as critical, and something that significantly curbed the potential use of EUVs. The painting/decorator enterprise, for instance, explained that they often got calls from customers during the day, calls that required unplanned trips, and this made it difficult to adapt to the capacity of the battery:

"It is the telephone that manages my day. I can plan as much as I like, try to be thrifty, and so on, but when they call from Orkanger I just need to go. I cannot say that I don't have batteries …" (7).

Unplanned trips were mostly expressed as a problem for roofing and painting businesses, where service was one of their work tasks. In these companies, the project managers who used the EUV circulated between different work sites, and sometimes there was a need to support customers. Still, most of the crafts workers had "fixed workplaces" for longer or shorter time spans and few ad hoc trips during the day.

In the service enterprises, daily trips tended to take on a regular pattern, i.e. they followed a set route. Home care workers as well as cleaners usually followed a pre-defined route between clients during the day, but the clients of the care worker would change within a geographical zone as a result of changing care needs. Similarly, mobile units in the security enterprises followed a given route of locations, even though they could be interrupted with more urgent operations during the day. Some of the security workers could have as many as 25 destinations during the day/night, but nevertheless it was a pre-defined route. In general, this made it easier to control for the use of electric power. Thus, as the likelihood of unexpected trips was lower, use of EUVs became more appropriate.

Affordability of the EUV, however, was also a question of flexibility of the work. As described above, the cars were often used by the administration or project managers in the field. Drivers were often in a position where they could organize their work hours and work trips freely during the day. A manager in one of the carpentry firms explained that he had a workday that evolved around a handful of destinations.

"I typically drive from home into the city centre, about 2 km. Then I buy some goods at the builders' merchants and drive out to a construction site, about 3 to 4 km. Then I usually have a few more trips during the day to buy something or to inspect another work site or something like that …" (1).

The same flexibility was described in the case of caretakers, who to a large degree could choose when to do their work. This flexibility made it easier to plan mobility, or to change their plans so that sufficient time was allocated for charging.

With limited battery capacity, several managers began to realize that the company needed to plan trips better when they had electric vehicles in their fleet. This included switching EUVs and regular cars among staff in accordance with expected driving distance, allocating time for charging and setting up routes where chargers were available. This type of planning was of course much easier when there were few ad hoc trips and higher work flexibility. In cases where the employees had very specialized knowledge, for instance, where only one or two workers could handle certain jobs, switching of people and cars could become more difficult. In some enterprises the employees also had a habit of taking their cars home, which could also make switching more difficult. As discussed later in this section, the willingness of managers and employees to change their routines and reschedule their plans appeared as an important characteristic of the crafts companies that had succeeded with the adoption process.

In one of the security enterprises (9), EUVs had been tested out earlier, but the test came to a halt due to problems with charging during the cold season. Implementation was then continued with a more step-by-step approach where they changed their routines, i.e. better planning of trips and charging, with support from the vehicle distributor. In the course of nine months they had then managed to have all of their fleet of security cars electrically powered.

Few vehicles are used privately, although some are used to get between home and work.

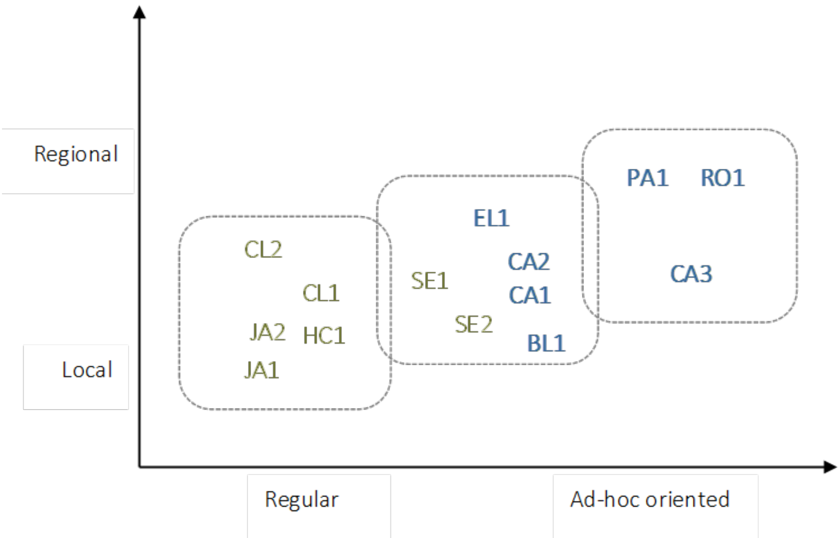

Figure 4.1: Travel regularity (x-axis) and mobility range (y-axis) for all case enterprises (green colour = craft enterprises; blue colour = service enterprises (for enterprise codes, see Table 3.1).

In summary, travel distance, regularity of trips and work flexibility were crucial factors in determining how well the enterprises handled range and charging challenges. In general, the crafts enterprises had more ad hoc oriented trips that made EUVs less practical, in particular if the company catered for customers over a wide area (Figure 4.1). Better planning of trips and of charging reduced implementation challenges.

4.5 Organizational experiences

Most of our informants expressed positive experiences, many saying that the cars had worked much better than expected. They were seen as easy to drive, comfortable and, not least, free of noise. The economic advantages in relation to reduced costs for fuel, toll roads, parking and yearly taxes were greatly appreciated by all enterprises.

Some unexpected advantages had also emerged, however. Several underscored how the EUVs were more reliable than their regular diesel vans, and the costs for service and repairs lower. As mentioned above, managers noticed that employees tended to drive more carefully, resulting in less damage to the cars. Moreover, a cleaning company manager said that the simplicity of use eliminated the risk of employees filling up with the wrong fuel, which was something that used to be a significant problem for them.

On the negative side, limited range was clearly the most urgent issue, particularly for the crafts workers, who sometimes needed to go on long journeys during the day. There were stories about workers who had become stranded in forests and on highways far away from any chargers and that had to be picked up by colleagues. Carpenters and painters/decorators said that battery capacity was good enough for driving to meetings or jobs in the city area, but insufficient for trips to workplaces further away.

However, according to several of our informants, battery capacity was sufficient for 90% of their daily trips. The problem was the few longer trips that came up every now and then. As expressed by a manager in the painting business, the driving range of EUVs was *almost* good enough:

"Yet, it is not that far away. If they could have 50 to 100 km more, a little bit better batteries, then we would have been there. They go almost far enough …" (7).

Batteries have much lower capacity in a cold climate. Figenbaum et al. (2015a) estimated that, in Norway, electric vehicles could have 25–50% less range in winter. Some managers described this as an unwelcome surprise. Workers who had EUVs with electric heating systems said that they sometimes had to drive in cold cars, wearing winter clothes, to save battery power. This problem is greater in EUVs than in passenger vehicles because of the much larger volume to be heated, and for users having frequent stops leading to a need to reheat the cabin.

Most of the crafts workers managed limited capacity by better use of planning. For the roofing enterprise, however, the disadvantage related to the limited battery capacity was seen as so fundamental that they did not want to pursue the adoption of EUVs any further. They felt that the risk of not managing the job or losing customers was too great (7). Most users, however, avoided running out of battery energy while on the move.

Another significant drawback mentioned by carpenters, bricklayers and roofing workers was the lack of a tow bar. In this regard, hope was expressed that new generations of EUVs would have better cargo capacity, a tow bar and four-wheel drive:

"A tow bar is important for all craftsmen I believe. With a bigger cargo capacity and a tow bar we have what we need – Tesla model X!" (6)

Most companies stated that present cargo space and size of the vehicles available were sufficient for the transport requirements of many of their craftsmen and service workers. However, this has to be seen in relation to what they actually use the vehicles for.

In general, the crafts workers expressed a hope that better EUVs (designed for craftsmen) would soon be available. For the time being, the general opinion was that the current models were not quite good enough for traditional crafts workers, but that they could function as a supplement to traditional (diesel) vans.

Among service enterprises, attitudes were more positive, and in general the cars were perceived as good enough for their needs. One security firm and a caretaker company said that they would like to see better space for equipment (including dogs), and that battery capacity was not much of a problem. Yet, managers in two service firms were concerned that the quality of the cars was poor, mostly related to older models, and that the second-hand price would turn out to be low. Those leasing vehicles said that the leasing companies estimated a very low residual value at the end of the lease period, leading to high rates.

4.6 The impact of governmental incentives

Earlier studies have documented that governmental incentives have lowered the barrier for firms purchasing EVs and have stimulated uptake in the private market (Fearnley et al. 2015, Assum, Kolbenstvedt and E. Figenbaum 2014, Aasness and Odeck 2015). The impact of these incentives on the professional market and on the use of EUVs, however, is less well known.

Based on our interviews, it seems that the exemption from taxes on the purchase and use of the car (exemption of VAT, registration, annual vehicle tax) has a significant effect on decisions to adopt EUVs, as also stated by Norwegian stakeholders for electric vehicles in general (Assum et al., 2014). There is little doubt that this was a central driving force in particular for crafts enterprises. However, for the larger service enterprises, including public sector departments, green certificates and environmental policies were more important for drivers. Still, reduced costs were undoubtedly a factor that strengthened motivation to cope with the adoption process.

The informants are somehow ambivalent when it comes to the other incentives. Managers in two of the craft enterprises (1,5) said that access to bus lanes was a key benefit, and that they would consider switching back to a traditional car if ever these benefits were to be taken away. The painting/decorator enterprise argued that it was too early for this measure to be taken away, believing that so doing would curb the ongoing innovation process in the professional market (7). Two other craft enterprises (3,7) located in the centre of Trondheim said that free toll roads was more important to them than bus lane access.

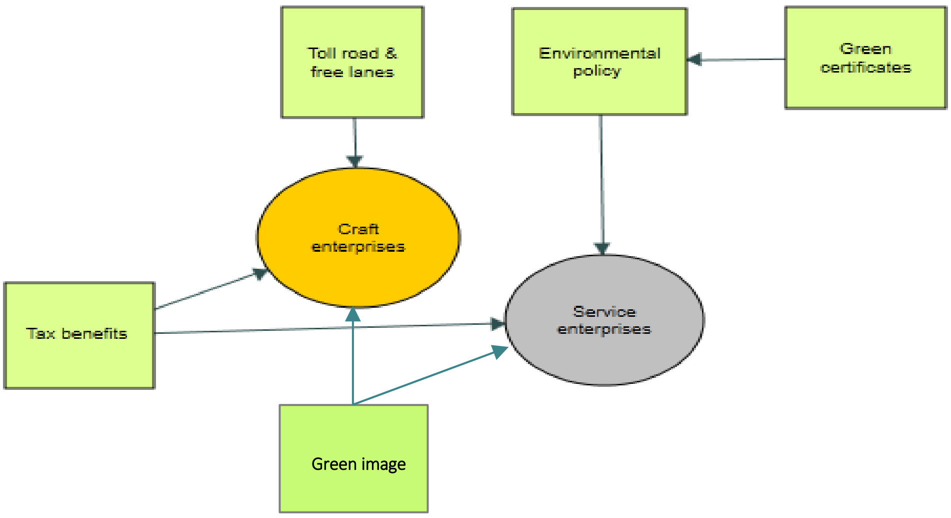

Figure 4.2: Incentives influencing adoption of EUVs in C&S enterprises.

In the other enterprises, public lane access, free toll roads and free parking were seen as positive benefits, but not decisive in their purchase and use of the vehicles. For most service enterprises it was possible to organize driving so that congested roads were avoided, and parking seldom represented a big problem. Most managers expected that access to bus lanes would be eliminated in the not too distant future. The manager in one of the security company said:

"The bus lane is not at all important. For my own part, I almost never use the bus lane not no irritate others. It is inessential. And I have also said that to the boys, use the bus lane as little as possible. Parking is OK, but that hasn't really anything to do with having an electric vehicle. We could have paid for that. And the toll – it is of course nice but not a reason for purchasing electric cars …" (6).

Most craftsmen did not see free parking as an important incentive, but companies 1 and 6 did. Service companies tend to park on private land and do not need public parking. Some companies see need for an improved public charging infrastructure (1, 6, 9) to support their charging needs during the day.

In sum, lower taxes on purchase and use was an important incentive for all crafts enterprises. Access to bus lanes and free toll roads was seen as crucial for about half of the crafts enterprises, most likely because they had a location and driving pattern that meant problems with congestion and required frequent use of toll roads. The service enterprises, however, were motivated mainly by environmental objectives and the governmental incentives had therefore limited impact, apart from those reducing the purchase price. Figure 4.2 illustrates the overall dynamics.

4.7 Discussion

Data from the interviews demonstrate that there was interesting variation in motives for adopting EUVs between the C&S industries. The smaller, traditional craft enterprises – painters/decorators, bricklayers, carpenters and roofing workers –were mainly driven by economic benefits, and in particular those related to cheaper fuels and tax reduction. For enterprises in the service sector – cleaning, caretaker services, home care and security – the environmental benefits were considered more important. This was usually based on the follow-up of green certification schemes.

An important aspect highlighted by several enterprises was a benefit and motive related to organizational identity and image. An organization's *identity* is what organizational members believe to be its central, enduring and distinctive character (Albert and Whetten 1985, Dutton and Dukerich 1991). *Image*, on the other hand, is what members believe people outside the organization use to distinguish it from other organizations. In our study, both identity and image were important in decisions about buying EUVs, although image was most clearly spelt out by the crafts managers.

Implementation in the smaller crafts enterprises was usually done informally through small-scale testing. In the service enterprises, however, EUVs were evaluated thoroughly before being fully implemented. In all cases, there was substantial informal and formal learning taking place.

Despite much resistance, in most cases the cars were evaluated positively. EUVs in the crafts enterprises were mainly used in combination with traditional diesel vans, while in the service enterprises they replaced all cars.

Battery capacity represented serious challenges, in particular for traditional crafts businesses. In general, crafts enterprises had more ad hoc oriented travel patterns that rendered limited battery capacity more problematic, in particular if the company catered for customers located over a large geographic area. The service enterprises tended to have more pre-defined mobility patterns, and a limited battery capacity was therefore more manageable.

Crafts workers were generally enthusiastic about the EUVs and hoped that improved models would soon be available. At the time of the interviews, the general opinion was that current models were only useful in combination with traditional diesel and petrol cars. For service workers, however, the EUVs were generally seen as good enough to meet their basic needs, even though more cargo capacity and a longer driving range would be highly welcome.

5 Future potential of EUVs – attitudes and needs

How much interest is there for EUVs among small craft enterprises? What are the attitudinal differences towards electric vehicles among craft managers? In this section we take a closer look at the interest in purchasing EUVs in a sample of craft workers in four urban regions. The first sections present results from a survey of Craft workers located in the largest urban regions in Norway.

5.1 Data

Data were gathered through a web-based survey of managers in small and medium-sized enterprises in seven craft industries, the main ones being carpenters, electricians, bricklayers, house painters, plumbers, installation contractors and tinners. These industries were selected since their work requires carrying tools, materials and other equipment necessitating transportation by car.

Respondents were recruited from among members of local craftsmen enterprises in the four largest cities in Norway (Oslo, Bergen, Trondheim and Stavanger). Sampling enterprises in urban areas, rather than nationwide, was motivated by the fact that e-vehicle infrastructure (charging stations, parking lots, etc.) is more developed in the major cities. The aim was to recruit managers on the basis of their general knowledge of the enterprise and their involvement in strategic decisions concerning technology adoption and environmental profile. This is particularly relevant in the SME context (Aragón-Correa et al., 2008). The research team received e-mail addresses from craftsmen member organizations in order to contact people in relevant enterprises. For the great majority, the contact person/respondent was the general manager, but in some cases, (s)he held another managerial position in the firm (Table 5.1).

E-mails providing information on the purpose of the survey and its content were sent to an 2360 enterprises, with prospective respondents being asked to participate by clicking on an attached link to the survey website. As an incentive into taking part, they could enter a raffle with the opportunity to win NOK 5,000.

Table 5.1: Key sample characteristics.

	Frequency	%
Type of company		
Contractor/carpentry	74	28
Electrical engineering	80	30
Tinner work	15	6
House painting/bricklaying	18	7
Plumbing	19	7
Technical installation	35	13
Other	23	9
No. of employees		
< 10	71	27
10 - 19	53	20
20-49	72	27
50 and more	68	26
Position		
Owner/general manager	178	67
Head of section	42	17
Other managerial position	27	10
Other position	17	6
Urban area		
Oslo	75	28
Akershus	16	6
Rogaland	85	32
Hordaland	46	17
Trøndelag	42	16
Total	264	100

Following a reminder, we received 317 replies. However, 53 questionnaires were rejected because they were incompletely filled in and/or the firm was operating in an irrelevant industry. A low response rate in research engaging SME owners/managers is common (Gadenne, Kennedy and McKeiver 2009), although it calls into question the representativeness of the sample and consequently any conclusions drawn based on the data. The largest enterprises were found in technical installation, while tinners, bricklayers and painters tended to be organized in smaller firms.

Table 5.2 indicate that on an overall level, the sample reflect the distribution of central groups of craft workers within building and construction[13]. The Carpenter/brick layers and other constructing workers are somewhat overrepresented, and the group of electricians underrepresented. Thus the small sample calls for cautiousness when generalizing results to a larger universe of craft enterprises. The study can only give rough indications when discussing differences across professions.

Table 5.2: Sample of selected groups of construction workers, national distribution (SSB 2014).

	All employees, 2014		Survey sample	
Electricians/electric installation work	14 923	59 %	134	51 %
Carpenter/brick layers and other constructing work	4 960	20 %	92	35 %
Other specialized building activities (tinners, roofing, etc	5 494	22 %	38	14 %
All	25 377	100 %	264	100 %

[13] The groups displayed are construction work, categories 4.2, 4.3 and 4.9.

5.2 Use of vans

The number of cars that enterprises deploy obviously has a bearing on the number of people employed. In general, however, most enterprises prefer small (i.e. VW Caddy, Renault Kangoo) or medium-sized vans (i.e. Toyota Hiace, VW Transporter). The smallest vans were most widespread among electricians, while plumbing companies had the largest average number of medium-sized vans (Figure 5.1).

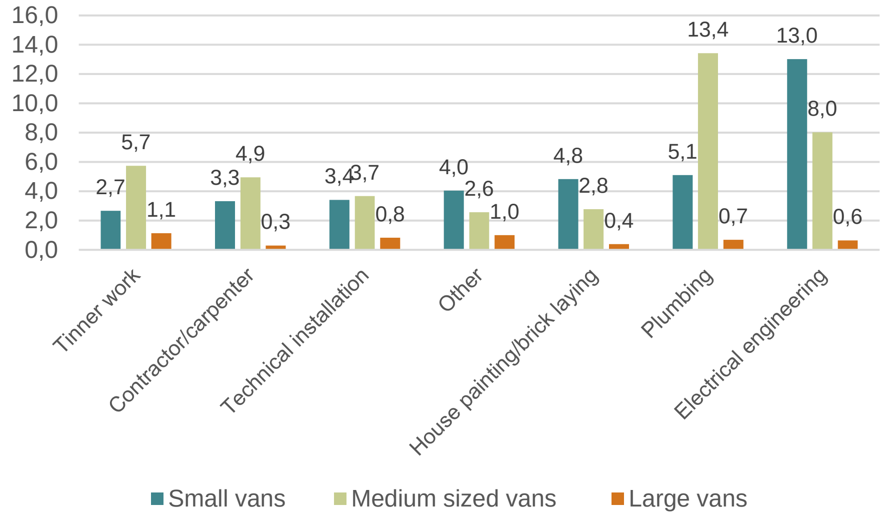

Figure 5.1: Numbers of vans in the enterprises and business type. Mean values.

Table 5.3: Number of vans available in the enterprises and number of employed. Mean values.

Employed	Small vans	Medium-sized vans	Large vans	Total
Less than 10	1.2	2.0	0.2	3.3
10-19	3.3	3.7	0.5	7.7
20-49	5.6	7.3	0.3	13.4
50 and more	13.6	9.2	1.1	24.3
Total	5.5	5.4	0.5	11.5

As expected, the adoption of EVs was relatively low in the sample; approximately 5% (14 in total) owned or had access to an electric car or EUV on a daily basis. This number corresponds reasonably well with data presented in section 2 on market shares of EUVs. Users were scattered across different business areas, although 6 out of 14 were electrical installation firms (see Figure 5.2). Of these small groups of users, four had a regular e-car, and the others between one and five electric vans (EUVs).

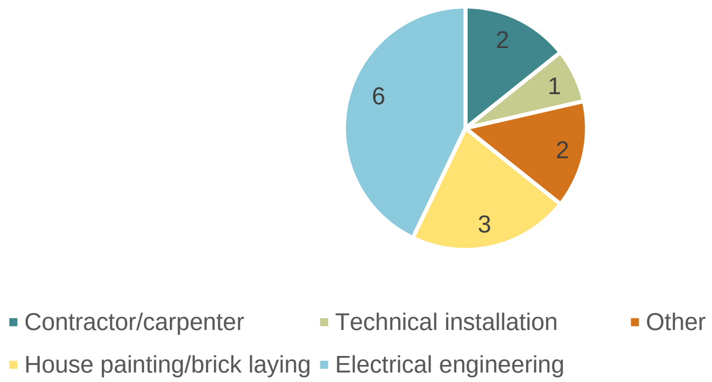

Figure 5.2: Craft enterprises with EUVs and business area. Numbers of enterprises.

5.3 Driving habits

Use of electric vans may be organized differently in different enterprises. In most cases, however, each craftsman has permanent access to the same van during the week or longer.

Most managers reported that the vehicles were driven less than 80 km per day. Yet, the distance tended to vary significantly (see Table 5.4). The shortest were reported among house painters/bricklayers and contractors/carpenters. In contrast, plumbers tended to drive for longer distances (see Figure 5.3).

Table 5.4: Average driving distance per car per day. Percent.

Average driving distance per day	Frequency	Percent
Less than 80 km	145	54.9
80-120 km	63	23.9
More than 120 km	6	2.3
Differs a lot – hard to give an average figure	50	18.9
Total	264	100.0

Table 5.5: Distribution of cars and size of enterprise. Percent.

No. of employees	% of vans driving <80 km per day	% of vans driving 80-120 km per day	% of vans driving ≥ 120 km per day	Total
Less than 10	66.8	31.0	2.2	100
10-19	58.8	34.8	6.5	100
20-49	60.6	34.2	5.3	100
50 and more	65.5	33.5	1.0	100
Total	62.9	33.7	3.4	100

As most enterprises had multiple vehicles, and distances tended to differ significantly, it is interesting to see how the cars are used. As indicated in Table 5.5, six out of 10 cars are used for less than 80 km per day, while just 3–4% of the vans are used for distances over 120 km. The differences between the larger and smaller enterprises are minimal.

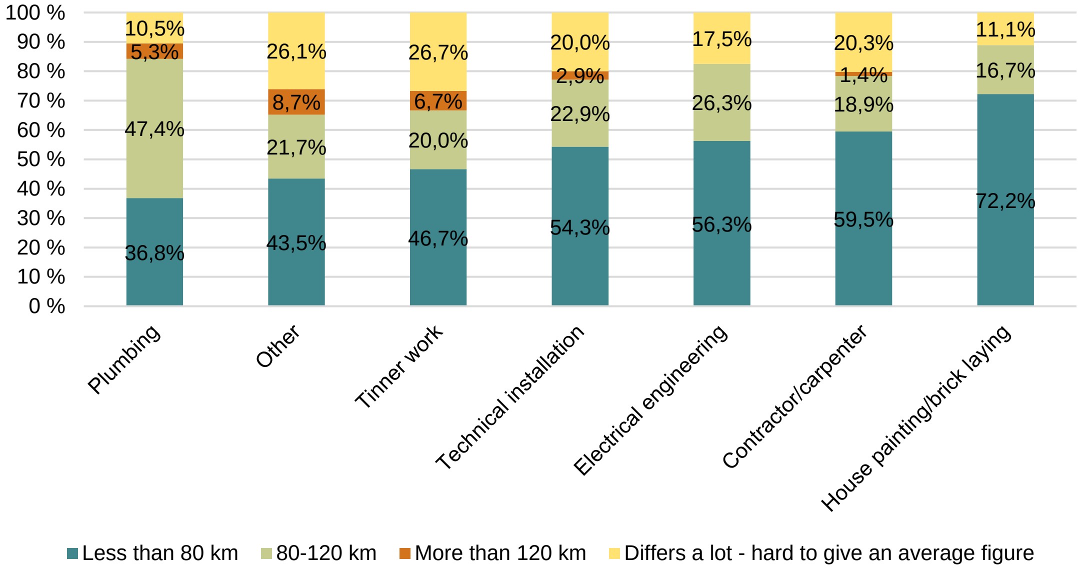

Figure 5.3: Estimated driving distance per car and business type. Percent.

5.4 Interest in future use of EUVs

According to this survey, the number of EUV users in the building -and construction segment of the crafts industry is currently low. Yet, there is a strong interest in possibly adopting electric vans in coming years. Looking two years ahead, about one in four of today's non-users say that it is likely, or very likely, they will adopt EVs in their company. For those who said it was unlikely that they would adopt during the next two years, over 27% believed it would be relevant during the next five years (Figure 5.4). Together, 51% of the informants said it was likely that the company would adopt EUVs in the coming two to five years.

Interest in adopting EUVs is most prominent among the carpentry/bricklayer firms and among electrical engineering firms (Figure 5.5). In general, over 40% of the informants said that they had discussed future use of EUVs in the management team.

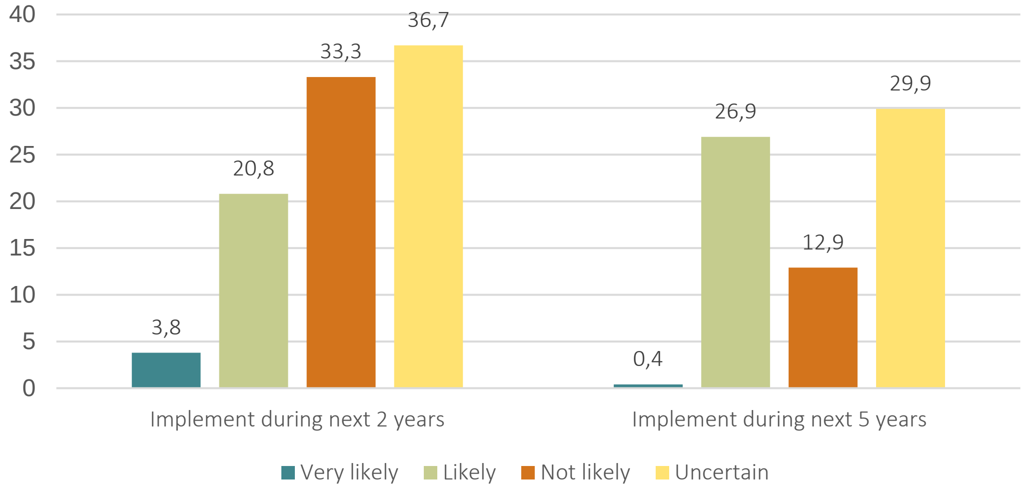

Figure 5.4: Interest in adopting EUVs two and five years ahead. Percent.

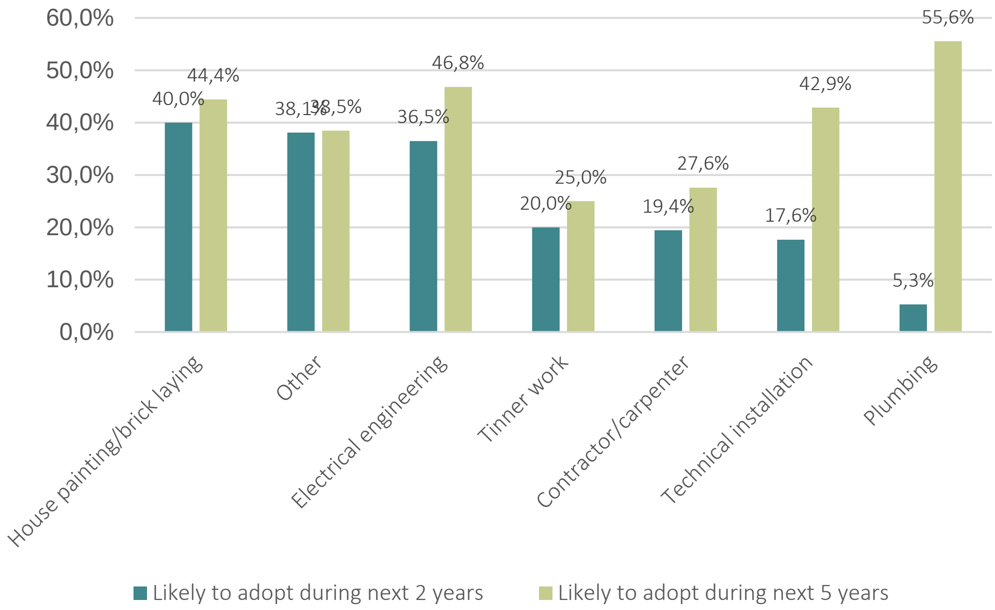

Figure 5.5: Interest in adopting an EUV in the next 2 to 5 years.

5.5 Attitudes to EUVs

As mentioned in section two, currently implemented incentives may stimulate the use of EV and EUVs among C&S workers. In fact, they already seem to have affected current EUV users (Figure 5.6). The most attractive incentives are free toll-roads followed by free parking. Moreover, about 45% indicated that the driving range was not good enough and 33% that the loading capacity was insufficient for their needs.

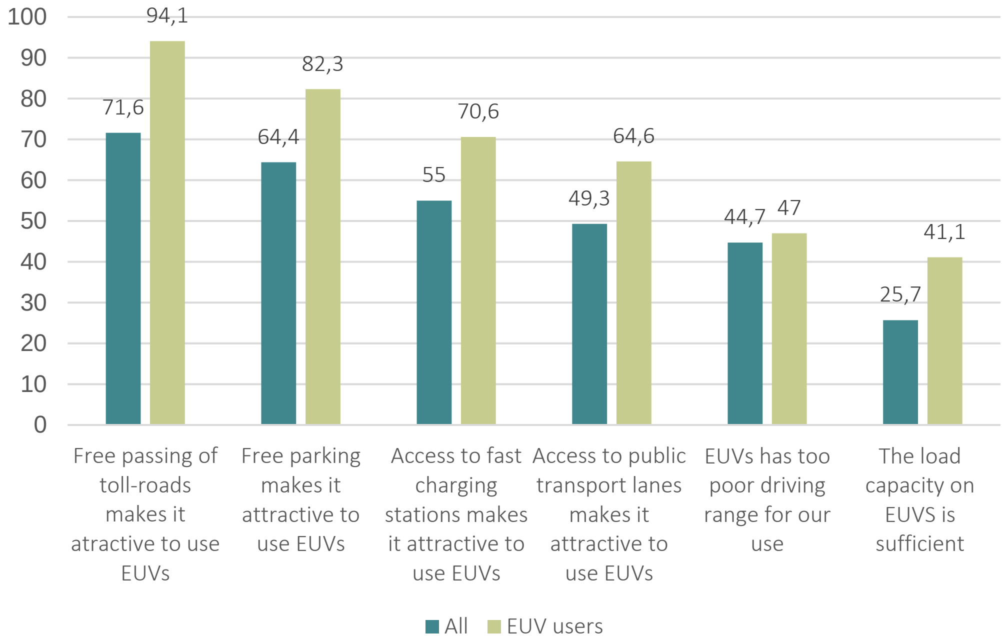

Figure 5.6: Attitudes among EUV users and all users to selected statements. Percent who agree to the statements.

5.6 Dimensions and differences

The electric vehicle is new technology and therefore opposing views of the pros and cons have to be expected. To explore attitudinal differences and perceived relevance of EUVs for a particular crafts business in the building and construction segment, a list comprising 17 statements was presented to informants. Level of agreement was registered on a regular 5-point Likert scale (see questionnaire in the appendix). An exploratory factor analysis was applied to locate attitudinal structures using principal component analysis and Varimax rotation. Statistical tests indicated that the data were suitable for this type of analysis [14].

In general, three major factors explained over 50% of the variance. These three rotated factors reveal clearly distinct attitudes to the benefits and drawbacks of EUVs. Table 5.5 shows how each of the statements/variables is loaded on the three factors. The *first factor* includes a set of statements positive to the practical benefits from using an EUV coming from the incentive systems, and a general preference for higher speed and reliability. This dimension is labeled "mobility benefit", as it refers to the advantages deriving from access to free passage of toll-roads, access to public transport lanes, free parking, and so on. The *second dimension*, on the contrary, consists of statements expressing uncertainty and doubt about EUVs – this related to technological quality as well as risk of buying and poor range of driving. This factor is labelled "Risk & uncertainty". The *third dimension* included statements that had a positive loading on statements focusing on enterprise image, economic benefits and practicalities. This therefore expressed a positive attitude to

[14] KMO and Bartlett's Test of Sphericity is a measure of sampling adequacy that is recommended for checking the case to variable ratio of an analysis (Johnson, R. A. & D. W. Wichern. 1992. *Applied Multivariate Statistical Analysis*. Englewood Cliffs: Prentice-Halls.). The KMO score ranges from 0 to 1, and the index accepted world-wide is over 0.6. In this study, the KMO value was 0.8. Bartlett's Test of Sphericity relates to the significance of the study and thereby shows the validity and suitability of the responses collected to the problem being addressed through the study. For a factor analysis to be recommended as suitable, Bartlett's Test of Sphericity must be less than 0.05. In this analysis, the value indicated is 0.000

purchase and use of EUVs, although accentuating aspects other than the first factor. This is labelled "Image & economy".

Table 5.5: Rotated component matrix (loadings below 0.4 are excluded).

Statement	Factors		
	Mobility benefits	Risk and uncertainty	Image & economy
Free passage on toll roads makes it attractive to use EUVs	0.888		
Free parking makes it attractive to use EUVs	0.884		
Access to public transport lanes makes it attractive to use EUVs	0.795		
Access to fast charging stations makes it attractive to use EUVs	0.750		
Assignments are reached more quickly with an EUV	0.440		
The quality of today's EUVs is uncertain		0.865	
The risk of using an EUV is high compared to regular vans		0.820	
It feels less safe to rely on an EUV rather than a traditional gas/diesel van		0.775	
The driving range of EUVs is inadequate for our use		0.575	
An EUV is a safe purchase		-0.525	0.499
EUVs make our enterprise look modern			0.821
EUVs give the enterprise a positive image			0.820
It is practical for us to use an EUV			0.543
The technology behind EUVs is well developed		-0.446	0.471
It is economically beneficial to use EUVs			0.424
The load capacity on an EUV is sufficient			0.414

There are significant attitudinal differences between enterprises that have adopted EUVs and non-adopters. The most prominent feature of current users (see Figure 5.7) is that they have a good understanding of the mobility benefits, followed by aspects relating to a positive and environmentally friendly image and economic benefits. For those planning to adopt in the coming two years, aspects relating to image and economy are more important than the current benefits, possibly because many of the mobility related benefits may be eliminated in the coming two years. The risk-related attitudes are more prominent among those that have a longer-term horizon on adoption and others reluctant to adopt in general.

There are also attitudinal variations among the regional areas included in the study, the mobility benefit factor being strong among company managers in Oslo and Trøndelag, but not in Rogaland and Akershus. This is most likely related to the fact that free toll-road passage and access to free parking are most relevant for enterprises operating in these two regions.

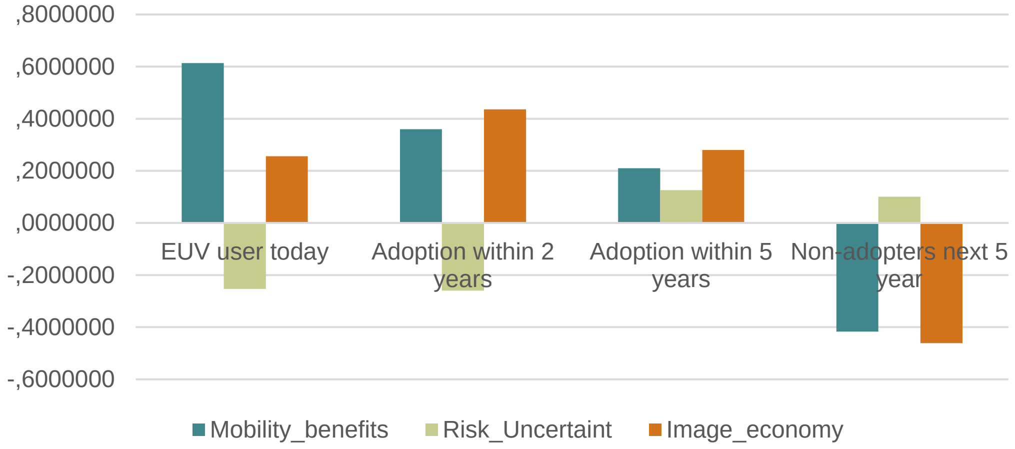

Figure 5.7: Current and likely future adoption of EUVs and factor scores. Mean values.

6 Potential use of EUVs based on data from electronic travel logs

Mobility management applications (MMA) can be used to analyse travel patterns when vehicle position, time and speed are logged at regular intervals.

6.1 Method and data

Crafttrans obtained data logs of the transport activity of seven craftsmen companies in order to get a better understanding of how craftsmen travel (see Table 6.1). The dataset was obtained from the Guard Systems electronic travel log (TRAVELLOG) database. TØI and Guard Systems obtained permission from these seven companies to access GPS data for their vehicles already stored in the Guard System operative database of logged travel. The seven companies operate 115 vehicles. Two weeks of data was extracted covering the period Monday 9 March to Sunday 22 March 2015. No information other than the number of vehicles in the company and the postal code of the company's main office is known about these vehicles.

Table 6.1: Vehicles and companies in the sample.

Company	No. of vehicles	Customer id	Municipality
A	4	1094	Oslo
B	7	1776	Oslo
C	7	2386	Oslo
D	15	3119	Oslo
E	4	3169	Røyken, ~20 km south-west of Oslo city centre
F	29	3998	Lørenskog, ~15 km east of Oslo city centre
G	49	4015	Oslo

6.2 Raw data

The data were obtained from the TRAVELLOG data-logging system, which is used as a business support tool for craftsmen fulfilling tax reporting requirements. The unit has a GPS and logs the vehicle position and speed each kilometre of driving and during events such as:

- Manoeuvres around curves
- Start/stop of periods of high speed
- Fast acceleration
- Start/stop of congested traffic
- Ignition on/off
- Every hour/half-hour when ignition is off

There will therefore be more log points when driving on winding roads and when accelerating than when on long straight roads. The driving distance of trips can be taken by the difference in position between adjacent data points. Some older versions of the system may have fewer data points associated with manoeuvres and will be less accurate. It is the immediate status of the system that is sent to the database from the onboard unit. The data format of the logs obtained from TRAVELLOG is given in Table 6.2. Data points may be lost if the communication link with the central system is lost, or if signal quality is poor.

Table 6.2: Data format of the data logs from TRAVELLOG.

Customer	Unit	ZIP	Logged-time	Longitude	Latitude	Speed
1094	254179	XXXX	09.03.2015 00:30	10.69796944	59.47059266	0
Customer	Anonymous code for the vehicle owner					
Unit	Anonymous code for the vehicle					
ZIP	ZIP (post) code					
Logged time	Data and time of logged data point					
Longitude, latitude	Longitude and latitude of the position at the time the data point is recorded					
Speed	Actual vehicle speed at the time the data point is recorded (km/h)					

The data are sent via mobile internet to a centralized computer system that owners of the vehicles have access to. Data can be retrieved from this system by each company and used for planning and reporting purposes.

6.3 Data processing at TØI

The dataset was first arranged by customer id, then by unit and logged time. Longitude and latitude were transferred to the UTM33 coordinate system to facilitate calculation of trip distance. Data points with obviously wrong coordinates (such as positions 0.0) were deleted from the dataset, which was split into trips for each vehicle (unit). A new trip was assumed whenever there was more than 25 minutes between trips. This approach means that two trips less than 25 minutes apart are logged as one trip, because it is assumed that a craftsman cannot carry out meaningful activities within such a short period of time. Short errands to collect items could be recorded as one trip, however, whereas it should ideally have been two. A motionless vehicle's position logged roughly every half hour generates a large number of meaningless trips. These and other very short trips with fewer than 10 data points were removed from the dataset.

Short trips usually contain one or two successive data points with long time intervals when it is uncertain whether the vehicle is moving or stationary. These points generate noise in the data. If the vehicle is stationary, then a new trip should have been defined; if it is moving we do not know how, and it will "jump" from position to position. The analysis is therefore concentrated on the longer trips that are better defined. Of a total of 256,396 data points, 63,005 were for trips shorter than 10 data points. Ninety-two percent (58,310) of these contained fewer than three data points, which should indicate that the vehicle is stationary. The remaining 8% of these short trip data points make up less than 2% of the total number. The impact on the calculation of a vehicle's total driving distance should be much less.

The position data for trips were transferred to travel activity maps using GIS and the distance between data points was calculated. Trip distances were calculated as the sum of these distances. The data were not pinned to the road network. While this method introduces an error in the calculation, the actual maps of travel show that the trips trace the roads well, apart from one of the company's vehicles.

An estimate of annual driving was obtained by multiplying the two weeks of data by 23 to get 46 weeks, taking into account Norway's 5 weeks of vacation as well as public holidays. This approach was chosen mainly to increase the readability of the report but the estimate is rather crude. There is a risk that variations over the year is not sufficiently captured. There are no earlier works available on the variability of driving over the year for Norwegian utility vehicles.

6.4 Geographical spread of driving patterns

When looking at the data logs of the seven companies, it became apparent that companies A, C and E used their vehicles within a small geographical zone in the greater Oslo Area (Table 6.3 and Figure 6.1 and Figure 6.2); and companies B, D and G over a larger regional zone covering Eastern Norway. Company F covered most of Norway, driving up to 1,200 km away from its headquarters.

Companies F and G are large and some long-distance driving should not therefore preclude opportunities to replace some of their vehicles with EUVs. Most of their driving was in the greater Oslo Area. Company B has few vehicles although operating in a large geographical zone and thus replacing diesel vehicles with EUVs is a challenge.

Table 6.3: Geographical spread of driving for companies A–G.

Company	Widest distance from office	Geographical zone
A	60 km	Larger Oslo Area plus trips to Moss 60 km from Oslo
B	200 km	Eastern Norway
C	20 km	Larger Oslo Area
D	220 km	Eastern Norway (mainly south part)
E	50 km	Larger Oslo Area
F	1200 km	Eastern, Middle and North Norway
G	200 km within Norway 250 km partly in Sweden	Eastern Norway + trips to Western Sweden

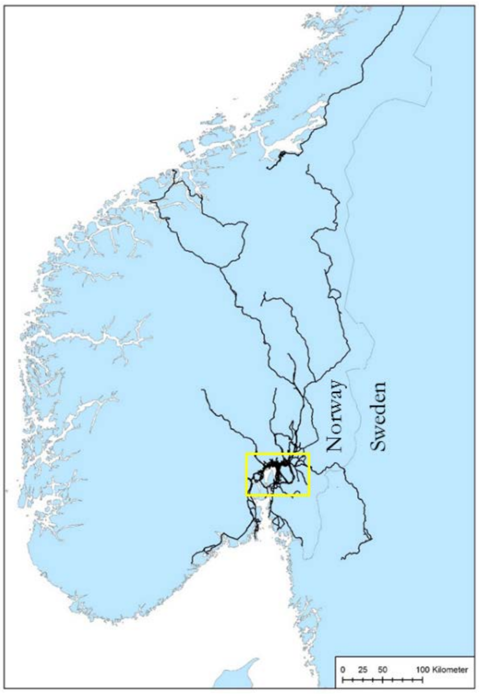

Figure 6.1: Spread of driving of 115 vehicles, 2 weeks, dates 9–22 March 2015. Black lines represent trips undertaken. The yellow square covers the approximate area of figure 7, the greater Oslo Area.

Figure 6.2 shows logged traffic in the greater Oslo Area (all vehicles) and the geographic positions of companies (A–F) owning the vehicles.

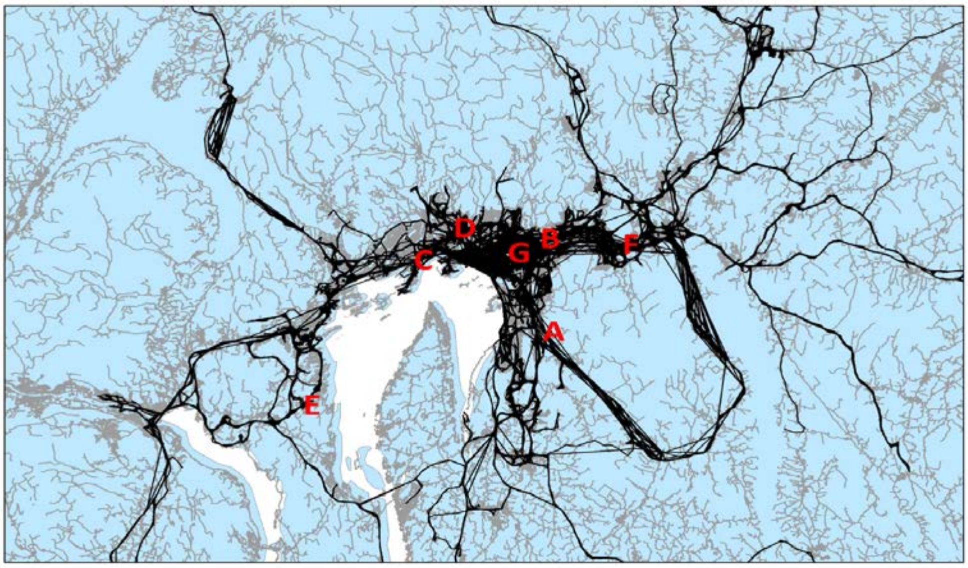

Figure 6.2: Logged driving in the greater Oslo area, 115 vehicles, position of companies A–F.

Data from individual companies are given in Figure 6.3 and Figure 6.4. The data logs from company B show more disturbance than those of the other companies (seen as straight lines not following the road network in Figure 6.4). The straight lines in some of the trips of company B are probably due to vehicles with older versions of the TRAVELLOG system not logging manoeuvres around bends.

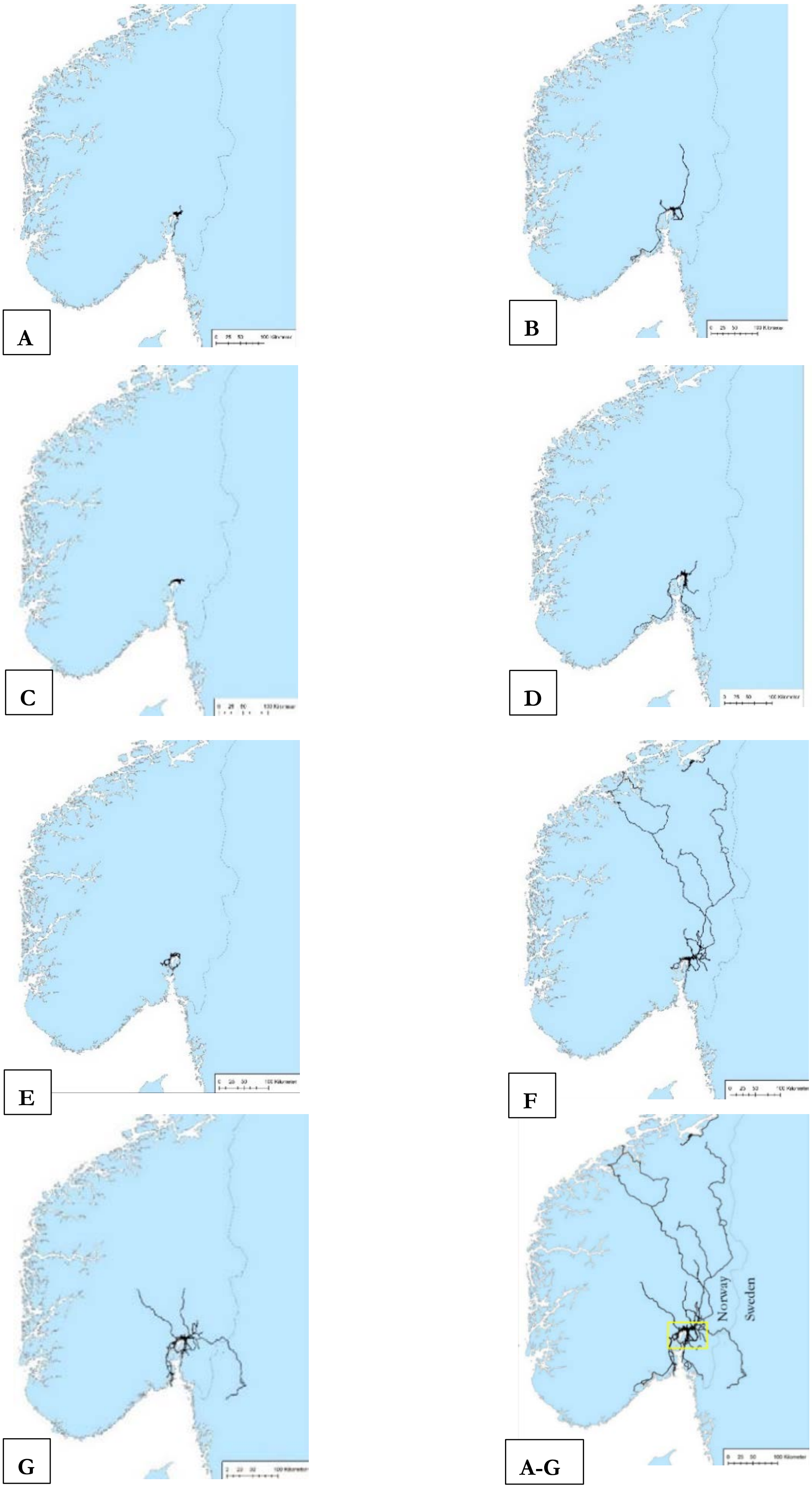

Figure 6.3: Travel pattern of each company and sum of travel of all companies.

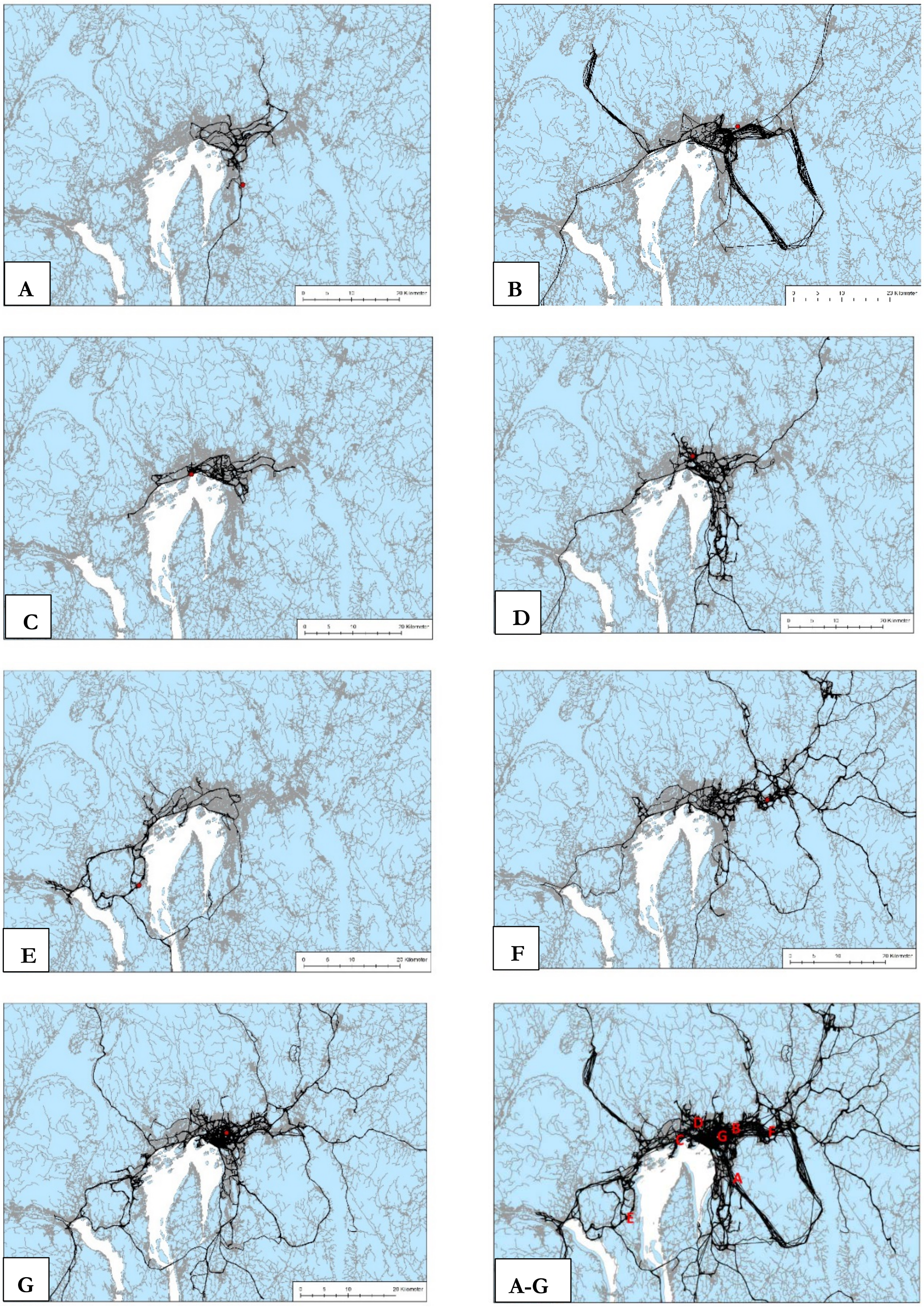

Figure 6.4: Travel pattern of each company and sum of all travel in the greater Oslo area.

The daily driving distance per vehicle over the logged calendar days 9 to 22 March 2015 (March 14–15 and 21–22 are weekends) show that few vehicles are on long-distance trips at weekends. Sixty-three percent are not used at weekends at all, and 27% less than 81 km; 3% have the maximum weekend day of use in the interval 81–120 km and only 7% have a maximum weekend day driving length exceeding 120 km. Few vehicles are used on very long trips.

It was apparent from the survey of Craftsmen enterprises and interviews with companies owning EUVs that they have a highly variable driving pattern. The data logs confirm this. Driving depends on where they get assignments, which could be for anything from a year to weeks or days. Variability in driving like this could preclude any replacement of diesel vans with EUVs that have a limited range. Several craftsmen had departments exclusively for servicing and upgrades of existing buildings or installations, departments that had extremely variable driving needs and assignments that could change even during the course of one day. Companies stated that EUVs could not be used by Craftsmen in these types of work. As servicing is normally of short duration, it is likely that EUVs operate within a limited geographical zone, but the number of starts and stops will be many. Some dedicated service companies had a highly predictable driving pattern, but also in these cases driving needs could change occasionally with a loss or gain of customers.

6.5 Average driving pattern

Figure 6.5 shows the estimate for average driving per year based on the two weeks' driving pattern of all the logged vans multiplied by 23 to obtain annual driving over the 230 workdays available. The estimated annual average travel length was 12 207 km, while the median was 10 947 km.

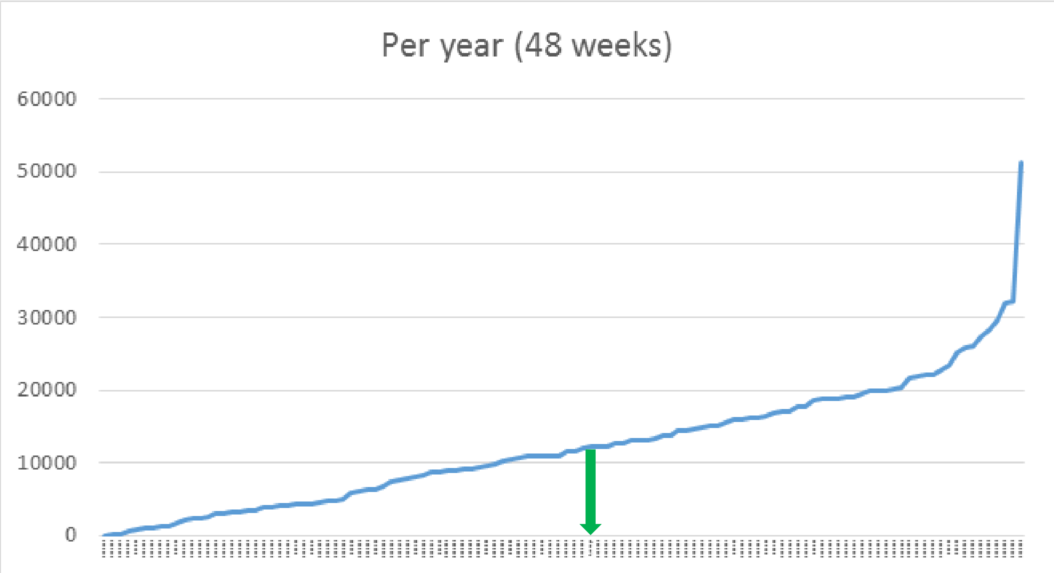

Figure 6.5: Estimated yearly (46 weeks) driving for 115 vehicles in increasing order, based on 2 weeks data logging (km). Arrow marks average. x-axis: vehicle ID.

The large share of vans with very short driving distances is surprising. Some of these companies are located in the densest parts of Oslo, however, potentially explaining the short distances. The use of vehicles also depends on the assignments carried out, i.e. ability to share vehicles could lead to some vehicles standing idle part of the time. Spread of the estimated number of days of usage per year per vehicle is shown in Figure 6.6.

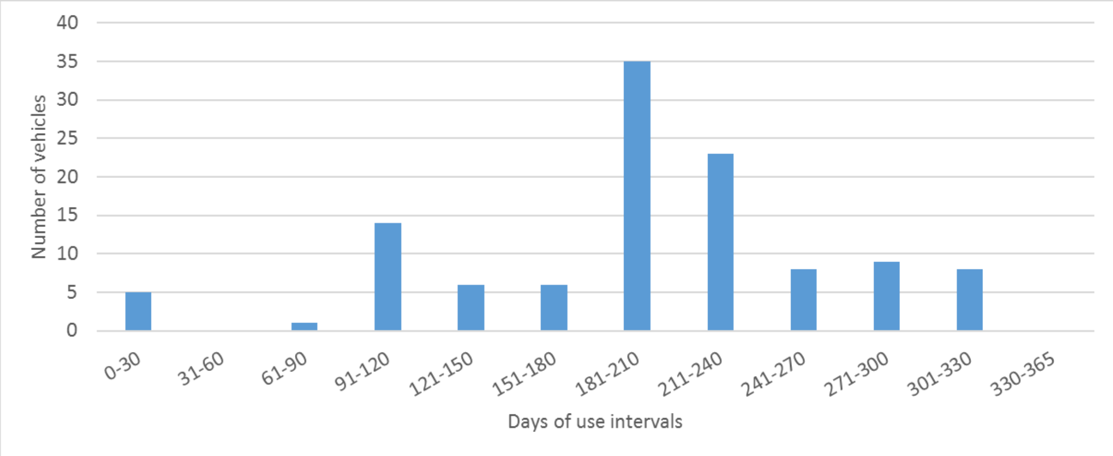

Figure 6.6: Number of vehicles per interval of days of use per year.

6.6 Day of driving with maximum distance

Figure 6.7 shows the spread of the maximum daily driving distance over the 2 weeks of data logging using the colour codes from Table 6.4. The base assumptions are that no charging is undertaken during the day, the usage pattern of vehicles is not altered and the available range is that of 2014-2015 EUVs. The effect on the number of replaceable vehicles of redistributing travel between vehicles is discussed in section 6.8, and opportunity charging during the day in section 6.9. In the discussion in section 6.10 the effect of new technology with longer range is presented.

The extra vehicles and transport work that is achieved within the light green segment is an uncertain interval for vans without diesel heaters. Vehicles may or may not be compatible. If diesel heaters for cabin heating are installed, then these vehicles are definitely replaceable by EUVs. The only EUV currently fitted with a diesel heater as standard is the Renault Kangoo. A retrofit can likely be done on other types of EUVs.

Table 6.4: Colour coding of vehicles and evaluation of the possibility to replace the diesel van with an EUV, by the day of maximum driving distance over the two-week period.

Distance driven on day of maximum driving length	Evaluation of potential to replace diesel vans with EUVs
Always under 51 km	All vehicles can be replaced
51-80 km	Vehicles can likely be replaced
81-120 km	Potential for replacement depending on type of road, driving style, speed, cargo, topography, temperature
Over 120 km	Not compatible unless possible to charge during the day

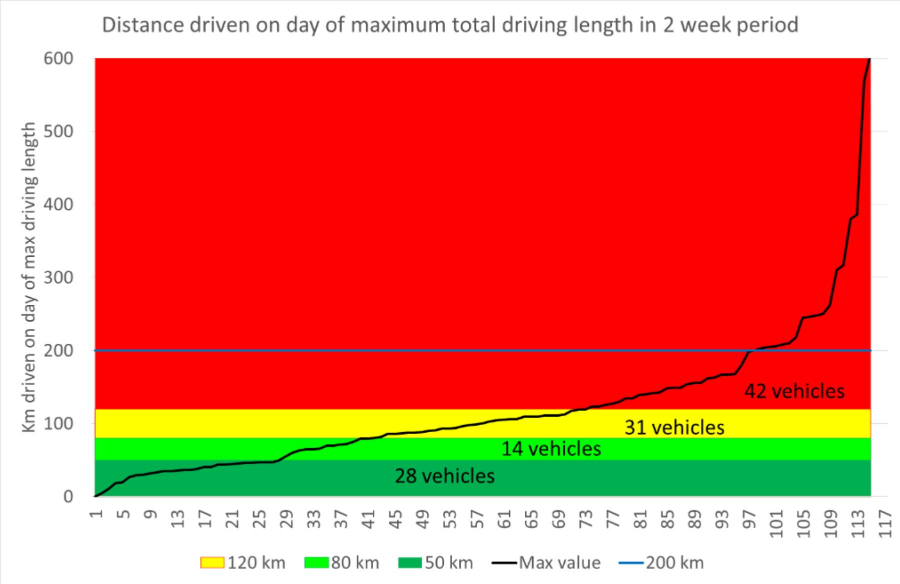

Figure 6.7: Vehicles divided into potential of being replaced by EUVs based on the length of travel on the day of maximum daily travel over the 2 weeks of 9–22 March 2015. No charging during the day, existing driving pattern and range of 2014-2015 year model EUVs is assumed.

6.7 Daily travel activity of all vehicles

The percentage of the fleet of 115 vehicles operating on specific days is shown in Figure 6.8. Travel activity is less at weekends and not much different Mondays to Wednesdays. Activity ramps up sharply from 05:30 to 06:30 and further increases until 07:00, which is the peak time. Nominal starting time for craftsmen in Norway is 07:00. There is generally less travel activity on Thursdays, whereas on Fridays it starts about 15 minutes later and ends 45 minutes earlier. Fridays are when the lowest share of the fleet is on the road, followed by Thursdays. Travel activity is fairly constant over the day up until 15:00. Most of the vehicles are parked between 15:00 and 16:00, but there is a long tail into the evening, particularly on the first days of the week. On Fridays the fleet is parked about an hour earlier.

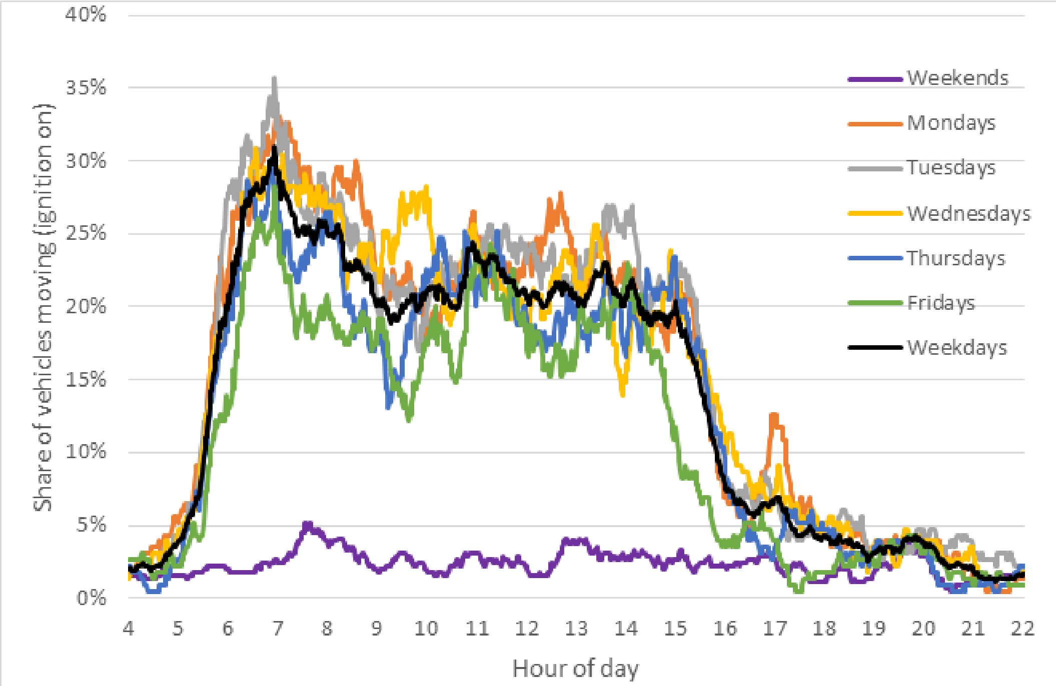

Figure 6.8: Travel activity by day of the week.

Movement data were compared with the toll road data of small vehicles passing through toll gates around central parts of Oslo. They contain the data of small passenger vehicles owned by enterprises, which makes direct comparison difficult. The curves have the same shape as seen in the left part of Figure 6.9. There is a peak at 07:00 in the morning and after 15:00 travel winds down. The normal working day for craftsmen is 07:00 to 15:00. The log data peak at 11.00, which is probably when the driver has lunch. Drivers of these vehicles are unlikely to drive through a toll gate to have lunch, which explains why the peak cannot be seen in the toll road data. Apparently the tail in the afternoon is larger for toll road data but, as can be seen in the right part of the figure, this is probably due to vehicles not passing through toll road gates.

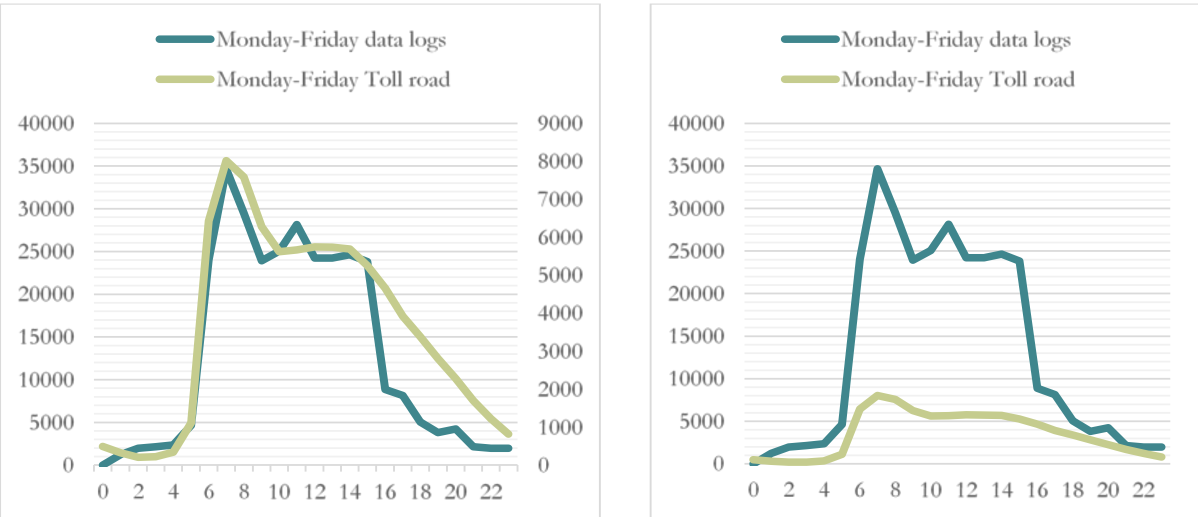

Figure 6.9: Travel activity per hour. Top: vans passing through the toll gates of Oslo, middle: registered movement of logged vehicles, bottom: vehicles passing toll gates and logged vehicles on Mondays.

For distribution of trip length per trip length interval for all 115 vehicles, and the number of trips longer than the trip length interval, see Figure 6.10.

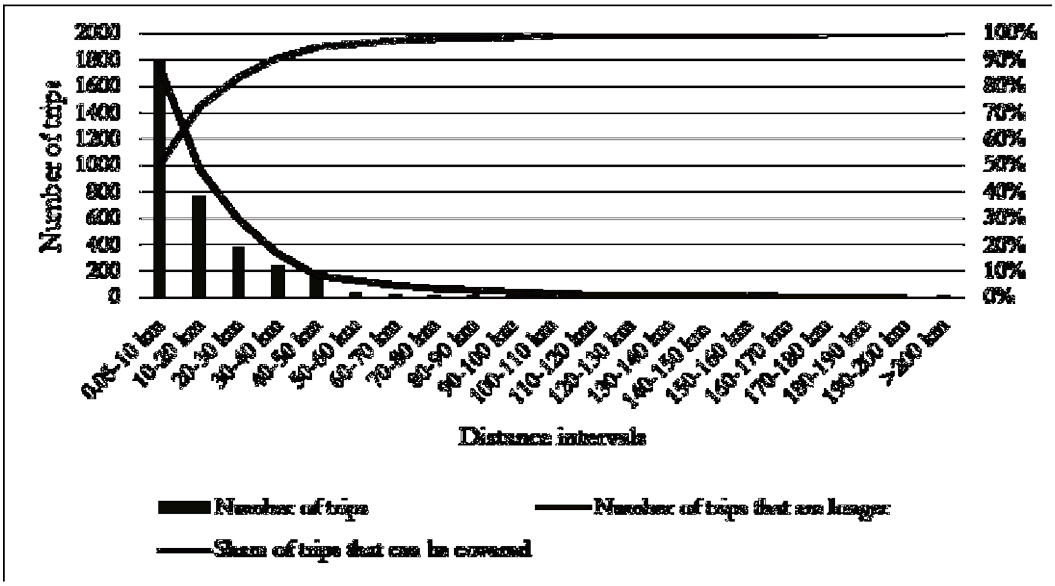

Figure 6.10: Number of trips in trip intervals, number of trips exceeding trip interval and accumulated share of total trips (percentage).

The number of days a vehicle is driven in distance intervals, the number of days of driving exceeding the distance interval, and the share of days that can be covered are all shown in Figure 6.11.

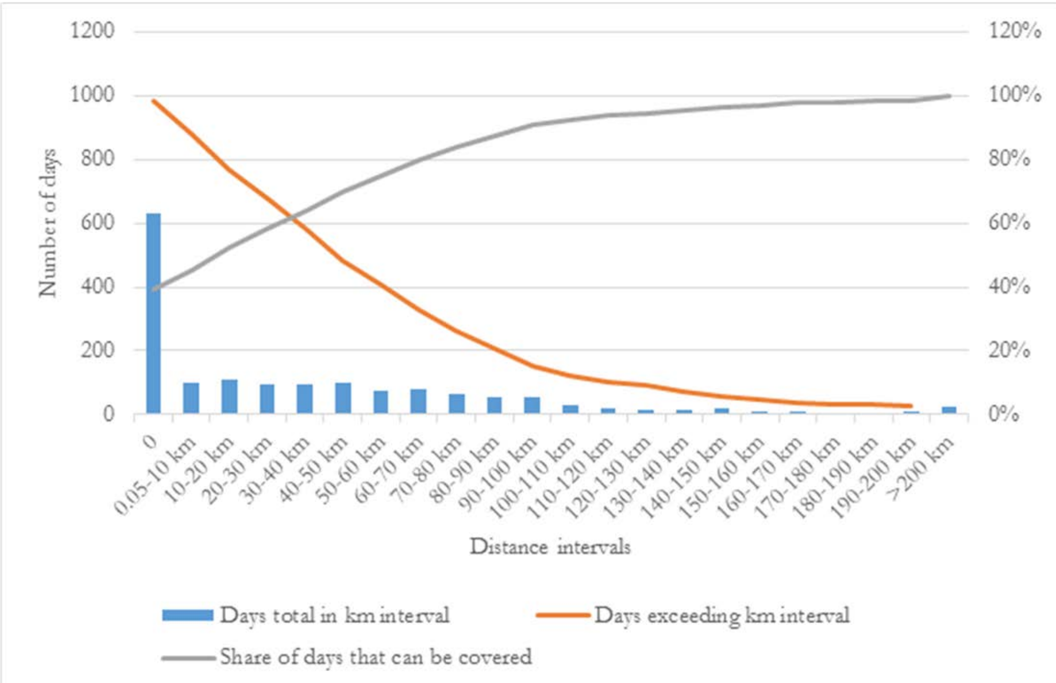

Figure 6.11: Days of travel by distance intervals, days exceeding and share of days that can be covered.

Figure 6.12 shows the spread of daily driving distances from shortest to longest regardless of the day: for all vehicles; for vehicles that are always driven below 81 km; vehicles occasionally in the 81–120 km range; and those above 120 km, respectively.

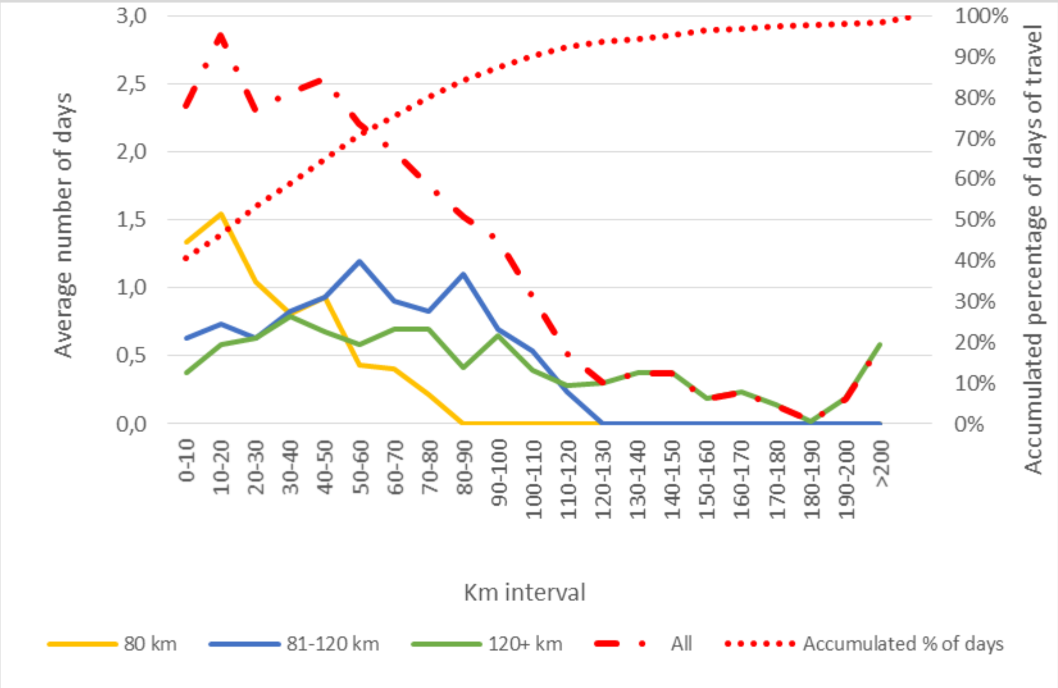

Figure 6.12: Average number of days in range intervals for all vehicles, vehicles never driven over 80 km, those driven occasionally in the 81–120 km range and those occasionally over 120 km. The number of days of driving less than 0.05 km is omitted (80 km: 42 vehicles, 308 days not used, 282 used. 81–120 km: 30 vehicles, 142 not used, 278 in use. Over 120 km: 43 vehicles, 208 days not used, 394 days used). 201 covers all driving above 200 km.

The percentage of vehicles by maximum day-of-travel intervals, transport work of vehicles by day-of-travel distance intervals, and transport work by vehicles by maximum day-of-travel distance intervals are all shown in Figure 6.13. The potential for replacing vehicles (blue) is much greater than for transport work when only vehicles that never exceed the maximum day-of-travel interval limits (grey) are replaced. The split of driving by all vehicles (red) by days of travel less than 81 km, 81–120 km and over 120 km, is the theoretical potential to replace total transport work for all the vehicles in the sample. EUVs would then replace diesel vehicles on all travel in these intervals. The figure shows that with a limit of 80 km driving on the maximum day of travel, 41% of vehicles can be replaced but only 13% of the transport work. If all transport could be replaced with EUVs on days of travel less than 80 km, 42% of the transport work could be replaced. This assumption is not realistic, as the vehicles belong to different companies. A 50% increase in range, which is achievable in a 5-year timeframe, would result in a much higher substitution of transport work. The share of vehicles would then be 68% and transport work 41%. In the interviews with EUV owners, several stated that the range was “almost good enough”, but a bit more would make the vehicles much more useful. The data logs support their statements.

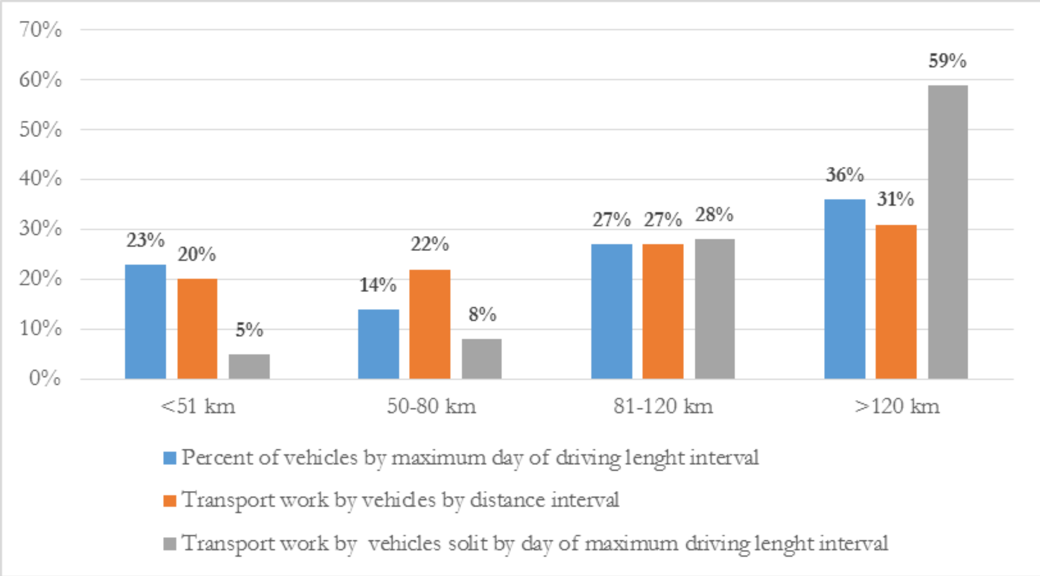

Figure 6.13: Percentage of vehicles by maximum day of travel length interval, transport work by all vehicles by daily distance interval.

6.8 Redistributing transport: fewer vehicles on long trips

The potential for replacing transport work could be greater if the transport activities of the companies were redistributed so that electric vehicles take the short distance trips they are capable of.

The company with most vehicles, company G, had 11 out of 49 vehicles in the red zone, i.e. they had been driven more than 120 km on the day of maximum travel distance. Redistributing long-distance driving brought the number of vehicles down to three; seven ended up in the green zones and one in the yellow. The colour coding in Table 6.5 indicates which vehicles take over the long-distance trips and in Table 6.6 the range limits specified earlier. While it is theoretically possible to have these three vehicles doing all the long-distance travel, in practice this would involve careful planning.

Table 6.5: Vehicles with daily travel exceeding 120 km in Company G, pattern for redistribution of transport within fleet (colours mark days to be redistributed between vehicles).

Vehicle\day	09	10	11	12	13	14	15	16	17	18	19	20	21	22
5471859	200	183	171	71				196	179	191	96			
5471886	205	158	195	119	41		67	96	159	69				81
5471962	33	36	34	246				66	34	53	26	23		
5471967	66	7	0	245	238	227	4	109	12	13	17	18		
5471998	386	46	1	18	0					79		336		
5472030	56	84	133	86	57	37	62			40	163			98
5472034	29	23	18			203		46	15	60	16	18	42	
5472043	13	16		8				57	76	108	73	101		206
5472075		22		48	140			46		16				
5472102	118	41	57					100	149	93	149	155		
5472120				28	167	78	22	64	80	62	53	17		

Table 6.6: Changed travel pattern of vehicles after redistributing transport between vehicles in company G.

Vehicle\Day	09	10	11	12	13	14	15	16	17	18	19	20	21	22
5471859	200	183	171	246	140	203		196	179	191	96	336		206
5471886	205	158	195	119	167		67	96	159	69	149	155		81
5471962	33	36	34	8				66	34	53	26	23		
5471967	386	7	133	245	238	227	4	109	149	108	163	101		98
5471998	66	46	1	18	0					79		0		
5472030	56	41	0		57	37	62			40	17			0
5472034	29	23	18			0		46	15	60	16	18	42	
5472043	13	16		8				57	76	13	73	18		
5472075		22		48	0			46		16				
5472102	118	84	57	86				100	12	93				
5472120				28	41	78	22	64	80	62	53	17		

The change in driving length per vehicle over the two-week period after the driving is redistributed can be seen in Figure 6.14.

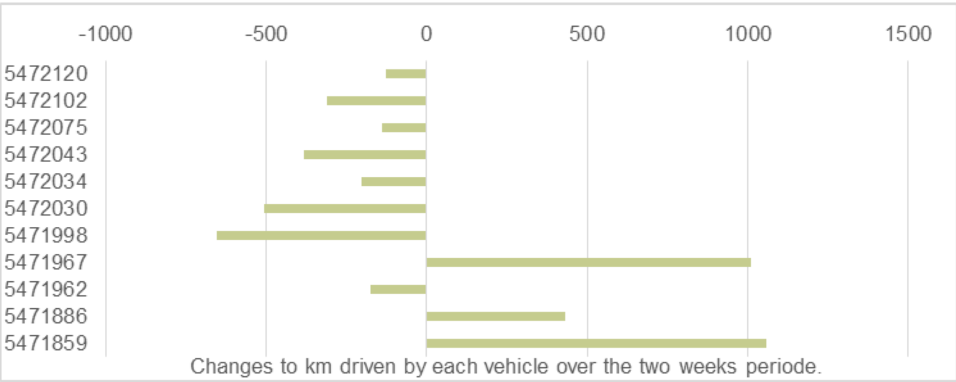

Figure 6.14: Change in total driving distance per vehicle that was originally in red zone after redistributing driving.

The changes to the travel pattern for each vehicle are shown in detail in Figure 6.15.

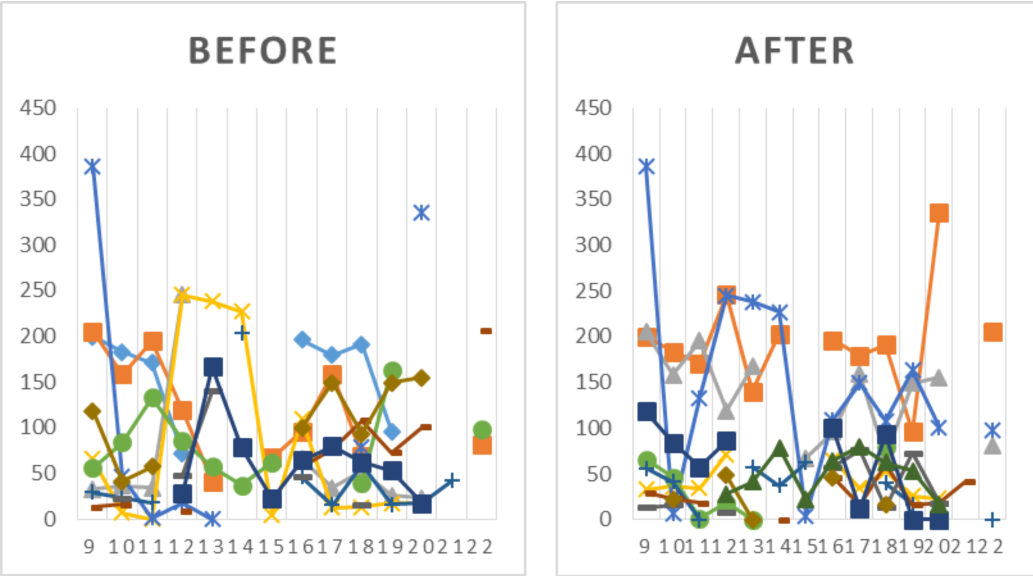

Figure 6.15: Driving pattern before and after reshuffling vehicles originally in red zone.

The same exercise was done on vehicles in the yellow zone (range requirement 80–120 km), with the result that seven out of the eleven could be transferred to the light green zones. In total, the redistribution of travel of vehicles in company G resulted in the changes shown in Table 6.7 and Figure 6.16, demonstrating potential increased use of BEVs by optimizing routing.

Table 6.7: Transport work over 2 weeks per vehicle category and estimated distance per year per vehicle in each category before and after a theoretical redistribution of transport between vehicles owned by company G.

	Before			After		
	# Vehicles	Total transport work 2 weeks, km	Average per year per vehicle km	# Vehicles	Total transport work 2 weeks, km	Average per year per vehicle km
Red zone # vehicles	11	8 499	18 500	3	5 935	47 500
Yellow zone # vehicles	12	6 046	12 100	5	3 630	17 400
Green zones # vehicles	26	3 649	3 400	41	8 629	5 100

If the technology improves to an all-year range of 120 km, then the gain by redistributing travel between vehicles would as expected be reduced from 15 vehicles and 4,980 km to 8 vehicles and 2,564 km. EUVs would then improve from covering 20% of transport work without redistribution to 47% with today's technology and 67% with the next generation. Next generation technology alone would cover 53% of the transport work. Improved technology is thus more important than optimized distribution of trips between available vehicles. The latter thus yields diminishing returns as technology improves.

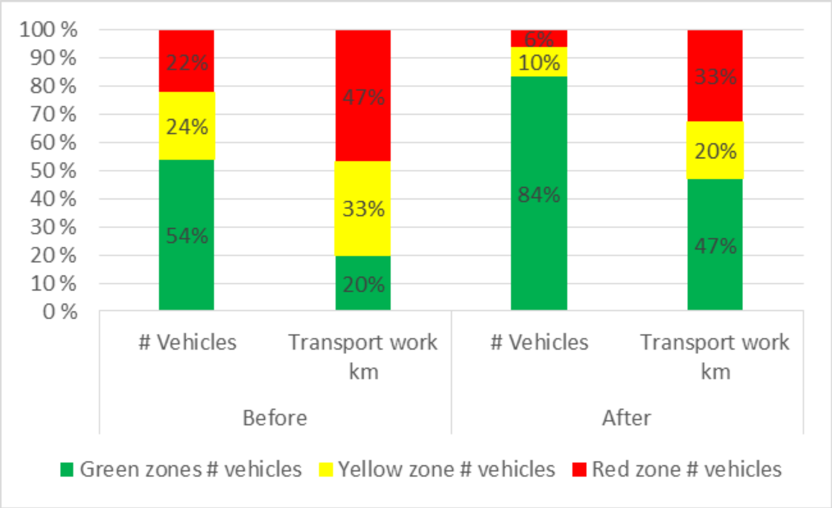

Figure 6.16: Company G, potential for electric vehicle share of fleet and share of transport work before and after redistributing days of travel between vehicles.

At the outset, company G – located fairly centrally in Oslo – had a rather unusual driving pattern with many vehicles covering very short distances. The detailed GPS data indicate that it has work in the immediate neighbourhood of the company office, and the very short distances covered by the vehicles in the green zone means that the company is ideal for introducing electric vans. The low mileage of the vehicles, however, indicates that the purchase price would be a barrier, as savings on reduced fuel costs would be limited, and the extra cost of the purchase of an EUV would not be recovered without incentives.

6.9 Stop pattern – Overnight charging and opportunity charging

The daytime and night-time stop pattern is shown in Figure 6.17 as a function of the number of days in use over the two-week period. The average accumulated stop times of the 115 vehicles are shown in the same figure.

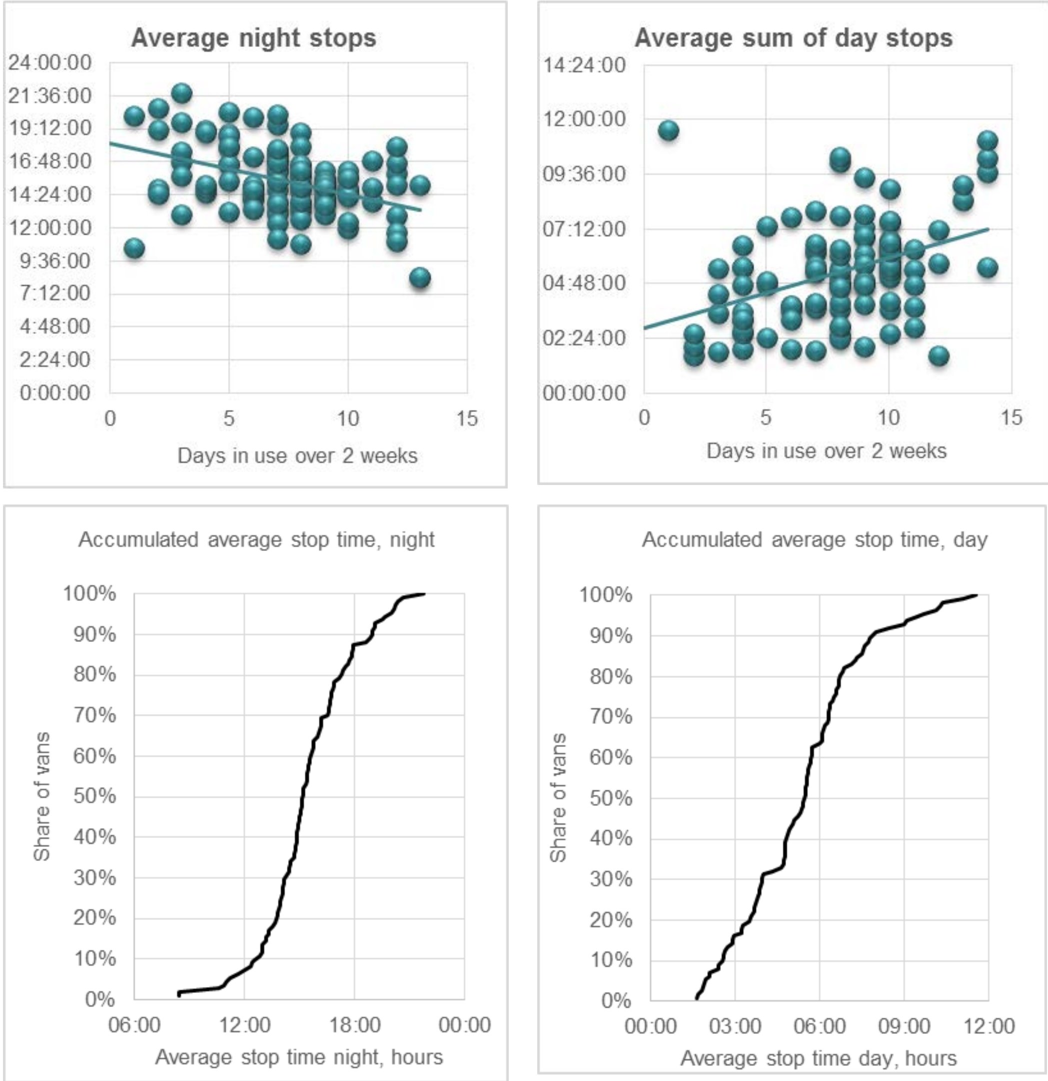

Figure 6.17: Average stop time pattern Day and Night as a function of usage days – 115 vehicles, hours, accumulated share of vehicles by their average overnight stop time.

Vehicles that are much used, i.e. many days in use, have shorter overnight stop times on average than vehicles used less. For daytime stop times the situation is the opposite, but the correlation is weak in both cases. The spread is much greater for daytime stops.

Eighty-one percent of the vehicles stop for more than 10 hours overnight, and can thus always be completely recharged. Twenty-two have stops of less than 10 hours and the parking patterns of these are shown in Figure 6.18. Eight of these vehicles had 1–2 days of overnight stops in the 9–10 hour interval, which should be enough to fully charged up. Three vehicles often had short overnight stops or very short stops, while the rest had occasional stops in the 6–9 hours' interval. The conclusion is that 81% have no issues with overnight charging, another 7% is likely OK, and 3% will have problems, as will the remaining 9% depending on usage pattern during the day.

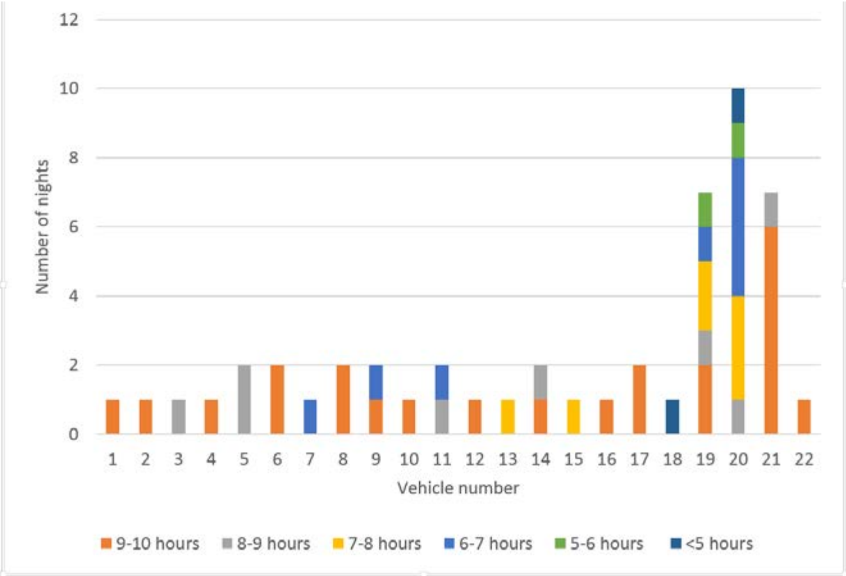

Figure 6.18: Overnight stop times for the 22 vehicles that had stop time below 10 hours.

Average daytime parking is substantial, i.e. 5 hours and 40 minutes for all vehicles. Each hour of daytime charging from 16A/230 V power supplies (effectively charging at 12 A, 2.8 kW) can potentially increase range by about 15 km in summer and 7–8 km in winter. Combining stopping time with potential range increase per hour of charge, and assuming the vehicles charge at every stop, the potential average daily range increase will be 85 km in summer and about 40 km in winter.

Fast charging is another way to recharge the vehicles during the day. Up to 80% of the battery capacity can be recharged in 20-30 minutes in the summer season. In the winter season it takes about twice as long. Three of the four EUVs that where available in the Norwegian market can be fast charged. The national policy in Norway is to only provide government financed economic support for fast chargers put in place along main roads between cities. The result is that few fast chargers are available within cities. Fast charging was not much used by the interviewees owning EUVs. Fast charging may become an important measure to increase the utility of EUVs for craftsmen if the offering improves and quoues can be avoided. The time spent charging may however still be a challenge as less time will be available to do work for customers.

6.10 Discussion of logger results

The base potential of replacing diesel utility vehicles with EUVs is not much; 23% of the vehicles travel up to only 50 km per day and are 100% replaceable by EUVs. They account for only 5% of the transport work of the logged vehicles. Vehicles in the next group, 14% of the total, are driven occasionally in the 50–80 km interval and account for 8% of the transport work. It is likely that most of these are also readily replaceable by EUVs. The base potential is thus up to 37% of vehicles and 13% of the total transport work. A technical development of EUVs resulting in winter range going up to 120 km, which could happen with next generation vehicles, or by shorter range vehicles opportunity charged during the day, would increase the number of vehicles that can be EUVs from 42 to potentially 73, covering 41% of the total transport work of the 115 logged vehicles. Fast charging could also be employed to increase the range on days with longer distance travels.

There is thus great potential for EUVs replacing diesel utility vehicles, but the impact on transport work is limited. If the travel of vehicles can be redistributed within the fleets, then more vehicles and more of the transport work could be replaced by EUVs. Redistributing vehicles is straightforward in theory, but in practice challenging. Realizing the full redistribution potential will however obviously not be possible. As the vehicles in the sample are unspecified, it is not known whether they are truly interchangeable (same size, same type of equipment). For many craftsmen the vehicle is their personal tool box and swapping vehicles will thus not be an alternative, but it might be possible to swap assignments, some craftsmen taking the jobs that are furthest away and others those that are local.

The travel pattern of these vehicles was analysed only over a two-week period. The pattern over the rest of the year is not known, but is likely to be variable. The ability to redistribute vehicles between missions is thus even more important if the potential for use of EUVs is to increase.

Being able to opportunity charge the batteries during the day has the advantage of extending the range the vehicle can cover during the workday. On average, the real winter range (corresponds to all year range) can be extended by some 40 km on average, 50% longer if the range is 80 km. The number of replaceable vehicles then increases substantially, as can be seen in Figure 6.19. Another way of achieving the same effect is to use fast chargers if they are available on the route of travel.

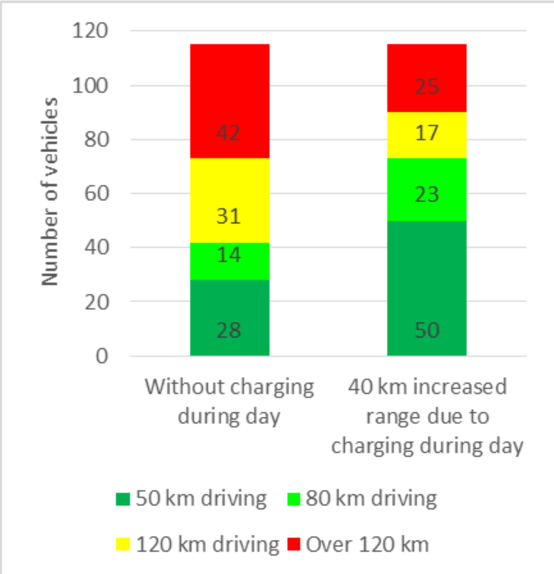

Figure 6.19: Number of replaceable vehicles with and without charging during the day.

EUVs offer best user economy when used as much as possible due to their low energy cost per km compared with diesel vehicles. Figure 6.20 shows the estimated annual driving of the vehicles, the range limits and rough estimates of saved costs per year. The green areas are the economically viable areas for electric vans having an on-cost of up to NOK 100,000 compared to diesel vans.

The smallest green area is currently the most economic use area within the range limits of electric vans. The market for EUVs in markets without incentives would thus be around 5%. Within the red area there are many vehicles, but little to save on fuel costs per year. Potentially, these could be older vehicles fulfilling occasional transport needs and may thus not be a primary target for replacement with EUVs. Local incentives available in the Norwegian market, such as exemption from toll roads and access to bus lanes, would not amount to much since they are used so infrequently. Free parking might be an interesting incentive, however.

The orange area offers some fuel savings and is within the range capabilities of EUVs. Local incentives could tip the TCO in favour of electric vans, but reduced purchase prices are likely to be needed to release the potential of these vehicles being replaced by EUVs. As diesel vans are levied a registration tax in Norway, while EUVs are not, some of this potential could be realized.

The second largest green area will be reachable with second generation longer range vehicles, as they become available on the market after 2016. Some of this potential could be realized with shorter range EUVs if they are charged during the day or if travel can be redistributed between vehicles.

The largest green area is what could be covered if the all-year round range of EUVs goes up to 200 km, which is the range that most respondents said would make EUVs an alternative for the entire fleet of vehicles. Long-range EUVs are unlikely to come on to the market until after 2020, but would open up most of the van market for EUVs.

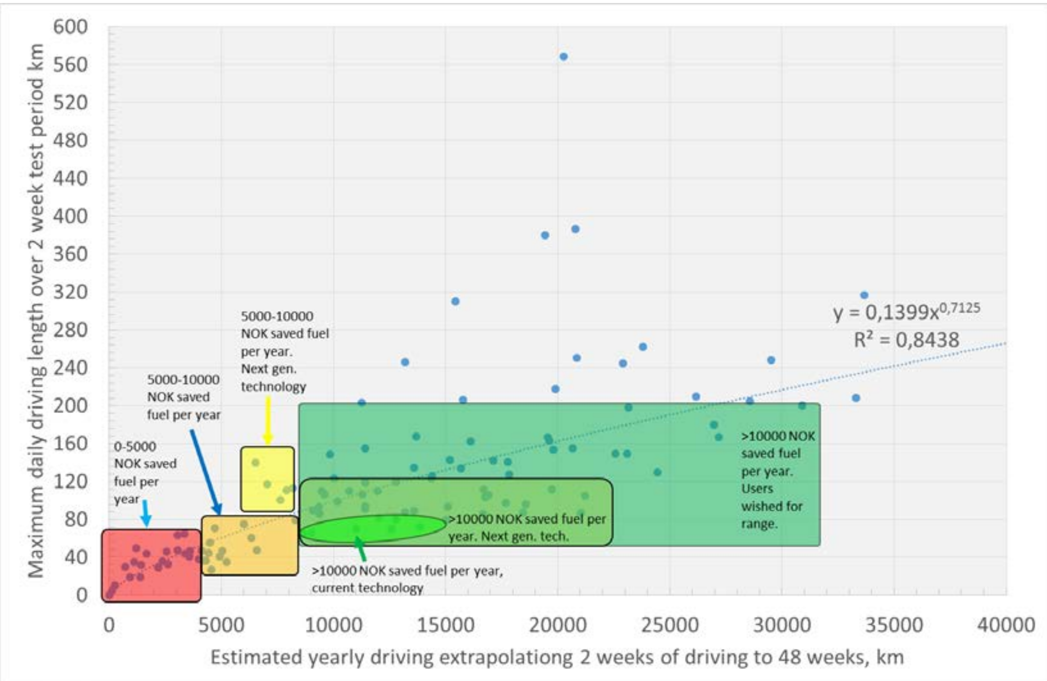

Figure 6.20: Economics and practicality of electric vans.

The market share of EUVs in Norway was only 2.1% in 2015, illustrating that potentials will not be realized by themselves. Incentives directed at lowering the purchase costs of the vehicle will have a greater impact on marketability of EUVs than incentives directed at their use given that many vehicles are already replaceable, but it might not be economic for users. However, incentives will be important in making companies bring EUVs efficiently into use and replacing more diesel vehicle kilometres.

7 How to initiate rapid transition to green mobility for C&S enterprises

The preceding sections provide insight into drivers and barriers to the adoption of important green innovations in Norwegian C&S enterprises. Based on studies of driving patterns in C&S enterprises, possibilities for a wider diffusion of innovative green travel have been discussed, and some of the overall conclusions that have emerged are summarized briefly below:

1. Interest in the broader use of EUVs is in general high among building and construction enterprises in the craft industries. In the reported study, every fourth manager is considering adopting EUVs during the next 2–5 years.
2. The uptake of EUVs is stimulated by economic benefits, as well as by managers' motives for developing "greener" organizational images and identities.
3. Adoption of both EUVs and MMA are often initiated and pushed forward by one "entrepreneur" that have a particular interest for the technology.
4. Today's EUV models are best suited for service enterprises and for crafts workers with light equipment. There is need for new EUV models that are better suited for crafts workers transporting more and heavy equipment.
5. Traditional crafts workers with unpredictable travel patterns and heavy tools face challenges with today's EUV models. However, many enterprises, particularly in the service sector, operate with a high degree of predictability, where fleet management is relatively easy.
6. The system tested for MMAs seems to have improved the travel efficiency of firms, although the impact on travel reduction is uncertain.
7. Not all trips conducted by H&S enterprises are compatible with the driving range of EUVs, but better coordination and organization of the fleet could make a large majority of trips convertible to the use of EUVs.

All in all, the situation is promising for further growth in use, although a faster transition will require initiatives and continued efforts along several dimensions.

This section is dedicated to thorough discussion of the possibilities of *initiating transitions* to a future mobility system with low CO_2 emissions and more efficient use of energy. What types of action can be taken to stimulate more rapid uptake and to create a stronger momentum for rapid uptake of EUVs and mobile applications that strengthen green mobility (MMAs)? And what could the longer-term organizational, social and environmental benefits be?

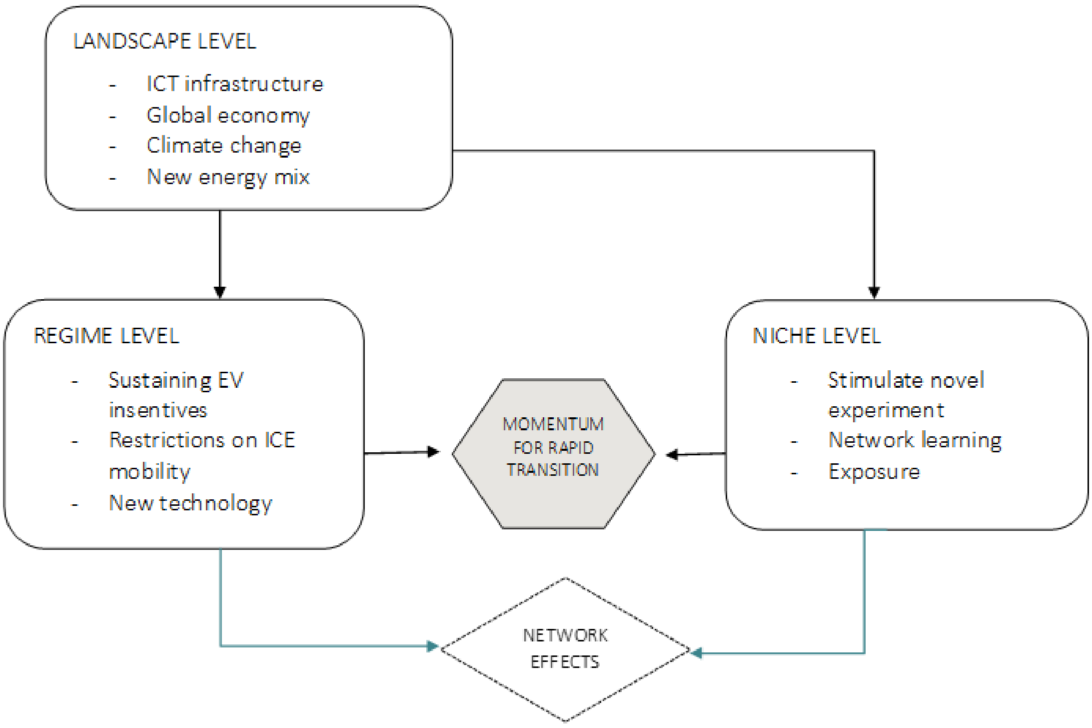

Figure 7.1: Factors initiating a stronger momentum for rapid transitions to green mobility in the C&S industries.

As outlined in the initial section of this report, transitions in mobility systems can be anchored in socio-technical innovation theory. We use the three-layer structure proposed by MLP to guide our discussion in this section, supplemented with key ideas from network innovation theory (Figure 7.1).

7.1 The current mobility system for C&S enterprises

A central idea from MLP is that emerging experimentation and testing of new innovation is done in relatively bounded niches such as enterprises adopting new technologies at an early stage. The socio-technical system sustaining existing mobility is described as a particular mobility regime, and transport for C&S (craft & service) may be considered a sub-regime.

The current C&S (subaltern) mobility regime emphasizes transport based on small diesel vans owned by enterprises, but at the disposition of the individual worker during all hours. This has been the "default option" for most C&S enterprises for several decades. The system is backed up by a material infrastructure, such as a network of petrol stations securing access to fuel and service for fossil-fueled vehicles. A variety of vans at different price levels is available for the enterprise's consumers, and the "image" circulating in popular media of a crafts worker is often connected with small diesel lorries or pick-ups. As noted earlier, a central part of the mobility regime is a dominant understanding of how these enterprises "should travel". For many crafts workers this implies high flexibility in their mobility and little long-term planning.

In a Norwegian context, there is tacit agreement that these types of travel are so important and challenging that they should be excepted from regular environmental constraints. On a policy and legislative level, policy-makers consider diesel engines as necessary elements of craft industries, and this is reflected in the tax on fuel and vehicles. Lock-in situations may occur when alternative fuel choices are made difficult or impossible.

Niche actors trying out vans with electric power systems have emerged in service industries such as public service organizations. These have mainly been on an experimental stage. In the craft enterprises, use of EUVs has until now been tried out only in a limited number of small enterprises operating on their own.

7.2 Initiatives on three levels

When lock-in situations in the dominant regime are interrupted, there may be opportunities for radical innovation. Thus, when radical transitions emerge, they are dependent on co-evolutions of factors on different levels. In this study, interest is in the necessary preconditions for rapid and radical change occurring related to use of EUVs among C&S enterprises (Figure 7.1).

By combining factors on multiple levels, a momentum for change may be developed that can help to spur the development of greener mobility among C&S enterprises. Key innovation related to energy-efficient fuel and use of ICT – such as EUVs and MMAs – should not be seen as isolated technology. By contrast, these are technological fields that benefit from each other, and smarter and more sustainable urban areas will be needed to stimulate their integration.

7.2.1 Landscape and regime level initiatives

Changes on a landscape level, such as in oil prices and global climate, will clearly impact on any transition to non-fossil-fueled mobility systems. In this discussion, however, we focus mainly on the meso- and micro-level, where it is reasonable to consider that changes may be initiated in a Norwegian context.

There is currently strong pressure at policy level to implement measures that would help to reduce emissions from diesel cars in urban regions. In Oslo, it has been decided that regular diesel and petrol-fueled cars will be banned from inner city areas. These regime level changes will provide opportunities for transitions in the C&S sectors. At this level, at least three crucial preconditions need to be sustained and improved if the transition process is to be pursued.

First, there is a need for *new EUV models* catering better for the needs of craftsmen. Second, the *incentive system* for purchasing and use of EUVs needs to be continued and further developed. The current system of incentives is not sufficiently well adjusted for EUVs. One important measure is to improve possibilities for fast charging of vehicles, not only in inner urban regions but also at key areas in the wider urban region. Measures need to be implemented to enhance the economic benefits of adopting electric cars rather than diesel or gasoline cars (see below). Third, the current *restrictions on ICE vans* in urban areas need to be strengthened.

7.2.2 Niche-level initiatives

On a micro level, *continued niche experimentation* among C&S industries is necessary. Yet, these experiments need to be increased in number, scope and diversity if a stronger impact is to be achieved. Better incentive systems may help to make this type of small-scale experimentation more attractive to C&S managers.

However, a *more diverse set of technologies* should be implemented, technologies involving not only alternative energy systems, but also various ICT-based mobility technologies. Thus, systems for low energy mobility among professional users should be integrated with new ideas for smart urban mobility involving systems that can help manage mobility resources more efficiently.

There is also need to *enhance learning* across the niches and create larger "networks of niches" that can learn one from the other. This would mean horizontal sharing of experiences between the partners involved, but also vertical knowledge sharing from niches to policy-makers and other stakeholders. While today's niches are mainly individual enterprises, there should be wider networks of interrelated users, regional clusters or perhaps even cities. This would give niches much stronger impact and exposure.

To *stimulate network effects* it is crucial to expose experiments and ideas on a wide scale along multiple channels. Highly relevant and innovative cases should represent "lighthouse cases" that can inspire other enterprises and decision-makers. Moreover, it is necessary to demonstrate the implication of new technologies more rigidly through longitudinal field studies and research-based experiments. Individual "entrepreneurs" can play an important role in pushing adoption of the new technology forward, in its initial phases in the enterprises.

7.3 Moving beyond the critical mass

To create a stronger momentum for transition, a central objective is in pushing the diffusion of EUVs beyond the niche level, so that it becomes wider practice. This is important in creating a momentum of change and a network effect, as described earlier, and will be reliant on the *establishment of necessary preconditions*. These include continuation of today's incentive systems that give users of EUV benefits related to mobility/accessibility (free passage along toll roads, free parking, etc.) as well as tax benefits. Of the current incentives, free passage along toll roads seems to be the most critical. New EUV models are needed that are appropriate for the crafts enterprise needs discussed above, and facilities for charging must be improved. Taxation systems of the traditional ICE cars (and fuels) must be continued to ensure the value of shifting energy systems. Some of the informants interviewed expressed doubts about the future value of EUVs, fearing a possible loss if second-hand pricing were to become lower than for ordinary vans. A simple solution to this dilemma would be to increase the depreciation rates for electric vehicles, for example by moving them from the present depreciation group C (20%) to group A (30%).

However, wider diffusion would benefit from a diverse set of *amplifying factors* that could make EUVs more relevant and useful. This would include better systems for fleet management and coordination of e-cars, more active use of green certificate systems, and stronger regulation of the purchase of C&S in the public sector; and, in particular, stronger regulation on the use of ICE vans in urban areas. This last-mentioned factor could help to trigger the diffusion of EUVs in C&S businesses. The dynamic is indicated in Figure 7.2, although the proposed list of policies is of examples.

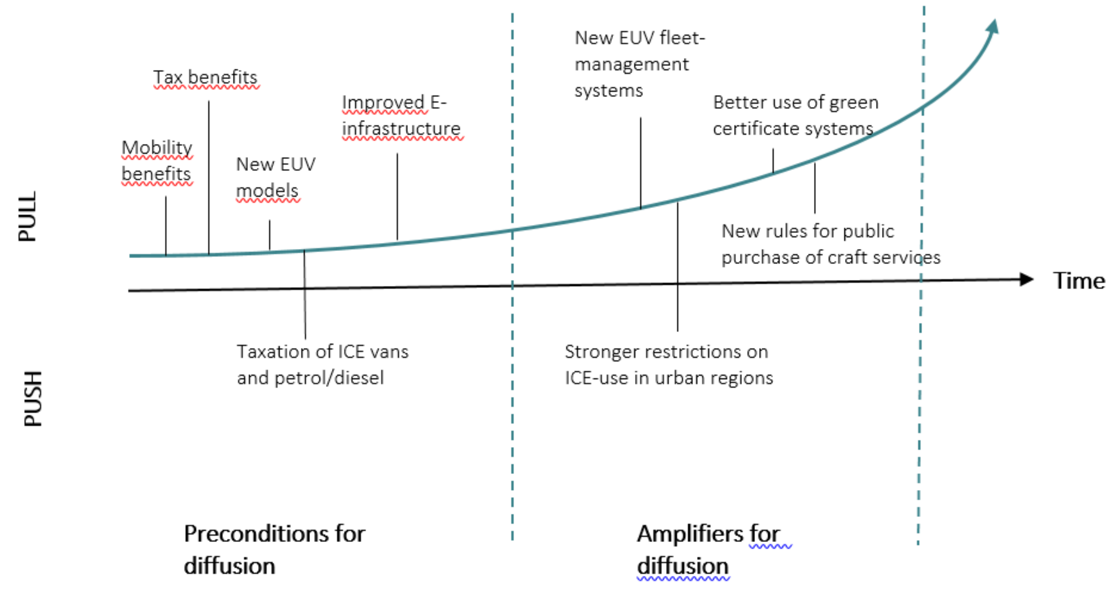

Figure 7.2: Potential diffusion of EUVs in C&S businesses and policy factors.

7.4 Potential environmental implications

EUVs could simultaneously contribute to reducing greenhouse gas emissions and local pollution from the transportation activities of C&S enterprises, while improving energy efficiency of the transport system and reducing the energy costs of users.

The de facto means of transport for C&S enterprises is the diesel utility vehicle, which provides reliable and flexible transport at the cost of greenhouse gas emissions and local pollution. Energy for EUVs will come mainly from electricity produced in Norway's hydroelectric power plants. Electricity has become a tradeable commodity as a result of cables across borders, and Norway is importing electricity from abroad at times when hydroelectric power cannot meet total demand. The imported electricity could be coal based. The electricity market is part of the European Union Emission Trading System (EU ETS) for greenhouse gas emissions, which has a cap on total emissions. The cap, and thus emission from the sectors inside EU ETS, is kept constant when an EUV user charges the vehicle, whereas emission from the replaced diesel utility vehicle is eliminated. The result is 100% reduction. Emission associated with production of the EUV is higher than that of a diesel utility vehicle, but will be offset within the first two years by reduced emissions in the usage phase. Emissions from the production of vehicles will occur in countries with vehicle production and be counted within their national emission budgets, but not in Norway's emission budget. Local pollution in cities in Norway will also be eliminated with the use of EUVs.

For the purpose of this analysis, the assumption is that EUVs reduce greenhouse gas emissions and local pollution by 100% when EUVs replace diesel utility vehicles. The effect on emissions from the enterprise, within a city and for Norway as a whole, is therefore calculated from the annual number of kilometers of travel with EUVs that would otherwise have been diesel utility vehicles.

The division of these vehicles into the maximum day of travel category in the data from the data-loggers shows that:

1. Thirty-seven percent of the vehicles were on all days driven for less than 80 km, but accounted for only 13% of the total transport work. *Replacing vehicles covering distances less than 80 km would thus potentially reduce transport emissions from these C&S enterprises by 13%.* A large share of their transport work is however done in parts of the Oslo region having substantial challenges with local air pollution. Their contribution to reducing air pollution could thus potentially be larger.
2. Relatively few, only 5%, of these vehicles are driven more than 10 000 km per year. The rest are split between vehicles driven less than 5 000 km per year and others in the interval 5 000–10 000 km. Low annual driving will result in little economic gain through reduced fuel costs or reduced toll road costs for users. The full replacement potential may thus be difficult to realize even with Norwegian incentives.
3. If vehicle travel can be redistributed between vehicles, then the potential is substantially increased. *A theoretical experiment has shown that for one of the companies the share of vehicle replaceable could increase from 54% to 84% and the share of transport work from 20% to 47% by optimizing travel so that a few vehicles did the long-distance trips.* During the interviews, users stated that planning trips at this level would be challenging. Those who had successfully implemented BEVs, however, did state that the ability to plan trips better was part of the success story.
4. *New technology increasing range by 50%, or users opportunity charging batteries during the day, could increase the number of vehicles replaceable to 64% and the transport work by EUVs to 41% of these C&S enterprise total transport work, resulting in a 41% reduction of emissio*ns. The share of vehicles driven over 10 000 km per year also increases substantially, making the potential easier to realize by the increased economic gain of users. But it may be difficult to charge up during the day, and new technology has yet to materialize for EUVs, although being introduced in passenger vehicles from 2016.
5. *If the range of EUVs could be increased to cover all days of transport up to 200 km, then both the logger data and opinions of the interviewed C&S enterprises support that most of the C&S enterprise sector's transportation needs can be covered by EUVs, thus leading to a reduction potential of greenhouse gas emissions and local pollution that could approach 100%.*

7.5 Summary

The near-term potential of diesel utility vehicles being replaced with EUVs is still limited, even less so when the low benefit to users of replacing vehicles that are little used is factored in. The potential can be substantially extended by fleet management or when stop times can be utilized for charging. Either way would be challenging given the random character of the work-load of Craftsmen, whereas prospects are better for Service enterprises with more or less fixed travel patterns.

New technology could triple the mid-term (2–5 years) potential if the EUV range increased by 50%. In the longer run, if ranges of 200 km in winter can be achieved for EUVs, then range will no longer be an issue. Realization of the full potential requires however also that models better suited to craftsmen transport needs become available, such as larger vehicles and vehicles with tow bars.

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