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ORIGINAL PAPER

E-mobility in agriculture: differences in perception between experienced and non-experienced electric vehicle users

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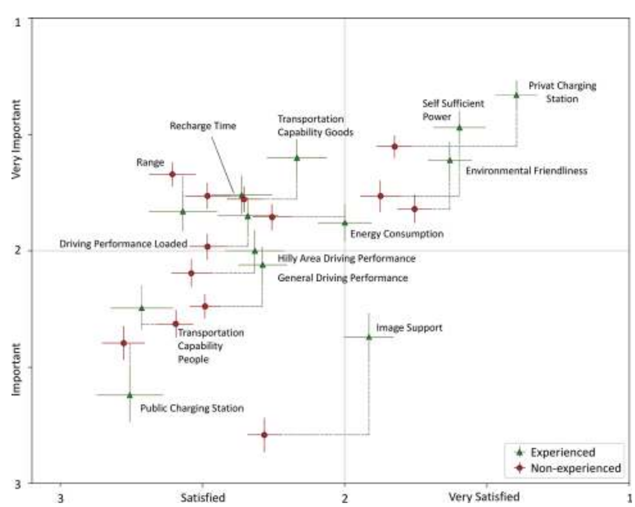
Abstract

A growing population and the impact of climate change represent clear challenges for the agricultural sector. Adapting agricultural machinery, e.g., raising the use of electric vehicles (EVs), is one way of meeting such challenges. Although interest in EVs and sustainable farming is becoming ever stronger, in practice the usage of EVs still remains at a relatively low level. As EV experience is key in deciding for or against e-mobility, the present paper focuses on the differences in perceptions between experienced and non-experienced electric vehicle users. The present study was conducted in the course of a pilot project on e-mobility in rural Austrian regions. Three hundred and thirty-four farmers were asked to assess the performance of 13 attributes regarding e-cars and agricultural EVs. While none of the selected attributes were deemed unimportant, there were clear differences in perceptions between those with and without EV experience. For example, farmers with experience were more satisfied with the performance of current EVs than those without experience. Availability of a private charging station for agricultural EVs is seen as important by both groups, but experienced farmers rate the respective importance, and also satisfaction with private charging stations significantly higher than farmers without experience. The results show that specific policy adaptations have to be made in order to increase the acceptance of EVs in the agriculture sector.

Graphical abstract



Keywords E-mobility · Agriculture · Importance–performance analysis · Perception gap

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Extended author information available on the last page of the article

Introduction

Demands for decarbonization represent a major environmental challenge in today's fossil fuels-based economies. The transportation and agriculture sectors are important in this respect as their current energy and carbon intensity is far beyond sustainable levels (Caetano et al. 2017).

Electric mobility (e-mobility) is thus a topic of growing interest between consumers and policy makers. E-mobility, despite the related challenges, is seen as a promising way of reducing the carbon intensity of transport systems (Majumdar et al. 2015; Teixeira et al. 2015). Assuming the electricity system is based on a high share of renewables (Ajanovic and Haas 2016), electric vehicles (EVs) contribute not only to improvements in local air quality, but also to a reduction in greenhouse gas (GHG) emissions. Thus, electric vehicles are seen as one means of contributing to sustainable transport systems. Despite a long-standing consensus that the automobile is the least favorable option for sustainable urban transport, it appears that powerful (industrial) actors continue to manipulate public discussion on sustainable transport policy (Schwedes et al. 2013) and that incumbent actors are able to ensure (often with the support of local, regional, or national authorities) that nominally *transformative* projects are actually only projects which are designed to reflect short- and medium-term commercial interests (Späth et al. 2016). From a *rational* policy perspective, e-mobility is of course just one item in a complex puzzle (Ajanovic and Haas 2016). For example, Augenstein (2015) argues that systemic change toward electric vehicles will only be successful when the current dominance of systemic support of individual mobility and fossil fuels is broken. Although several European countries have put EV policies into practice, and their short-term success appears to be quite feasible (van der Steen et al. 2015), it still seems unlikely that current policies will be sufficient to achieve long-term goals (i.e., significant shares of e-mobility, or the dominance of e-mobility over the internal combustion engine).

From a usability perspective, e-mobility has made significant advances over the past years. Based on a study of driving patterns in two Italian provinces, de Gennaro et al. (2014) conclude that approximately one-fourth of the urban fleet could be replaced by electric cars (i.e., the share of the fleet for which range limitations are not relevant at all) and that EVs are already capable of covering a large share of the (non-commercial) mobility demand in the urban areas, which currently is covered by conventional vehicles. Thus, the target of 50% EVs in urban areas could already be achieved by relatively minor modal shifts. Similarly, Cellina et al. (2016) in a pilot study undertaken in a Swiss province found significant substitution potential for EVs even though EV range and initial cost remain major barriers.

Adoption of electric vehicles

Whether consumers are willing to adopt EVs is dependent on several factors, and several studies examined drivers for and barriers against consumer adoption of EVs (Rezvani et al. 2015). For example, Krupa et al. (2014) analyzed factors influencing the potential for plug-in hybrid electric vehicles (PHEV) and found that respondents were more likely to buy PHEV when they reported reducing GHG emissions as an important target. However, in their study potential fuel cost savings were scored as more important than cutting GHG emissions (Krupa et al. 2014). Rezvani et al. (2015) conducted a review of 16 empirical studies focusing on consumer adoption of EVs. They split their results into technical factors (e.g., performance, speed, safety, environmental attributes, recharging time, range), contextual factors (e.g., charging infrastructure, visible charging stations in public, tax incentives, manufacturer rebates), cost factors (e.g., purchase cost, running cost, potential fuel costs saving, long payback time), and individual and social factors (e.g., pro-environmental lifestyle, education, gender, age, hands-on experience with EVs). They identified the range limitation and charging behavior as influencing factor against the adoption of EVs. Other than that, attitudinal factors, knowledge and opportunities, social norms, or a neighbor effect can be influencing concerning the adoption of EVs (Kahn 2007; Lane and Potter 2007; Moons and de Pelsmacker 2012; Rezvani et al. 2015).

Egbue et al. (2017) applied a logistic regression to predict how individuals with engineering and technology background differ in EV adoption compared with the general population. Among other factors, their results suggest that the perceptions of electric vehicles with regard to environment friendliness and speed are significant for the respondents' willingness to purchase an EV. In another study, Egbue and Long (2012) used a Chi-square test to identify differences in perception and attitudes about EVs and found that people who are considered as technical affine are more likely to be early adopters of EVs, if EVs surpass conventional vehicles in terms of performance.

The most sensitive target group with respect to alternative fuel vehicles includes the younger, well-educated, and environmentally aware car buyers who mainly undertake urban trips and can plug in their car at home (Hackbarth and Madlener 2013). However, one still needs to remember that current early adopters of EVs are by no means a homogeneous group, for example, low-end and high-end adopters differ considerably (Hardman et al. 2016). The different characteristics of early adopters need to be analyzed in order to carefully design EV campaigns and to prevent information deficiencies and misperceptions (Vassileva and Madlener 2017).

In the studies mentioned above, the focus was on EV diffusion in urban areas. However, several attempts have also been made to examine the diffusion of EVs in rural regions, e.g., a pilot project in the rural area of Bremen/Oldenburg in Germany (Fornahl and Wernern 2015) found that 80% of conventional vehicles could be replaced by EVs by 2020 (including replacement by hybrid cars).

Influence of experience on perception

Experience of EVs is known to be a major factor in determining consumer behavior and has already been investigated in several studies (Bühler et al. 2014; Bunce et al. 2014; Jensen et al. 2013; Johnson and Lehmann 1997; Peters and Dütschke 2014). Hands-on experience with EVs can change the individual preferences and attitudes in a positive way (Jensen et al. 2013; Rezvani et al. 2015). This was shown in a two-wave stated preference experiment by Jensen et al. (2013), where the respondents had to state their choices before and after a three-month test period. Bühler et al. (2014) examined how the current state of EV technology is perceived by a sample of early adopters and how experience influences their evaluation. They used a six-month field trial, acquiring data from 79 participants using EVs in the Berlin area and identified changes in attitude and behavior through EV experience by applying repeated measurements within a six-month field trial.[1] According to their study, experience can significantly change perceptions with respect to EVs. Bunce et al. (2014) investigated responses concerning the recharging of plug-in EV batteries among drivers in the UK. One hundred and thirty-five participants were interviewed in order to compare their attitudes and experiences prevailing before they obtained their EV and with those after they had been driving the EV for three months. The results of their study demonstrated that drivers became more relaxed over time about the frequency of recharging. Finally, their study found an interesting difference in drivers' awareness concerning the environmental impacts of driving and recharging an EV before and after gaining EV experience. Peters and Dütschke (2014) analyzed four groups of respondents in order to find differences in their perception of EVs. They used multivariate analyses for analyzing if the groups differ in rating EVs and univariate analysis to depict if the use intention decreases when the interest in EV is lower. Their results show that experienced users are willing to pay more for an EV and the attributes are rated more positively than users with less experience. These examples show that the level of EV experience influences user perceptions regarding e-mobility satisfaction and performance.

[1] The Van der Laan Acceptance Scale was used for measuring the satisfaction and usefulness of EVs.

Research objective

Apart from its impact on public and private transportation, e-mobility might also become relevant in agriculture.

The present paper aims to shed light on the topic of EV utilization in agriculture by considering the respective perceptions of experienced and non-experienced user groups. For this purpose, farmers were asked about the importance and perception of EV attributes. The identified perception gap of experienced and unexperienced EV users provides important insights for future EV campaigns within the agricultural sector. The novelty of the present study lies in the fact that, in contrast to previous studies (Bühler et al. 2014; Bunce et al. 2014), which used a single-sample approach, this study applied a two-sample approach, including respondents with and without experience with EVs.

The study was conducted in the course of a pilot project on e-mobility in rural Austrian regions. In Austria, farms are rather small in comparison with the USA or other countries in the European Union. In 2013, the total number of farms in Austria was 166,317, with a mean area per farm of 44.2 ha (Statistik Austria 2017). Another characteristic of Austrian farms is that they (still) are often run as family businesses. Based on a report from the Austrian Ministry for Agriculture, Forestry, Environment, and Water Management (BMLFUW 2016) in 2013, 92.3% of farms were one-person/family businesses. More than 50%, in total, 91,560 farms, were run on a part-time basis (BMLFUW 2016). As agriculture is very energy intensive, sometimes referred to as the turning of (fossil) fuel into food, farming offers considerable potential for a move toward increased sustainability, irrespective of farm size or structure. Currently, although renewables are playing an increasing role, e.g., the utilization of agricultural biogas (Brudermann et al. 2015), and the installation of photovoltaic modules on farming premises (Brudermann et al. 2013), the potential for e-mobility in this sector still remains largely unexplored.

Methods

For the purposes of this study, a quantitative online survey was applied in order to identify and compare the relevant features regarding the respective perceptions of respondents with and without EV experience.

Identification of attributes

Attributes of EVs were identified on the basis of a comprehensive literature review. As the present study was based on a pilot project in which farmers had the possibility to test agricultural EVs for free, financial aspects were deliberately left out from this particular analysis.[2] The current study focuses on the importance and performance of non-monetary aspects of agricultural EVs.

The literature review yielded product attributes relevant to agriculture, particularly with respect to the perceptions prevailing between the respondents with and without EV experience. Attributes such as *range*, *battery recharge time*, and *operating expenses* were identified as highly relevant in the literature (Döring and Aigner-Walder 2015; Peters and Hoffmann 2011; Türnau 2014). Türnau (2014) found in his study on EV renters that the respondents assessed *range* and *battery recharge time* negatively in terms of satisfaction and that such attributes were seen as being highly significant. In another study on EV user acceptance, the same attributes, *range* and *battery recharge time*, were mentioned between two of the four disadvantages with respect to e-mobility (Peters and Hoffmann 2011). *Range, battery recharge time, energy consumption* and *self-sufficient power use* were all added as product attributes. The availability of *public charging stations* (Krause et al. 2018) is well interlinked with these and thus was also considered. Finally, the availability of *private charging stations* was added since the use of an on-farm power plant (e.g., photovoltaics) could significantly reduce operating costs.

Approximately 70 percent of Austrian cadastral areas belong to mountain regions (BMLFUW 2015), which means vehicles in general, and agricultural vehicles in particular, have to perform well in such regions. Accordingly, the *hilly area driving performance* was added as a product attribute. The driving style of a person and the driving behavior of the car, e.g., the reaction of the car to the steering of the driver, acceleration and reaction to external factors, is another aspect identified in the literature (Knowles et al. 2012). Thus, the two attributes *general driving performance* and the *driving performance when loaded* were added. The latter is seen as especially important for agricultural EVs. In the case of EV use in agriculture, the vehicles are used for commercial and private reasons. Hence, the *transportation capability of people* and the *transportation capability of goods* were also added as product attributes.

Frenzel et al. (2015) conducted a survey on the user behavior of 3111 e-car owners in Germany. The majority of the respondents (84%) attach great importance to the environmental aspects of using EVs. EVs are considered as environmentally friendly and therefore suitable for use in sustainable businesses and by business managers (farmers) with high environmental awareness (Hanelt et al. 2017). As the demand for sustainable businesses is increasing, aspects such as *environmental friendliness* and *image support* were added as a product attribute.

Early interest of consumers in sustainable and eco-friendly products, such as EVs, is related to personality (Quintelier 2014). Questions relating to the *technology affinity* of the farmers were added to the questionnaire. The closure of the questionnaire included several questions concerning technical facilities, e.g., own power generation sources, amount of vehicles in the business, and planned energy-related investment for the future. The questionnaire is provided as supplementary information to this article.

Sampling and data collection

A survey consisting of two samples was conducted with the geographical scope of the federal state of Styria Austria, where approximately 40,000 farmers are reported to be active (BMLFUW 2015). The first sample consisted of 22 participants in an EV pilot project of the Chamber of Agriculture Styria (Chamber of Agriculture Styria 2016). The second sample was recruited by the chamber by e-mails and social media channels, and 312 farmers who had not participated in the pilot project responded to the invitation to participate in the survey.

In total, there were 334 respondents to the online survey. Hence, it can be assumed that the sample has no strict, general representativeness for the farmers in Styria. The sample is most likely biased toward farmers with e-mobility experience, which is a consequence of a non-response bias caused by the higher motivation of experienced farmers to respond. However, looking at other characteristics of the sample like key operating indicators such as business type (see Table 1) or age (50% between 36 and 53 years) and gender (85% male), it can be stated that the sample is diverse and more or less typical for the farmers in the study region (BMLFUW 2015, 2016). The bias toward e-mobility experience may, however, be causing indirect effects on, e.g., technical affinity or environmental concern. Nonetheless, since the study aims to investigate the differences between experienced and non-experienced farmers, this bias can be accepted.

The sample composition and description is provided in Table 1. Approximately 30% of the total sample indicated experience with e-mobility. Experience in the context of the present study means if the respondents have user experience or hands-on experience with EVs, respectively. From those 101 experienced e-mobility farmers, 30 already owned an EV and 71 indicated to have some experience in e-mobility but did not own an EV. The other 233 farmers (70%) did not have any experience with EVs. For further tests, the respondents who own an EV, the 22 participants in the pilot project, and respondents who indicated experience were subsumed and labeled *respondents with experience*.

The standardized questionnaire was pretested ($n = 10$), and the final version included general questions, questions regarding EV experience, and questions relating to

[2] Several studies on the economics of e-mobility have recently been published; see, e.g., Egbue and Long (2012), Ajanovic and Haas (2016), or Langbroek et al. (2016).

Table 1 Overview of the sample composition ($n=334$)

Type of e-mobility experience	E-vehicle ownership	Other experience in e-mobility	No experience		
	9%	21%	70%		
Share of experienced participants in different age groups	18–35 years	36–53 years	< 53 years		
	40%	30%	20%		
Business type[a]	Livestock farm	Wineries and fruit growers	Arable farming	Others	
	58%	20%	51%	17%	
Operation type	Conventional farming	Organic farming			
	77%	23%			
On-site electricity generation/storage[a]	Battery storage	Photovoltaic system	Wind/Hydro	Other	N/A
	3%	49%	2%	1%	48%
Special farm features[a]	Farm-gate sale	Guest beds	N/A		
	31%	18%	59%		
Technical affinity	Very positive	Positive	Partly	Negative	Very negative
	52%	43%	5%	< 1%	< 1%

[a]Multiple answers possible

socio-demographics. Additionally, the respondents were asked to select the three most important attributes of e-cars and agricultural EVs. Importance and performance of EV attributes were assessed on a five-point Likert scale.

Data analysis

A deductive approach was employed to highlight the differences in perception between experienced users and non-experienced respondents. This entailed the use of a cross-sectional analysis based on several important characteristics. The characteristics selected for the cross-sectional analysis were: point of time, representativeness of results, the possibility of comparing specific features across groups (i.e., those with and without experience of EVs), and feature recognition (Kuß et al. 2014).

The collected data were evaluated by means of univariate and bivariate statistical methods. To analyze whether certain parameters as, e.g., the technical affinity of people influence the evaluation of EV attributes, a Chi-square test was used. In order to avoid false positives when testing for multiple comparisons, Bonferroni correction was applied, which reduced the significance level to $p<0.004$ (Haynes 2013; Holm 1979).

In the present study, a *t* test was used to analyze the differences in the perception of importance and satisfaction of attributes of EVs which differ between experienced and unexperienced respondents. The differences in perceptions between the two groups (people with and without experience concerning the use of an EV) were then mapped and analyzed using the importance–satisfaction matrix, based on the quadrant analysis of Weinfurter and Hansen (1999). The importance–satisfaction matrix has already been used in various fields, for example, in studies on customer perception gaps concerning the importance and performance of 14 automotive service attributes (Martilla and James 1977) or with respect to an organization's services (Detlor and Ball 2015). Other studies analyzed the gap between customer and manager perceptions with respect to public transportation services (Sezhian et al. 2011) or the supplier and buyer perceptions concerning softwood lumber quality requirements (Weinfurter and Hansen 1999). In general, the matrix depicts customer priorities and product feature evaluations (Duke and Mount 1996). The graphical visualization, and the possibility of plotting both the importance and performance of various features in one grid, makes it relatively easy to interpret (Martilla and James 1977; Weinfurter and Hansen 1999).

The importance–satisfaction matrix allows for identifying the perception gap between respondents with and without experience: Respondents without experience convey their personal attitudes and interests and experienced respondents express their experience and satisfaction with specific attributes.

Results

This section is divided into three parts: The first part discusses predictors for EV experience. The second part discusses importance and performance attributes of

Table 2 Importance rank of attributes of e-cars and frequency of indications as "among three most important" by experienced and non-experiences respondents

E-Cars	Experienced		Non-experienced		Diff. (%)	Asymp. Sig. (2-sided)
	Rank	(%)	Rank	(%)		
Battery recharge time	7	14	4	24	– 10	0.043
Self-sufficient power	1	69	2	49	20	**0.001***
Range	3	47	1	57	– 10	0.076
Environmental friendliness	2	49	3	47	2	0.826
Image support	4	32	5	21	11	0.037
Public charging station	12	5	8	17	– 12	**0.003***
Private charging station	8	13	5	21	– 8	0.078
Energy consumption	6	16	7	18	– 2	0.565
General driving performance	5	22	9	11	11	0.008
Hilly area driving performance	11	6	12	7	– 1	0.754
Driving performance when loaded	13	2	13	3	– 1	0.474
Transportation capability of people	9	12	10	9	3	0.42
Transportation capability of goods	10	8	11	8	0	0.951

*$p < 0.004$ (Bonferroni correction)

electric cars, while the third part addresses importance and performance attributes for agricultural EVs. A special focus is placed on the differences in perception by respondents with EV experience and those without.

Predictors for experience with EVs

Looking at the *technical affinity* of the respondents, we find that 52% have a very positive attitude toward new technologies. However, respondents with experience have a more positive attitude toward new technologies than those without ($p < 0.001$).

Another question was regarding the *business type* of the farms. Multiple answers were allowed here. The results show that most of the farms (58%) are livestock farms, followed by arable farms (51%). Apart from that, the sample also included wineries and fruit growers (20%), and others. Interestingly, owners of arable farms have almost no experience with EV compared with owners of other types of farms (Chi-square test, $X^2(df = 1) = 5.696$; $p < 0.05$).

In addition to the business type, the farmers were also asked about the *operation of their business* and whether they were engaged in conventional or organic farming. The majority of them (77%) operated a conventional farm.

Farmers who sell their products directly from the farm are significantly more likely to have experience with EVs compared with farmers who do not ($X^2(df = 1) = 11.558$; $p < 0.001$).

Another important aspect is the possibility of farmers using *self-generated electricity*. About 52% of the respondents have their own source of power production, e.g., photovoltaic, wind or water power plants or other sources. Here, a highly significant relation was determined; farmers with their own power generation system also showed more often EV experience ($X^2(df = 1) = 14.714$; $p < 0.001$). About 84% of respondents having their own source of power generation had a photovoltaic installation. Again a significant relationship between experience with EV and ownership of a photovoltaic plant ($X^2(df = 1) = 15.860$; $p < 0.001$) could be determined.

E-cars

Most important attributes of e-cars

The 334 respondents were asked to identify, out of 13 possibilities, the three most important attributes of e-cars. The results are listed in Table 2. The importance rankings are given for both groups (experienced and non-experienced), as is the share of the sample who named the respective attribute as one of the three most important. Furthermore, the asymptotic significance of the differences in ranking between the groups experienced and non-experienced is provided.

In total, 55% named *self-sufficient power* as the most important attribute. The *range* was ranked as the second most important attribute (54%), followed by environmental friendliness (48%). Just 7% of the respondents named *hilly area driving performance* (maybe due to the location of their farms) and 3% the *driving performance when loaded*, as one of the three most important attributes.

Looking at the groups with and without experience separately, the results are very similar. Differences in the ranking of the three most important attributes of e-cars for the experienced and non-experienced are merely related to the order of the chosen attributes and not to the attributes themselves

Table 3 Difference in perception of e-car attributes between respondents with and without experience, with regard to importance and performance

E-Cars	Importance			Performance		
	Mean exp.	Mean non-exp.	*p* value	Mean exp.	Mean non-exp.	*p* value
Battery recharge time	1.822	1.694	0.193	2.5	2.631	0.347
Self-sufficient power	1.436	1.856	**0.000***	1.680	1.855	0.103
Range	1.515	1.536	0.800	2.87	2.903	0.811
Environmental friendliness	1.47	1.674	0.058	1.49	1.607	0.201
Image support	2.346	2.848	**0.000***	1.871	2.196	**0.002***
Public charging station	2.099	2.052	0.680	2.798	2.717	0.545
Private charging station	1.415	1.515	0.227	1.5	1.764	0.007
Energy consumption	2.08	1.969	0.351	1.854	2.015	0.129
General driving performance	2.257	2.32	0.565	1.979	2.351	**0.000***
Hilly area driving performance	2.37	2.184	0.110	2.258	2.559	0.018
Driving performance when loaded	2.363	2.225	0.233	2.523	2.75	0.079
Transportation capability of people	2.228	2.210	0.879	2.238	2.397	0.121
Transportation capability of goods	2.188	2.292	0.388	2.969	3.010	0.759

*$p < 0.004$ (after Bonferroni correction)

(Table 2). This is also true for the attributes with the fewest nominations. However, some differences in the ranking of the attributes between the two groups are significant and show a weak correlation. The results show that *self-sufficient power* was mentioned more frequently as most important attribute by respondents with experience than those without ($X^2(df = 1) = 11.828$; $p < 0.004$). The present study shows that respondents experienced with EVs rated *public charging stations* less often as a highly important attribute ($X^2(df = 1) = 9.021$; $p < 0.004$).

Importance and performance fulfillment of e-cars

Analyzing the importance of the attributes of e-cars, the results show that all respondents consider all of the attributes to be important or very important and that all respondents are satisfied or very satisfied with the related attribute performance.

Differences between experienced and non-experienced EV users can be seen with respect to *self-sufficient power* use. For respondents without experience, the *range* is more important than *self-sufficient power use*. Experienced respondents rated the attributes *hilly area driving performance* and *driving performance when loaded* as least important. In contrast, farmers without experience find *image support* as least relevant. Besides these dissimilarities, a few significant differences exist between the rating of attributes and the EV experience. In general, the ratings are relatively homogeneous. Only for the attributes *self-sufficient power use* and *image support* are the differences between the two groups highly significant ($p < 0.001$) (Table 3).

Beside the relative importance of e-car attributes, the respondents also had to assess their satisfaction with respect to performance. The respondents with EV experience assessed satisfaction based on their actual experience and those without experience based on their expectations. Based on the results, it can be stated that the performance satisfaction received fewer positive valuations than those relating to attribute importance. The attributes *environmental friendliness*, *private charging station*, *self-sufficient power* and *energy consumption* are generally rated as (very) good. The *transportation capability of goods* and the *range* are those attributes associated with least performance satisfaction. Nevertheless, some differences in the perception between both groups are significant: Highly significant ($p < 0.001$) is the difference between the groups regarding the *general driving performance* and *image support*. With respect to all the other attributes, no significant differences were found between the EV experience and the satisfaction level of the performance fulfillment (Table 3).

The results of attribute importance and related performance fulfillment (Table 3) were combined to produce a so-called importance–satisfaction matrix, shown in Fig. 1. Here, the x-axis indicates performance satisfaction and the y-axis the level of importance. This matrix allows one to visualize the differences in perception between the two groups (experienced and non-experienced EV drivers). Within this importance–satisfaction matrix, the arithmetic mean, including the standard error of the mean (the crosses at each point) of the perceived importance and performance satisfaction, can be seen for all attributes. The figure is usually divided into four quadrants. As the data gained in the present study lie exclusively in quadrant II of

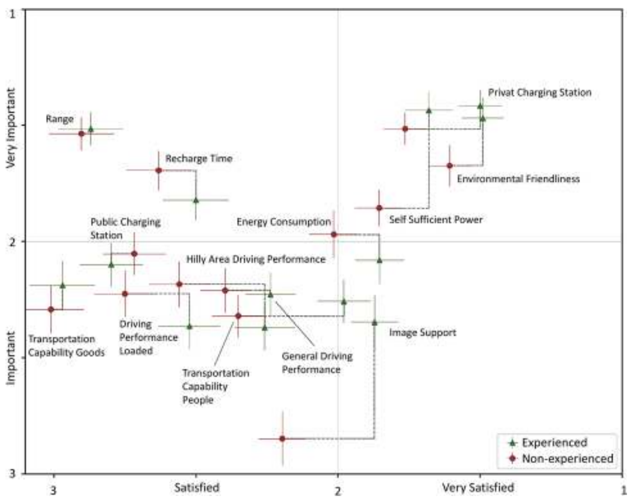

Fig. 1 Importance–satisfaction matrix for e-cars. The *x*-axis depicts the respondents' satisfaction with the performance of the attributes, whereas the *y*-axis depicts the importance of attributes. The crosses represent one standard error in each axis ($n = 334$)

the matrix, only this part of the whole matrix is shown in Fig. 1. The notation of the quadrants indicates the answer options available to the respondents in the questionnaire.

Surprisingly, all attributes except *public charging stations* are evaluated more positively in terms of performance by respondents with EV experience than by those without experience, i.e., experienced respondents are more satisfied than non-experienced.

Both groups of respondents rated the *range* and the *battery recharge time* as highly important, and both were satisfied with related performance levels. For those with EV experience, the importance and satisfaction levels associated with image support were higher than for those stated by the non-experienced.

Satisfaction and importance for the three attributes *environmental friendliness*, *self-sufficient power* and *private charging station* were assessed as very high. While the ratings on all three attributes were higher on both axes for the experienced respondents than for the non-experienced, the differences in perceptions were not significant (Table 3).

Agricultural EVs

Most important attributes of agricultural EVs

After sharing their perception of e-cars, respondents also were asked to assess the importance and performance of different attributes for the case of agricultural EVs. Fifty-two percent of the respondents named *self-sufficient power* as one of the three most important attributes, followed by *transportation capability of goods* (42%) and *range* (41%). Just 5% of the respondents named *public charging station* and *image support* as one of the three most important attributes. The results, including the significance of perception differences for respondents with and without EV experience, are listed in Table 4.

The results indicate that people with e-mobility experience choose *self-sufficient power* ($X^2(df = 1) = 10.647$; $p < 0.001$) more often as one of the three most important attributes than farmers without experience.

Furthermore, significant differences in the ranking of attributes between the two test groups can be shown. The non-experienced respondents were more likely to rank the

Table 4 Importance rank of attributes of agricultural EVs and frequency of indications as "among three most important" by experienced and non-experienced respondents

Agricultural EVs	Experienced		Non-experienced		Diff. (%)	Asymp. Sig. (2-sided)
	Rank	(%)	Rank	(%)		
Battery recharge time	9	11	5	29	− 18	**0.000***
Self-sufficient power	1	65	1	46	19	**0.001***
Range	3	36	2	43	− 7	0.214
Environmental friendliness	4	30	7	23	7	0.177
Image support	10	10	13	3	7	0.008
Public charging station	13	3	12	6	− 3	0.305
Private charging station	5	29	4	30	− 1	0.868
Energy consumption	11	7	9	12	− 5	0.135
General driving performance	12	5	11	11	− 6	0.073
Hilly area driving performance	8	13	10	12	1	0.740
Driving performance when loaded	6	19	6	25	− 6	0.226
Transportation capability of people	7	15	8	21	− 6	0.161
Transportation capability of goods	2	53	3	37	16	0.005

*$p < 0.004$ (Bonferroni correction)

Table 5 Difference in perception of agricultural EV attributes between respondents with and without experience, with regard to importance and performance

Agricultural EVs	Importance			Performance		
	Mean exp.	Mean non-exp.	*p* value	Mean exp.	Mean non-exp.	*p* value
Battery recharge time	1.76	1.764	0.966	2.363	2.483	0.360
Self-sufficient power	1.47	1.765	**0.002***	1.598	1.875	0.016
Range	1.83	1.671	0.102	2.570	2.607	0.798
Environmental friendliness	1.61	1.820	0.031	1.631	1.755	0.198
Image support	2.37	2.792	**0.000***	1.916	2.283	**0.000***
Public charging station	2.62	2.397	0.102	2.756	2.778	0.875
Private charging station	1.33	1.552	**0.004***	1.398	1.825	**0.000***
Energy consumption	1.879	1.855	0.807	2.0	2.256	0.029
General driving performance	2.06	2.239	0.052	2.289	2.492	0.045
Hilly area driving performance	2.0	2.096	0.355	2.316	2.540	0.073
Driving performance when loaded	1.85	1.982	0.168	2.342	2.483	0.253
Transportation capability of people	2.245	2.314	0.532	2.714	2.595	0.343
Transportation capability of goods	1.6	1.778	0.067	2.169	2.355	0.123

*$p < 0.004$ (Bonferroni correction)

attribute *battery recharge time* as more important than experienced respondents ($X^2(df = 1) = 12.562$; $p < 0.001$).

Importance and performance fulfillment of agricultural EVs

The respondents also had to assess performance satisfaction with respect to agricultural EVs, again using a five-point Likert scale. This revealed several differences with respect to the importance assessment relating to e-cars. The *transportation capability of goods* is more important for agricultural EVs than for e-cars, and the respondents are in general more satisfied with this feature when it comes to agricultural EVs compared with e-cars. Moreover, the attribute *range* is seen as more important for e-cars than for agricultural EVs, whereas *public charging stations* are not as important for agricultural EVs as they are for e-cars.

The performance satisfaction of agricultural EVs was only assessed by farmers with knowledge of such vehicles, i.e., by 290 respondents. Most of these respondents stated that they were (very) satisfied with respect to all attributes. The highest satisfaction and importance were given to the attributes *private charging station*, *self-sufficient power*, and *environmental friendliness* (Fig. 2). This is very similar to the satisfaction assessment found for e-cars. Once again, these attributes are viewed as being more important and are assessed in better terms by respondents with EV experience than by those without.

When the results are split into two groups (experienced and non-experienced), there are several significant differences in perception that come to light. Significant differences between the two groups can be determined with respect to the attributes *private charging station*, *image support*, and *self-sufficient power*. This is true for both the importance and the satisfaction level except for *self-sufficient power* where significant differences occur just for the importance rating (Table 5). Furthermore, it can be said that experienced EV users assessed all attributes except the *transportation capability of people* more positively than non-experienced respondents (Table 5). The perception gap is significant ($p < 0.001$) when summing up the assessments of all attributes for both groups separately. In other words, respondents

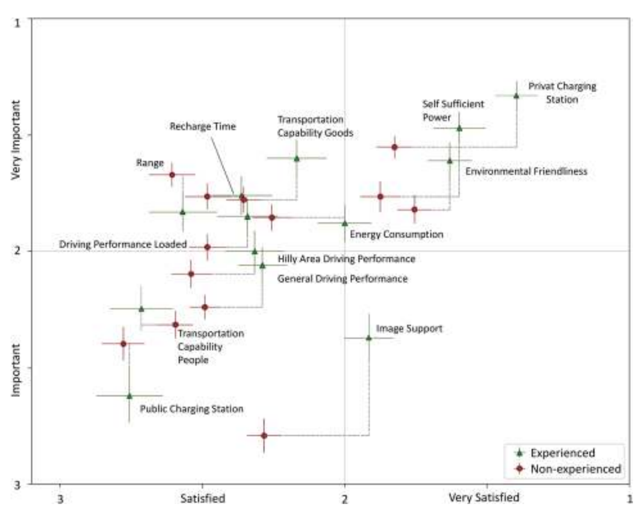

Fig. 2 Importance–satisfaction matrix for agricultural EVs. The *x*-axis depicts the respondents' satisfaction with the performance of the attributes, whereas the *y*-axis depicts the importance of attributes. The crosses represent one standard error in each axis ($n = 290$)

with experience tend to be more satisfied with attributes of agricultural EVs than those without.

The results of the assessments regarding attribute importance and performance for agricultural EVs are again combined in the importance–satisfaction matrix, as shown in Fig. 2. As was the case in the importance–satisfaction matrix for e-cars in Fig. 1, all attributes can be found exclusively in quadrant II. This covers the arithmetic means of the evaluations going from partly important to very important and from partly satisfying to very satisfying.

Figure 2 illustrates that the experienced respondents are least satisfied with the items *public charging station* and *transportation capability of people* and that the non-experienced find the lowest levels of satisfaction with *public charging station* and *range* (Fig. 2).

For all respondents *range*, *battery recharge time*, *transportation capability of goods*, *energy consumption* and *driving performance when loaded* are very important, and related performances levels are merely viewed as being satisfactory. The attributes *public charging station*, *transportation capability of people*, *general driving performance*, and *hilly area driving performance* are seen as being important and satisfactory.

As shown in Fig. 2 and given in Table 5, the arithmetic means of *battery recharge time*, *energy consumption* and *transportation capability of people* hardly differ from each other. However, highly significant differences between the two groups can be seen with respect to *image support* ($p < 0.001$), where the ratings given for level of importance and for satisfaction were higher for experienced EV users than for non-users. Significant differences can also be found in the assessments of *self-sufficient power* (regarding importance) and *private charging station*.

In addition to the above questions, the respondents were also questioned concerning the usefulness of agricultural EVs (using a five-point Likert scale, ranging from 1—very useful to 5—not useful at all). The results show that respondents with e-mobility experience viewed agricultural EVs as being more useful than non-experienced respondents (mean usefulness rating of 2.55 and 2.95 respectively, $p < 0.01$).

Discussion

The study provides a consistent picture regarding the respondents' perceptions of the 13 EV attributes within the context of experience. As is the case in comparable studies (Bühler et al. 2014), the present study is limited to a specific sample of participants. However, in contrast to previous studies (Bühler et al. 2014; Bunce et al. 2014), which used a single-sample approach to investigate the perceptions of individuals before and after EV experience, this study applied a research design based upon two independent samples in order to allow comparison of experienced and non-experienced respondents. While a single-sample approach offers the advantage of being able to control (and therefore norm) how experience is gained, it may also lend itself to the introduction of a social compliance bias (i.e., by tending to encourage responses which are somehow considered as being more *correct* or *desirable*). Thus, while the two-sample approach used in this study allows for relatively limited control concerning the experience investigated, (e.g., in terms of duration, type, and situation), it does allow for the inclusion of larger samples and thus reduces the impact of potential bias arising from EV demonstration projects. Usually such projects provide free use of EV to participants for a limited time period in order to help them gain experience. There is a danger, therefore, that participants are more likely to provide positive ratings merely in return for the free service. However, one needs to remember that the sample of participants in the pilot project ($n = 22$) was relatively small compared with the overall sample ($n = 334$) used in this study. Apart from the respondents of the pilot project and the respondents who owned an EV, respondents who indicated having EV experience were also labeled as such; this rough categorization, however, does not take into account different levels of experience. In general, sample selection in such a study is always tricky given the various possible sources of bias and the potential for lack of sample representativeness. This study used several communication channels available to the Styrian Chamber of Agriculture in order to contact farmers. Although limited to the specific target group of Styrian farmers, the sample may still have been subject to certain biases. For example, the share of those interested in EVs was much larger between survey respondents (even though they may have had no experience) than that normally found among the general population. In addition, due to the fact that the study was carried out as an online survey, it is likely that farmers with limited IT skills or IT infrastructure were un(der)represented. On the one hand, this implies that our results are limited to the observed sample, while on the other hand no factor could be identified (except the e-mobility experience itself) that would be expected to have a biasing influence on the results.

All 13 attributes covered in the present study were rated as being rather important and satisfactory. Thus, while it can be concluded that the study covered many important factors (although there may be even more), it is possible that it failed to identify those factors which are unsatisfactory or those which explain why respondents have not yet bought an EV, e.g., the relatively high price of EVs. Furthermore, although rated overall as satisfactory, the *range*, *recharge time*, and availability of *public charging stations* might also act as barriers when individuals are attempting to make a purchasing decision. However, it needs to be remembered that the purchasing decision was not the subject of the present study. Qualitative research methods need to be applied to investigate this issue in more detail.

In a similar vein, the issue of social compliance also has to be taken into account when considering, for example, the high ratings regarding the importance of *environmental friendliness*. Such an attitude–behavior gap is common among choices driven by ethical considerations, especially when it concerns consumer choices (Bray et al. 2011).

The results of this study on agricultural EVs are in line with previous studies on non-agricultural EVs. EV acceptance is rising among those with no direct experience, not just as a result of improved communication (Peters and Hoffmann 2011), but also as a result of observing the practical experience with e-cars (Bühler et al. 2014; Bunce et al. 2014; Jensen et al. 2013). In contrast to Türnau (2014), none of the attributes tested in this study were classified as unimportant or unsatisfactory, while *range* and *charging time* were identified by both groups examined here as being relatively important, but less satisfactory.

This study showed in detail that the importance of some attributes is highly influenced by the respondents' EV experience. This is in particular true for *self-sufficient power use*, the *image support* and availability *of public charging stations* in the case of e-cars. Non-experienced users relatively overrate the importance of *charging time* and *public charging stations*, whereas *self-sufficient power use*, *image support* and *driving performance* are relatively underrated. In the case of agricultural EVs, the attributes *range* and availability of *public charging stations* are losing their significance, while *transportation capability of goods* is becoming much more important, especially for experienced respondents. A likely reason for this difference in the perception of e-cars and agricultural EVs stems from the different types of use. Public charging stations are less important for agricultural EVs, as they rarely leave the vicinity of the farm. For similar reasons, the range is more important for e-cars. On the other hand, driving performance when loaded is a more important issue for agricultural EVs, as e-cars probably will less often be fully loaded.

Comparing the performance and importance ratings in Figs. 1 and 2, it is obvious that *image support* and *environmental friendliness* (soft factors) as well as *self-sufficient power use* and presence of a *private charging station* (hard drivers) are by far the most important factors distinguishing between experienced and non-experienced respondents. This observation fits very well with the higher share of organic farmers and farmers with energy production facilities in the experienced group. It can be concluded that these factors are likely to be the driving forces behind farmers' interest in EVs, and thus lead them to actually gain EV experience. As has been shown, such EV experience generally improves performance perceptions relating to e-cars. In the same way, some attributes appear to become less important once experience is gained, indicating that their role was previously overrated. This is true for e-cars regarding *recharging time, energy consumption, hilly area driving performance* or *driving performance when loaded*. Overall, the gaining of experience shows almost no impact on the *driving range* perception (importance and performance) for e-cars.

Some differences arise here when attention is shifted away from e-cars and toward agricultural EVs. For example, in contrast to the respective results for e-cars, items such as *driving range* and access to *public charging stations* are less important for experienced agricultural EV respondents. It seems that practical experience is necessary for the respondents to become aware of the fact that agricultural EVs rarely operate in conditions that require frequenting public charging stations. For most of the other attributes, the results for agricultural EVs are similar to those found for e-cars, with ratings for importance and performance mostly increasing by experience (e.g., for *general driving performance, driving performance when loaded, hilly area driving performance, transportation capability of goods, image support, environmental friendliness, private charging station* and *self-sufficient power use*). The *transportation capability of people* is the only item with respect to agricultural EVs that shows slightly increased importance with slightly decreased satisfaction, thus indicating a relatively weak association with experience. Finally, for EVs and agricultural EVs *energy consumption* and *recharging time* exhibit steady levels of importance but increasing satisfaction by experience.

Conclusions

This study focused on how farmers assess the importance of different attributes of electric cars and agricultural electric vehicles and how satisfied they are with their performance. Considering the 13 attributes used in this study, it can be stated that the farmers who responded to the survey are already relatively satisfied with the performance of EVs and that in general satisfaction increases with EV experience. Thus, farmers can be viewed as a specific target group in EV campaigns. Pilot projects which allow farmers to test EVs under their individual practical requirements are likely to be a helpful tool in increasing acceptance. As interest among potential adopters is driven by their perception of the environmental friendliness of EVs, and the resulting potential for enhancing the farm's image, farms active in organic farming and direct marketing are a clear target group for EV dissemination.

One important factor for the respondents in our study is the on-farm generation of electricity (mainly PV) and the infrastructure needed to charge EVs. An implication for environmental policy therefore is that support for on-site generation of renewable energy is likely to promote farmer's interest in EVs of all kinds. Support for decentralized renewables and agricultural EVs thus should not be discussed separately, but approached with integrative policies.

Although farmers in this study showed clear interest in EVs for agricultural purposes, agricultural e-mobility of course is a niche market. On the other hand, agricultural EVs are much less dependent on public charging stations than private EVs. Thus, by bypassing what is often considered to be a major impediment, implementation in the agricultural sector could be easier than elsewhere.

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