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Acceptance of e-motorcycles: A longitudinal study based on a survey of motorcyclists at the motorcyclist meeting point "Loewensteiner Platte" in South Germany

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Executive Summary

The acceptance of e-motorcycles among German motorcyclists is in focus of this quantitative longitudinal study. By comparing survey results of 2017 and 2022 questions about changes in perception of e-motorcycles over time as well as possible stimulating factors shall be analyzed. Findings show that the willingness to consider an e-motorcycle at the next purchase was low in 2017 and even dropped from 20% to 5% in 2022, which contrasts with rising sales figures of e-motorcycles in the German market.

Keywords: sustainable mobility, electromobility, e-motorcycle technology, motorcyclists, social acceptance, behavioral economics

1 Introduction

Electromobility is playing an increasingly important role in Germany. Car manufacturers such as Volkswagen with its id-models are establishing a market segment. However, the focus is mainly on e-cars. Motorcycles have also been appearing in the e-mobility segment for some time, but the public has hardly noticed them so far. Currently, there is no state support for e-motorcycles in the form of purchase premiums or environmental bonuses. Research on acceptance of e-motorcycles is growing, but rarely examined in German context e.g. [1], [2], [3], [4], [5]. Several studies investigated the specific technological, environmental, political and economic factors of e-motorcycles worldwide [1]. There it became obvious, that the assessments and concerns of the motorcyclists play an important role in the acceptance of e-motorcycles. This paper aims to fill this gap and analyses and compares the acceptance of e-motorcycles in Germany based on a longitudinal

regional survey. Conclusions are drawn about the market potential of e-motorcycles in Germany and an overview of general assessments and concerns of motorcyclists is created.

The study is divided into a methodological, theoretical and empirical part. First, the methodological part presents the research questions and explains the procedures used to answer the questions. In the theoretical part of the paper, the relevant scientific fields are presented and an overview of the current state of research is given. The empirical part presents and evaluates the results of the survey on the acceptance of the e-motorcycle.

2 Methodology

The research design is built on a literature research, secondary literature analysis and a survey of motorcyclists. Statistical procedures are used for data analysis and interpretation. The literature analysis enables the integration of the present study into the current state of research [6] and [7].

A longitudinal quantitative survey based on a random sample builds the empirical core approach of this study [8], [9] and [10]. By using standardized, closed questions comparable data should be generated to answer the research questions. The questions included in the questionnaire can be divided into two basic types. On the one hand, there is the identification type, the aim of which is to identify the respondent, for example by gender and age. However, no identification questions are asked about personal information, which would endanger the anonymity of the person. On the other hand, there is the selection type, in which there are alternative answer options to a question. Regarding the selection type, one decides on a combination of a yes-no type, where only one yes or no answer can be selected. In addition, an attitude scale is used for several questions, in which one can develop a certain tendency to a given statement. As a third type, multiple-choice questions are used in the context of the selection type, in which more than two answer categories are selectable [11], [12] [13].

Two surveys were conducted in October 2017 and October 2022 at the motorcyclist meeting point “Loewensteiner Platte” in Southern Germany.

3 Literature Review

3.1 Motorcycle technology

The electric motor and the high-voltage-battery are the main parts, which determine the vehicle concept and therefore the whole driving experience of e-motorcycles. The weight of the battery is considerable, but the electric engine delivers maximum torque instantly, whereas the torque curve of a combustion engine reaches its maximum at a specific rotation speed only [14]. There is no remarkable engine sound, no need for a gear box and the overall concept is simpler. Due to less wear parts, the effort for maintenance and repair is lower than for conventional motorcycles [15]. Looking at ecological sustainability of e-motorcycles, there is a substantial potential to reduce in-use exhaust emissions worldwide [16]. E-motorcycles beat conventional motorcycles not only in the emissions of greenhouse gases, but also in the energy consumption in all categories tank-to-wheel, well-to-wheel and over the lifecycle [4].

3.2 Sustainability mobility

One of the biggest problems associated with the operation of conventional vehicles are the pollutants emitted by combustion engines. Globally, internal combustion engines from vehicles are now responsible for a large part of air pollution [16].

Electrically powered vehicles are now seen as a means of reducing the consumption of oil or gasoline and lowering the emission of pollutants from individual traffic. In this respect, e-motorcycles can represent an alternative to the e-car that has received little attention in Europe to date. Pollutant emissions can be reduced by replacing conventional motorcycles with e-motorcycles. This can be an important factor, especially in cities with high levels of air pollution. Looking at the environmental impact of e-motorcycles compared to conventional motorcycles, it should be noted that although the use of e-motorcycles reduces pollutant emissions, the production of e-motorcycles consumes significantly more energy than the production of conventional motorcycles [4].

Figure 1 and 2 illustrate the energy consumption and greenhouse gas emissions of the respective two-wheel drive vehicles. The following two diagrams look at energy consumption and greenhouse gas emissions from the tank-to-wheel and well-to-wheel perspectives. In addition, the entire life cycle of a vehicle is considered. Tank-to-wheel refers to pure operating consumption. In addition to the tank-to-wheel approach, the well-to-wheel approach considers the energy required to produce fuel and electricity [17].

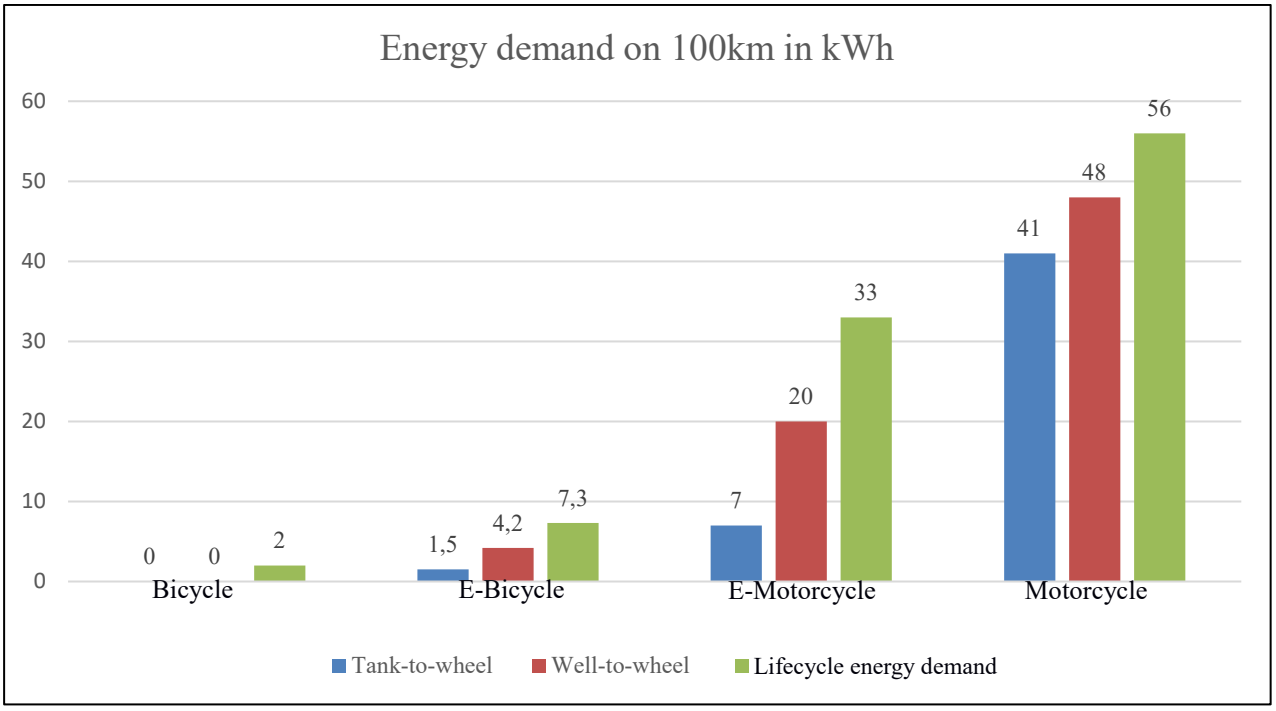

Figure 1 Energy demand of two-wheelers Own source in accordance with [4]

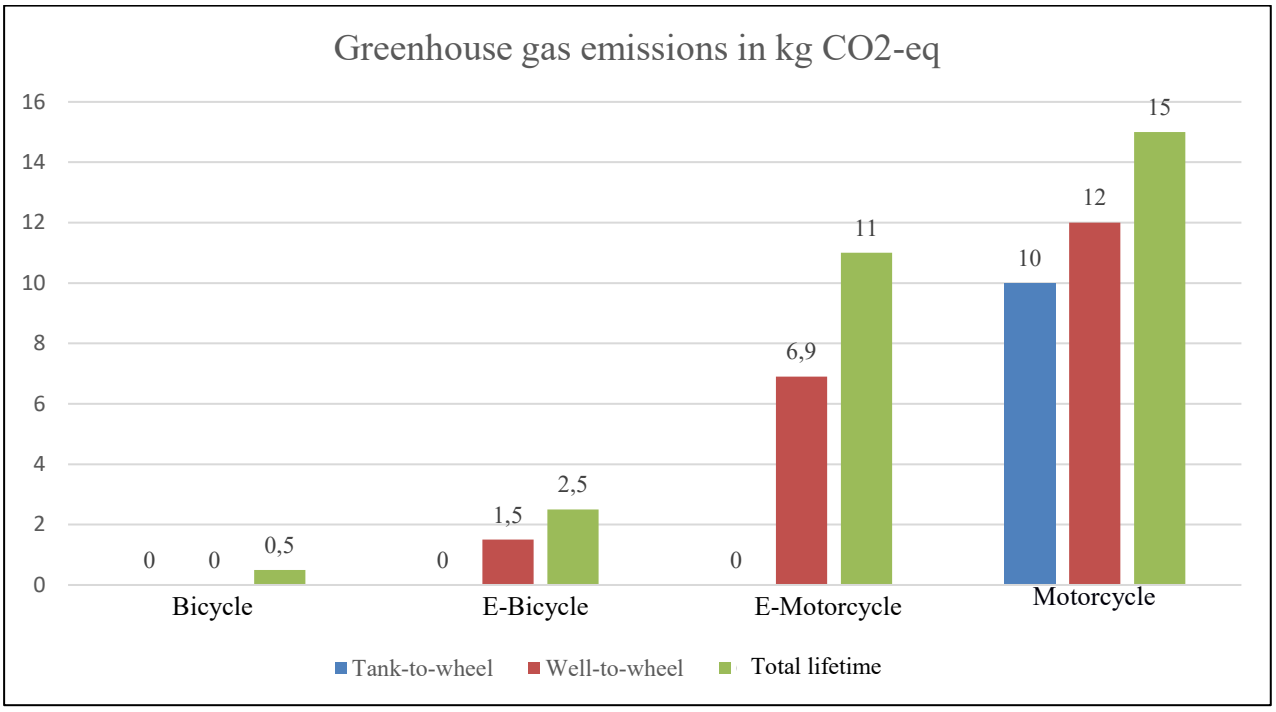

Figure 2 Greenhouse gas emissions from two-wheelers. Own source in accordance with [4]

Apart from the avoidance of pollutants when operating electric motorcycles, they also offer other advantages that sustainably reduce the burden on the environment. For example, electric drives are significantly more efficient than conventional gasoline-powered engines, since the energy in electric drives is converted directly into motive power, while internal combustion engines convert part of the energy into heat. In addition, it should be noted that electric motorcycles are significantly quieter than conventional motorcycles. This actively reduces the noise pollution caused by traffic [18].

Despite the environmental benefits that would result from a switch to electrically powered motorcycles, there has not yet been any great success on the market for e-motorcycles. This is due not least to the higher acquisition costs and existing technical problems. The lower range compared to conventional motorcycles, together with a still limited charging infrastructure, has so far prevented the sustainable success of e-motorcycles [16].

Technological, economic, and social developments are therefore important for sustainable market development for e-motorcycles. A growing market, especially in Asia, is also leading to falling prices because of economies of scale and increasing competitive pressure. As a result of falling prices, the market attractiveness of e-motorcycles is increasing. Market developments in East Asia show that falling electricity prices, together with rising gasoline prices and an increased demand for mobility, can accelerate the market for electrically powered vehicles. So far, however, developments have not resulted in an increasing market share for e-motorcycles either in Europe or in Asia. The main problem here is that e-motorcycles do not offer their buyers any direct added value for the higher price compared with conventional motorcycles. In contrast, e-bikes offer their customers an additive benefit through an additional e-drive compared to normal bicycles [4].

3.3 Social acceptance and behavioral economics

Social acceptance is a key element in many debates surrounding the sustainability transition [19] and [20]. *Fournis and Fortin* describe a socio-technical paradox known from the context of wind energy: “the social dimension has become a factor of equal importance to technology in the wind farms implementation” [19]. This paradox can be probably also be applied to sustainable mobility and the acceptance of e-motorcycles. Also various studies come to the conclusion that social acceptance is vital in terms of technology and innovation transfer [21], [22], [23] and [24].

According to *Upham et al.* social acceptance can be understood as “a favourable or positive response (including attitude, intention, behaviour and – where appropriate - use) relating to a proposed or in situ technology or socio-technical system, by members of a given social unit (country or region, community or town and household, organisation)” [23] and (p. 102 in [24]). Social acceptance can be divided into three dimensions as proposed by *Wüstenhagen et al.* [20] and (p. 3 in [24]):

- Socio-political acceptance points to the overall “societal climate towards a technology or innovation within a society” (p. 3 in [24]). In the case of this study, this dimension would refer to how approaches to achieve sustainable mobility or in particular the diffusion of e-motorcycles are positively or negatively perceived by the public and opinion leaders [20] and [24].
- Community or local acceptance focuses on “attitudes and behaviours exhibited by those indirectly affected” (p. 3 in [24]). Related to e-motorcycles this could be nearby residents of charging infrastructure.
- Market acceptance can also be understood as “the process of market adoption of an innovation” (p. 2685 in [20]. Stakeholders such as consumers and investions are relevant in this dimension. Market acceptance is e.g. measurable in market shares, purchase behavior of motorcycles (p. 3 in [24]).

Whether a general transition towards sustainable mobility, including an increase in electric mobility will be successful is dependent on the acceptance levels in the above-mentioned three dimensions, amongst other things. For this study, the dimensions of socio-political and market acceptance are the main focus.

Looking at the situation in Germany from a behavioral economics perspective, *Augenstein* [25] believes there seems to be a dichotomy of opinion. On the one hand, people have a generally positive attitude toward the topic and diffusion process of electromobility. On the other hand, there is a blockade against recognizing electromobility as a holistic substitute for existing drive systems [25].

However, this study focuses specifically on the e-motorcycle vehicle segment. In Southeast Asia, where transportation is dominated by motorcycles, the economic aspect of the customer plays an essential role, because apart from the European view, the motorcycle represents an essential medium for locomotion [16]. Since an e-motorcycle has lower consumption values and at the same time lower emission values than a conventional motorcycle, one would think that in these countries there is a fundamental acceptance and will to opt for an e-motorcycle. But here, too, a societal dichotomy is evident. A study by *Guerra* [26], which looks at the acceptance of the e-motorcycle in Indonesia, shows important technical prerequisites that must be in place to promote social acceptance. The time required for recharging, the recharging infrastructure, and the higher purchase costs in relation to conventional motorcycles do not yet overlap with the ideas of potential customers. From *Guerra*'s empirical analysis, it is possible so far to depict individuals who possess the following characteristics and demonstrate acceptance regarding e-motorcycles. This applies to younger people who are critically concerned with environmental influences and lead a healthy lifestyle [26].

Despite the ecological advantages, market success is not seen yet, due to additional costs and technological immaturity. With a share of nearly 2 % of the German motorcycle sales in 2021, e-motorcycles are a small, but fast growing segment with a plus of 149 % in the first half of 2022 [17]. The relatively low range in addition with a limited charging infrastructure is seen as a main disadvantage for e-motorcycles [16]. Looking at Germany, the general positive attitude towards E-mobility contrasts with the low willingness to change mobility patterns and technologies [24] and [25]. Focusing on the motorcycle segment in Germany, purely economic criteria cannot explain customer behavior.

Several German studies focus on the social acceptance of electric vehicles by the demand side, especially by private users [24], [27] and [28], but up to now researc has largely neglected the role of motorcyclist in the transition to e-mobility [3] and [4].

Based on the literature review, this research aims to fill the research gap by answering three fundamental research-guiding questions:

RQ 1: Does the e-motorcycle has the potential to replace the motorcycle in the long run?

RQ 2: What are relevant aspects for the acceptance of e-motorcycle over time?

RQ 3: Would a state purchase bonus raise the acceptance of e-motorcycles?

4 Findings

4.1 Description of the object of investigation

With the help of a scientific questionnaire, the acceptance of the e-motorcycle was analyzed. The Löwensteiner Platte in the town of Löwenstein in Baden-Württemberg was selected as the location for the survey. This choice is based on the high visitor frequency of motorcyclists who rest at this location. In addition, the surveys were conducted at the end of the regular motorcycle season, on October 28, 2017 and repetitively on October 22, 2022. Both times, a total of 41 people were surveyed. This included 33 motorcyclists and eight female motorcyclists. The survey contained a total of seven questions, two of which were used to identify the respective age classification and gender of the person. The remaining questions were intended to elicit clarifying results on acceptability in the areas of vehicle technology, sustainability, and behavioral economics. The set of questions was mostly identical for the two survey dates to allow a comparison or changes in acceptance of e-motorcycles. Two questions were added in the survey of 2022 that investigate about the willingness to buy an e-motorcycle, if it would be supported with a state premium and if the participants already own another type of e-vehicle.

4.1 Gender and age correlations with social acceptance

The mean value of the communicated answers was classified into four asymmetric categories when evaluating the questionnaires. Thus, the significance of the results in columns one and four of Table 1 of a smaller interval should be strengthened.

Table 1 Result classification of the mean values (Own table).

no acceptance	Rather no acceptance	Rather high acceptance	high acceptance
$X \leq 1{,}5$	$1{,}5 < X \leq 2{,}5$	$2{,}5 < X \leq 3{,}5$	$3{,}5 < X \leq 4$

The results of the survey yielded a cumulative mean value of 2.1 in 2017 and 1.7 in 2022, which means that there is a rather negative consensus regarding the acceptance of the e-motorcycle within the scope of this study (Table 2).

Table 2 Result classification of the mean values for 2107 and 2022 (Own table).

Mean value	2017	2022
Frequency 1 (<=1,5)	4	14
Frequency 2 (1,5< x <=2,5)	29	25
Frenquency 3 (2,5< x <=3,5)	8	2
Frequency 4 (x > 3,5)	0	0
	41	41

Checking the correlation between gender and the total sum of the mean value, a low correlation can be found with a value of -0.27 for 2017 and 0.17 in 2022. The results for women were thus never in the range of positive acceptance. Men, on the other hand, tended to rate acceptance positively with a percentage of 24%. It was striking that no results could be assigned to a high acceptance of a value greater than 3.5 in both years. If one considers the correlation between the criterion of age and the mean value, a higher degree of correlation of 0.40 for 2017 can be determined, whereas in 2022 the correlation dropped to -0.15. Only male persons with an age of over 60 years were classified as having a rather high level of acceptance, which was greater than a value of 3.0.

4.3 Selected results for state of social-acceptance

The results reveal a rather critical view on e-motorcycles. Even though the prominence and visibility of e-motorcycles among participants has increased by 25% in 2022, the willingness to buy such a vehicle has decreased by 27% compared to 2017 (Table 3). The willingness to consider an e-motorcycle at the next purchase was low in 2017 and even dropped from 20% (8 survey participants) to 5% (2 survey participants) in 2022. This is interesting, as the knowledge about e-motorcycles grew significantly over this period. Although, with regard to other kinds of electrically powered vehicles, the participants seem to be less tentative or show a greater acceptance, as 15% of the participants already call an e-bike, e-scooter or e-car their own.

Table 3 Result classification of the mean values for 2107 and 2022 by survey question (Own table).

Year		Age	Q1	Q2	Q3.1	Q3.2	Q3.3	Q4.1	Q4.2	Q4.3	Q5	Q6	Average MV (without Q5+6)
2017	Mean value	2,05	1,39	1,59	2,61	1,80	2,63	2,19	2,08	1,73			2,09
2022	Mean value	2,88	1,73	1,15	1,87	1,39	2,25	1,81	1,79	1,48	1,15	0,20	1,67
Delta 2022 - 2017		0,83	0,34	-0,44	-0,74	-0,41	-0,38	-0,38	-0,28	-0,26			-0,42
Change in % compard to 2017		40 %	25 %	-27 %	-28 %	-23 %	-15 %	-17 %	-14 %	-15 %			-20%

In 2022 78% of the interrogated motorcyclists consider the technology still in the development stage. The lower cost of ownership in comparison with a conventional motorcycle are not seen as a countable advantage by 74%. The environment friendliness and the lower noise emission are not relevant factors for 58% of the motorcyclists. On the contrary, the missing acoustic profile of a combustion engine seems to be a negative factor for the acceptance of e-motorcycles for 88%. Charging duration and the low range together with the limited charging infrastructure are seen as weaknesses for e-motorcycles, too. It adds to the picture, that only 5% of those questioned would buy an e-motorcycle in case of a state purchase bonus of approximately 4000€ like in Italy or Austria.

In conclusion, the acceptance scores slightly decreased consistently between 14% and 28% (Q3.1 to Q4.2) (Table 3). Also the general indicator acceptance (average of all MV) decreased by 20%, when comparing the results of 2017 and 2022. These are remarkable results, as in contrast to these, the sales figures of e-motorcycles in the German market rose significantly in the first half year of 2022 [16].

Even by looking at the results of the two additional questions used in the 2022 survey, the social acceptance remains low, if incentives were in place. Only two people of the 41 survey participants (5%) would be willing to buy an e-motorcycle, if they would receive state subsidies of 4.000 € (as e.g. in place in Austria and Italiy).

5 Discussion and implications

The analysis of motorcycle technology, ecological sustainability and behavioral economics reveals insights in the structure of the e-motorcycle segment. The relevant aspects have been addressed during two surveys from 2017 and 2022, showing that motorcyclist´s acceptance of e-motorcycles was relatively low and even declining. The study results suggest that perceived technical immaturity cannot be overcome with incentives either.

Unlike in other countries, e.g. Asian countries, two-wheeled vehicles play a minor role in everyday traffic in Germany. In many Asian countries, motorcycles and scooters form an important means of transport, as they are cheaper and space-saving and oftentimes replace cars [2] and [4]. Whereas in Germany the car is the means of transportation for a large part of the population with regard to work commuting, in 2020 68% regularly used a car to reach their workplace. Motorcycles fell into the 1% other vehicles [29]. Even though in German urban areas electrified two-wheeled vehicles are increasingly used for fulfilling micro-mobility needs or in the context of sharing offers in more sustainable way, e.g. e-scooters or e-bike-sharing, riding a motorcycle is predominantly a leisure activity [4], [16]. The power of the engine, the sounds of the motor are part of the experience for many motorcyclists, which might not be same when riding an e-motorcycle. For many users riding such a powerful and loud vehicle is part of their lifestyle.

When looking at the dimension of socio-political acceptance of e-motorcycles, the results of this study suggest that even though there is a political wish for an increase in electrically powered vehicles and traffic, perceived technical immaturity still leads to little acceptance in the market among classic motorcyclists.

Market acception, i.e. the adoption process of market innovations for e-motorcycles seems to be slowly, when looking at the “traditional” consumer segments of motorcyclists, but at the same time there is a strong growth in sales figures. It would be interesting to find out whether new target groups are responsible for the growing sales figures of e-motorcycles or how this increase can be explained.

The survey only asked about the lower maintenance costs of an e-motorcycle as a possible important factor for acceptance, but not whether a possibly higher purchase price of an e-motorcycle could also be an impeding factor, in addition to the technical restrictions.

Therefore, further research might focus on the following research question: If the traditional motorcyclist is reluctant to buy e-motorcycles, what are the profiles of the new e-motorcycle-buyer? It could be a promising approach to use the study results to identify and analyze these customer segments. The study offers insightful practical implications for e-motorcycles manufacturers. The findings could help them to better understand the mindset of the motorcyclists and derive potential target groups from the results. This study examines the motorcyclists only in South Germany, and therefore it should be noted that the power of generalization is limited. Further research steps should also consist in rolling out the questionnaire to other European regions.

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