

Rethinking the spatiality of Nordic electric vehicles and their popularity in urban environments: Moving beyond the city?

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Abstract: With a global transition to electric vehicles (EVs) slowly gaining traction, it is expedient to move the debate to issues connected to geography, space, and place. One of these emerging issues is the uptake of EVs in rural areas. This paper provides a spatial state of affairs in the Nordic region and it explores how EVs are perceived and argued to fit within rural-suburban-urban categories by users and potential adopters. To do so, it draws on a mix of original and secondary data: (1) a randomized survey among 4322 respondents, (2) 227 expert interviews, (3) eight focus groups conducted across Iceland, Denmark, Sweden, Finland and Norway, and (4) geographically mapped municipal level vehicle registrations across Norway and Sweden. This data shows that while the uptake primarily takes place in (sub)urban regions, EVs are used in rural environments, partly for self-sufficiency reasons. After acknowledging that individual choices and circumstances dictate final purchase decisions, the paper concludes that planners and researchers should be aware of and, if possible, prevent that a skewed urbanized popularity keeps people elsewhere from looking at EVs as a viable option.

1. Introduction

Generally, electric vehicles (EVs) are depicted by advocates, planners, and even drivers as urban vehicles given their range (with perceptions of inadequate driving coverage), their need for public charging infrastructure (which has a better business case in densely urban environment), and the presence of environmentally concerned highly educated and well-earning individuals who can afford the premium price of a new EV (Bakker and Jacob Trip 2013; Ioannides and Wall-Reinius 2015).¹ Simultaneously, cities struggle with increasing levels of local air and noise pollution for which EVs with their absent tailpipe emissions and quieter operations offer a clear substitution (Ajanovic and Haas 2016). Furthermore, EVs lack direct combustion in congested traffic and their transmission and acceleration favour stop-go traffic cycles in cities (Newman et al. 2014; Raslavičius et al. 2015). As Newman et al. summarize this argument: 'Electric vehicles support urban environmental considerations while the urban environment is most practical to the running of electric vehicles (2014, 312).'

This seems to be a broadly shared and easily grasped point, one

recurrent in popular media and policy documents and frequently confirmed by academia. For example, spatial analyses based on either stated preference or historic EV registration data overwhelmingly find the uptake of hybrid vehicles, PHEVs and EVs to cluster in more well-to-do (sub)urbanized neighbourhoods where income, education and homeownership are relatively high and peer-to-peer dynamics generate demand, which in turn feeds-back into charger and dealer availability (Aultman-Hall et al. 2012; Zubaryeva et al. 2012; Chen et al. 2015; Dimatulac and Maoh 2017; Liu et al. 2017; Morton et al. 2017; Morton et al. 2018; Ferguson et al. 2018; Zhuge and Shao 2019). One recent interdisciplinary 'Research and Development Agenda' proposed and led by the U.S. National Renewable Energy Laboratory even argues that it is 'imperative' to further orient EV research activities to understand 'the characteristics and relationships among urbanization, electrification, and cities' with 'urban cities' and 'urban actors' identified as 'key players' in this domain (Romero Lankao et al. 2019, 1).

While we do not disprove these findings (and in fact confirm some of them below), we would argue that there are three reasons why this view should be critically examined. First, because EVs might be better

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¹ In this paper, EVs refer to all pluggable electric vehicles (PEVs). Wherever needed a distinction is made between full battery electric vehicles (BEVs) and pluggable hybrid electric vehicles (PHEVs).

suit for non-urban regions. In contrast to studies that are based on stated preferences and historic hybrid and EV registrations, a number of studies that trace EV projects or that engage qualitatively with (potential) EV drivers instead conclude that highly urbanized regions might not be the best place for EVs, given that EVs are not a long-term solution to traffic congestion and use of public space (Newman et al. 2014; Plötz et al. 2014; Wappelhorst et al. 2014; Fornahl and Wernern 2015). Newman et al. for instance argue that EV advocates ‘allowed optimism to displace objectivity (2014, 308)’ by pointing out that the longer driving distances and higher utilization of rural and suburban areas are much better suited for EVs from a consumer perspective, as it means that they benefit more from the lower operation costs of an EV. This argument is confirmed by Fornahl and Wernern (2015), who also highlight fewer available public transport services, a prevalence of two-car households and the space for home charging as arguments in favour of rural EVs. Plötz et al. similarly confirm the necessity of a minimal distance per day or year and conclude from their empirical study that ‘respondents with a high interest in EVs are less likely to live in larger cities, while EV users are more likely to live in villages (2014, 105).’

Second, urban-centric reasoning forgoes the important role that the active intervention of local authorities in supporting EVs can play in determining EV ownership – and the lack of such incentives in rural environments. Figenbaum et al. (2015) show this clearly by highlighting how EV ownership in Norway concentrates in suburban regions, due to HOV lane access which reduces commuting time (but also shows peaks on islands due to reduced costs for tunnels or ferries). Likewise, Bjerkan et al. (2016) highlight how priority HOV access is a core incentive for many Norwegian BEV owners, especially those living near Oslo, while purchase incentives instead seem to focus on men over 45 who live outside the greater Oslo area. Furthermore, both Mannberg et al. (2014) and Morton et al. (2017) find significant effects from congestion charging on the purchase of, respectively, alternatively fuelled vehicles in Stockholm (Sweden) and hybrid EVs in London (United Kingdom). Although clearly successful and relatively cost-effective (as these measures are aimed at higher density population and traffic regions), most of these localized incentives hardly benefit rural inhabitants or those living near small regional towns that do not have toll roads or heavy traffic congestion. The lower demand in turn means that rural inhabitants lack easy access to dealerships with EV stocks and companies installing charging stations.

Third, from transitions studies we gain that early EV adopters constitute a different consumer group than the early and late majority of consumers (cf Hardman et al. 2016). As such, one can question whether the slower rural uptake of EVs means that rural inhabitants are early to late majority consumers or that they constitute a class of their own and should be seen as early rural EV adopters? And secondly, if there are different uptake groups how valid are conclusions and projections based on early registration data? On that note, some scholars suggest that there is a rural data shortage as well. For instance, Ioannides and Wall-Reinius remark that ‘the majority of studies undertaken on this subject such as research on people’s attitudes, their fear about range, and the effects of EVs have most frequently been carried out within metropolitan areas (2015, 35)’. This is an observation that is repeated by Weldon et al. (2016, 208) in their GPS tracked EV fleet study in Ireland as well as by Pagany et al. (2019, 443) when they discuss approaches to charging station planning. This leads some to argue that rural data and dynamic uptake population data ‘represents an area which could benefit from focused attention (Morton et al. 2018, 128).’

To address these concerns this paper turns the question around by asking why people in rural environments would consider an EV in the first place? To answer this question, the paper examines EV uptake across rural and urban environments in Iceland, Norway, Sweden, Finland and Denmark (the Nordics) using mixed methods data. Specifically, this paper utilizes municipal level public data on EV registration in Sweden and Norway, and it draws from a large Nordic EV

and V2G project, which includes a randomized survey ($n = 4322$), focus groups ($n = 8$ with 61 respondents) and expert interviews ($n = 227$ with 257 participants), to discuss the spatial diffusion of EVs in the Nordic and understand the popularity of EVs and reasoning behind (potential) EV ownership in rural and semi-urban environments. Particularly, the paper examines (3.1) current spatial EV deployment patterns, (3.2) self-reported preferences and driving distances, (3.3) a qualitative discussion about vehicle attributes across urban and rural regions and (3.4) expert opinion on diffusion pathways.

As Kester et al. (2018) and Sovacool et al. (2018) argue more extensively, the Nordics are generally a comparable group of countries that show a variety of EV adoption rates. This includes Norway’s globally leading EV adoption rate, increasing adoption in Iceland and Sweden, the lessons from Denmark’s fluctuating EV incentive policies, and Finland’s more moderate uptake. In terms of geography the countries are characterized by long distances, cold and harsh climates, and mountainous areas in case of large parts of Iceland, Norway, Sweden and Finland. The southern parts of Sweden and the whole of Denmark have milder climates, flatter geography and a higher population density. This makes the Nordic region a relevant and comparable case study with global lessons (IEA and Nordic Energy Research 2018).

2. Research methods and data

This section offers a brief overview of the data and methods that this paper draws on to look more closely at the interaction between level of urbanization and EV adoption in the Nordics. Two remarks are in order before briefly introducing the empirical methods behind the Nordic EV and V2G study.

First, we do not explicitly discuss the secondary vehicle registration data here. It should be noted, however, that the registration data from the respective national statistical offices, EV associations and European Alternative Fuels Observatory was set at the end of 2016, in order for it to coincide with the timing of the empirical data (autumn 2016 until summer 2017).

Second, there are a variety of definitions pertaining to what counts as rural, suburban and urban, depending on categorizations of population density per geographic unit, that vary between countries (Florczyk et al. 2019). While we have location data of the survey respondents, that is only valid for illustrative purposes as in the Nordics the internet providers bundle connections on their own networks to a limited number of internet access points (e.g. different IP addresses but similar locations attached to them). Add to this that people were free to take the survey at work or on holiday, and this explains why subsequent attempts to correlate these survey locations with the categorizations from the European Commission’s Joint Research Centre’s Global Human Settlement Layer proved inconclusive. We therefore fall back on the self-identification of respondents and participants as living in (based on a survey question) and descriptive of (in qualitative interviews and focus groups) their level of urban environment.

2.1. Survey

To collect data on the demographics of electric mobility, we firstly relied on a structured online questionnaire consisting of three parts with 44 total questions (including a choice experiment, which is excluded here). The first part asked about the vehicle background and the existing mobility patterns of respondents, namely how often they drive or use other forms of transport, how far, how much they are willing to pay for a new car, etc. The second part asked respondents what they valued most (or least) when they considered future purchases and forms of private automobility, such as acceleration, size, safety, etc. as well as some questions specifically about EVs (like charging, range, battery life, and so on), asking them to rate these features on a five-point Likert type scale ranging from very unimportant to very important. The final part of the survey asked respondents for basic demographic information

Table 1
Overview of Nordic survey respondents.

| | Rural (n = 881) | Suburban (n = 1974) | Urban (N = 1463) |
|-------------------------------------|--------------------|------------------------|---------------------|
| Female | 48.4% | 50.5% | 50.0% |
| Age (mean) | 44.19 | 42.61 | 42.00 |
| Household size (mean) | 2.56 | 2.53 | 2.27 |
| Household nr. of cars (mean) | 1.72 | 1.29 | 0.98 |
| Country | | | |
| Denmark | 23.3% | 21.4% | 22.3% |
| Finland | 16.7% | 23.6% | 23.8% |
| Iceland | 10.6% | 14.0% | 8.5% |
| Norway | 26.1% | 21.4% | 21.0% |
| Sweden | 23.4% | 19.7% | 24.5% |
| Household income (Euro) | | | |
| Prefer not to answer | 20.7% | 19.1% | 18.0% |
| Under 10.000 | 9.3% | 8.4% | 9.4% |
| Between 10.001 and 30.000 | 20.1% | 23.9% | 24.7% |
| Between 30.001 and 50.000 | 22.6% | 21.5% | 23.7% |
| Between 50.001 and 70.000 | 15.9% | 14.4% | 13.3% |
| Between 70.001 and 90.000 | 7.4% | 6.7% | 6.7% |
| Over 90.001 | 4.1% | 6.0% | 4.2% |
| Education | | | |
| Other & prefer not to answer | 18.3% | 16.7% | 16.6% |
| Secondary school | 18.9% | 19.4% | 17.6% |
| Undergraduate degree | 25.9% | 26.9% | 27.1% |
| Postgraduate degree | 36.9% | 37.1% | 38.7% |
| Occupation | | | |
| Other & prefer not to answer | 7.2% | 7.2% | 6.3% |
| Unemployed/Disability/ Sick | 9.4% | 9.7% | 9.2% |
| Student | 11.6% | 13.2% | 15.5% |
| Retired | 17.8% | 16.2% | 13.2% |
| Non-profit/NGO | 4.5% | 5.9% | 4.9% |
| Academic institution | 6.0% | 4.8% | 6.1% |
| Government | 10.2% | 10.6% | 9.8% |
| Private sector | 33.2% | 32.3% | 34.9% |
| Political orientation | | | |
| Prefer not to answer | 27.4% | 29.4% | 28.4% |
| Other | 6.4% | 7.1% | 7.0% |
| Socialist/Green | 16.6% | 13.6% | 16.6% |
| Social Democrat | 21.7% | 18.7% | 20.3% |
| Christian Democrat/ Conservative | 10.1% | 11.1% | 9.7% |
| Liberal | 17.8% | 20.0% | 18.0% |

such as age, gender, education, and occupation as well as more sensitive questions about income, political affiliation, and environmental values (among others).

After excluding surveys that were incomplete (although we allowed for respondents to skip questions) or obviously answered falsely, the survey was completed by 4322 randomized respondents (facilitated through a survey hosting firm) from across the Nordic countries. [Table 1](#) offers an overview of the distribution on some of the core demographic variables. In this paper we mainly use descriptive and single level statistics to study the interaction between the variable 'living area', which denotes the rural, suburban and urban self-classification, and variables on EV ownership, car use and EV interest. To be clear, the rural, suburban or urban classification is a self-classification by the respondents based on a question that asked them whether they lived in rural/suburban/urban environment. The answer is accepted as is. The survey also included geolocation data of most participants' IP addresses, which allowed for illustrative plotting of EV ownership and other variables on a Nordic map.

Table 2
Overview of Nordic expert interviews.

| | Interviews (n = 227) | Respondents (n = 257) | % of respondents |
|------------------------------------|-------------------------|--------------------------|---------------------|
| Country | | | |
| Iceland (Sept–Oct 2016) | 29 | 36 | 14.0% |
| Sweden (Nov–Dec 2016) | 42 | 44 | 17.1% |
| Denmark (Jan–Mar 2017) | 45 | 53 | 20.6% |
| Finland (Mar 2017) | 50 | 57 | 22.2% |
| Norway (Apr–May 2017) | 61 | 67 | 26.1% |
| Gender | | | |
| Male | 160 | 207 | 80.5% |
| Female | 40 | 50 | 19.5% |
| Groups | 27 | | |
| Expertise | | | |
| Transport or logistics | 73 | 81 | 31.5% |
| Energy or electricity system | 63 | 75 | 29.2% |
| Funding or investment | 10 | 12 | 4.7% |
| Environment or climate change | 12 | 16 | 6.2% |
| Fuel consumption and technology | 22 | 23 | 8.9% |
| Other | 13 | 14 | 5.4% |
| EVs and charging technology | 34 | 36 | 14.0% |
| Sector | | | |
| Commercial | 68 | 70 | 27.2% |
| Public | 37 | 46 | 17.9% |
| Semi-public | 40 | 51 | 19.8% |
| Research | 37 | 39 | 15.2% |
| Non-profit and media | 12 | 13 | 5.1% |
| Lobby | 23 | 25 | 9.7% |
| Consultancy | 10 | 10 | 3.9% |

2.2. Expert interviews

A second method involved the conduction of 227 semi-structured interviews with professionals working directly or indirectly on electric mobility across the five Nordic countries while visiting 17 cities from late September 2016 until May 2017 ([Table 2](#)). The interviews crossed several sectors, including local, regional and national government ministries, agencies, and departments; regulatory authorities and bodies; universities and research institutes; electricity industry players; automobile manufacturers and dealerships; private sector companies working on charging equipment, transport software, alternative transport technologies or electricity and fuel traders; and industry groups and civil society organizations. Questions were asked about the major energy and transport challenges, about the benefits of EVs as well as the challenges of EVs, about potential suggestions to speed up the EV transition, and about vehicle-to-grid (its benefits, challenges and potential incentives). The interviews lasted between 25 and 90 min and were conducted in person (primarily) or by phone. We differentiate between number of interviews and number of respondents as some interviews were conducted with two, three or four experts.

Both the expert interviews and the focus groups below were recorded (only one expert declined), fully transcribed by the authors, and inductively coded by one individual in NVIVO on a statement by statement level. The subsequent codes were then gathered in larger categories and themes. For this paper, we gathered all the statements dealing with rural, urban and other spatial aspects.

2.3. Focus groups

In contrast to the interviewees, who all in some way were working in fields related to electric mobility, the eight focus groups gathered members of the public with the aim to discuss EVs with people not

Table 3
Overview of focus groups.

| Classifications | Participants (n = 61) | % of participants |
|--|-----------------------|-------------------|
| F1: Iceland (Oct 2016) | 5 | 8.2% |
| F2: Sweden (Nov 2016) | 6 | 9.8% |
| F3: Denmark [Mixed Gender] (Feb 2017) | 10 | 16.4% |
| F4: Finland 1 (Mar 2017) | 9 | 14.8% |
| F5: Finland 2 (Mar 2017) | 7 | 11.5% |
| F6: Denmark [Male] (Jun 2017) | 7 | 11.5% |
| F7: Denmark [Female] (Jun 2017) | 8 | 13.1% |
| F8: Norway (Sept 2017) | 9 | 14.8% |
| Female | 32 | 52.5% |
| Driver's License | 50 | 81.9% |
| Currently own/frequent access to a car | 29 | 47.5% |
| Experience with an EV | 8 | 13.1% |
| Own an EV | 0 | 0.0% |

directly involved with them (neither with the transition and sale process, nor owning them). The focus groups also contrast with the interviews as the goal of semi-structured focus groups is never a quick round of questions and answers (a group interview), but to have the group talk on themes and questions brought up by the moderator, without the moderator interrupting or partaking in the discussion itself (Kamberelis and Dimitriadis 2013; Kitzinger 1995; Krueger and Casey 2014; Wiklund et al. 2014). The participants in Table 3 discussed topics based on similar questions as those asked to the interviewed experts, although simplified and personalized (e.g., they were asked what would need to change for them or their family members to buy and EV). Overall, the groups were tilted towards participants living in urban/suburban regions and towards (advanced) students and young professionals. Gender was relatively equal, but age ranged from 19 to 61, with the majority in their late twenties and early thirties. In general, the groups lasted between 1.5 and 2 h, and, in line with Krueger and Casey (2014), consisted of 5–10 and ideally 6–8 participants.

3. Results and discussion

This section describes our findings and it reflects on critical points of discussion.

3.1. Current status of EVs in the Nordic region

There are large differences in EV adoption rates across the Nordic region. Table 4, focusing on vehicle registrations at the end of 2016 (in

the middle of our primary data collection), shows that where Norway is a global leader with a sales share in the double digits and Iceland is showing a lot of promise but lacks the absolute numbers that Sweden has, Finland and Denmark remain behind. This is primarily mediated by EV incentive programs (but also due to different vehicle market conditions like the fact that Sweden is a car producing country) (Kester et al. 2018). For example, both Norway and Iceland have import and VAT exemptions for EVs, and Norway has an additional range of preferential arrangements for bus and priority lanes, toll roads, parking, etc. At the time of our study, the three other countries did not have these incentives or had them to a lesser degree.

Interestingly, these different incentive schemes and the way they are organized not only have an effect on the amount of EVs but also on the type of vehicle that is bought. This becomes clear if we look at the current distribution of EVs in Sweden and Norway, the only two Nordic countries, to our knowledge, that offer public BEV and PHEV ownership data on the level of municipalities (Statistics Norway 2018; Transport Analysis 2018). Regarding the type of vehicle, Fig. 1 maps the number of full battery electric vehicles (BEVs) and plugin hybrid electric vehicles (PHEVs) in the municipalities of these two leading Nordic countries, and the deployment patterns are remarkably different. If range is indeed the main concern for any EV adoption (Egbue and Long 2012; Li et al. 2017), then one would expect Norway to be primarily blue too. It does not, which indicates that other factors, like the incentive programs, are influencing the choice for vehicle type.

A further mapping of the number of pluggable-hybrids and full EVs as a percentage of the municipal private vehicle stock results in Fig. 2. From this figure three observations can be made. First, the percentage of EVs was clearly higher in Norway compared to Sweden at the end of 2016. And second, that EVs do indeed congregate around urban environments, with clear spikes around Oslo, Bergen and other major Norwegian cities, and lesser spikes around Swedish cities. Third, however, Fig. 2 also shows that EVs are not purely urban vehicles, as there are several rural regions with lower but still surprising EV shares in both Norway and Sweden.

Summarizing Section 3.1, we observe comparable (sub)urban hot-spots and spatial distributions in Norway and Sweden as found in Canada (Dimatulac and Maoh 2017), the United Kingdom (Morton et al. 2018) and elsewhere (Zhuge and Shao 2019; Zubaryeva et al. 2012). The international comparative aspect of Sweden and Norway further points to a need to compare the effects of different policy incentives as they clearly mediate the choice for type of vehicle, as well as the number of vehicles sold, across countries and thus most likely also within countries (Mannberg et al. 2014). In short, this brief glance at Norway and Sweden confirms that EVs are primarily oriented to urban regions, in particular suburban regions around cities, but that they are

Table 4
EV shares and daily driving patterns in Denmark, Finland, Norway and Sweden.

| | EV status (31/12/2016) | | | Average ^c Cumulative daily driving distance ^c | | | | |
|---------|--------------------------|--------------------------|----------|---|-------|--------|--------|--------|
| | Sales share ^a | Fleet share ^b | | (in km/s) | 50 km | 100 km | 150 km | 250 km |
| Denmark | 0.63% | 0.44% | Weekdays | 43.4 | 71.2% | 89.2% | 95.1% | 98.5% |
| | | | Weekend | 32.0 | 80.6% | 91.9% | 95.7% | 98.6% |
| Finland | 1.20% | 0.10% | Weekdays | 45.2 | 71.4% | 88.0% | 93.7% | 97.7% |
| | | | Weekend | 51.0 | 65.5% | 83.1% | 84.7% | 94.2% |
| Norway | 29.04% | 5.09% | Weekdays | 36.6 | 78.3% | 91.1% | 95.5% | 98.4% |
| | | | Weekend | 33.2 | 77.8% | 90.1% | 91.1% | 96.1% |
| Sweden | 3.60% | 0.55% | Weekdays | 35.2 | 79.9% | 93.4% | 96.9% | 98.8% |
| | | | Weekend | 30.6 | 78.4% | 91.9% | 92.8% | 97.6% |
| Iceland | 6.28% | 0.85% | | | | | | |

^a Based on EAFO (2017).

^b A rough estimate of PEV stock. Based on cumulative new registrations for pluggable EVs from 2009 onwards divided by the registered private vehicle stock. Data: Denmark (Statistics Denmark, EAFO, Danske Elbil Alliance), Finland (Statfin, EAFO), Norway (SSB and EAFO), Sweden (SCB, EAFO, PowerCircle), Iceland (Statistics Iceland, EAFO, Samgöngstofa).

^c Based on Liu et al. (2015).

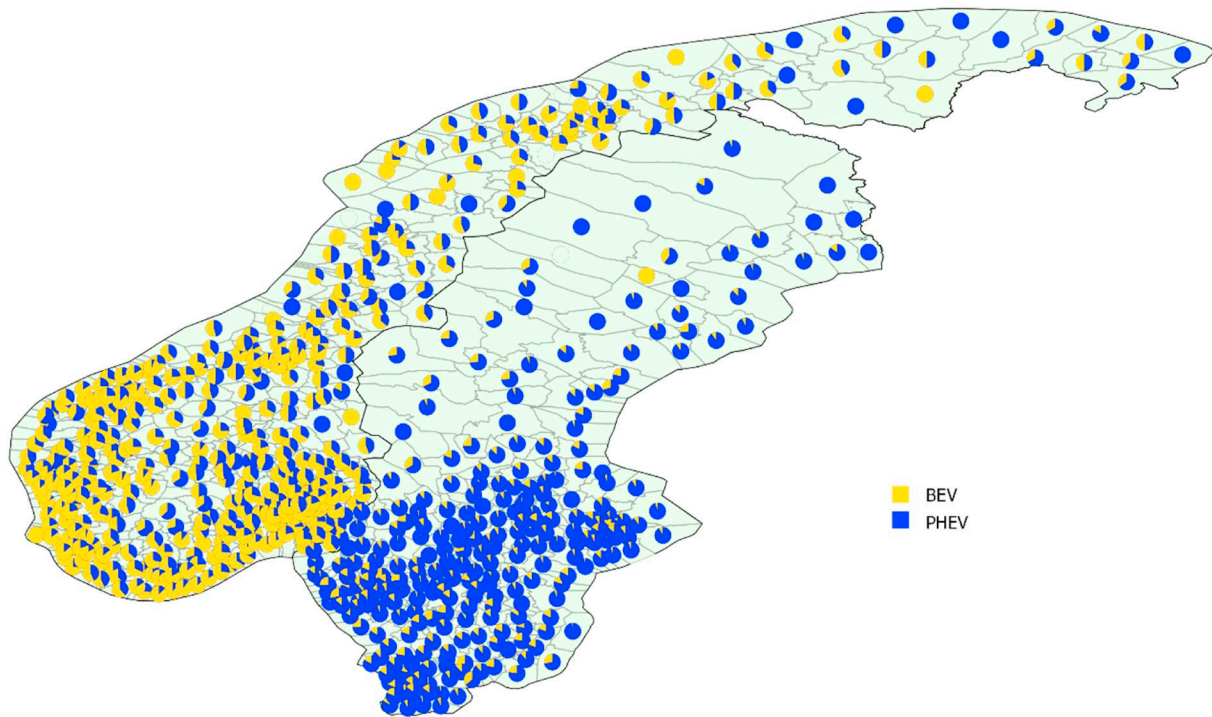


Fig. 1. Policies matter. 2016 BEV and PHEV ownership shares per municipality in Norway and Sweden. MapInfo: OpenStreetMap. Data: [Statistics Norway \(2018\)](#) and Swedish [Transport Analysis \(2018\)](#).

sold and used in rural municipalities as well.

3.2. Rural, suburban and urban driving patterns and preferences

The Nordic EV and V2G data offers further support that EVs are not exclusively used in urban or sub-urban environments. Before analysing the actual survey responses, we briefly plot EV ownership and EV

interest across the Nordics to give an indication of the spatial spread. First, [Fig. 3](#) illustrates the self-reported EV ownership of our survey respondents and illustrates that although ownership concentrates in and around urban regions, it is not limited to those regions. Likewise, [Fig. 4](#) depicts the location of non-EV owning respondents with a high level of interest in EVs. One can observe again a concentration in highly populated areas, but also that there are people in rural areas with high

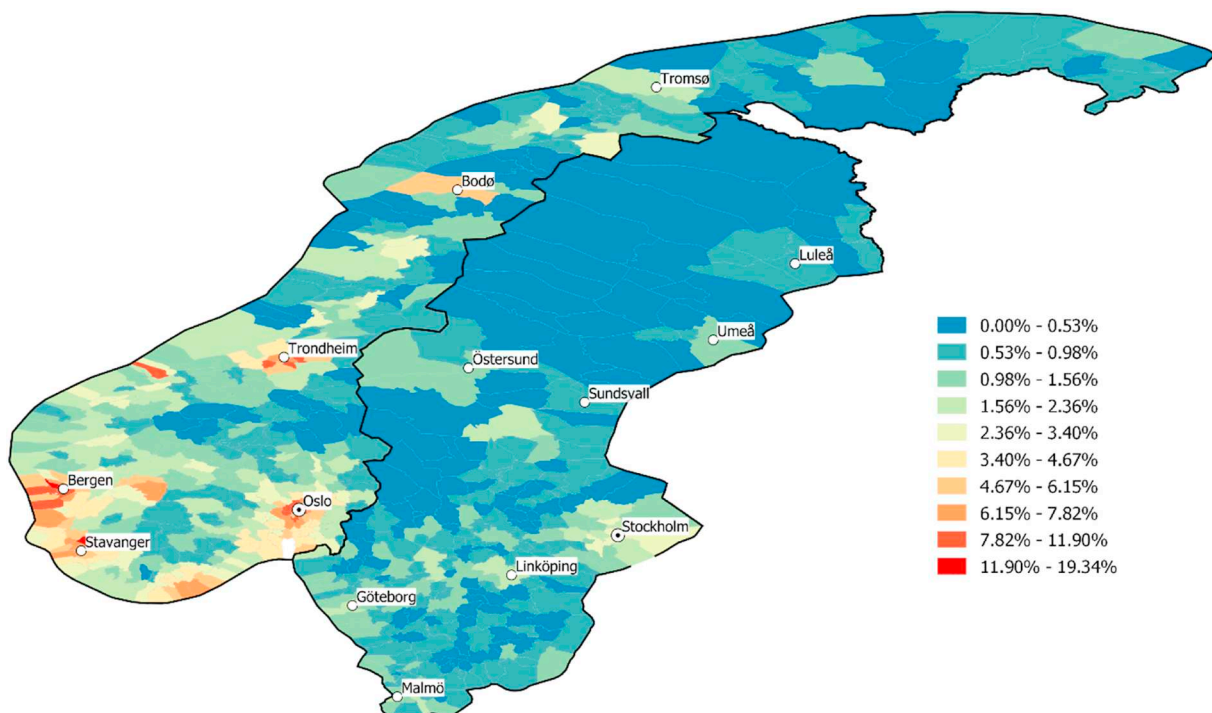


Fig. 2. EVs as percentage of Norway's and Sweden's 2016 municipal private vehicle stock. MapInfo: OpenStreetMap. Data: [Statistics Norway \(2018\)](#); Swedish [Transport Analysis \(2018\)](#).

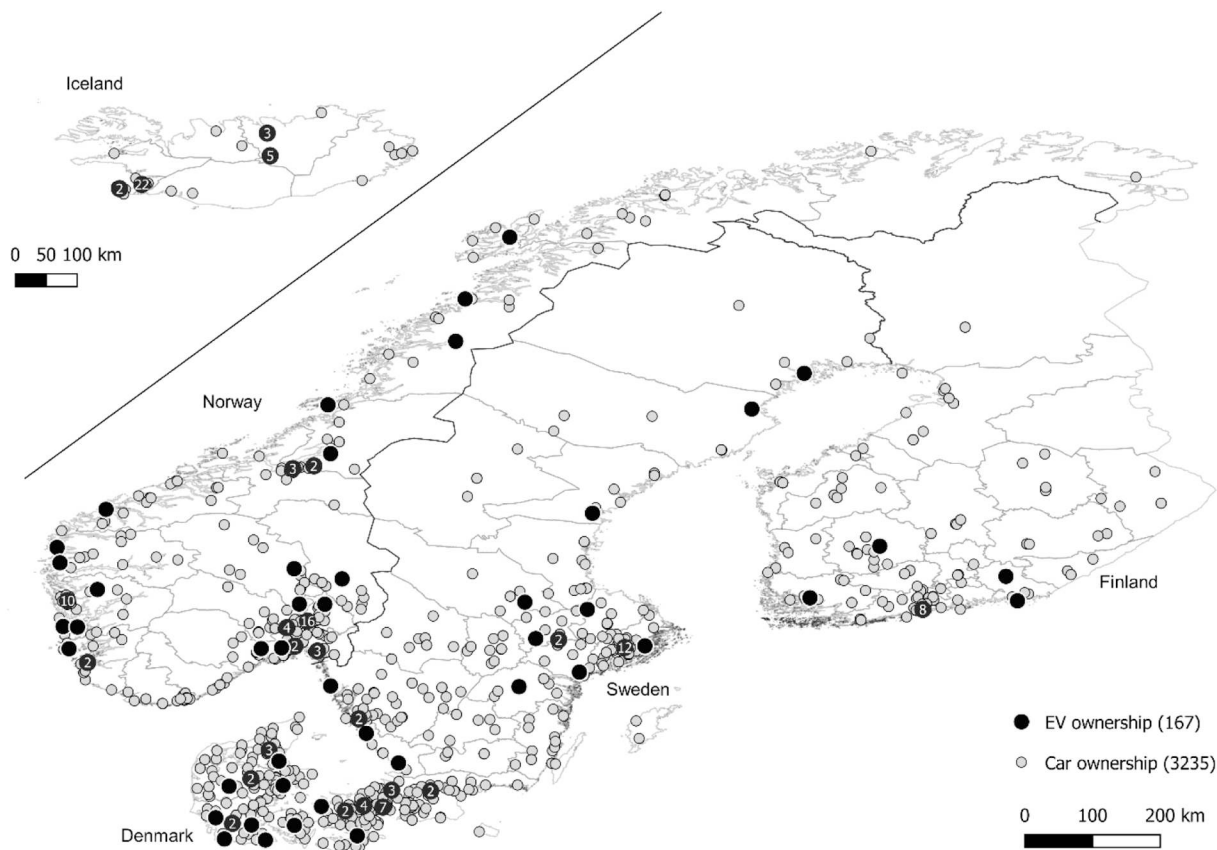


Fig. 3. Self-reported EV and car ownership in Denmark, Finland, Iceland, Norway and Sweden.

MapInfo: DIVA-GIS. Data: Nordic EV and V2G Survey. Note: The central dot on Iceland represents multiple respondents with missing or hidden location data, transformed by the survey bureau to the centre of the island.

and extreme interest in EVs as well.

Moving beyond simple visuals to actual analysis, the survey indicates that a larger percentage of self-proclaimed rural inhabitants own EVs and that this percentage slowly decreases with increasing levels of urbanization (Table 5). While this relative ownership rate is not reflected in absolute numbers (47.5% of all EVs are owned by suburban respondents, 30.1% by rural and 22.3% by urban), it gives rise to a range of questions as it breaks with the notion that EVs are urbanized vehicles due to a perceived lack of range. Similar ownership distributions can be found in the Nordic countries, especially in Denmark, Finland and Sweden, although the highest percentage of EV owners states to be urban in Iceland and suburban in Norway. These relative EV ownership rates make sense as Table 5 further confirms that car ownership generally is higher among rural respondents and that their daily travelled distances by car are slightly longer. Simultaneously, we observe that EV interest is correlated to more urbanization. Where the significantly different EV ownership percentage ($r_s = -0.059$, $p < .01$) is witness to a rural correlation, the significantly different binary coded EV interest ($r_s = 0.043$, $p < .01$) favours urban residents. While both these results can be explained with previous research and argumentation – those confirming EVs for rural and (sub)urban environments and commutes (c.f. Plötz et al. 2014), and those arguing for EVs as environmentally friendly city vehicles (c.f. Ajanovic and Haas 2016) – it is the diverging directionality that interests us, for what could explain this?

The earlier discussed (sub)urban inclined incentives and available vehicle and charger supply chains could be part of the answer. Another answer could be that the groups prefer different vehicles. In this respect, Fig. 5 shows the different ratings per subgroups of non-car owners, car owners and EV owners for the importance of several car

characteristics. Across the whole sample of the survey a Kruskal-Wallis test shows significant variance for four of the 14 car attributes between rural, suburban and urban respondents. There is some variance on size and comfort ($p = .038$, with a two-sided adjusted Bonferroni post-hoc centring on an urban-rural difference with a higher mean rank for rural responses $p = .042$), reliability ($p = .022$, post-hoc: suburban-rural difference with $p = .04$ and a higher mean rank for rural responses), public charging ($p = .035$, post-hoc: suburban-urban with $p = .044$ and a higher mean rank for urban responses), and EV range ($p = .014$). EV range is of particular interest as it shows variance for all three subgroups, with a two-sided adjusted Bonferroni post-hoc test showing that rural participants score this higher than suburban participants ($p = .017$) and urban participants ($p = .035$). That would explain part of the lower rural interest in EVs, but also makes the actual rural EV ownership rates more remarkable.

Zooming in to the different preferences of rural, suburban and urban car owners ($n = 2971$), a Kruskal-Wallis test finds no significant variance among the groups for the car attributes. This differs when focussing on EV owners ($n = 158$). Visually, Fig. 5 indicates that this group is witness to a wider variety in mean importance for many of the car attributes, yet Kruskal-Wallis tests only indicate variance for Design and Style ($p < .01$, post-hoc: suburban-rural with $p < .01$ and urban-rural $p = .012$ both with higher rural means), purchase price ($p = .035$, but no significant post-hoc tests) and V2G capacity ($p = .037$, post-hoc: suburban-rural with $p = .046$ and higher mean rank for rural respondents). In other words, among our sample there is some variance in preferences among respondents from different environments, in particular on size, reliability and range, but less when looking within current car and EV owning subsets. To us this indicates that there could be a difference between the generalized perceptions about EVs from non-EV

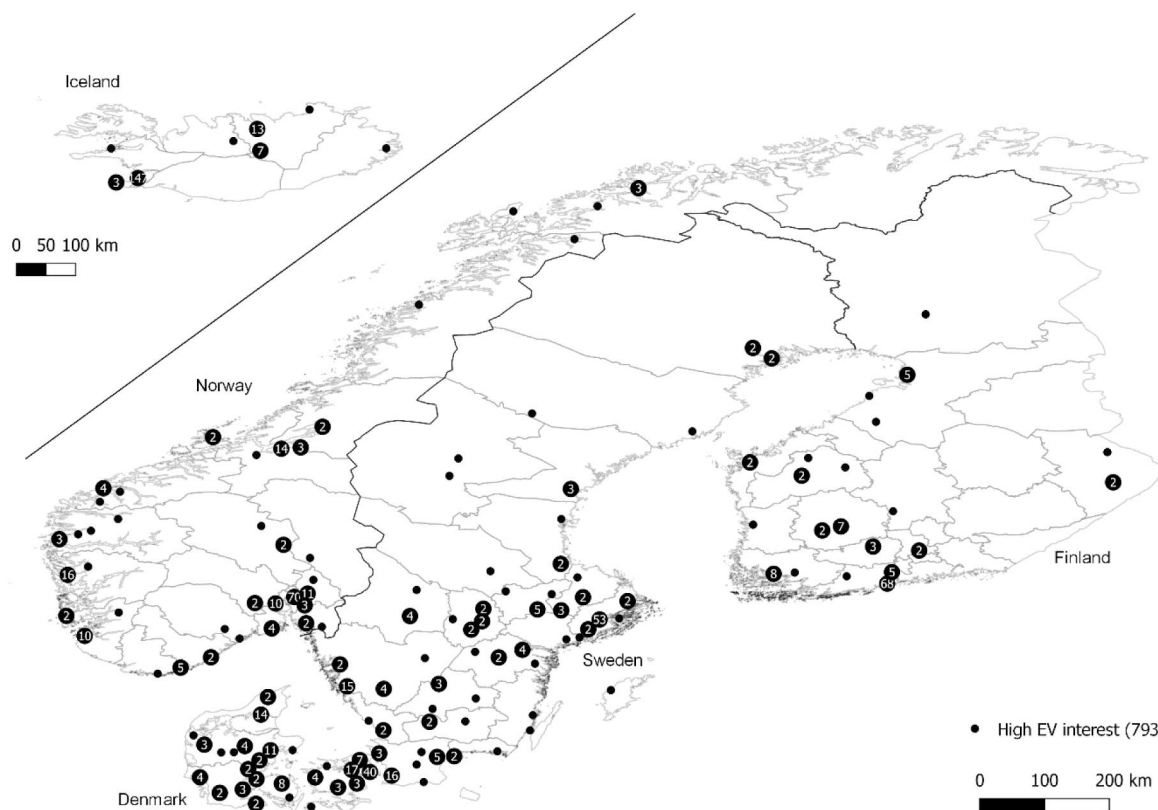


Fig. 4. EV interest of car owners in Denmark, Finland, Iceland, Norway and Sweden.

MapInfo: DIVA-GIS. Data: Nordic EV and V2G Survey. Note: The central dot on Iceland represents multiple respondents with missing or hidden location data, transformed by the survey bureau to the centre of the island.

Table 5
Private and electric cars in rural, suburban and urban environments.

| | Rural | Sub-urban | Urban | Chi-square |
|---|----------------|-----------------|-----------------|---------------------------------------|
| | <i>n</i> = 881 | <i>n</i> = 1974 | <i>n</i> = 1436 | |
| Own car | | | | |
| No | 18.2% | 21.9% | 33.7% | $X^2(2, N = 4316) = 90.61, p < .01$ |
| Yes | 81.8% | 78.1% | 66.3% | |
| KM per day | | | | |
| Rarely | 21.7% | 25.4% | 38.3% | $X^2(10, N = 4318) = 121.76, p < .01$ |
| 0–20 km | 27.8% | 30.9% | 28.4% | |
| 20–50 km | 31.2% | 29.0% | 22.1% | |
| 50–80 km | 11.1% | 7.8% | 6.2% | |
| 80–100 km | 3.7% | 3.5% | 2.1% | |
| > 100 km | 4.4% | 3.5% | 2.9% | |
| EV interest | | | | |
| Not (really) interested | 49.2% | 47.6% | 43.7% | $X^2(2, N = 4029) = 7.62, p = .022$ |
| Somewhat or very interested | 50.8% | 52.4% | 56.3% | |
| EV experience | | | | |
| Don't know or never driven an EV before | 79.3% | 83.1% | 79.6% | $X^2(2, N = 4016) = 9.18, p = .01$ |
| Yes | 20.7% | 16.9% | 20.4% | |
| Own EV | | | | |
| No | 90.9% | 93.1% | 95.0% | $X^2(4, N = 4318) = 16.28, p = .003$ |
| Yes (but no longer) | 3.5% | 2.9% | 2.4% | |
| Yes | 5.6% | 4.0% | 2.6% | |

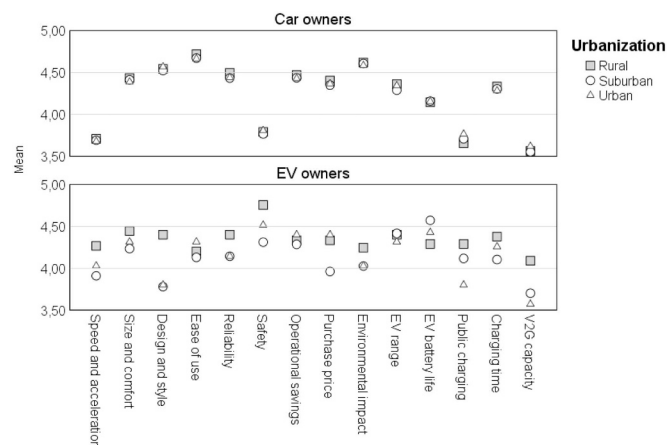


Fig. 5. Mean importance of car attributes for car and EV owners per level of urbanization.

owners and the actual experience and geographic mediated preferences of EV owners.

Rephrased, the concern with range (as well as size, reliability and charging), does not always inhibit people to own and drive an EV, even if they live in a rural environment. This can be explained if we move beyond desire and fear to actual use considerations. As has been shown for other regions, EVs can cover around 85–95% of daily trips (Neubauer and Wood 2014; Pearre et al. 2011; Saxena et al. 2015; Zhang et al. 2015) and the average of the daily driven private vehicle kilometres in the Nordic region is no different. Table 4 (above) shows

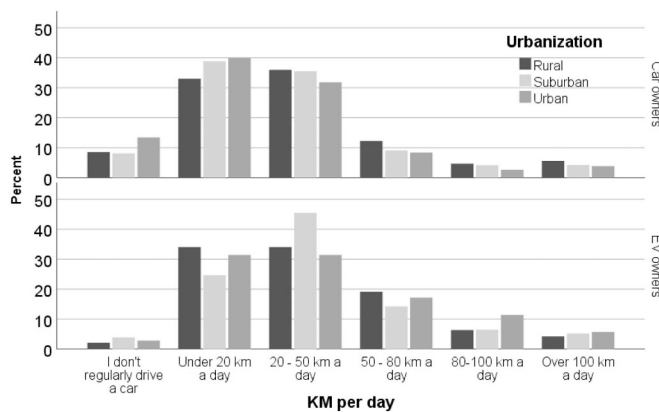


Fig. 6. Average kilometres per day per car-owning survey respondents in percentage.

some of the results from Liu et al. (2015), who draw from respective national travel surveys and find for Denmark, Finland, Norway and Sweden that over 90% of the daily distances fall within 150 km. The only exception is Finland, where 15.3% of the population drives > 150 km on a weekend day. This is a distance that modern-day EVs are already well equipped to handle. In fact, Figenbaum (2018) recently found that the use of Teslas compared to other BEVs in Norway is more or less similar irrespective the former's range benefit. Our survey data provides similar numbers and shows that on average 85.6% of the respondents' state that they drive < 50 km a day. Focussing on only those respondents with a car, the number drops slightly to 81.7%, which remains a significant number of daily kilometres that could be travelled by any EV without use of public charging.

More in-depth, along levels of urbanization, Fig. 6 shows a similar image for all three groups but confirms a slightly higher percentage of rural respondents with a higher average km a day. Interestingly, the survey respondents who claim to own an EV seem to keep to a different daily driving pattern. First, a smaller percentage of drivers use their EVs rarely compared to non-EV car owners. Second, EV drivers drive more (27.6% of EV owners drive > 50 km a day compared to 18.3% of car owning respondents) and there is a clear peak in the percentage of EV owners living in a suburban area who drive between 20 km and 50 km a day compared to the other regions. Lastly, while rural inhabitants drive more on average per day among ICE car owners, among EV owners it is not the rural but the urban group that has the largest percentage driving over 80 km a day. Rural EV drivers, percentage wise, use their vehicle more regularly and a larger percentage drives 50–80 km a day. Taken together this indicates that EV drivers do indeed use their vehicle more intensively.

In short, the survey confirms that EV ownership is concentrated around urban environments but highlights its dispersal over the Nordic region and finds a small negative correlation between EV ownership and level of urbanization in favour of self-proclaimed rural inhabitants. A map of EV interest across the Nordics offered a similar urban centric image, but also showed that even in remote regions some respondents have an interest in EVs. However, in contrast to ownership, the correlation in this case favoured urbanization. To explain this tension between the relatively higher rural EV ownership rate and higher urban EV interest, we looked at the importance rating of certain car attributes across car and EV owners in rural, suburban and urban environments. While there was some variance in importance attached to size and comfort, reliability, EV range and public charging across levels of urbanization for the overall sample, we found a shared level of concern for EV range and most of the other car attributes across rural, suburban and urban subsets within both groups of vehicle owners. With the car attributes offering an inconclusive answer to the tension, we turned to average daily driving patterns. Again, there is some basis for the

tension, with rural drivers indeed driving more than suburban or urban drivers (indicating a potential range concern), however we also observed stated EV drivers utilize their vehicles more and for slightly longer distances. Future studies should reflect on actual distances per car in multi-car households across various geographies and over a certain timespan, but the above indicates that it is possible to question, if not potentially dispel the notion that EVs are short-distances and city vehicles.

3.3. Consumer discussions on cars, public transport and EVs

Our focus groups and interviews provide additional insight into the reasoning behind the EV ownership and EV interest tension across rural and urban environments, as well as on more general spatial deployment patterns and the self-reported driving preferences and habits discussed so far. Within the focus groups, participants paid particular attention towards public transport, the need for personal automobility and the (potential) role of EVs in this.

First, in terms of the need for personal automobility, it is interesting that even though our participants, to various degrees, believed strongly in public and active forms of transport, all agreed that it really mattered where you lived. Cars were deemed a necessity based on geographic circumstances, commuting distances and the absence or time inefficiency of public transport alternatives.

G3F1: I live [] just outside of Aarhus, but [] there is a smaller town [] just 5 km further out and they have a bus like maybe once an hour. As soon as it gets evening or weekend then it can be really difficult if you have to do something, to just have to sit down and wait for an hour to get anywhere. So, I expect they would be more likely to have a car as well.

G3F2: Especially at night I guess there are no busses.

G3F1: Yes, it is pretty scary out there at night.

G3F3: Because people don't have cars?

G3F1: No, because there is just no light anywhere. And a big forest and then nothing.

In urbanized regions, however, cars were imagined primarily for family or children related trips and goods transport: 'it's basically [about] bringing something from IKEA to my place [G2M]'. One participant even discussed cars in an urban environment as nothing more than an option for inter-city related travel [G3M]. In a similar line, a participant in Denmark remarked that 'the electric car is especially for the city' and later argued that EVs 'should be pretty small, actually like a Smart or something like that [G6M]'. In short, the focus groups participants see cars as a core transport mode for many, although they were rather specific as to the groups of people they thought could (and should) have one.

Focussing on rural regions, a number of reservations were made towards EVs after the above acknowledgement of the need for cars in these regions. Range returned as a core concern but primarily in relation to long distance trips, e.g. peak travel days:

G8F: Then, range for me is one of the things. Because honestly, I do drive Oslo – Bergen a lot, and yes it's possible now but you do have to stop and charge, and it is just not the scenario that I think is, seems like that much fun. That you have to stop in the mountains. That you have to charge for an hour. You know, you have to plan around that. So, for me to be able to do a full eight hours drive in a stretch that would really increase my willingness to buy an electrical car.

Interestingly, the link to rural areas was implicit here as most participants discussed the EV long distance problem in relation to inter-city or holiday trips. Specific for rural regions were the bad road conditions and strong winter weather that inspired strong doubts about the reliability of current EVs in most of the Nordic countries. Among others, participants in multiple groups discussed the fear of stranding in the

middle of nowhere in combination with freezing temperatures:

G6M: I think the infrastructure would have to be better, that's my main concern, because the thought of an electric car always scares me to think that I'll be stuck somewhere in the middle of nowhere, with nowhere to charge my car. So, that idea kind of keeps me from considering buying an electric car.

The fear here was not just the lack of charging infrastructure, but also the uncertainty about what to do if you are stranded with an empty battery.

In response to these challenges, one participant in Finland remarked in response to the question what would need to change for their family or friends to buy an EV:

G4M: They could if they are mainly living in Helsinki area and they mainly travel short distances. But my parents live in the country side, so I don't think it would work for them. Also, if the family has two cars, one that we take for the long distance [...] and one electric that we use for shorter distances and go to shops. That could also work.

EVs were thus suggested as an option for those living in two-car rural households, thereby simultaneously acknowledging that EVs are possible in rural environments and doubting their role there.

In short, our focus group respondents – while quite pro EVs and public transport – still deemed conventional cars a necessity for certain (rural) regions and market segments. To such an extent even, that most of the EV challenges were approached from an (sub)urban perspective. Range and charging infrastructure for example seemed primarily a peak travel day concern and one of the few discussed concerns regarding EVs in rural areas was the uncertainty that people have about what to do if the car strands in the middle of nowhere. In terms of the tension between relative EV ownership and EV interest, this seems indicative of an urban focussed narrative – one that precludes and/or limits serious consideration of the potential of EVs in rural areas.

3.4. Expert statements on cars and EVs in cities and beyond

Comparable to the focus groups, the experts also suggest that the public sees cars as a necessity in both urban and rural locations, but of course offered more systematic depth to their downsides and discussed potential alternatives and solutions. EVs are one of these solutions and experts discussed both their value and how their uptake and function differs between urban and rural environments.

First, experts remarked on the public's felt need for a car across all spatial contexts as they discussed the strongly ingrained position of cars in our societies through personal and more abstract reflections. Some experts reflected personally, like R069:

Some of the politicians say that, okay, if you're living in a large city you should go by public transport, you should bike and you should walk, okay. But sometimes in life it's not possible to do that. You need to take your children to day-care, you need to go to work, you may have work only for a few hours and then change, so it's pretty difficult to do that.

While others approached the need for personal automobility more abstractly:

R238: But always when some city planner or visionary comes with the idea of making the cities car free, at least, there is a lot of reaction to that. Still it feels like a right that you can drive a car anywhere, everywhere and park it everywhere. It is quite strange, because the car is not a human right, it is like a car right. And what has not been so much discussed in Norway [] is whether we really want to just replace our habits around fossil cars with electric vehicles or should we use this opportunity to think a bit more on when and where we use the car. Maybe we do not need such big batteries

in electric vehicles because we do not need to use the car for this and this.

R245: I think people have come to expect a high degree of flexible mobility. And public transport can never satisfy that for people at all times during the whole year, so of course you can cover that expectation by having some kind of carpool or car sharing services, but I do not think you can be that idealistic that you only will base the transport on public transport even in the big cities.

A third group instead put the need for private cars in perspective. R113 for example highlights that one-third of the Danish population does not own a car, see also (Liu et al. 2015), and then reflects that this means that two-thirds 'has a car. And they want a car.' Similarly, R096 discusses the popularity of bicycling in Denmark, only to conclude: 'but if you move outside people have a bike but it's not used as a mode of transport so I would say [that] outside the cities Denmark is very much a car culture country as well.'

Second, experts discussed the downsides and unsustainability of private automobility, especially insofar as vehicles can create externalities in urban areas. This included their limited actual use on a 24-h basis and their underutilized passenger capacity (R188), but also smog, accidents and congestion concerns. As R088 further reflected, EVs 'will get some environmental benefits, some CO2 benefits, but you might not get a benefit for the transport system.' Others similarly warned for potential rebound effects; that subsidizing EVs should not result in a subsidizing of private mobility (R207). Another frequently discussed aspect that returned in Denmark, Sweden and Norway involved the space use of private vehicles, including EVs, and the pressure in urban environments to accommodate more transport demand, let alone more personal cars. Besides an EVs environmental impact, the space of EVs as a private form of automobility is thus an increasingly discussed topic with paradoxical relationships to further urbanization and congestion.

Even though the above gives the impression that experts see a clear space concern within cities and that they observe local city governments actively minimizing private car use, not all agreed. R096 for instance makes this point:

Actually, getting rid of the cars is currently not a priority of the majority in the city. But on the other hand, it is not like they are forgetting the bikes and public transport. They are also doing stuff there. But I wouldn't say that Copenhagen is going to transform into a low car city [] because so much of the traffic is coming [] in from the suburbs. And the city wants people to have jobs here and to have accessibility and be attractive and so on. So, they are very keen not to put any sand into the machinery of the growing city...

On a national level, R112 makes a similar point when reflecting on the numbers in Denmark that show public transport is decreasing while car use is growing (bike use is growing as well) in particularly through a growing number of two-car households in Denmark. Likewise, R080 reflects on the commuter incentives in Norway, Sweden and Denmark that reimburse people for the distance they travel to and from their work beyond a certain distance, no matter the mode of transport used.

Third, irrespective of the contention among experts about the importance of cars, a range of alternatives and options was brought forward to improve the sustainability of transport. This included a reduction of car ownership and traffic, or vice versa, an investment in active and public transport alternatives. Measures like halting all new road construction (stated with a wishful, slightly mocking laugh by R117) were proposed alongside inhibitive measures like reducing access to specific areas, which is especially relevant for suburban car owners, as argued for by R080:

Access. If you don't have access to the city with cars, you won't buy a car. If we force car users to park outside of the city, so the shortest distance from point A to point B is not the car route, [but] if you need to change mode of transportation ... For example, I take the car

to a parking place outside the city and then I have to take the bus or a bike into the city, then people probably are thinking about taking the bike or the public transport system all the way.

Other options included support for higher capacity public transportation in cities (R139, R248), like light rail (R170), or support for electric bicycles and bike lanes (R029, R061, R186). It also includes strong targets, like in Norway where the growth in personal transport is set to zero on private cars – and in Oslo even reduced by 20% – by the end of 2019 (R235). Of course, these targets are coupled to the Norwegian toll roads, which gives them a policy instrument that other countries might not have available. Another set of suggestions revolved around ‘urban densification’ as a strategy to reduce private car transport, as it positively interacts with many of the alternative transport modes (R193) and because congestion itself will incentivise people to alternative and more optimal modes of transport (R095, R169).

Noteworthy is that most of the expert comments so far concern urban environments. Implicit and explicit is the assumption that cars are a plain necessity in rural areas due to long distances, difficult topology, low population densities and the subsequent absence of a proper public transportation network, especially valid in the Nordic countries. Experts refer here to a public transport network that is co-ordinated, on time, reliable and cost-effective for both an individual consumer and society. As R221 reflects on the Norwegian topology and dispersed population:

The option that people often choose is traveling by plane across Norway. More locally, there is the public transport offering which is often not as good as it should be, and often a bit too late and unpredictability, and also the reason why people choose to take their car instead.

All of this implies that while our interviewees see options to reduce vehicle use and optimise road use, e.g. by shifting traffic over time, the actual reduction of private car ownership is deemed a difficult matter.

With limited options to reduce mobility in general or to move trips to public or other active modes of transport, substitution remains as a quick and ‘easy’ fix (R227). As R193 argues:

You are not going to be able to tell people in democratic developed societies to reduce their standard of living or to reduce their mobility. That is not going to work. And it is going to be very hard to have major parts of the road users, the motorists, to move on to public transport. [] The only thing that could conceivably work [for a large percentage of people and a large percentage of emission reductions], is to make the vehicles themselves emission free. So that is the strategy to follow in my opinion.

Similarly, R053 argued to develop things ‘in parallel’: to promote EVs, but to keep working on (electrified) public and active transport alternatives as well.

Some expert respondents did suggest that EVs are best suited for urban areas or vice versa not suited for rural areas. R148, like R065 and R092, for instance links EVs and their range to predictable commutes and cities:

If your main use of the car is to go from the south to the north [of Finland] and backwards, then the EV today is not an option because of the range. But if you [] live in Helsinki and your work is in Helsinki and 99% of your driving is in the region of Helsinki, then the electric vehicle is absolutely a very good target and/or solution.

Interestingly, this quote does not exclude rural areas inherently – it details peak travel days and not rural driving patterns – but it does focus on urban centres. R024 was even shorter and more explicit: ‘[N]o, I don’t have any concerns of the range, because it’s a city car.’ In turn, EVs were seen as a reluctant fit in rural regions. One expert stood out in this respect as he rejected EVs for rural areas based on the lack of comfort of most models (R052). Other interviewees highlighted that

EVs might be usable for short distances in small villages and towns (visiting neighbours, the nearest shop, pizza delivery), but that they do not fit the long inter-city distances in rural regions (R30, R044, R089, R162, R181). Some argued for technological and economic benefits of biofuels for vehicles in rural environments over EVs (R184), or mentioned the lower incomes in rural areas which they saw as negatively correlating with the higher purchase prices of EVs and other new cars in general (R074), which led to a reflection on the systemic benefit of trickle down effects from urban to rural regions (R037).

That said, the confinement of EVs to urban areas was not universally accepted among experts. R037 stated quite strongly: ‘No vice versa I would say. EVs are much more easy in rural areas and suburban areas, not in city areas.’ Similarly, R051 argued: ‘Yeah, I think that’s completely the wrong focus. We’re trying to say that EVs are the best car out in the countryside’, while R056 added that ‘people in the city don’t drive that much’ either. Similarly, R098 offered a long-term perspective wherein EVs and autonomous vehicles will be plentiful in rural areas given the lack of public alternatives that take precedence in urban environments. In turn, R075 voiced the economic consideration that was mentioned in the introduction as to why EVs are ‘ideally suited for rural areas’:

I think now that range is up, I think the electric car is ideally situated for rural areas. Because, as yet it’s a more expensive car to buy and cheaper car to drive, so once you start having a little bit of distance that’s your way to regain that costs. So ideally you should have a driving distance of at least 50 km a day or more in order to get your money back. So, this whole perception issues that you use your car in the city: no! You should go biking or something else, you will never get your money back if your distance is that short.

R152 provides another infrastructural perspective, and argues that EVs are in fact becoming the only choice for rural areas:

Actually, I would say that the electrification of passenger cars could have its place, not only in inner cities, but [also] the less populated areas because actually, well, electricity is the only alternative that is already there. If you want to use for instance, bio-methane, you have to have production, [] cleaning and [] compression. To be able to offer people alternative fuels you have to have the refuelling infrastructure built. But electricity is everywhere.

Similar arguments were made by R079 and R042, who for Sweden remarked that Stockholm was actually the runner up for a while in terms of the relative percentage of PEVs sold after the more rural Sundsvall area up north.

What’s more, some respondents mentioned the financial troubles of petrol stations as a major potential advantage for EVs in rural areas. Both R042 and R051 reflected on the reduction of the number of petrol stations in those areas. As R051 explained:

So up in the north, you have huge distances of course, [but] your distance to the nearest gas station is also increasing all the time [because of bankruptcies]. However, you have your outlet at home with very good and fine electricity on low prices and you always have it there [for when you drive to] your neighbour and when you go to your relatives. Also, it’s possible to build charging infrastructure on the highways there. So, we’re trying to give the perspective that electric vehicles are good, not only in the cities in Sweden but also in the countryside. And with increasing range that problem will be much less.

This is not just theoretical, R217 remarked for Norway as an EV sales representative that:

We had a number of interviews with some customers at a quite early phase of the launch because we suddenly saw that, like in the really remote areas of Norway a lot of cars were sold to farmers. Why? And they said, ‘Well, you know, now we’re self-sufficient. Before we had

to drive like thirty kilometres to fuel up the car. And now [] I can fuel at home [] and then I go to all the neighbouring vicinities to do what I need. I don't have to go a long way to and from, just to fuel my car, to be in my area." So, I thought this really was one of those moments where you see [that] people find use for EVs in their different areas.

Likewise, in Denmark the small EV consumer organization FDE has most of its members living 'right out in the countryside,' with R105 attributing this to the fact that in Denmark many people live on social islands with work and most of their friends and family nearby. Nevertheless, while these remarks confirm an alternative vision, admittedly the number of experts that mention them also indicates that it is not a greatly popular one and that most EV attention is still directed at (sub)urban regions instead of rural.

To sum up, among experts there was more diversity and nuance on car use and how EVs fit rural, suburban and urban environments. On the one hand, we found experts who confirmed popular images of the EV as a commuter or city vehicle, for various environmental and economic reasons. On the other, we found transport and city experts who questioned the long-term viability of private car transport in urban and suburban regions based on traffic congestion and space limitations in urban environments. Additionally, experts working in either EV sales or EV consumer organizations shared that EVs are not just sold in (sub)urban environments but are also a popular choice for certain people in rural regions due to self-sufficiency. This questions the notion that range is a problem for all rural drivers and indicates that EVs everywhere are an individual purchase choice related to whether or not a household has multiple cars, can predict its majority of trips, and estimate the number and additional charging time of longer trips.

4. Conclusion and implications

This paper explored why people in rural environments would purchase an EV after finding a tension in the literature between scholars concluding that EVs are city vehicles and others concluding that EVs are better served in rural environments. Based on quantitative and qualitative data our study adds depth and nuance to this discussion about the spatial distribution of EVs across the Nordic region, as summarized in Table 6.

In short, the paper first confirmed that the use of EVs is heavily mediated by incentives, not only in terms of the number of cars but also

the type of EVs and the region where they are purchased. Registration data from Norway and Sweden shows clustering around urban centres, thus confirming earlier spatial analyses. Next, based on the Nordic EV and V2G survey, we observed that EVs and high EV interest are not solely concentrated around cities but can also be found in more remote regions of the Nordic countries. The survey further indicated that the largest share of EV owners self-identified as rural respondents, even though absolute numbers favoured suburban EV ownership. This contrasted to the EV interest of non-EV owners, which was correlated towards those self-identifying as urban citizens. To us this contrast points to a belief in EVs as prime city cars that is disconnected from actual use (to which we return below), especially as a major share of the survey respondents' average daily trips seem to be covered by modern EVs, with minimal differences between levels of urbanization. More qualitatively, the focus groups and interviews showed a general awareness that EVs might be a more desirable option than ICE vehicles, but that they remain personal vehicles and thus suboptimal as a mode of transport. Similarly, the finding that urban EV owners drive more and longer distances than rural EV owners deserves further study, but probably is mediated by the higher availability of urban public charging infrastructure, inter-city traffic, and more rural multicar households.

EVs are thus not *only* urban vehicles. Existing deployment patterns and other urban concerns provide valid reasons why EVs are in fact valid rural and suburban vehicles as well. These include urban space limitations and the availability, and environmentally preference, of public and active transport alternatives. In addition, EVs, like any car, need a certain daily distance to make sense economically for individual consumers, again pointing to a better fit for the driving patterns from rural and suburban respondents. Furthermore, EVs have a place in rural areas, not only as a substitution for cars in the absence of public transport, but also for the self-sufficiency of home charging. Moreover, the results above show that respondents who believed that they lived in a rural area might drive a bit more and longer distance on average, but that they too mainly drive predictable short distances.

This finding might seem self-evident, yet we make it nevertheless. Primarily, because a fair share of current quantitative analyses simply aims to find the most important predictors of EV uptake, which, due to the price level of EVs, centres around income levels and associated variables like education and homeownership. In doing so, such studies essentially extrapolate the characteristics of the existing consumer base and assume a (spatial) trickledown effect for further uptake. While there is value to such studies, this has at least two effects: (1) they

Table 6
Overview of benefits, challenges and results for Nordic electric mobility.

| | Benefits | Challenges | Findings |
|----------|---|---|---|
| Urban | Low distances; Economies of scale for charger and EV industry; High incomes; No tailpipe emissions. | Congestion; Limited space; Competition of private vs public/shared modes of transport; Peak travel days. | Urban ICE vehicle owners drive least and show a low but positive correlation to EV interest; Confirmed that space is an increasing concern in urban environments; The share of current urban EV owners' daily average kilometres is higher than current rural EV owners. |
| Suburban | Regular commutes and a minimal economic driving distance; Home charging. | Access to towns/parking; Peak travel days; Need for public charging stations. | Highest absolute number of EV owners; Car ownership mediated by urban access policies (positive through minimal emission demands, negative through reduction policies); Minimal economic daily kilometres; Parking and charging at home. |
| Rural | Minimal economic daily driving distance; No space limitations; Home charging = self-sufficiency; Reduced need for heavy infrastructure investments (gas/biofuel stations). | Fear of stranding (and what to do if that happens); Peak travel days (more than urban/suburban); Road and weather conditions (requiring larger and reliable car models); Need for economic unviable charging stations. | Highest share of EV owners; Regular daily distances slightly higher than other groups, but not infinitely so; Slightly higher longest distance of peak travel days (higher frequency unconfirmed, but implied among experts and focus groups); Home-charging; Clear desire for less charging stops among focus group participants, although need for this was questioned. |

popularize and subsequently promote ‘efficient’ policies that focus on like-based high-income groups and spatial regions (ignoring already present incentive biases), and as such (2) they have ethical implications as they hide developments and reasoning at the fringes of EV uptake: in rural regions, among lower-income groups, or among women, elderly or non-white ethnicities.

We thus need studies that focus on these fringes and that include quantitative travel patterns and qualitative reflections on purchase, ownership and travel decisions. At a certain stage in a transition, academic and political focus needs to shift away from the most-likely to the least likely consumer groups, with studies that are aware of socio-geographical context and individual socio-economic circumstances that dictate final purchase decisions. Above all, coming back to the discrepancy between urban EV interest and actual EV use in rural environments, we would argue that these individual purchase choices should not be influenced by an incomplete yet popularized conception of EVs only as ‘city’ cars, that potentially predetermines and thus artificially narrows the true range of potential consumer uses, aspirations, and deployment patterns.

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