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Incentives for promoting Battery Electric Vehicle (BEV) adoption in Norway

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ABSTRACT

Norway has become a global forerunner in the field of electromobility and the BEV market share is far higher than in any other country. One likely reason for this is strong incentives for promoting purchase and ownership of BEVs. The purpose of this study is to describe the role of incentives for promoting BEVs, and to determine what incentives are critical for deciding to buy a BEV and what groups of buyers respond to different types of incentives. The questions are answered with data from a survey among nearly 3400 BEV owners in Norway.

Exemptions from purchase tax and VAT are critical incentives for more than 80% of the respondents. This is very much in line with previous research, which suggests that up-front price reduction is the most powerful incentive in promoting EV adoption. To a substantial number of BEV owners, however, exemption from road tolling or bus lane access is the only decisive factor.

Analyses show that there are clear delineations between incentive groups, both in terms of age, gender, and education. Income is a less prominent predictor, which probably results from the competitive price of BEVs in the Norwegian market. Perhaps most interesting is the assumed relation between incentives and character of transport systems the respondents engage in.

Introduction

As an answer to greenhouse gas emissions, and to some extent local pollution and national energy security, we are currently witnessing a new wave of interest in electromobility – understood as a road transport system with vehicles using electricity for propulsion. Achieving electromobility depends on solving significant challenges related to technology and complex, social change (Grauers et al., 2013). Electric vehicles (EVs) are vehicles that are partly or fully powered by electric motors, and include Battery Electric Vehicles (BEVs), plug-in hybrid vehicles (PHEVs) and range-extended electric vehicles (REEVs) (Plötz et al., 2014). They emit less CO_2 compared to vehicles powered by internal combustion engines (ICEVs), especially when energy is generated by renewable sources. EVs are also advantageous in terms of energy-efficiency, energy security, lower user costs/km, noise and local air pollution (Grauers et al., 2013), although recent research finds that the impact

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on SO_2 emissions depend on the power grid used to charge the vehicle batteries (Nichols et al., 2015). Considering that 80% of increases in CO_2 emissions the past 45 years have come from road transport (Sims et al., 2014), broad scale global introduction of electromobility is considered an important measure for reducing greenhouse gas emissions from the transport sector (U.S. Department of Energy, 2015; WWF, 2012).

Norway has become a global forerunner in the field of electromobility, particularly when it comes to use of BEVs. Seventy thousand BEVs are registered in Norway (gronnbil.no/en), accounting for approximately 18% of new car sales in 2015. This BEV market share is far higher than in any other country in the world (ICCT Europe, 2014). One likely reason for this relatively high market penetration is strong incentives for promoting purchase and ownership of BEVs. Due to a comprehensive incentive package for BEVs the purchase price for a BEV is more or less equal to the price of a comparable ICEV. On top of the purchase price incentives there are also incentives making the EV more convenient and cost-efficient in daily use.

The apparent success of incentive policies for increasing sales of BEVs makes Norway an interesting case to learn from for other regions who aim in the same direction. Also, the diversity of incentives allows for discerning which strategies are likely to be the most successful in order to achieve higher market shares of any type of EVs. Also, as pointed out by Plötz et al. (2014), successful market strategies and policies depend on knowledge about what are the characteristics and needs of early adopters.

In line with this, the purpose of this study is to describe the role of incentives for promoting BEVs: *what incentives are critical for deciding to buy a BEV and what groups of buyers respond to different types of incentives?* The questions are answered with data from a survey among nearly 3400 BEV owners in Norway.

EVs in Norway

The last few years the growth rate of EVs in Norway has been formidable. Fig. 1 shows the cumulated number of registered EVs in Norway between 2009 and the first quarter of 2015. Numbers are gathered from the project Green Car (http://www.gronnbil.no/en/). The figure shows that from a total BEV and PHEV fleet of barely 10,000 registered vehicles in 2012, the number has risen to more than 50,000 BEVs and PHEVs in 2015. This brings the share of BEVs in the Norwegian passenger car fleet to nearly 2%. Naturally, the BEV models which dominate the market have changed significantly over this period: while the Think and Buddy comprised more than half of all EVs in 2009 and 2010, contemporary users tend to favor Nissan (39% market share in 2014) and high-end models such as Tesla (15% market share).

The majority of EVs in Norway are privately owned, and statistics from *Green Car* show that by the end of 2014 81% of EVs were owned by private households. The real number is expected to be even higher, as a substantial share of company owned vehicles are owned by one-man companies.

Research on EV adoption and incentives

EV adoption

Technology adoption is typically described by attributes of the technology or attributes of the adopter. Such explanations are heavily influenced by innovation diffusion theory (IDT) (Rogers, 1962) and subsequent extensions (such as the TOE framework, see Tornatzky and Fleischer, 1990). They often emphasize the adopter's perception of new technologies, related to performance expectancy (usefulness), effort expectancy (ease of use), social influence and facilitating conditions (Venkatesh and Davis, 2000; Venkatesh et al., 2003). These attributes are also prominent in research on EV adoption.

There has been a considerable increase in research on EVs and adoption the last few years. In a recent study, Rezvani et al. (2015) reviewed 16 studies on adoption of BEVs (normal and extended range) and PHEVs in the period 2011–2014. A relevant review is also provided by Hjorthol (2013). Most studies on EV adoption are concerned with technological factors as well as individual/social factors which influence the likelihood of EV adoption. Sierzchula et al. (2014) distinguish between three sets of factors which influence EV adoption: technological aspects, consumer characteristics and context factors, such as fuel prices, electricity costs and availability of charging stations.

Attributions of technology typically revolve around battery specifications (Lieven et al., 2011; Carley et al., 2013; Graham-Rowe et al., 2012), noise (Skippon and Garwood, 2011), emissions (Krupa et al., 2014; Jensen et al., 2013; Peters and Dütschke, 2014), practicality/reliability (Schuitema et al., 2013) and design (Burgess et al., 2013).

Consumer characteristics are typically found to be less important than technological aspects (Sierzchula et al., 2014). Such factors include lifestyle orientations (Axsen et al., 2012; Lane and Potter, 2007), social norms (Caperello et al., 2013; Moons and Pelsmacker, 2012), environmental beliefs (Carley et al., 2013; Egbue and Long, 2012; Krupa et al., 2014) and socio-economic characteristics (Zhang et al., 2011). Although the number of studies trying to identify early adopters of EVs is limited, certain characteristics are often repeated. Studies find that the likelihood of buying an EV is greater in men (Plötz et al., 2014), young or middle-aged (Hidrue et al., 2011; Plötz et al., 2014), educated (Hidrue et al., 2011), affluent (Curtin et al., 2009; Ozaki and Sevastyanova, 2011) and persons from multi-car households (Gärling and Thøgersen, 2001; Graham-Rowe et al., 2012).

Most of the above studies, however, focus on *potential* users or buyers of EVs, and do to little extent describe *actual* EV users or owners. A handful of qualitative studies with in-depth interviews of BEV users in France (Pierre et al., 2011),

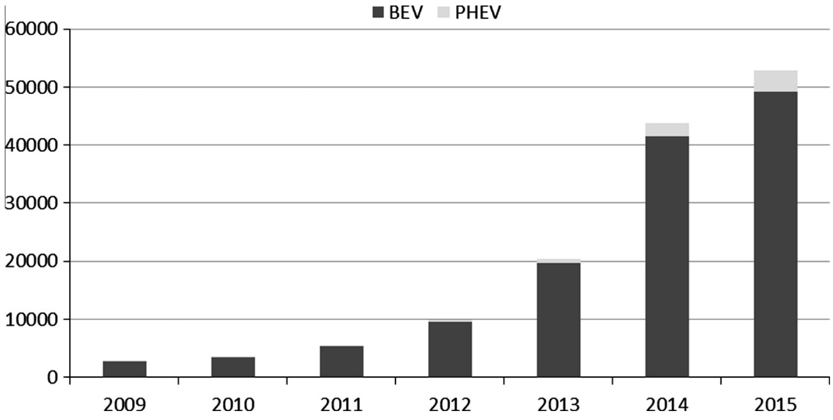

Fig. 1. Number of registered BEVs and PHEVs in Norway 2009–2015 (Q1).

Germany (Cocron et al., 2011) and the UK (Graham-Rowe et al., 2012) investigate the users' experiences with the vehicles, their feasibility in accommodating everyday needs, and attitudes toward e-mobility. There are hardly any studies which describe populations of BEV users. An early study of travel behavior among Norwegian EV owners found that the typical owner is a man between 30 and 60 years of age, with high education and high income, living in multi-person and multi-car households (Econ Analyse, 2006). These characteristics are also confirmed by more recent studies (Figenbaum et al., 2014), but despite distinctive differences between EV users and users of conventional cars, Norwegian studies show that EV ownership is not more socially skewed than multiple car ownership, regardless of vehicle type (Figenbaum and Kolbenstvedt, 2013).

Incentives for EV adoption

The market share of EVs is generally low across countries. Research has identified a range of barriers contributing to the relatively low competitiveness of EVs, relating to actual costs and cost perceptions, risks, technological conservatism, (unproven) technological performance, unfamiliarity and lack of knowledge (see f.ex. Diamond, 2009; Egbue and Long, 2012; Edison and Geissler, 2003; Lane and Potter, 2007; Sovacool and Hirsh, 2009; Oliver and Oliver, 2010).

In order to overcome barriers toward adoption of EVs many countries and/or regions have developed policies for promoting EV use, and existing literature accounts for incentives implemented in Europe (Kley et al., 2010; Gass et al., 2014; BERR and DfT, 2008), in the US (Lingzhi et al., 2014) and worldwide (Leurent and Windisch, 2011). These apply different categorizations of incentives (see Table 1), but are coherent in their presentations of relevant incentives. Thus there is a general consensus regarding which incentives are considered relevant and appropriate. Predominant incentives relate to tax or other economic benefits such as reduced/exempted parking fee or congestion charges, but in some instances also allow access to bus lanes or car pool lanes.

Most measures for increasing use and adoption of EVs are so-called pull measures, encouraging EV purchase rather than disincentives discouraging use and purchase of ICEs. Naturally incentives favoring EVs will also function as disincentives for ICEs, but as most measures related to EV promotion target EVs explicitly we will in the following refer to them as *incentives*.

Norwegian consumers have since the mid-90s benefited from strong incentives for EV adoption. Most incentives are directed toward BEVs. As Norway, along with Denmark, has the highest purchase taxes on new cars in the world, heavy financial incentives bring the purchase cost of a BEV to the same level as a comparable ICEV. Firstly, BEVs and hydrogen cars are exempted from *vehicle registration tax*, which involves substantial savings. Hybrids are not included in the taxation scheme, but as the tax is based on engine power as well as CO_2 and NO_x emissions the total tax value remains low also for these vehicles. Secondly, BEVs are exempted from *value added tax* (VAT), which in Norway currently is at 25%. These two tax exemptions have a substantial effect on EV purchase costs. Table 2 gives a few examples of purchase costs in 2014 when buying a specific EV model compared to comparable ICE model.

Thirdly, BEVs and hydrogen cars pay the lowest rate of the *vehicle license fee*. This involves lower savings than from the other tax incentives, but they are in return repetitive. Other financial incentives for BEVs in Norway include exemption from road tolling and from paying ticket fees on ferries in most counties, and free parking on municipal public parking for BEVs and hydrogen cars alike. Finally, BEVs have access to bus lanes (a thorough review of Norwegian incentives is provided by Figenbaum and Kolbenstvedt, 2013).

Regarding the transferability of the Norwegian incentives to other countries, some can be adopted fairly straight forward whereas others would need to be adjusted to other circumstances. The financial incentives – exemption from purchase tax, VAT and 80% of the registration tax – are particularly strong incentives due to Norway's high level of vehicle taxation. For countries with lower vehicle taxation the direct adoption of the tax exemption incentive would not yield the same price

Table 1
Categorization of incentives for EV adoption.

Kley et al. (2010)	Lingzhi et al. (2014)	Leurent and Windisch (2011)
Regulatory: impose restrictions on automotive manufacturers, e.g. certain emission targets for new vehicles. These restrictions focus on the inputs, the outputs or define certain required production processes *Examples:* standards in production, obligatory emission targets	**Direct incentives**: direct monetary value to consumers *Examples:* purchase subsidies, license tax/fee reductions, Electric Vehicle Supply Equipment (EVSE) financing, free electricity, free parking, emission test exemptions	**Command and control:** usually in the hands of public authorities and applied at a country wide level. Their effectiveness stems from their legally binding character that mainly obliges EV-system supplying stakeholders to provide products that conform to quality or safety standards
Economic: influence market outcome using quantity or price changes *Examples:* CO_2 certificates, tax reductions, subsidies, scrapping scheme, congestion charges, parking fees	**Indirect incentives**: no direct monetary value to the consumer, but save time and provide convenience *Examples*: high-occupancy vehicle (HOV, i.e. carpool lane) access, emissions testing exemption, time savings, public charger availability	**Economic**: purported to overcome the cost barrier to EV development. Support the development of EV technology or give financial incentives to potential buyers *Examples:* direct investments in R&D or infrastructure, preferential pricing policies, subsidies for EV purchase or EV infrastructure construction and tax incentives for EVs
Suasive: used to persuade buyers and manufacturers by providing information, creating a better administrative landscape or funding R&D programs *Examples:* special labelling, information campaigns, developing standards (e.g. plugs)	**Disincentives**: schemes, regulations etc. with (unintended) negative impacts of EV attractiveness *Example:* annual fee for EV to compensate lost gasoline tax revenue	**Procurement**: aim to push the demand for clean vehicles and enable for scale economies in their production
Organizational: reduce hurdles such as developing the necessary infrastructure or installing supervisory bodies to control market structures *Examples:* charging infrastructure, high occupancy lanes, free parking spots	**Other incentives:** Other approaches to expand the market of EVs *Examples:* Zero Emission Vehicle programs, research and development, insurance discounts and protections, incentives provided by utilities or for EV fleets	**Collaborative**: network management approach by a government, based on the principle that the State should exert a collaborative and managing role in the society and the markets
		Communication and diffusion: informing and educating the public in order to develop their interest for and acceptance of EVs

competitiveness compared to ICE vehicles. However, many countries have (or has had) direct subsidies for purchase of EVs, e.g. France, India, Japan, the Netherlands, Spain and United States (IEA, 2013). In general the incentives in these countries are weaker in strengthening EV price competitiveness than in the Norwegian case. Regarding road tolling, the Norwegian case is not very special. Costs of passage and extensiveness of road tolling systems are comparable to many other countries. EV exemption from road tolling could be made revenue neutral by increasing prices for ICE vehicles in stages reflecting past lost revenue from the free passage of EVs. The same principle applies to free parking and ferry passage, though the latter seldom is relevant in the day-to-day mobility of citizens outside of Norway. Regarding bus lane access, this is a "free" incentive that can be applied as part of a market introduction package in smaller and medium size cities wherever until the number of EVs reaches a level where it becomes a serious obstacle for public transport. With 70,000 vehicles on Norwegian roads, bus lane access for EVs has been restricted only on one road, where it has become mandatory for EVs to have at least one passenger to use the bus lane.

Though the EV incentives seem to have a fairly broad support across the spectrum of political parties, the issue is very much debated and high on the general agenda in Norway. A common criticism is that the EV incentives are subsidies for the most affluent in society. Although studies have shown Norwegian EV owners to have higher education and higher income than the general population and ICE owners (Figenbaum et al., 2014; Econ Analyse, 2006), these studies rarely take into account that most EV owners own new EVs, which suggests that the socio-economic status of EV owners should be compared with owners of *new* ICEVs in terms of socio-economic status.

The role of incentives

Incentives have historically been important for the introduction of alternative fuel vehicles, but are also crucial for the adoption of BEVs as such purchases are considered risky, unfamiliar and expensive compared to ICEVs (Bandhold et al.,

Table 2
Examples of purchase costs with and without exemption from vehicle registration tax and value added tax in 2014. Approximate figures in USD.[a] *Source:* Green Car.

	Without exemption ($)	With exemption ($)	Reduction (%)
Tesla S Performance	140,000	70,000	50
Nissan Leaf	35,000	27,000	20
Volkswagen e-up!	28,000	22,000	21

[a] Complete source: http://www.gronnbil.no/nyhetsarkiv/hvor-mye-ville-egentlig-en-tesla-kostet-med-avgifter-article364-239.html.

2009). The majority of research on incentives for EV adoption relates to financial incentives and taxation. Sierzchula et al. (2014) examine the correlation between financial incentives and EV market shares in 30 countries and find that financial incentives, along with number of charging stations and presence of EV production, are strong and significant predictors for EV adoption. High purchase price is the strongest barrier toward EV purchase (Larson et al., 2014), and several studies find that up-front costs are more heavily emphasized than reductions in variable costs (see for instance Gass et al., 2014; Lingzhi et al., 2014). Brand et al. (2013) explore carbon effects of three fiscal incentives: vehicle purchase taxes, graduated vehicle road taxes and scrappage schemes. They suggest that governments design incentive schemes with strong up-front price signals as car purchases tax and feebate[3] policies are most effective in accelerating low-carbon technology uptake. Bakker and Trip (2013) report results from a workshop where experts from five European countries rate 10 policy measures for EV adoption according to effectiveness, efficiency and feasibility. The experts' cumulative ratings place exemption from road tolling or congestion charging in the middle-bracket in terms of effectiveness, while access to bus lanes is found at the bottom of the list. They do not consider, however, the most prominent economic incentives such as purchase taxes and circulation taxes.

The majority of studies investigating incentives for EV adoption are concerned with hybrid-electric vehicles (HEV), and several studies have confirmed the positive effect of tax incentives on sales of HEV (Sallee, 2011; Beresteanu and Li, 2011; Gallagher and Muehlegger, 2011; Eppstein et al., 2011). Diamond (2009) finds that government incentives on HEVs cause significant changes in market share in a selection of American states, and that purchase or tax waivers have stronger effect than rebates or tax credits. Gallagher and Muehlegger (2011) suggest that waivers on purchase taxes are three times more effective on sales than income tax credits. Further, Kley et al. (2010) make an assessment of eight price instruments based on a literature of experience with hybrids or similar support schemes for other technologies. In line with other research, they describe tax reduction and subsidies as more attractive if received at the time of purchase, but they also argue that the dissimilar cost distribution between HEVs and BEVs make up-front initiatives more relevant to BEV buyers. They further examine support schemes across Europe and find that, despite incentives, EVs are still unattractive in every country compared to ICEs. The exceptions are Norway and Denmark, where ICE taxes are significantly higher than in other countries.

An early Norwegian study had EV owners rate the importance of selected incentives for their choice of purchasing an EV (Econ Analyse, 2006). Exemption from road tolling, vehicle license fee reduction and reduced purchase costs were considered most important. The authors state that a prominent challenge with such studies is to uncover the actual significance of incentives, as EV owners might state that all incentives are important in fear of losing benefits even though their impacts on own adoption is limited.

Data and methods

This study investigates the role of incentives in promoting BEV ownership in Norway. The study is based on a member survey of the Norwegian EV association. An invitation was sent to their 11,000 members in June 2014. A total of 3405 respondents replied, giving a response rate of 31%. The respondents corresponded to 12% of the EV owners in Norway at the time. Upon purchasing an EV in Norway most purchasers are awarded a one-year membership in the EV association, and thus the sample does not merely exist of the most dedicated enthusiasts. Given that over half the sample purchased their BEV within the last years, it can be expected to represent a wide specter of purchasers.

The sample mostly includes owners of BEVs (99.5%), and given the characteristics of Norwegian incentives (P) HEV owners (0.5%) are omitted from the analyses. The sample is presented in Table 2.

With Norway as the exception, EVs are still more expensive than ICEVs. Due to this, the international literature (Campbell et al., 2012; Plötz et al., 2014; Curtin et al., 2009) on potential EV buyers seem to take it for granted that early buyers are very likely to have a socio-economic status well above average. The Norwegian case might be different in this respect. Thus, Table 3 also presents characteristics of the Norwegian population of users of new cars, as documented by the National Travel Survey of 2013/14. Considering the sharp increase in BEV purchases the last few years, the overall age of the Norwegian BEV fleet is relatively low. A total of 60% of BEV owners have purchased their BEV within the last year, and a cumulated 75% within the last two years. Thus, Table 2 provides a comparison of EV users and car users with cars less than 3 years old.

The table shows that the EV sample is dominated by men, age group 36–55 years, persons with college/university degree, high personal income and living in the capital area where the pressure on the transport system is particularly large. As such, the composition of this EV user group is similar to characteristics of EV users presented in earlier research, also when compared to owners of new ICEVs.

This study investigates the role of 7 different incentives: exemption from purchase tax, exemption from VAT, vehicle license fee reduction, exemption from road tolling, free parking, bus lane access and free ferry tickets. Although recognized as very important, recharging infrastructure is not included here. One reason is that no variable in the data indicates whether recharging infrastructure is critical for purchase. Another is that a majority of Norwegians (approx. 73%) live in row houses, family homes, detached and semi-detached houses (Statistics Norway, 2014), where there is normally in-house opportunity for charging EVs. As such, public infrastructure for normal charging is less crucial than in many other countries. High-speed charging might be more relevant, but is not specified in the data.

[3] A feebate is a combination of a vehicle purchase tax/fee and a rebate/subsidy which rewards buyers of fuel efficient vehicles and penalize buyers of less fuel efficient vehicles (Brand et al., 2013; Gallagher and Muehlegger, 2011).

Table 3
Sample (n = 3384) and population of new car (2012–2014 model) users (n = 10,281).

	EV users (%)	New car users (%)
Gender		
Male	81	54
Female	19	46
Age		
18–25 yrs	1	7
26–35 yrs	18	13
36–45 yrs	34	22
46–55 yrs	27	22
Older than 55 yrs	20	37
Education		
Elementary education	3	6
Secondary education	21	36
College/university	76	59
Personal income		
<400′ NOK	10	33
401′-550′ NOK	27	27
551′-700′ NOK	22	14
701′-850′ NOK	16	7
851′-999′ NOK	10	3
>999′ NOK	15	16
Cars in household (avg.)	1.87	1.78
Region		
Capital area	38	23
Eastern interior	3	7
Eastern Norway	16	22
Southern Norway	5	6
Western Norway	28	28
Central Norway	9	8
Northern Norway	2	6

The first research question of this study is *what incentives are critical for deciding to buy a BEV*. The *role of incentives* is measured by two sets of questions. The first set consists of respondents' rating incentives on a scale from 1 = *not important* to 10 = *very important*. The second set asks respondents whether they today would have purchased a BEV if a given incentive was *not* in place. In investigating the value of different incentives, all incentives are treated separately.

The second research question of this study is *and what groups of buyers respond to different types of incentives?* These groups are in the following labelled "target groups". In exploring potential *target groups* incentives are categorized into three groups of incentives: reduction of fixed costs (RFC), reduction of use costs (RUC) and priority to infrastructure (bus lane) (PRI). This categorization is the result of factor analysis for eigenvalues greater than 1 suggesting three components (see Table 4).

A target group refers to a group of respondents which responds to a particular incentive group. Respondents are assigned to an incentive group if their importance rating of one of the incentives belonging to that group is within the 3rd quartile (cut-off-point) of that incentive. The cut-off points for the individual incentives are described in Table 5. In order to make a clear distinction between potential target groups, respondents who do not belong to either incentive group (n = 722) and respondents who belong to more than one group (n = 817) are omitted from analysis. The sample for analyzing target groups thus consists of 1845 respondents with the following distribution between groups: RFC n = 1391, RUC n = 91, and PRI n = 363. This constitutes 54% of the sample and approximately 6% of the population of Norwegian EV owners.

In order to identify which BEV owners respond to different types of incentives, logistic regressions are performed. Dependent variables in the regression analyses are belonging to incentive group (i) reduced fixed costs, (ii) reduced use costs and (iii) priority. Independent variables include gender, age, education, personal income, place of residency, and recent ownership (owned BEV less than one year). Finally, Tesla ownership is included as a proxy for purchase budget.

Results

Critical incentives

Fig. 2 shows how respondents rate the importance of incentives for purchasing a BEV (diamonds) and percentage of respondents stating that purchasing a BEV depends on a specific incentive (columns). The figure shows that there are small differences in the respondents' rating of incentives, but the role of different incentives is more distinguished when considering which incentives are more critical for purchasing a BEV today: exemptions from purchase tax and VAT are decisive for

Table 4
Component matrix for factor analysis.

Rotated Component Matrix	Component		
	1	2	3
Ex. VAT	.678	.001	−,113
Ex. purchase tax	.732	−.066	.002
Vehicle license fee reduction	.521	.261	.202
Free parking	−.018	.690	.216
Free ferry ticket	−.091	.710	−.190
Ex. Road tolling	.259	.459	−.020
Access bus lane	−.013	−.017	.944

The gray shade values indicate the components included in each incentive group.

Table 5
Cumulative percentage and cut-off points for separate incentives.

		Reduction fixed costs			Reduction use costs			Priority
		Ex. VAT	Ex. purchase tax	Red. vehicle license fee	Free parking	Free ferry	Ex. road tolling	Bus lane access
Importance (1 = not important, 10 = very important) important=	1	9	8.2	14.1	9.1	4.6	11.2	7.3
	2	27.3	24.8	21.4	14.9	8.6	21.7	12.8
	3	34.3	32.8	26.6	22.2	45.6	27.9	36.6
	4	39	36.4	30.9	29.6	56.2	31.6	48
	5	42.7	40.5	38.4	42.3	65.3	38.5	56.9
	6	46.5	43.7	46.7	55.2	71.3	45.6	64
	7	49.6	47.6	56.3	67.5	77	54	70.2
	8	55.2	53.1	70.9	82.6	84.9	66.9	80.1
	9	60.7	58.4	83	91.1	89.6	77.7	86.5
	10	100	100	100	100	100	100	100

The gray shade values indicate cut-off points for being included in the target group.

more than 80% of the respondents. This is very much in line with previous research, which suggests that up-front price reduction is the most powerful incentive in promoting EV adoption. This data further show that exemption from road tolling and reducing the vehicle license are critical to half of the sample, whereas the remaining incentives are critical for more particular groups. As discussed earlier, recharging infrastructure is not included in the analyses. Data shows, however, that recharging infrastructure has a lower importance rating (mean 4.52) than all of the included incentives.

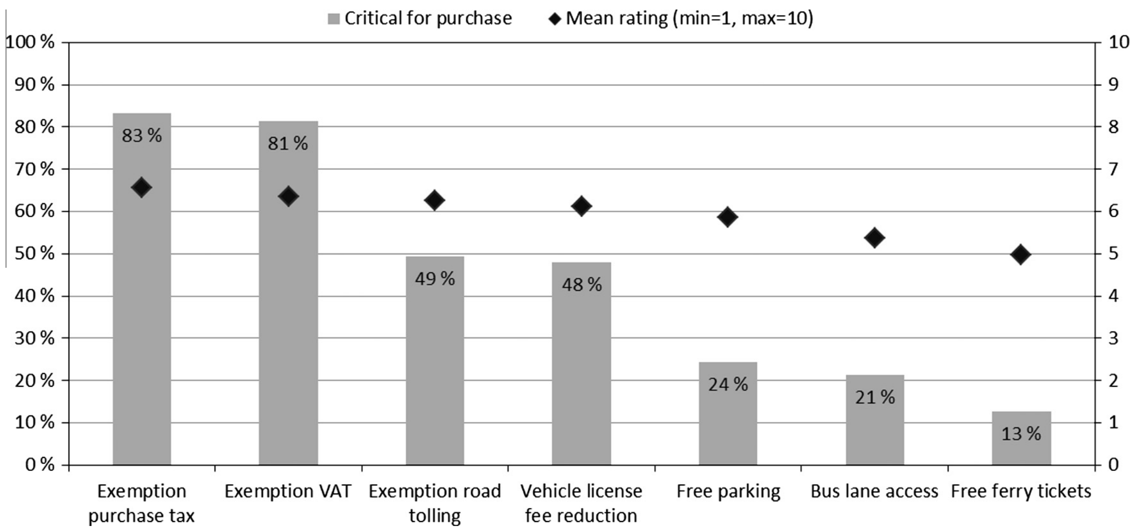

Fig. 2. Role of incentives for BEV purchase ($N = 3384$).

Table 6
Number of critical incentives (n = 3384).

No of incentives	n	Percent	Cumulative (%)
0	551	16	16
1	282	8	25
2	728	22	46
3	629	19	65
4	520	15	80
5	332	10	90
6	183	5	95
7	159	5	100

As suggested by previous research (Econ Analyse, 2006) respondents might in fear of losing their benefits overrate the actual importance of incentives, resulting in small rating differences between incentives. Table 6 shows how many critical incentives respondents have reported. To 16% of the respondents, none of these incentives are critical for purchasing a BEV today. Conversely, 5% state that all incentives need to be present should they buy a BEV. The average number of critical incentives is 2.98, and more than half of the respondents would purchase a BEV with 3 incentives or less.

The perhaps most interesting group is the one stating there is one, single incentive which persuades them to purchase a BEV. This group is found in the far left column of Fig. 3. The overall less prominent incentives, such as bus lane access and tolling exemption, are located here. Although exemption from purchase tax still dominates, exemption from road tolling and bus lane access are to a substantial number of BEV owners the only decisive factor. Considering the marginal role of these incentives in other groups, they are not effective in broad recruitment of BEV users but could very well be the tip of the scale for potential BEV buyers not perceptive to normally critical economic incentives.

Conversely, the dominant role of purchase price reductions is manifested in representing critical combinations of incentives. This is confirmed by Table 7, which shows the prevalence of combinations of two critical incentives. In total 66% of the respondents state that a combined exemption from both purchase tax and VAT is critical.

Potential target groups

As described earlier, factor analysis suggests that incentives can be categorized into three groups: (i) reduced fixed costs (RFC), (ii) reduced use costs (RUC), and (iii) infrastructure priority (bus lane access) (PRI).

Table 8 shows results from logistic regression on belonging to the incentive groups. For one, the model shows that responding to RFC incentives is more likely among men, respondents above 45 years of age, Tesla owners and respondents having bought their BEV within the last year. Further, the primary target group of such incentives lives outside the city of Oslo and its neighboring communities. Interestingly, income levels do not significantly predict belonging to this target group, suggesting that these incentives are important in increasing BEV adoption in all income groups. These tendencies are substantiated when examining open-ended responses to why respondents have bought a BEV. Respondents typically reply that incentives allow them to get more value for money: on a fixed budget, RFC incentives allow for purchasing a vehicle normally outside their price range. This is particularly the case for Tesla owners.

Secondly, the regression model shows that incentives which reduce use costs (RUC) are more likely to influence respondents with a college/university degree, lower income groups and respondents living in or near the city of Trondheim. Thirdly, the model shows that responding to priority incentives (access to bus lanes) is more likely in respondents with an elementary education and respondents living in neighboring communities to Oslo. Conversely, less probable target groups are men, respondents above 45 years of age, respondents with low incomes, Tesla owners and respondents having bought their BEV within the last year.

The regression model show interesting results, but the explanatory power of the models is low. The r^r value range between 4.2 and 16.1, meaning that there are other important factors not accounted for in the current survey as to explaining why people buy electric vehicles.

Discussion

The purpose of this study has been to explore what incentives are critical for deciding to buy a BEV and what groups of buyers respond to different types of incentives. In line with previous research, this study finds purchase cost reduction to be the strongest incentive in promoting BEV adoption. These incentives are prominent among most BEV users and fairly undebated because they strongly increase the market competitiveness of BEVs.

However, there are certain exceptions from the general appraisal of these incentives. Interestingly, to some BEV users, less prominent incentives such as bus lane access and road tolling exemptions are the only decisive incentive. Considering the generally marginal role of these incentives, they cannot be considered effective in broad recruitment of BEV users, but could very well be the tip of the scale for potential BEV buyers not perceptive to normally critical economic incentives. This is substantiated by logistic regression findings. Residents in Trondheim, where road tolling is extensive, are particularly prone to

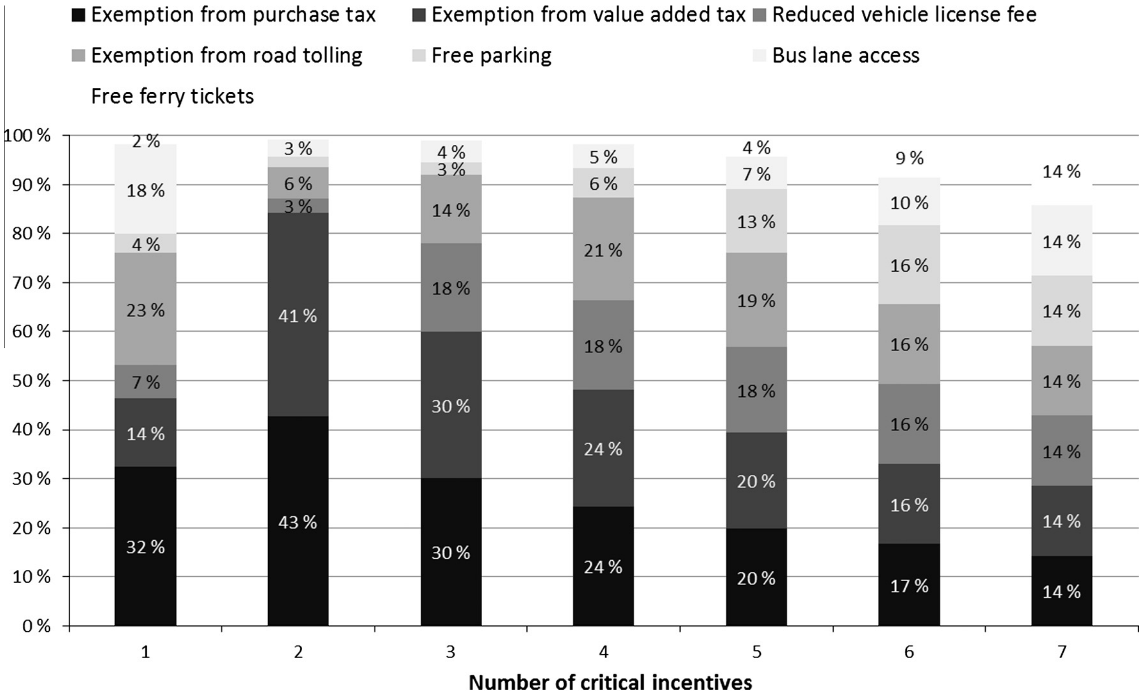

Fig. 3. Prevalence of critical incentives in groups with low and high incentive demand ($N = 3384$).

Table 7
Percentage of respondents with combinations of two critical incentives ($N = 3384$).

	Ex.purchase tax (%)	Ex. value added tax (%)	Red. veh. license fee (%)	Ex. road tolling (%)	Free parking (%)	Bus lane access (%)	Free ferry tickets (%)
Ex. purchase tax	.	66	39	38	20	16	11
Ex. value added tax	66	.	38	38	20	16	11
Red. vehicle license fee	39	38	.	29	17	12	9
Ex. road tolling	38	38	29	.	20	13	11
Free parking	20	20	17	20	.	10	9
Bus lane access	16	16	12	13	10	.	6
Free ferry tickets	11	11	9	11	9	6	.

incentives which reduce use costs. Road tolling is widespread in Norway and one could expect greater emphasis on use costs reductions also in other cities where road tolling is implemented.

However, as the road tolling system in Trondheim was recently reestablished and expanded, it has been subject to extensive local debate which might have expedited BEV purchases. In 2014, 16 additional road tolling stations in the city were established, and according to statistics from the Green Car project (www.gronnbil.no/en) the BEV fleet in Trondheim more than doubled (from 924 BEVs to 2065) from the year before. A strong increase was also seen nationally, but not as pronounced as in Trondheim. As such, the combination of extensive road tolling and exemptions for BEVs has proved quite effective in promoting BEV adoption.

Unsurprisingly, priority through bus lane access is particularly critical for respondents living in neighboring communities to Oslo. Considering heavy rush-hour traffic to and from Oslo, bus lane access provide significant time savings for commuters, and the extensive presence of BEVs in bus lanes on major roads has caused intense political debate about removing BEV access because it delays public transport. This might also explain the low importance Oslo neighbors place on reductions in fixed costs.

The role of geographic premises inherent in incentives could be considered an expression of the challenges experienced in a particular transport system and the policy instruments implemented. Incentives that are successful in promoting BEV adoption thus contribute to ease inconveniences that these challenges and/or instruments represent in a particular local transport system. This calls for strong local management of such incentives, and cooperation between neighboring municipalities in finding the right incentives.

A prominent argument in debates on BEV incentives is that they favor already affluent motorists. This is partly rejected by this study, largely because heavy purchase cost reductions provide BEV alternatives to ICEVs almost regardless of budget

Table 8
Logistic regression models. Dependent variables: belonging to incentive group reduced fixed costs ($n = 1733$, $r^2 = 10.0/16.1$) reduction use costs ($n = 1665$, $r^2 = 4.02/13.1$) and priority ($n = 1648$, $r^2 = 8.0/12.9$).

	Reduced fixed costs B [Exp(b)]	Reduced use costs B [Exp(b)]	Priority B [Exp(b)]
Male	0.641*** [1.898]	–	−0.613*** [0.543]
Age 46–55	0.469** [1.584]	–	−0.446* [0.64]
Age above 55	0.340** [1.495]	–	−0.33** [0.714]
Elementary education	−0.536 [0.5859]	–	0.764 [2.147]
College/University	–	0.659** [1.933]	–
Personal income less than 400 k	–	1.175*** [3.237]	−0.477* [0.62]
Personal income 401–550 k	–	0.66* [1.935]	–
Recent owner (less than 1 year)	0.594*** [1.812]	–	−0.556*** [0.573]
Neighboring community to Oslo	−1.027 [0.358]	–	1.062*** [2.891]
Trondheim	–	1.191** [3.289]	–
Owns Tesla	0.893*** [2.442]	−1.518*** [0.219]	−0.761*** [0.467]
No critical purchase incentive	−0.615*** [0.541]	1.041*** [0.254]	0.358*** [1.43]
Constant	*0.105* [1.111]	*−3.823*** [0.022]	*−0.454** [0.635]

*** $p < .001$.
** $p < .01$.
* $p < .05$.

size. The logistic regression of reduced fixed costs suggests that these incentives are important in increasing BEV adoption in all income groups. These tendencies are substantiated when examining open-ended responses to why respondents have bought a BEV. Respondents typically reply that incentives allow them to get more value for money. This could imply that, on a given budget, RFC incentives allow for purchasing a car normally outside the respondents' price range. This could particularly be the case for Tesla owners and explain the high BEV market share (16%) of that particular brand. It might also partly explain why men are more susceptible to RFC incentives: Norwegian consumer surveys shows men's car purchase budgets to be higher than women's (Pedersen, 2005), consequently increasing the value of fixed cost reductions.

Income levels do matter, however, when it comes to use costs. When purchase costs of a BEV and an ICEV are similar, low income groups might more than other groups favor the alternative which also reduces use costs. For instance, using Tesla ownership as a proxy of purchase budget, the low probability of Tesla owners valuing use costs could be an indication that buyers of more costly BEVs are less prone to respond to that kind of economic incentive.

As respondents who are more indifferent to incentives are not included in the regression analyses, the analyses can be considered a comparison of respondents with high valuation of the different incentive groups. As such, Table 6 clearly shows that the incentive groups hold distinct characteristics: for instance do variables related to gender, age and education hold opposite signs in the RFC and priority group. Similar tendencies are found for the other variables. This proves the distinction between these three groups to be appropriate.

The results also indicate certain qualitative differences between the incentive groups. The interesting group of respondents which report no critical incentives is less prone to RFC incentives, but more likely to respond to RUC and priority. Their position in the analyses presented in Table 6 can indicate that although neither incentive is critical for their purchase, they have grown accustomed to and appreciative of incentives influencing everyday travel and use. As such, instead of regarding both RFC and RUC as economic incentives, RUC could be considered an incentive for simplifying travel and parking, hence reducing impracticalities related to travels. In that regard, RUC incentives bear more similarities to priority incentives, which clearly contribute to facilitate mobility.

Despite the expected and logical results of this study, the regression analyses hold low explanatory power. One explanation might be in line with technology adoption theory arguing the importance of attitudinal variables such as environmental beliefs. One could, for instance, expect BEV users with low environmental awareness and concern, or a low sense of altruism, to value incentives higher than other respondents. This might particularly be the case for RFC, as these provide great savings when purchasing a car, but this is not possible to explore with the survey data at hand. In general, data should be supplemented with variables which indicate other motivations for purchasing a BEV which might increase the explained variation, such as technological interest, the qualities of EVs, political correctness and status related to being an early adopter.

However, as the regression analyses only include respondents with high valuation of a certain incentive group, the effect of including attitudinal variables cannot be expected to be more than moderate at best.

Further, the data largely consist of recent BEV owners (60% purchased within the last year), and as the regression analysis shows, this group values incentives differently from more experienced users. This implies that more diverse data in terms of experience might provide different results.

Another plausible explanation for the low explanatory power is that it is simply difficult to identify general patterns among respondents. As exemplified through use of road tolling exemption and bus lane access above, the individual respondents' choices and the influence of the incentives on the individual depend on his or her particular needs related to daily transport. For instance, to commuters taking the ferry to and from work every day, free ferry tickets might be the tip of scale for purchasing a BEV. However, these particular respondents are not possible to identify in the material, and if they were, they would be too few to provide any statistical contribution to the analyses. That does not mean, however, that free ferry tickets are insufficient incentives, but rather that quantitative data, although valuable in revealing the broad picture, are insufficient to capture the complexity of factors which underlie decision making and thus the full value of public incentives for EV adoption.

Conclusion

The purpose of this study has been to describe the role of Norwegian incentives for promoting BEVs. For one, it has investigated what incentives are critical for deciding to buy a BEV. In line with previous research, Norwegian BEV owners particularly emphasize the significance of incentives for reducing purchase costs: exemption from VAT and purchase taxes.

The study also examines BEV users which respond to three categories of incentives: (i) reduced fixed costs, (ii) reduced use costs and (iii) priority to infrastructure. Analyses show that there are clear delineations between incentive groups, both in terms of age, gender, and education. Income is a less prominent predictor, which probably results from the competitive price of BEVs in the Norwegian market. Perhaps most interesting is the assumed relation between incentives and character of transport systems the respondents engage in. Although these are mere musings on the part of the authors, the low explanatory power of the models presented here indicates the need for richer data, and perhaps more qualitative data, in order to capture the full complexity of factors which underlie EV adoption and the role of different public incentives.

Nonetheless, this study is one of few which investigate the role of incentives based on data with a diverse group of BEV users from a market with relatively high BEV penetration. The rapidly growing research literature on EV adoption greatly recognizes the need to identify barriers and potential incentives for promoting EVs. Existing research is largely concerned, however, with hybrid electric vehicles (HEVs) and mostly relate to *potential* EV users. As such, this study provides valuable insight into mechanisms which have been very efficient for promoting BEVs in Norway and which are relevant for facilitating increased market shares of EVs worldwide.

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