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A Green Dream: Municipal Cars Driving on Electricity

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Summary

In order for Norwegian municipalities to contribute with their share in reducing national greenhouse gas emissions, an important strategy is replacing their fossil fueled utility cars and personal cars with light battery electric vehicles (BEVs). We know much about what drives investment in BEVs in Norway in general, but little about what influences procurement of BEVs for the services in Norwegian municipalities. This study examines the drivers and barriers for procurement of municipal BEVs in 14 densely and sparsely populated municipalities in the counties Hedmark and Oppland in inner, rural Norway, and their experiences with these. These two counties may be regarded as challenging cases to introduce municipal BEVs in, because the municipal employees have to drive in hilly or mountainous terrain, drive along roads that may be windy, little maintained, steep, and after snow fall also unplowed, associated long driving distances, and regularly experience significant periods with very low temperatures in the winter. Important drivers to municipal BEV procurement have been: political decisions, economic factors, the BEVs' improved driving range and general high standard, and that entrepreneurial employees have promoted municipal BEVs over long time. Important barriers include: the need for BEVs with four-wheel drive, range anxiety, limited knowledge about BEVs, and structural conditions such as the length of existing leasing contracts. The BEVs are generally experienced as comfortable, economic, and easy to drive. Many Norwegian municipalities are planning to increase their share of BEVs in the coming years.

Keywords: battery electric vehicle, municipality, Norway, drivers, barriers.

1 Hedmark and Oppland in inner Norway – Tough Areas to Introduce Municipal Battery Electric Vehicles

Norwegian policicians have sought to make Norway the world's leading country in battery electric vehicles (BEVs) to attain various targets, such as reducing greenhouse gas (GHG) emissions and create a market for

BEVs that may stimulate the car manufacturers internationally to opt for BEVs. To achieve this, a number of different incentives have been launched since the 1990s onwards. This have proven successful. Globally, Norway today is the leading country in the world in terms of fleet share of light BEVs, and is also a front runner in terms of share of plug-in hybrid electric vehicles (PHEVs). More than 7% of the total car fleet consists of BEVs. By the end of 2019, the Norwegian Car Manufacturer's Import Association (Bilimportørenes Landsforening, BIL) forecasts that more than 50% of the sales of new personal vehicles will consist of BEVs [1]. This will put Norway on track to meet the national target that all cars sold in Norway shall have zero emissions by 2025 [2].

Norway has committed itself under the United Nations Framework Convention on Climate Change (UNFCCC), and also by legally committing itself to the European Union's climate and energy policy, to contribute significantly to the EU achieving a 40% reduction in emissions of greenhouse gases (GHGs) by 2030 [3]. To attain this target, all sectors in Norway have to reduce their GHG footprint. 30% of the national GHG emissions come from the transport sector [4]. Replacing conventional cars, i.e. internal combustion engine vehicles (ICEVs) with BEVs is regarded as a "low hanging fruit" for Norwegian society in this regard [5] for several reasons, including that 100% of Norway's electricity comes from renewable energy sources.

Norwegian municipalities are significant actors in this joint national effort. Compared to municipalities in other European countries, they are delegated significant political authority and carry out a number of important tasks, for example provision of public services like elementary schools, kindergartens, and healthcare. Norwegian municipalities and counties employ more than 500 000 persons in total [6], which equals 9,5% of the Norwegian population and 18,5% of all persons who are employed [7, 8]. The municipal sector is thus a major employer, as well as an important agent of procurement of various goods and services. Most municipal services, including nursing, information technology and technical services are generally well suited for use of BEVs; Either they do not drive extreme distances daily, or they drive relatively stable routes. This makes it easier to plan when and where to charge the BEVs' batteries.

A study of municipal procurement of BEVs is relevant for a number of reasons; First, the driving range of BEVs has expanded significantly, enabling them to be used more varied than before. Second, BEVs are now viewed as equal to, or better than, ICEVs in terms of comfort. This is central for municipal services because many drive a lot, and their cars thus function as a main work tool. Third, the large growth of BEVs in Norway has been stimulated by a number of tax exemptions, for example from the value added tax and from the registration fee, in addition to other benefits that make them economically beneficial, such as low costs of electricity per mile compared to fossil fuels and biofuel, free public parking, and reduced or no price in toll roads [9]. Thus, buying a BEV has, at least since 2014, been economically beneficial compared to buying an ICEV in Norway [10]. This has also been a main motivation for the acquisition of BEVs for the average private costumer [11], and makes it also likely that BEVs are similarly economically beneficial for Norwegian municipalities. Fourth, various supportive measures have been launched to stimulate municipalities to invest in BEVs, including support for municipal BEV charging infrastructure from the Norwegian Environment Agency (Miljødirektoratet). BEVs are hence likely more useful than ever for the Norwegian municipal services. Fifth, a number of studies on what generally promotes BEVs in Norway [e.g. 9, 12, 13, 14], and on general BEV user experiences have been published [11, 15, 16]. However, we know little about the drivers and barriers to the introduction of BEVs for the employees in Norwegian municipalities, and to what extent the municipal employees are driving BEVs.

Several features make Hedmark and Oppland counties,[1] particularly interesting in this regard; The counties include both several densely and many sparsely populated municipalities, with large distances, difficult driving conditions and areas with very hilly/mountainous terrain. A further important factor is that the municipalities in these two counties have periods with very low temperatures in the winter (-15 to -30 °C), which shortens the driving range of the BEVs significantly [e.g. 17]. These factors make them *challenging cases* for the introduction of BEVs for the municipal services. Accordingly, if use of BEVs satisfies the municipal services' needs there, use of BEVs will likely be relevant in the services of most other municipalities in Norway, and possibly also in municipalities in other countries too. We also know little about how the municipal BEV fleets are organized, and what kind of experiences the municipalities have

[1] Hedmark and Oppland will merge to become the county of Innlandet 1. January 2020.

with them. To our knowledge, no studies have, to this date, attempted to answer these questions systematically and in depth. Therefore, our research questions are:

1) What are the drivers and barriers in the municipalities in Hedmark and Oppland for acquiring and driving municipal BEVs?

2) How are the municipal fleets organized and what are the experiences of the users of the municipal BEVs in inner rural Norway?

2. Methodological Considerations

The municipalities in the sample were strategically chosen to obtain a mix of densely and sparsely populated municipalities in the two counties. Initially, the web pages of all (i.e. 46) municipalities in the two counties were screened. We also conducted systematic internet searches in the Norwegian search engine Kvasir to obtain knowledge about to which extent the municipalities had acquired BEVs and which municipalities likely held the larger BEV acquisitions. Moreover, we searched systematically the University of Oslo's comprehensive research database with keywords like: Norway, municipality, incentive and electric car. From this initial data search, it appeared that at least some of the larger municipalities in terms of population size already possessed a fleet of BEVs.

The larger municipalities in population size are relevant for a number of reasons: 1) they possess the larger car fleets because they have a larger population to serve and more extensive services than the smaller municipalities. Larger car fleets are less vulnerable to introduction of BEVs than small car fleets because there is a higher number of vehicles that the services can rotate in using. 2) Because they dispose larger car fleets, they may procure BEVs more frequently. c) Because of their larger population, they include densely populated areas where services that are driving a lot, like the nursing services, may have shorter routes. Such routes are well suited for BEVs; The normal BEVs' driving range restrictions here likely do not pose limitations that are significant. Therefore, it is likely that the densely populated municipalities that we did not know already possessed a municipal BEV fleet also already had procured BEVs. Thus, we included all the six municipalities in Hedmark and Oppland that were densely populated and featured towns were in the sample: Elverum, Hamar, Kongsvinger, Ringsaker (towns: Brumunddal and Moelv), Gjøvik and Lillehammer. All these municipalities have more than 15 000 citizens.

In addition, we included a number of municipalities that were decentrally located within various parts of the two counties. These are located in areas which feature vast forests, mountains and are regarded as rural. These include: Eidskog, Gausdal, Lom, Nord-Fron, Ringebu, Søndre Land, Tolga and Tynset, and all have less than 7 000 citizens. These small municipalities were relevant because: They dispose smaller car fleets and replace their cars much less frequently than the densely populated ones due to smaller municipal economies. Here, there are also fewer options for using BEVs for the services that are driving a lot and may drive long distances year around. In the municipalities in Hedmark and Oppland, both the central and decentral ones, municipal employees may generally have to travel long distances and in hilly and/or mountainous terrain.

Due to shortage of publicly available data on municipal BEV procurement, procurement motivations and experiences, collection of interview data was essential. We therefore gathered data from semi-structured interviews and/or correspondences with 25 persons who represent the roles of a buyer and/or a user of BEVs in 14 of the municipalities we investigated, and buyers in municipalities that had not (yet) acquired at least one municipal BEV [for more information, see 18]. The users were chosen in the municipalities that had already acquired at least one BEV and were contacted based on suggestions and contact details from the buyers.

The interviewees who were buyers held various positions, for example as Heads of the Economic Unit, Heads of Procurement, Climate and Environment Advisors, and Heads of Administration. Several of these persons also represented the role of BEV users because they either themselves drive the municipal BEVs, or because they held extensive knowledge about user experiences after communication with various users.

The interviewees who only represented groups of BEV users worked in various municipal services, including nursing, parking, the municipal administration, maintenance, and an emergency/fire department. All persons representing buyers of BEVs in the municipalities who were asked for a research interview agreed to this (= 100%), and approximately half of those representing the role of users (5/11 = 45%).

The interview questions were based on initial knowledge by project participants, input from persons knowledgeable on the topic, some initial data collection, and a review of research about what the main economic, political and practical drivers and barriers to municipal investment in BEVs might be (see Framework for Analysis below). Subsequently, and in line with the Norwegian research guidelines, the interviewees were offered a quote check, in line with guidelines for research, which they appreciated and also found inspiring for their future work with the municipal BEVs. This communication provided us with essential feedback and additional data. The interviewees were offered anonymity in order to enable them to be open about potential sensitive issues, such as possible conflicts about acquisition of BEVs. To verify the interviewees' statements and data, additional data was sought for data triangulation, such as information available on the municipalities' web pages and in local newspaper articles. Other data sources in the study include: the municipalities' and counties' climate and environment strategies, research articles identified by searching leading research journals like *Energy Policy* and *Transportation Research Part D*, data from Statistics Norway, and documents obtained from the Norwegian Environment Agency.

3. What may Potential Drivers and Barriers to BEV Adoption in Norwegian Municipalities be? A Framework for Analysis

We hypothesized that there may be several drivers as well as barriers to procurement of municipal BEVs in Norway. They formed the basis of the questions in our interview guide, and include the following factors:

1) The size of the municipal fleet, the rate of procurement and the length of existing leasing contracts, which often run for 3-5 years.

2) *Economic factors*, including the existence of public support schemes for charging infrastructure for the municipal BEVs and other support schemes. For example, the Norwegian Environment Agency has, through a programme named *Klimasats*, since 2016 supported BEV charging infrastructure for municipal services by reimbursing up to 50% of the cost on the premise that they acquire one BEV per charging point supported. Other economic factors that singificantly may influence procurement decisions include: the BEV purchase price and lease price compared to that of an ICEV, maintenance costs, the existence of toll roads and public parking that are subject to fees, and the price of the electricity compared to the price of gasoline and diesel as a fuel.

3) *Various campaigns*, like the information campaign run by the EU-funded interreg project called Green Drive Region, which was administered by the regional energy council, Energiråd Innlandet. Here, municipalities could test BEVs for a certain period, and information events were organized.

4) Since the municipalities' policies are ruled by their elected political representatives. Thus, it is pertinent to enquire whether and how *political decisions* and other political actions have been instrumental for municipalities' strategies for procurement of BEVs. Political factors also include decisions made at the county level, at the national level, and potential participation in environmental bodies and networks. Municipalities that are working towards sustainable standards may attain the label Environment Lighthouse (*Miljøfyrtårn*) after a round of certification and become a part of the network of municipalities holding this status. It is moreover more likely that municipalities that have already instigated "green policies" will opt for BEVs than those that are less environmentally ambitious. In addition, it is more probable that municipalities where political parties regarded as "green" hold strong positions (i.e. the Green Party, the Socialist Left Party and the Liberal Party) will make plans for acquisition of BEVs and press for the cause.

5) Previous research has documented that *local political entrepreneurs* may be instrumental in influencing Swedish municipalities' procurement [19]. Sweden and Norway are neighbouring countries with numerous

similarities, including the actors in the energy system and how electicity production and transmission is organized [20]. This to our knowledge also goes for Swedish and Norwegian municipalities. Therefore, it is pertinent to investigate whether and how that also may be the case in the 14 municipalities in the sample.

6) *Attitudes among the municipal employees* may also be decisive for the decision of whether or not to purchase an BEV, similar to in private households. Previously, critical attitudes to BEVs driving range have been widespread among those persons that do not have their own BEV [15], and such attitudes have been particularly prevalent in Hedmard and Oppland. One may also imagine that although, for example, a Head of Procurement has good arguments for acquisition of a BEV and the capacity to procure one, other employees in the municipal services may be skeptical. For example, they may deny to drive the BEVs, and may thereby make such procurement and use difficult. Thus, it is relevant to enquire into employees' attitudes and how BEVs potentially have been introduced.

7) *The increased driving range and improved standards of BEVs* have previously been influential in stimulating sales of BEVs [13]. Therefore, it is reasonable to hypothesize that with the rapid increase in driving range as well as improved standards, to the level where BEVs may even be regarded as better cars than ICEVs, these factors may also influence municipal procurement decisions.

4. Results and Analysis

4.1 Overview of municipal BEV procurement and organization

All but two of the municipalities in the sample had acquired at least one BEV or were in the process of doing so. The municipalities' share of BEVs and the level of ambition with regard to rapid electrification of the car fleet varied. The densely populated Hamar municipality, for example, opts for full electrification of their municipal car fleet by the year 2021, seemingly the first municipality together with the Oslo and Skedsmo municipalities in Norway to do so. Sparsely populated Søndre Land, in contrast, possesses one BEV, but has no plans about further increasing their share of BEVs. Most municipalities provided one municipal charging station per BEV, and the BEVs were mainly charged during the night. The municipalities often offered either garages and/or car ports for them. One municipality, Tolga, wanted to install a municipal charging station at the same parking lot as a public fast charging station so that employees easily could fast charge when needed.

The largest municipalities in terms of population size also held the *largest number of BEVs*. Table 1 presents the municipalities in the sample, their number of citizens (2018), their associated town(s), the number of municipal BEVs in summer/early autumn 2018, and keywords about their future BEV investment plans.

Table 1: The municipalities in the sample, number of citizens, cities/towns, number of BEVs and procurement plans for BEVs. Sources: interviews 2018, Statistics Norway [21] and Thorsnæs [22].

Category	County	Municipality	No. of citizens (2018)	Town(s)	No. of BEVs	Future plans for BEV investments

Category	County	Municipality	No. of citizens (2018)	Town(s)	No. of BEVs	Future plans for BEV investments
Larger municipality with town(s)	Hedmark	Elverum	21 143	Elverum	13	Will expand the share in accordance with the ordinary renewal of the car fleet
		Hamar	30 915	Hamar	20	50 BEVs are under procurement so that the total number is 70 within 2018, 96 more in 2019, full electrification within 2021
		Kongsvinger	17 878	Kongsvinger	9-10	5 BEVs are procured autumn 2018, gradual phasing in of more BEVs
		Ringsaker	34 207	Brumunddal, Moelv	8	12-15 BEVs are under procurement
	Oppland	Gjøvik	30 628	Gjøvik	2	Will have minimum 20 BEVs in 2019 and 50 BEVs in 2022
		Lillehammer	28 010	Lillehammer	21	Will likely expand the share of BEVs
Small municipality	Hedmark	Eidskog	6 130		0	No concrete plans, but future procurement of BEVs likely
		Tolga	1 563		0	1 BEV is under procurement; 1 further BEV is considered
		Tynset	5 600		1	No concrete plans, but likely with higher share of BEV in the future
	Oppland	Gausdal	6 154		0	No concrete plans, but BEVs will likely be procured
		Lom	2 323		0	1 BEV is procured for the municipality's administrative unit
		Nord-Fron	5 727	Vinstra	1	More BEVs in the future
		Ringebu	4 460		3	More BEVs in the future
		Søndre Land	5 645		1	No concrete plans

The municipalities had procured a number of different BEV models. Among the personal vehicle sized BEVs, they had the following models: BMW i3, Citroën C-Zero, Hyundai Ioniq, Mitzubishi iMiev, Nissan Leaf, Volkswagen E-Golf and Volkswagen E-Up. Some municipalities had also acquired small utility BEVs: Nissan e-NV200, Peugeout Partner Electric and Renault Kangoo Electric. Several of them had bought the BEVs and several also leased them, whilst some both bought *and* leased BEVs, depending on the service in question. Various car businesses, including leasing companies and car selling companies, supplied them with these vehicles. Most municipalities procured new cars, but some also procured cars from the market for used cars. One of the municipalities, Ringsaker, held Norway's first BEV used in the fire service.

In most municipalities, the nursing services and/or the administrative unit used at least one of the BEVs. In the nursing services, the BEVs were often driven on the most central routes because they could also drive them in the winter without suffering from driving range limitations. Some municipalities used their BEVs for all nursing routes during summer, and only the most central during winter, whilst some municipalities used their BEVs in three shifts (i.e. around the clock) to save money on energy costs. To attain driving around the clock, charging had to be carefully planned; The employees for example charged the BEVs during lunch breaks and during the afternoon session where they exchange information with the persons working the next shift. The registered driving ranges for the municipal cars generally differed widely, from 5 000 to 50 000 kilometer per car yearly, depending on the service, municipality and typical driving routes in question. The BEVs were usually charged during the night (interviews 2018).

Joint acquisitions for all municipal services were conducted in one of the municipalities, Elverum. This proved to have several benefits, including scale-up benefits such as better prices from the car selling companies and better service agreements with them. The different municipal services could rotate the cars within and between the services since they have different needs. Moreover, it proved to be an advantage to have professional organization and maintenance (interview, procurer, Elverum municipality, 2018). Among several of the other municipalities, they organized joint acquisitions of various goods and services, including for various types of vehicles. This cooperation and coordination saved them time and effort, and likely contributed to a higher quality of the acquisitions (interviews, municipality procurers, 2018).

4.2 Drivers for BEV procurement and use

The interviews identified several drivers behind the procurement of BEVs. The most important factor according to the interviewees for municipal BEV procurement may be labelled *political signals* (interviews, 2018). In several of the municipalities, the municipal board had decided that the municipality should procure BEVs for the municipal employees. This was often then written down in central documents like the municipalities' climate plans, for example in Elverum [23], Gjøvik [24] and Tynset [25]. These plans shall guide later procurements among the municipal services. Acquisition of BEVs had been a topic of debate in several of the municipalities' board meetings. In particular members of the Green Party have pressed for the topic. Usually, there was general agreement among the politicians to opt for BEVs.

In some municipalities, key personnel like the Major or the Head of Administration had argued extensively for BEVs. Several municipalities were a part of the previously mentioned Environmental Lighthouse organization and attained environment lighthouse certification. Such participation was also based on political decisions. In at least some municipalities, this membership had been significant for the procurement of BEVs (interviews, municipality procurers, 2018).

Another type of driver, closely connected with the first, was *"green" attitudes* among the municipal employees. In several of the municipalities, there were employees with such "green" attitudes; They regarded environmental protection as imperative and held that municipalities should pose as role models for the citizenry as well as for the local businesses. Municipal efforts are an important contribution in the combined effort to attain Norway's international commitment in reducing national GHG emissions. Driving a BEV was generally regarded as environmental, positive and future oriented.

A third driver for BEV procurement was *economic incentives*. The municipal BEVs may be economically smart because they have low fuel costs, benefit from various tax exemptions, and have in many cases received support for BEV charging infrastructure investment. A majority of the interviewees who were responsible for procurement argued that when all costs were included, BEVs were clearly economically beneficial compared to ICEVs. Several interviewees also commented that in the last round of vehicle acquisition, they had received economically beneficial offers from the car businesses for BEVs and plug-in hybrid electric vehicles. The monetary support from the Norwegian Agency for the Environment had also been stimulating in helping them to overcome economic barriers to BEV investment (interviews, municipal procurers, 2018).

A fourth driver, and also a BEV procurement precondition for several municipalities, was the *increased driving range and standard*, making them generally compatible with the user needs (interviews, municipal procurers, 2018). Presently, more leasing firms and car selling businesses offer BEVs, and the range of BEV models available to lease or buy is also larger than earlier. Since several of the municipal services have essential functions in maintaining the health and wellbeing of the citizens, these services will not opt for BEVs unless they can be completely safe in knowing that they would always be able to drive to the users. The interviewees generally seemed well informed about the technical specifications of the BEVs, their driving range, and how they could be operated optimally. This is seemingly also a new finding in research on municipal BEV drivers. Several interviewees held that in the future, the driving range of BEVs would not be a barrier at all due the strongly increasing driving ranges (interviews, 2018);

> When the BEVs [in the price range for the average customer] are reaching this limit of 500 kilometers, I do not see that Kongsvinger municipality should any longer drive with fossil fueled cars (interview, procurer, Kongsvinger municipality, 2019).

A fifth driver identified in the data was the presence of *local political entrepreneurs* who have worked for BEVs in their respective municipality. These were persons in central political, administrative or other positions who over a period of time have worked towards the procurement of BEVs to the employees in the municipality, and have also answered to critical questions which were posed. Two of these had background from car sales businesses and thus were very knowledgeable about cars. These entrepreneurs held various positions in their municipalities, including being a Major, Head of Administration, the responsible for the cars in the nursing services, Climate and Energy Advisors, the persons in charge of the municipal fleet, and other persons. This finding, that the presence of local political entrepreneurs may be important for the procurement of municipal BEVs, supports the aforementioned finding of Wikström, Eriksson [19].

The analysis also revealed a number of other drivers, coined “other factors.” These include participation in the aforementioned Green Drive Region project, associated positive experiences with BEVs that they had borrowed for trial, and other types of BEV lending. Some of the persons responsible for procurement had also lent BEVs privately in order to test how they were to drive, and some procurers owned a BEV privately. In some cases, persons who drove BEVs at work were inspired to acquire a BEV privately and vise versa. Positive experiences with BEV use in one municipal service may lead them to procure BEVs for other services also. Finally, there seems to have been a certain “neighbor effect:” when one municipality had opted for a BEV, this could motivate the municipalities nearby also to procure one (interviews, 2018).

4.3 Barriers to BEV procurement and use

The data also revealed several barriers to procurement of BEVs. The first and most important barrier according to the interviewees was the need for BEVs with *four-wheel drive*. For services that were to drive up to 1 000 height meters upwards and downwards, on windy, narrow, steep, and often badly maintained roads, which also could be unplowed after snowfall, driving a car with four-wheel drive was viewed essential for safe driving and for reaching the destinations. The users of the nursing services here could for example be elderly people living in remote mountain farms. Other municipal services needing four-wheel drive were those that had other emergency functions (interviews, 2018). This seems to be a further new finding in research about barriers to municipal BEV uptake. As of autumn 2018, only Tesla (with Model S and Model X) offered BEVs with a four-wheel drive in the Norwegian market. However, these Tesla models were (and are) more expensive than what the municipalities could afford (interviews, 2018).

In addition, a *tow hook* was another function that was missing among the personal BEVs, for example to carry large and heavy equipment such as equipment for persons with disabilities. Among the light duty BEVs, for example Renault Kangoo ZE and Nissan E-NV200 were available with a tow hook. The wish for a BEV with four-wheel drive and a tow hook in the normal customer price range also seems to be common among the population in Hedmark and Oppland in general (conversation, Norwegian Electric Vehicle Association, 2018).

Critical attitudes among municipal employees represented another important barrier. Several of the persons responsible for procurement had experienced that municipal employees were worried about the BEVs' driving ranges, particularly if the BEVs would be able to cover their daily travel needs at work (range anxiety, *ladeangst* in Norwegian). A worry was to get stuck with an empty battery in the midst of vast forests at night, and that the BEV would not be sufficiently charged with the fast chargers available. Such skepticism to the BEV driving range is also widespread among the general population that does not personally dispose a BEV [15].

Several municipal employees had, however, changed their attitude to BEVs, for example when they were participating in choosing which BEV car model the municipality should choose, and also after test driving a BEV personally. This underlines the importance in involving the municipal users in the choosing of the BEVs to procure the BEVs that cover their needs optimally. In some cases, employees were afraid of how the municipal driving needs should be covered in the case of long-term electricity supply stop, for example if the electricity grid is impaired after a storm. This had not proven to be a problem so far. Generally, when electricity lines are broken, they are repaired very soon. However, repair of such damages may be an issue in certain remote areas in Norway, like Finnmark in the very far North (interviews, 2018). In addition, municipal services would become more vulnerable to technical issues regarding the BEV charging stations (interviews, 2018). Several of these critical persons also had limited knowledge about BEVs.

The third barrier identified in the data was *economic issues*. For example, the municipality may have to invest in charging and other types of infrastructure to deploy BEVs. The cost of a charging station, which would typically be at least NOK 10 000 (around 1 000 Euros) or more, and more for the flexible charging stations and the fast chargers [26], represented another economic barrier. To install a charging station in one municipality, a transformer station would also have to be installed, which may cost NOK 500 000 – NOK 1 000 000 (50 000 – 100 000 Euros). This would make the total cost of the investment too large. Some municipalities rarely acquired new cars due to their small sizes in terms of population, and those cars procured were mostly bought second hand. In some municipalities, economic drivers like exemption from toll roads, ferry fees and parking fees were not relevant, and thus the BEVs were not as economically beneficial there as elsewhere. In Norway, small utility vehicles get full exemption from the value added tax, regardless of their fuel. This makes electric light utility vehicles less economically beneficial than what otherwise would have been the case. Thus, the Norwegian Environment Agency has also supported municipalities economically with acquisition of such light utility BEVs. Scant research has shed light into these economic barriers to municipal BEV procurement before.

The last barriers may be summed up as *structural factors*. For example, the municipalities could not start to use more BEVs before their current leasing contracts expired. Some lacked charging infrastructure, and several BEV models had long delivery times from the car manufacturers due to their high popularity. In some cases, the municipalities had previously only been offered one of very few, or no models of BEVs when they had contacted various car businesses. In some cases, the car businesses had not tried to win when there had been launched public tenders for BEVs. In one municipality, municipal procurers had asked for BEVs for eight years before this was offered (interview, procurer Kongsvinger, 2018). Some municipal employees feared queues at fast charging stations in very remote areas (interview, procurer Nord-Fron, 2018). Furthermore, in some municipalities, there are hardly any fast charging stations, which presents another potential barrier to BEV use. Last, in some municipalities, they had simply lacked available persons with the correct competence in law and public tenders to create contracts for procurement of BEVs.

4.4 Positive and negative BEV user experiences

The main experiences of BEV users were positive: They were easy to drive, comfortable, safe, and covered the municipal services' driving needs in terms of driving length. The BEVs made little noise, were practical and were regarded as comfortable vehicles to drive. The comfort came not least due to functions like driving wheel warming and seat warming in the winter, the option to hold the BEV warmed up while meeting the users of for example the nursing services, and that they have no gears. Some of the interviewees underlined that the municipal BEVs were so popular that there was a fight to get one, and that some users always preferred them, also on the long routes in the nursing services (interviews, procurers, Eidsvoll, Elverum and Hamar, 2018).

Several of the BEVs had also been bought with extra equipment, which contributed to making them very comfortable. Other positive features with the BEVs were their efficient braking and acceleration. The drivers of BEVs did not have to use time to fuel the cars, which made driving more convenient, while the persons in charge the municipal BEVs did thus not have to deal with creating purchasing agreements with the fuel retailers for gasoline and diesel, which saved them time and effort.

Nonetheless, some of the interviewees had negative experiences that were not coincidental. These users were not negative to BEVs in general, but they held that the BEVs that they could use did not cover their driving needs. They commented that the municipal BEVs were not good enough to drive in winter conditions: They were too light, had too narrow tires for roads with gravel/snow, the driving range in the winter was too short, and the cars did not drive well enough in roads with steep gradients (interviews, users Gjøvik and Ringebu, 2018). These persons did not have a say when the municipal BEVs were acquired. The procurers of the BEVs confirmed their stories (interviews procurers, Gjøvik and Ringebu, 2018). In Ringebu, the BEV in question was thus mostly not used during the winter. In Gjøvik, the municipal service was therefore in the process of attaining cars with four-wheel drive.

5. Conclusion

All but two of the municipalities in the sample have procured or are in the process of procuring BEVs. At least one of them, Hamar, will completely electrify its car fleet within a very few years. In procuring BEVs, the municipalities reduce municipal GHG emissions, save money, and offer their employees cars that are regarded as comfortable, safe and easy to drive.

There are a number of drivers hat have contributed to municipal investment and use of BEVs. The by far most important one according to the interviewees (interviews, 2018) is political factors, such as municipal boards' decisions to opt for them. Other important drivers have been "green attitudes" among the employees, economic incentives like low fuel costs, tax exemptions and support for charging infrastructure. To our knowledge, no studies have previously documented the importance of political decisions and other types of political signals for the attainment of municipal BEVs. That also attitudes of municipal employees may play a role in municipal procurement of BEVs is to our knowledge a new finding. To our knowledge, these findings about the economic benefits of municipal BEVs are new. The BEVs' increased driving range and good standard have been a precondition for procurement. Moreover, in several municipalities, individuals have held the roles of political entrepreneurs and have by their own efforts influences the decision processes of acquiring BEVs.

Barriers to BEV procurement include the need for four-wheel drive. This was the most important barrier to further BEV investment, and indicates that there is likely a large market for such cars within the price ranges affordable to the average customers. A tow hook for personal BEVs was also missed. Critical attitudes among municipal employees represented another barrier, for example skepticism to the BEVs' driving ranges. Moreover, economic conditions could make it hard to invest in a BEV, such as that the municipalities' economy did not enable for procurement of cars very often, or procurement of new cars.

Last, structural factors such as the length of existing leasing contracts, that some BEV models had very long delivery times, and lack of available personnel to run public tenders for BEVs presented other barriers.

There is reason to believe that Norwegian municipalities in the coming years will invest large-scale in municipal BEVs, similar to the general Norwegian population. For example, a number of municipalities have successfully applied the Environment Directorate for economic support for charging stations in 2018 [27], which means that they also will procure at least one BEV per charging station supported. However, such large-scale procurement may also put municipalities in a situation where they more carefully than before will have to plan for back-up electricity supply in the case there is disruption of electricity supply. One way to achieve this is by placing charging stations for services that are essential to the citizens' health and wellbeing next to emergency electricity supply aggregators, install large emergency supply batteries nearby charging stations, or in sites which are particularly well supplied with electricity from various sources. The climate effect of the BEVs also include indirect effects like that they may inspire the employees and other private persons, and businesses to drive BEVs, and that municipalities inspire other municipalities to procure BEVs.

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References

1. Lindvoll, E., *Forventer at det selges 150.000 personbiler i år*, in *Din Side*. 2019.
2. Ministry of Communications, *Meld. St. 33. (2016-2017). National Transport Plan 2018-2029*. 2016, Norwegian Government: Oslo.
3. Ministry of Climate and Environment, *Meld. St. 41 (2016-2017) - Norway's Climate Strategy for 2030: a transformational approach within a European cooperation framework. Report to the Storting (white paper)* 2016, Norwegian Government: Oslo.
4. Norwegian Environment Agency. *Klimagassutslipp fra transport*. 2018 Ikke oppgitt [cited 2018 26 June]; Available from: http://www.miljostatus.no/tema/klima/norske-klimagassutslipp/utslipp-av-klimagasser-fra-transport/#heading1.
5. Fridstrøm, L. and K.H. Alfsen, *Vegen mot klimavennlig transport*. TØI report. Vol. 1321/2014. 2014, Oslo: The Institute of Transport Economics (TØI).
6. Statistics Norway. *Sysselsette i kommunal sektor*. 2018 [cited 2019 19 February 2019]; Available from: https://www.ssb.no/arbeid-og-lonn/statistikker/komregsys.
7. Statistics Norway. *Arbeidskraftundersøkelsen*. 2019 24 January 2019 [cited 2019 13 March]; Available from: https://www.ssb.no/aku.
8. Statistics Norway. *Folketallet*. 2019 22 February 2019 [cited 2019 13 March]; Available from: https://www.ssb.no/aku.
9. Mersky, A.C., et al., *Effectiveness of incentives on electric vehicle adoption in Norway.* Transportation Research Part D, 2016. **46**: p. 56-68.
10. Solberg, S.M., *Lønner elbil seg? Her er svaret*, in *Nettavisen*. 2014.
11. Haugneland, P. and E. Hauge, *Norwegian electric car user experiences 2014.* World Electric Vehicle Journal, 2015. **7**(4): p. 650-658.

12. Fearnley, N., et al., *E-vehicle policies and incentives - assessment and recommendations*, in *TØI Report 1421/2015*. 2015, Transportøkonomisk Institutt: Oslo.

13. Figenbaum, E., *Perspectives on Norway's supercharged electric vehicle policy.* Environmental Innovation and Societal Transitions, 2017. **25**: p. 14-34.

14. Bjerkan, K.Y., T.E. Nørbech, and M.E. Nordtømme, *Incentives for promoting Battery Electric Vehicle (BEV) adoption in Norway.* Transportation Research Part D, 2016. **43**: p. 169-180.

15. Figenbaum, E., M. Kolbenstvedt, and B. Elvebakk, *Electric vehicles - environmental, economic and practical aspects. As sen by current and potential users*, in *TØI Report*. 2014, The Institute of Transport Economics (TØI): Oslo.

16. Lorentzen, E., et al., *Charging infrastructure experiences in Norway - the worlds most advanced EV market*. 2017, Norwegian Electric Vehicle Association: Oslo.

17. Laurikko, J., R. Granström, and A. Haakana, *Assessing range and performance of electric vehicles in Nordic driving conditions – Project "RekkEVidde".* World Electric Vehicle Journal, 2012. **5**: p. 45-50.

18. Ydersbond, I.M., *A green dream: municipal cars driving on electricity* 2018, The Institute of Transport Economics (TØI): Oslo.

19. Wikström, M., L. Eriksson, and L. Hansson, *Introducing plug-in electric vehicles in public authorities.* Research in Transportation Business & Management, 2016. **18**: p. 29-37.

20. Ydersbond, I., *Aiming to be Environmental Leaders, but Struggling to go Forward: Sweden and Norway on Energy System Transformation.* Energy Procedia, 2014. **58**: p. 16-23.

21. Statistics Norway, *Kommunefakta*. 2018, Statistics Norway.

22. Thorsnæs, G., *Byer i Norge*, in *Store Norske Leksikon*. 2017, Aschehoug, Gyldendal: Oslo.

23. Elverum municipality, *Energi- og klimaarbeid i Elverum 2014 – 2018*. 2014, Eleverum municipality: Elverum.

24. Gjøvik municipality, *Klimaplan 2018 - 2022*. 2018, Gjøvik kommune: Gjøvik.

25. Tynset municipality, *Klima- og energiplan for Tynset kommune 2010 - 2020. Del 2 Handlingsplan 2015 - 2018.* . 2015, Tynset municipality: Tynset.

26. Birkeli, K., et al., *Tiltakskostnader for elbil. Samfunnsøkonomiske kostnader ved innfasing av elbiler i personbilparken*. 2016, Norwegian Environment Agency: Trondheim.

27. Norwegian Environment Agency, *Klimasats - tildeling av tilskudd 2018*. 2018.

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