Global Journal of Flexible Systems Management (September 2023) 24(3):459–481
https://doi.org/10.1007/s40171-023-00349-w

ORIGINAL RESEARCH

The Role of Automotive Flexibility in Supporting the Diffusion of Sustainable Mobility Initiatives: A Stakeholder Attitudes Assessment

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Received: 12 May 2023 / Accepted: 20 July 2023 / Published online: 10 August 2023

Abstract *Even if the European Commission is acting against the climate change, greenhouse gas emissions are still increasing in the transport sector. In this scenario, the flexibility characterizing the automotive sectors could invert this negative trend. The goal of this work is identifying suitable methodologies to evaluate flexible initiatives in automotive contexts, with a specific focus on sustainable mobility and electric vehicles (EVs). The results show that stakeholders identify purchase price as a determinant in the choice to purchase an EV, while for a model toward a sustainable e-mobility transition, experts place emphasis on renewable energy production and consumers on charging stations. A flexible approach in policy choices is also suggested in order to foster a pragmatic sustainability model in which the deployment of EVs is accompanied by green and circular practices. However, such change also requires attention to be paid to the social sphere with job creation and a spread of consumer knowledge toward sustainable choices.*

Keywords Analytical hierarchy process · Consumer attitudes assessment · Electric vehicles · Flexibility · Survey · Sustainable mobility

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Introduction

Sustainability is a major challenge of today's society, as it involves defining a new paradigm that aims to put stakeholder engagement at the center of the agenda (D'Adamo, 2022). In this framework, flexibility has always been described as an opportunity rather than a threat. In fact, the literature places increasing emphasis on the management of flexible systems (Sushil & Dinesh, 2022). The goal is identifying suitable methodologies to evaluate flexible initiatives (Sushil, 2018), and this choice needs to consider sustainability issues (Singh et al., 2021). Indeed, this topic is crucial to the development of civil society. For this reason after a brief description of the concept of flexibility, the paper proceeds to describe the European framework geared toward promoting sustainability. The focus, then, turns to the topic of this work, which is the existing relationship between sustainable mobility and electric vehicles (EVs), also evaluating consumer research.

The Role of Flexibility in Sustainability

The issue of supply chain flexibility is a strategic theme geared toward reducing unwanted supply chain uncertainty (Stevenson & Spring, 2007). Specifically, flexibility is the ability of a business to respond quickly and affordably to changes in the environment, technology, organization and strategy. As a result, it consists of initiatives aimed at improving efficiency and organizational performance (Shukla et al., 2019; Sushil, 2015). However, an inadequate communication among stakeholders in the value chain can lead to distortions (Dwivedi et al., 2021). Hence, stakeholders' engagement can contribute to the formation of ecosystems combining sustainability and digitization (Sassanelli & Terzi, 2022), as digitalization is changing business models of industries (Lamperti et al., 2023).

In addition, the framework in which a business operates is extremely complex due to dynamic and unpredictable aspects. In this regard, risk management should be related to the economic dimension and cost control (Settembre-Blundo et al., 2021). Within this framework, different regulatory systems in several countries can lead to further market distortions. On the one hand, there is an aim to reconcile climate policy flexibility mechanisms toward the inclusion of developing countries (Atici, 2022); on the other hand, some analyses show that EU emissions Trading System (EU ETS) does not cause carbon leakage (Naegele & Zaklan, 2019; Verde, 2020). However, Europe has established a defense mechanism called the carbon border adjustment mechanism (European Commission, 2023). Other analyses propose the introduction of a flexible consumption tax (Gerbeti, 2021).

The energy sector is also characterized by flexibility (Zahedi et al., 2022), and the mobility sector in particular is seeing the development of EVs, which are geared to have a reduced environmental impact compared to internal combustion vehicles. However, their impact on urban power systems needs to be well-studied (Vilathgamuwa et al., 2022). The literature pays attention to its deployment in Europe (Lanz et al., 2022; Razmjoo et al., 2022). Therefore, more details about the European framework should be provided.

The European Framework

The growth of greenhouse gas (GHG) emissions in the transport sector saw continuous growth from 2013 to 2019 in Europe reaching 835 million tons of CO_2 equivalent (compared to 673 $MtCO_2eq$ in 1990). The COVID-19 pandemic resulted in a deceleration in 2020 (727 $MtCO_2$-eq), but 2021 estimates show a rising trend again (777 $MtCO_2eq$) (European Environment Agency, 2022). The transport sector is responsible for about 25% of Europe's GHG emissions, so its reduction is necessary to achieve the European Green Deal. That is, Europe has a goal of achieving climate neutrality by 2050. However, this sector contributes 5% of gross domestic product and employs about 10 million people (European Commission, 2021). European Environment Agency reports that "transport is a vital sector but our current mobility system is simply not sustainable" (European Environment Agency, 2023). Starting in 2035, the European Union decided that all new cars sold in the market must be zero-emission vehicles. The current European context is characterized by a strong debate on the future of sustainable mobility. Some countries prefer to focus on e-fuels, others on biofuels and others on electrification. In this way, we understood the relevance of the issue, also emphasized in the literature (Tsakalidis et al., 2020; Wolf et al., 2021), and the need therefore to provide new assessments on the issue of sustainability.

Sustainable Mobility and Electric Vehicles

The automotive chain can be improved through cost efficiency (Jasiński et al., 2021), measuring the impact of dynamic models (Rosa & Terzi, 2018) and strategic alliances (Rajan et al., 2023), but also directing its choices toward flexibility concepts (Solke et al., 2022). Sustainable mobility is the achievement of an overall volume of physical mobility meeting basic needs through appropriate technologies limiting GHG emissions in order not to alter ecosystem integrity (Banister, 2008; Bardal et al., 2020).

Electric mobility is emerging to minimize environmental impacts. However, there are many challenges to be faced (Onat et al., 2021). Indeed, the use of green sources is required as much in the production phase as in the use one (Shafique & Luo, 2022) including the use of energy storage systems (Gupta & Shankar, 2022). The environmental impact battery should be investigated considering its impacts (Xia & Li, 2022), and a significant amount of components and raw materials are required (Baars et al., 2021), in particular lithium (Sun et al., 2022). Here, the attention should be paid to their end-of-life management (D'Adamo & Rosa, 2019), by encouraging circular solutions along the entire supply chain (Taddei et al., 2022) and providing benefits and opportunities (Molla et al., 2023). Interesting results are modular EV platforms (Lampón, 2022) and innovation in electric mobility ecosystems (Arribas-Ibar et al., 2021). The green transition in electric mobility requires the use of renewable energy, local industrial development of the sector and battery recycling (D'Adamo et al., 2023). Furthermore, large-scale EV adoption will not hinder the automotive industry's long-term development (Guo et al., 2022), and the life cycle of batteries also requires in-depth analysis (Schulz-Mönninghoff & Evans, 2023).

Consumer Perspective and Electric Vehicles

Consumer analyses on EV issues show contradictory views also stemming from the difficult balance between energy transition and mining impacts resulting from the complex supply chain of EVs (Liu et al., 2022). Purchase cost is the most influential factor in the purchase of EVs (D'Adamo et al., 2023). In addition to purchase price, availability of the required charging infrastructure and charger subsidies are believed to be the enabling factors for EV adoption (Almansour, 2022). In this way, government subsidies at the purchase stage are decisive, and some analyses try to quantify the value demanded by consumers (Dong, 2022). In addition, other authors highlight to better evaluate how tax incentives might lead the consumer to purchase such vehicles (Secinaro et al., 2022).

However, purchase choices also involve other perspectives. In fact, while knowledge of EVs is considered the most relevant cognitive measure (Jaiswal et al., 2022), studies should more include some factors such as individuals' environmental concerns and green trust facilities (Yeğin & Ikram, 2022). In addition, consumer preferences vary by purchasing group: private buyers of EVs are more interested in high-density charging facilities, while cab drivers are more interested in high range (Xiong et al., 2023). Regarding autonomy, a very useful application could be battery swap technology. Its adoption is positively influenced by attitude, knowledge, perceived usefulness and subjective norm (Adu-Gyamfi et al., 2022). Consumers' perception about the ecological attributes of EVs seems to be vague, and therefore they are unwilling to pay more for such products (Shi et al., 2023). In addition, an awareness campaign on the EV segment should also be evaluated (Bryła et al., 2023). Renting an EV can help people get past consumer confidence and affordability. In addition price value does indirectly impact through the mediating effect of willingness to pay (WTP) the rental intention of young consumers (Gulzari et al., 2022).

Research Questions

This work builds on the approach proposed by D'Adamo et al. (2023), in which the factors influencing the purchase of an EV and the factors driving electric mobility toward the green transition were examined. A different methodological approach (analytic hierarchy process (AHP) vs. Likert scale) is provided using academic experts, and also given the increased focus on consumers, it is necessary to conduct an online survey on EVs to identify consumer choices in Italy. Consequently, this work aims to focus on sustainability challenges in electric mobility, by identifying whether a flexible strategy can support the decarbonization of the transportation sector. The following research questions (RQs) will be investigated:

RQ1. Which factors influence the purchase of an electric vehicle?

RQ2. Which factors are driving electric mobility toward a green transition?

RQ3. Which are the consumer behaviors toward electric vehicles?

Materials and Methods

The methodology used in this work consists of a hybrid model composed of the AHP and the online survey.

Analytic Hierarchy Process

AHP is a multi-criteria decision support technique. Its approach is widely used to evaluate choices in the areas of sustainability and flexibility (Jain & Raj, 2013; Mangla et al., 2015). This method aims at identifying the relevance of specific criteria and could be used to compare different alternatives. The output of AHP is a priority level assigned to each criterion based on a nine-point rating scale, and it is based on pairwise comparison (Saaty, 2008). The most important criteria are given the highest weight, and all weights are normalized for comparison. AHP can capture the subjective as well as the objective view of problems, and measuring the consistency of the decision reduces the bias against the decision (Kumar & Pant, 2023). However, other multi-criteria methods are also suitable for decision making, but AHP has the advantage in which factor weights are assigned in an easy way and is very appropriate for sustainable mobility (Alex et al., 2022).

Within this work, AHP is used to answer the RQ1 and RQ2. AHP allows to measure the reliability of assessments, by calculating a consistency ratio (CR). The maximum value of CR can be 0.10 and is calculated as the ratio of consistency index (CI) to random inconsistency (RI).

AHP consists of the following steps: (i) objectives' identification; (ii) experts' identification; (iii) criteria selection; (iv) weights assignment; and (v) weights aggregation.

The objectives of the analysis are RQ1 and RQ2, respectively. These are the same topics analyzed in a previous step of the research (D'Adamo et al., 2023). However, in addition to changing the expert panel, we chose to use AHP. The 10-point value is an excellent method, but we opted for the AHP for two reasons: (i) to conduct an analysis not at the level of a single variable, but in pairs, and (ii) to have a consistency index on the ratings provided by the experts. Similar choices are also seen in other studies (Jin et al., 2022; Leung & Mo, 2019).

The goodness of the results of an AHP depends on the selected experts, and therefore their experience is considered a relevant parameter (Tsyganok et al., 2012). This work considered ten academics selected from authors who published works on sustainable mobility and EVs in the period 2022–2023 with at least ten years of experience (D'Adamo et al., 2023). The initial e-mail recalled the goal of the project, highlighted the differences with previous research work, and indicated the necessary steps. It also reported that only the first ten positive responses would be considered. Table S1 presents the list of academics with some characteristics, such as their role, country of reference, and years of experience. It shows that 20% of them are female.

The Identification of the Criteria

The selection of criteria for continuity to the approach proposed in this work is defined in accordance with the literature (D'Adamo et al., 2023). However, this previous research presented thirteen criteria for RQ1 and twelve criteria for RQ2. Consequently, it may be necessary to use the local–global priority method, but although Saaty (2008) suggests that the best choice is a number of criteria equal to 5 ± 2, we analyzed that the value of RI is provided even for a number of criteria equal to ten. Therefore, an intermediate step for criteria formation was thought of. Therefore, the idea was to ask the first five experts who had expressed interest in participating in this analysis to indicate which criteria should be disregarded, as they were considered less important. For Table S2, it was requested "please insert an X to eliminate any of the following criteria. Specifically, the analysis will be repeated for a 10×10 matrix, so please indicate the 3 least relevant criteria." Results show that all experts indicated "administrative benefits" and "noise abatement risk" (due to quietness of vehicle toward people/animals). As for the third criterion to be eliminated, the choice fell on "driving experience," which collected three negative opinions. It is shown that these three criteria were the ones that had gathered the least weight. In addition, it was suggested to change savings into economic savings in order to underline the economic dimension. As for Table S3, a similar approach was taken: "please insert an X to eliminate any of the following criteria. Specifically, the analysis will be repeated for a 10×10 AHP, so please indicate the 2 least relevant criteria." The responses for that RQ saw a different situation from the previous one. Some experts (three out of five) identified the "improve public mobility" criterion not to be considered. This criterion was the second least relevant in the previous analysis. The last was increase "incentives at the purchase stage," which in this pre-analysis garners on par with "bonuses for returning old vehicles" two out of five negative opinions. In addition, that criterion "Reduce environmentally harmful subsidies" was changed to "Discourage the purchase of cars fuelled by fossil fuel" as it allows for a better remark that no economic subsidy can be allocated to vehicles with high environmental impact. The solution, suggested by the experts themselves, was to combine them. After this intermediate step, it is possible to have a complete methodological framework. In fact, Fig. 1 shows the ten factors for RQ1 and RQ2.

The ten criteria were administered to the experts, who were given the opportunity to clarify doubts about the proposed alternatives through an online meeting. The excel sheet that the experts received showed that the analysis was conducted over the same time frame, but separately for the two RQs. In addition, it was specified to the five experts not chosen at the initial stage, the initial process that had led to considering ten criteria. The survey was conducted between February and March 2023, and the experts were informed of the automatic CR calculation within the sheet given to them.

The Assignment of Weights

The compilation of a 10×10 matrix turns out to be the most complex, in which forty-five responses are provided. Each expert can provide a score between 1 and 9 (Table S4) (Saaty, 2008). In addition, the normalized approach (Subramoniam et al., 2013) allows for the sum of all criteria to give a value of 1. CR, as stated above, is the ratio of CI to RI. CI is calculated as $(\lambda_{max} - n)/(n - 1)$, in which λ_{max} is the inner product of the row vector containing column sums and the eigenvector matrix, and n is the number of criteria. Finally, RI is defined according to the number of criteria (Table S5).

Online Survey

The research adopts behavioral methodology in line with the literature (Sovacool et al., 2018), and questionnaires represent a quick and effective way to collect consumer opinions (Xia et al., 2022). In particular, the literature emphasizes the advantages associated with web-based questionnaires (Menegaki et al., 2016), which are found to be convenient and also adequately provide answers on the perception of EVs (Jaiswal et al., 2021). This form of survey is developed to understand consumer attitudes (Wu et al., 2020), and some analyses cover the Italian territory using either a hybrid approach with face-to-face interviews and Internet-based questionnaires (Giansoldati et al., 2018), or with an online-only survey approach (Danielis et al., 2020). Consequently given the potential expansion of EVs and Italy being a well-known country in the automotive industry, it is deemed useful to propose a new study. This online survey is geared toward providing

RQ1: Factors influencing the purchase of an electric car	F1 - Battery autonomy
	F2 - Contribution to society
	F3 - Respect for the environment
	F4 - Purchase incentives
	F5 - Operating costs
	F6 - Purchase cost
	F7 - Infrastructure (electric columns)
	F8 - Noise pollution
	F9 - Charging time
	F10 - Economic savings
RQ2: Critical factors for the green transition in electric mobility	CF1 - Increase incentives at the purchase stage including bonuses for returning old vehicles
	CF2 - Regulating& controlling the price of electricity
	CF3 - Informing and raising consumer awareness
	CF4 - Green energy production
	CF5 - Local industrial development of the sector
	CF6 - Improving battery autonomy
	CF7 - Increasing the presence of charging stations
	CF8 - Discourage the purchase of cars fueled by fossil fuel
	CF9 - Reducing purchase price
	CF10 - Battery recycling

Fig. 1 List of criteria

responses to RQ3. The objective of the questionnaire was threefold:

i. to assess the degree of knowledge and habits toward the vehicle sector, with a specific focus on EVs;
ii. to calculate the willingness to pay (WTP) of consumers in the automotive sector with a focus on electric, also proposing a comparison between the choice of internal combustion engine (ICE) vehicles and EVs;
iii. to evaluate from the consumers' point of view the factors that were previously analyzed from the experts' point of view through AHP analysis with respect to both questions (see Fig. 1).

The questionnaire was administered through social channels (e.g., LinkedIn) during March 2023 according to the literature (Hoeft, 2021). A limitation of our approach is that we do not provide a participant compensation system that typically characterizes other online surveys (i.e., Amazon Mechanical Turk platform) (Colasante et al., 2022).

The questionnaire was first validated by two experts from those proposed in the previous phase (Table S1) and consisted of 25 questions (Supplementary File). In addition, a filter question was asked at the beginning such that only people with a type B driver's license completed the questionnaire. Its purpose was introduced to the participants at the beginning of the questionnaire; in addition, anonymity was guaranteed. The total number of responses obtained was 252, and of these after the filter question, 241 remained.

The questionnaire was divided into six main sections:

- The first related to consumers' sustainable or non-sustainable habits and information about their current car fleet.
- The second with the aim of obtaining information on consumers' current knowledge about the automotive sector, specifically electric.
- The third section, on the other hand, went to analyze consumers' willingness to pay for the purchase of a car, whether internal combustion or electric.
- The fourth section proposes the decision-making process in the evaluation between two alternatives (electric car and internal combustion car).
- The fifth section is closely related to the AHP analysis conducted earlier. Consumers were asked to rate the same criteria assessed by the experts to analyze any inconsistencies.
- The sixth section identified socio-demographic information.

The questions in the questionnaire are mainly multiple-choice answers, in which the Likert scale (1–5) was used whenever possible.

Results

The structure of the work provided two distinct methodologies to describe the three objectives. Specifically, the first two subsections are proposed for RQ1 and RQ2. In contrast, for the purpose of greater clarity on the representation of different outcomes for RQ3, seven additional subsections are proposed.

Factors Influencing the Purchase of an Electric Car

The aim of RQ1 was to understand what elements were influencing consumer buying behavior, and why the electric car market is struggling to grow today.

Tables S6–S15 show the weights provided by the experts related to RQ1. We would like to point out that the anonymity of experts is guaranteed since there is no correspondence with the number of experts provided in Table S1 (the same is true throughout the work). For example, expert no. 1 (E1) proposed that criterion F6 (Purchase cost) has a higher impact than all the others, and it follows that it has an average weight of 0.23. Instead, expert no. 2 (E2) assigned it to criterion F1 (Battery autonomy) with an average value of 0.17. This analysis thus allows for the integration of different perspectives and relevance.

In accordance with the AHP methodology, the file provided by each expert was verified to be consistent. Once this step was performed on the CR, the different responses were aggregated individually (Table 1).

The findings show that most of the experts (7 out of 10) identified F6 (Purchase cost) as the factor that most influences the results. In contrast, the remaining experts assigned relevance to three other factors: F1 (Battery autonomy), F4 (Purchase incentives) and F10 (Economic savings). The last step was to aggregate the ten averages from the experts considering that each of them had equal relevance—Fig. 2.

The AHP not only provides a ranking, but also quantifies the relevance of these factors, and factor F6 excels very significantly with 0.206 (factor average rate). This means that one-fifth of the weight is associated with this criterion alone. This factor together with the previous three and the F7 (Infrastructure) factor influences about 70% of consumer relevance according to expert opinions.

Critical Factors for the Green Transition in Electric Mobility

The aim of RQ2 was to understand what critical factors should be met to achieve a green transition in the electric mobility sector.

Regarding RQ2, all pairwise-comparisons are proposed in Table S16–S25. Again, the two experts identified a different criterion that has greater relevance: E1 assigned it to criterion CF4 (Green energy production) with 0.22, while E2 assigned it to criterion CF10 (Battery recycling) with 0.17. Also at this stage, it was verified that the experts' CR was consistent with what was expected. Table 2 aggregates the different judgments individually.

The results show that again some criteria are chosen more than the previous ones. Specifically, four experts opt for CF4 (Green energy production), three for CF5 (Local industrial development of the sector), two for CF1 (Increase incentives at the purchase stage including bonuses for returning old vehicles) and one for CF10 (Battery recycling). Also for this phase of the work, it is necessary to aggregate single contributions provided by experts considering that have the same relevance—Fig. 3.

For this RQ, there is no one critical factor that predominates over all the others; in fact, it can be seen that the difference between the first and fourth ranking RQ2 turns out to be 0.052, while the difference between the first and second ranking RQ1 was 0.070. In particular, it emerges

Table 1 Aggregation of weights—electric car

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
E1	0.054	0.062	0.081	0.179	0.047	**0.226**	0.092	*0.040*	0.071	0.148
E2	**0.171**	0.087	0.067	0.099	*0.050*	0.129	0.148	0.058	0.077	0.113
E3	0.062	0.092	0.105	**0.235**	*0.046*	0.136	0.071	0.054	0.081	0.119
E4	0.094	0.067	0.079	0.189	0.039	0.140	0.050	*0.033*	0.055	**0.254**
E5	0.169	0.069	0.079	0.099	0.044	**0.281**	0.064	*0.035*	0.051	0.111
E6	0.189	0.062	0.070	0.099	*0.040*	**0.236**	0.086	0.054	0.047	0.118
E7	0.135	0.056	0.063	0.163	*0.035*	**0.273**	0.113	0.041	0.048	0.072
E8	0.135	0.080	0.077	0.095	*0.041*	**0.204**	0.176	0.048	0.056	0.087
E9	0.146	0.067	0.116	0.058	*0.050*	**0.170**	0.103	0.101	0.076	0.114
E10	0.204	*0.019*	0.019	0.083	0.066	**0.261**	0.120	0.027	0.114	0.087

Bold: max weight; italic: min weight

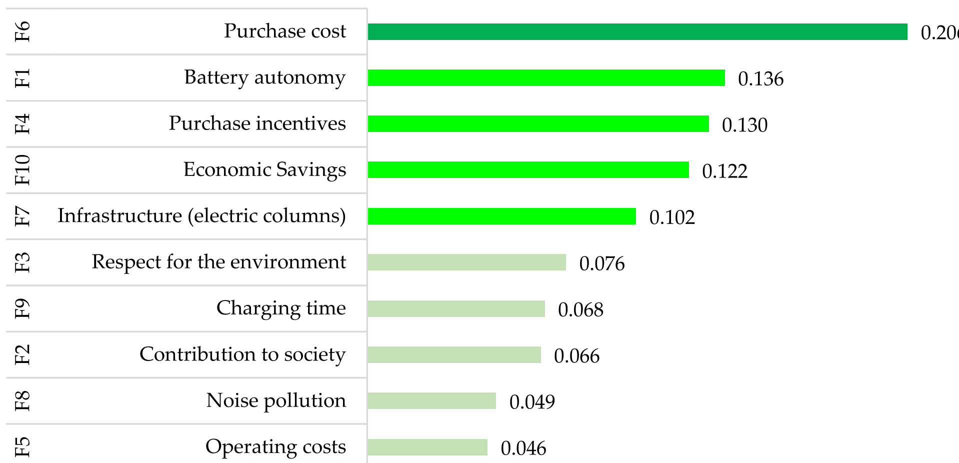


Fig. 2 Ranking of factors in accordance with experts—purchase of an electric car

Table 2 Aggregation of weights—green transition in electric mobility

	CF1	CF2	CF3	CF4	CF5	CF6	CF7	CF8	CF9	CF10
E1	0.107	0.054	0.072	**0.216**	0.111	0.082	*0.046*	0.062	0.108	0.142
E2	0.099	*0.050*	0.077	0.129	0.148	0.067	0.058	0.113	0.087	**0.171**
E3	0.110	*0.041*	0.056	0.160	**0.213**	0.068	0.049	0.091	0.091	0.121
E4	**0.194**	0.052	0.078	0.167	0.109	0.096	*0.044*	0.069	0.066	0.125
E5	**0.197**	0.066	0.049	0.164	0.144	0.070	*0.042*	0.078	0.084	0.106
E6	0.079	0.041	0.070	**0.234**	0.177	0.062	0.054	*0.035*	0.047	0.202
E7	0.093	*0.041*	0.063	**0.208**	0.180	0.082	0.055	0.072	0.048	0.157
E8	0.121	0.069	0.069	**0.205**	0.176	0.053	0.045	0.069	*0.039*	0.154
E9	0.113	*0.050*	0.087	0.148	**0.171**	0.077	0.067	0.099	0.058	0.129
E10	0.108	*0.045*	0.048	0.112	**0.149**	0.129	0.094	0.094	0.123	0.098

Bold: max weight; italic: min weight

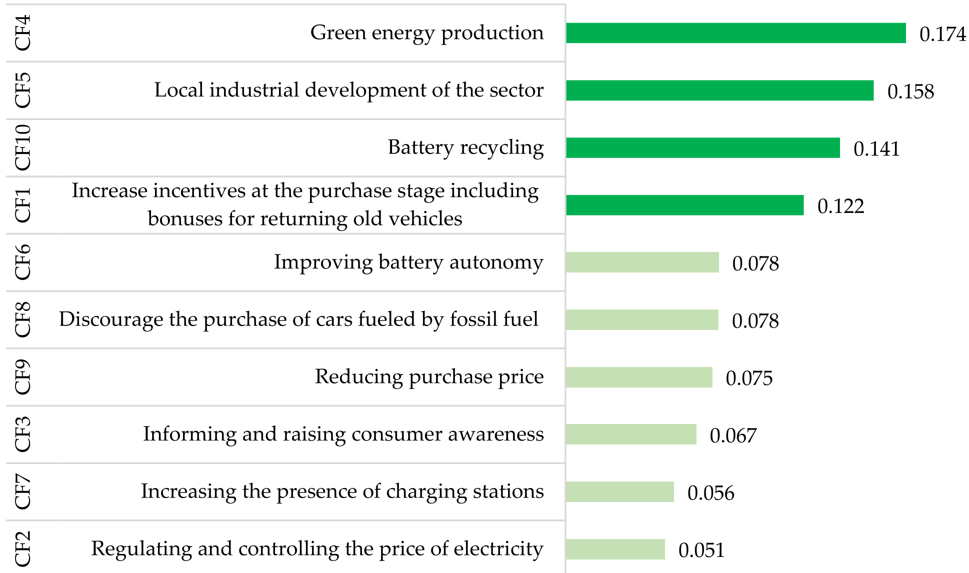


Fig. 3 Ranking of factors in accordance with experts—green transition in electric mobility

that the four critical factors mentioned above account for 59.5% of the total.

Consumer Behaviors toward Environmental Issues and Electric Vehicles

The goal of RQ3 is to assess consumer behavior toward EVs in Italy. The results are separate for each of the six sections of the questionnaire.

Socio-Demographic Data of Respondents

The analysis of the questionnaire starts from the information provided in the last section. Regarding socio-demographic data, the sample analyzed is characterized by an average age of 34 years old, with a range of 18–80. The sample can be divided as follows: 18–24 years (37%), 25–34 years (27%), 35–44 years (9%), 45–54 years (11%), 55–64 years (14%) and > 64 years (1%)—Fig. S1. As for gender predicts a slight presence of the male sample (56%) compared to the female sample (43%)—Fig. S2. Educational qualification sees those with a bachelor's degree (34%) excel over diploma (29%) and master's degree (27%)—Fig. S3. Finally, the socio-demographic section considers the altruistic character of people where about half consider themselves more altruistic than selfish (51%). On a Likert scale of 1–5, there is a mean value of 3.9—Fig. S4.

Consumers' Sustainable Habits

The results of the first section highlight sustainable habits and a significant attention of consumers to environmental issues emerges. In fact, 50.6% of the sample gives a rating of "agree" and 30.7% "very agree" resulting in an average value of 4.1. Breaking down this value by age cluster (Fig. 4), it is evident that younger people (18–24 years, i.e., the largest sample of our respondents) are the least attentive on a daily basis to pursuing sustainable behaviors (mean value 4.0), while with increasing age, it tends to increase rather significantly reaching its peak (4.4) with the 35–44 years range. The data for consumers older than 64 years is not statistically significant numerically, as the sample is little. A regression analysis was also conducted to test for a correlation between consumers with virtuous sustainability behavior and character traits, given the value of 3.9 that emerged in Fig. S4. However, there is no evidence of a relationship between the two variables (Fig. 5).

The analysis of the first questions on EVs, unequivocally shows that few citizens own electric cars (7.5%) compared to internal combustion ones. This value highlights the need to produce such analyses in order to understand the reasons for this choice. Consumers are asked where they routinely park their cars, and whether they have the possibility of installing a charging station for an EV at this location. It turned out that the majority of the sample park their cars on the street (46.5%), with the remainder in private shelters (private driveway, condominium parking, shared garage, private garage)—Fig. S6. Of these, 59% would have the option of installing a charging station. Specifically analyzing the small sample of people with electric cars showed that only 11.1% of people park their cars on the street.

Compared to the total sample, more than double the number of people shelter their car in a private garage (77.8%). This gives insight into how important it is today to have a private place in which to leave the car in charge. In fact, about 90% of people who own an electric car have the possibility of installing a charging station in the car's usual shelter (+ 30% compared to the entire sample). In

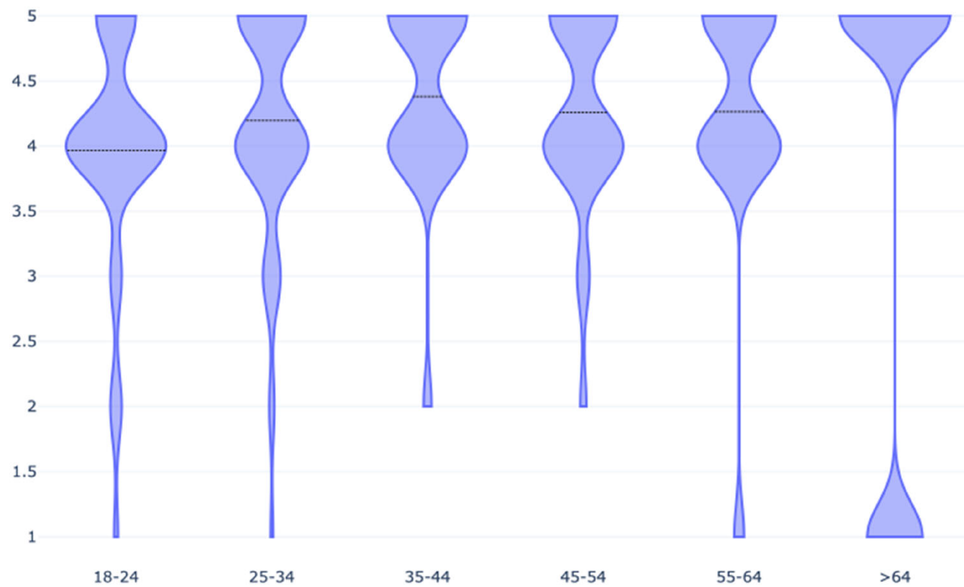


Fig. 4 Attention to environmental issues—the following average values are obtained: 4.0 (18–24 years); 4.2 (25–34 years); 4.4 (35–44 years); 4.3 (45–54 years); 4.3 (55–64 years); and 3.7 (> 64 years)

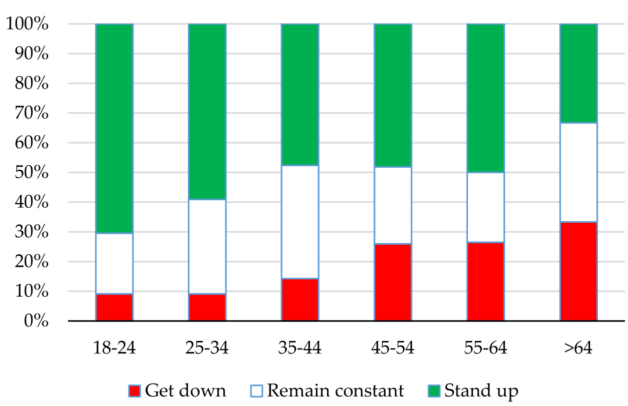


Fig. 5 Fossil fuel price trends in the future—the following average values are obtained: get down (14.2%), remain constant (26.4%) and stand up (59.4%)

addition, consumers were asked what they thought regarding the price trend of fossil fuels in the near future. Most (59.4%) believe that the price will rise—Fig. 5. Breaking down the sample by age, it can be seen that it is the 18–24 age group that believes most in a price rise in the near future. As age increases, this belief decreases.

Consumer Knowledge about the Automotive Sector

The second section of the questionnaire sought to extract the current state of consumer knowledge in the field of electric mobility by asking three questions using the Likert Scale (1–5). Consumers consider themselves neutrally informed about electric cars, with a mean value of 3.1. Instead, relevance is given to the source by which electric cars are recharged. In fact, a significant delta of 1.6 is recognized if cars are recharged with only energy obtained through renewable sources (4.3), compared to using a mix of energy sources including fossil fuels (2.7)—Fig. 6.

By dividing the sample by age, it was possible to highlight the fact that the youngest part of the sample is the one that considers itself least informed about electric cars (2.9) together with the 55–64 range. The data on the very young is also verified in the next two questions, as the sample aged 18–24 recognizes less importance to electric car charging through only the use of renewable sources (4.2), with a delta of only 1.3. Similarly, the sample aged 25–34 gives the most importance to it (4.4) along with the 55–64 range, with a delta of 1.8. Thus, a difference emerges between the very young and the young (statistically more significant than the other groups) and the need to strengthen knowledge at the university level on these issues is identified—Figs. 7, 8 and 9.

Willingness to Pay toward Electric Vehicles

The RQ3 analysis consists of several perspectives, and the third section of the questionnaire aims to investigate the more economic sphere of the respondents. We proceed below to analyze consumers' WTP. First, the information on WTP was extracted in the case where price was not a major constraint (a price in the range of 5000–65,000 € at intervals of 5000 € could be chosen). The mean value obtained was 29,515 € (Fig. 10). Analyzing by age, the clusters of 18–24 years, 25–34 and 35–44 turn out to be those with the highest WTP, with an average value above 30,000 € (Fig. S7).

The situation changes when consumers are asked about current WTP, considering price as the relevant variable. In this case, the younger cluster that the one previously found to have the highest WTP switches to having the lowest,

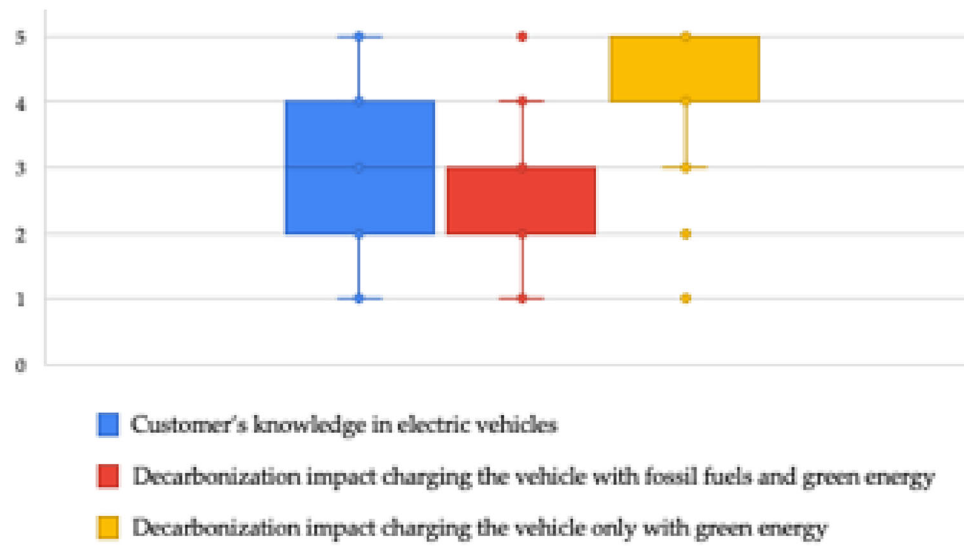


Fig. 6 Consumer knowledge—the following average values are obtained: 3.1 for customer's knowledge in electric vehicles; 2.7 for decarbonization impact charging the vehicle with fossil fuels and green energy; and 4.3 for decarbonization impact charging the vehicle only with green energy

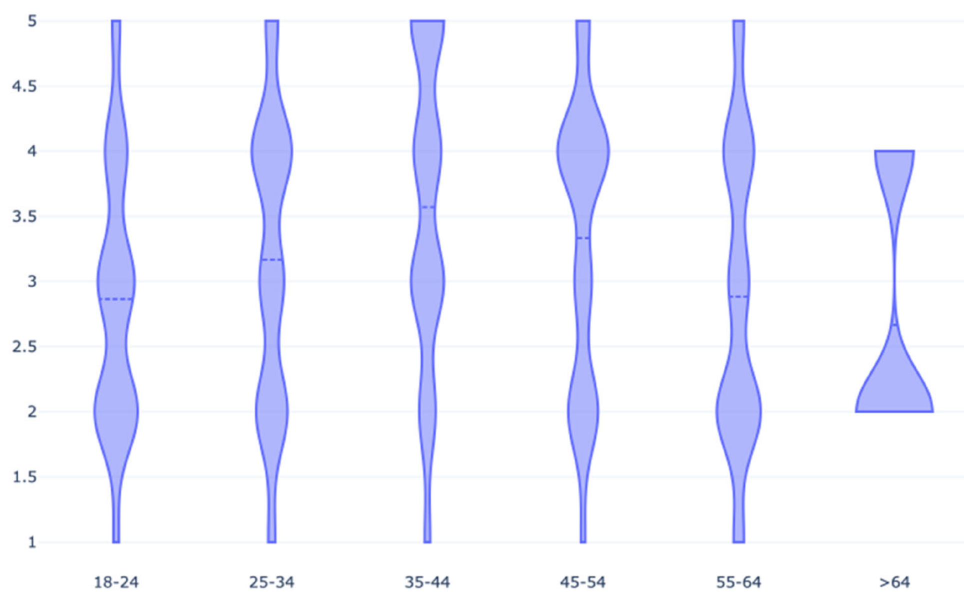


Fig. 7 Customer's knowledge in electric vehicles—the following average values are obtained: 2.9 (18–24 years); 3.2 (25–34 years); 3.6 (35–44 years); 3.3 (45–54 years); 2.9 (55–64 years); and 2.7 (> 64 years)

with an average value of about 18,000 € (Fig. 10). WTP tends to increase with increasing age, peaking at about 28,000 € with the 45–54-year cluster, and then decreasing again. Analyzing the entire sample, the average WTP is about 21,525 € (Fig. S8), which represents a major decrease from the previous situation (– 26%). Thus, from this finding, it emerges how younger people are more detached from the real context, strengthened even by expenses not incurred directly by them but typically by their parents. However, when they are then faced with price as a constraint, they tend to incorporate that issue into their choice process.

Another very interesting result is that consumers tend to give relevance to their needs. In fact, in a context where the price of the electric car is high, only a quarter of them would be willing not to buy the car by waiting for the price of EVs to decrease (26.1%). Notably, these data have its lowest value among the youngest (18–24 years)—Fig. S9. There is a sample of about 16.2% who would not change their choices on the classically powered car, while 57.7% would opt for a hybrid car. Analysis by age also shows that the 45–54 range is the least interested in purchasing the hybrid option, maximizing the choice toward the other two available options.

Next, the analysis proceeds to focus on an additional filter. Indeed, it investigates who would be willing to pay a premium price for the electric car. The positive response concerns only 54.4% of the "valid" sample of 241 participants. We then proceed to the 110 respondents how much they recognize this premium price as a percentage. On average, the consumers analyzed would be available to recognize a WTP equal to 14% more for an EV (Fig. 11).

Fig. 8 Decarbonization impact charging the vehicle with fossil fuels and green energy—the following average values are obtained: 2.9 (18–24 years); 2.6 (25–34 years); 2.8 (35–44 years); 2.7 (45–54 years); 2.6 (55–64 years); and 1.7 (> 64 years)

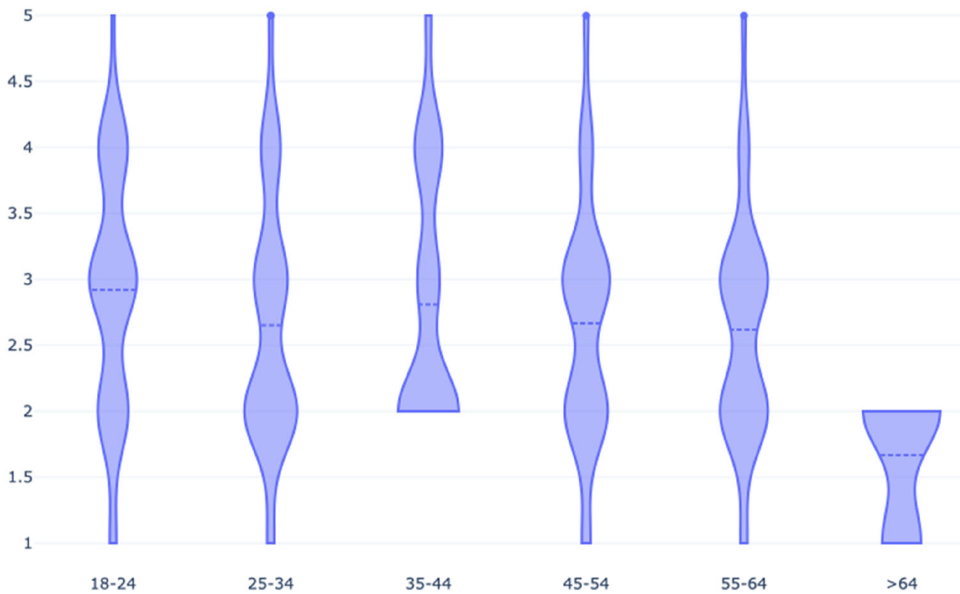
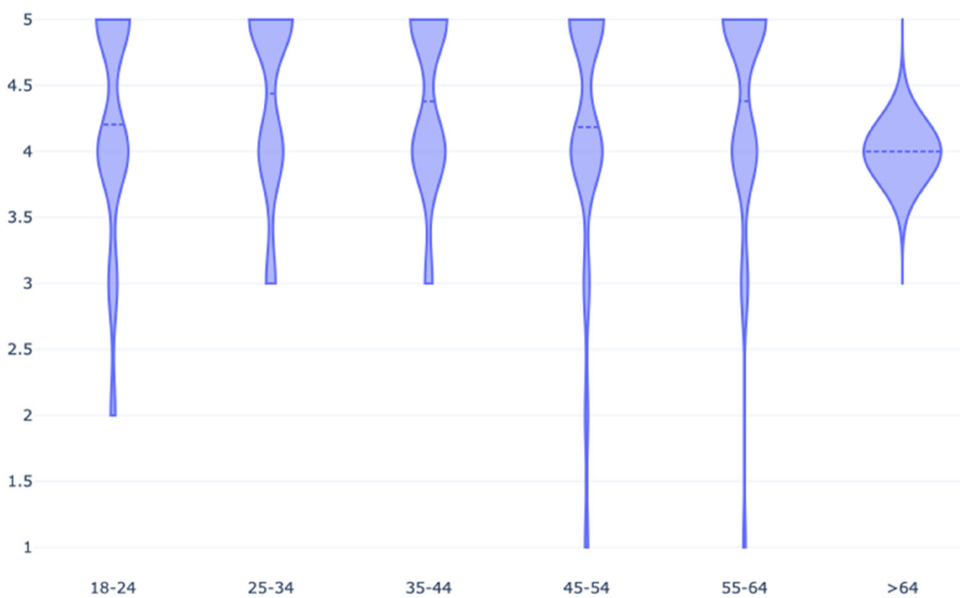


Fig. 9 Decarbonization impact charging the vehicle only with green energy—the following average values are obtained: 4.2 (18–24 years); 4.4 (25–34 years); 4.4 (35–44 years); 4.2 (45–54 years); 4.4 (55–64 years); and 4.0 (> 64 years)



These results indicates that only half of the people are willing to recognize a higher price to electric cars, and since the price of these cars is higher than that of internal combustion cars, this inevitably results in a severe restriction of the potential market. No significant differences are found on the data broken down by age (Fig. S10).

Making use of the data extracted in the previous sections of the questionnaire, an attempt was made to characterize and identify the 110 consumers who associate a premium price with the electric car. Specifically, this segment of consumers turns out to be more attentive in their daily lives to environmental issues, obtaining an average value of 4.4, which represents a notable increase over the value of 4.1 obtained with respect to the sample as a whole. Moreover, if with the sample as a whole consumers considered themselves informed for a neutral value of 3.1, again there is an important average increase to 3.5. Consumers who would spend more on an electric car thus seem to be more aware and informed about the current situation. Moreover, to support the argument these consumers consider it crucial for decarbonization that electric cars be recharged with energy obtained from renewable sources, with a mean value of 4.5 representing an increase from 4.3 for the sample as a whole (Fig. S11).

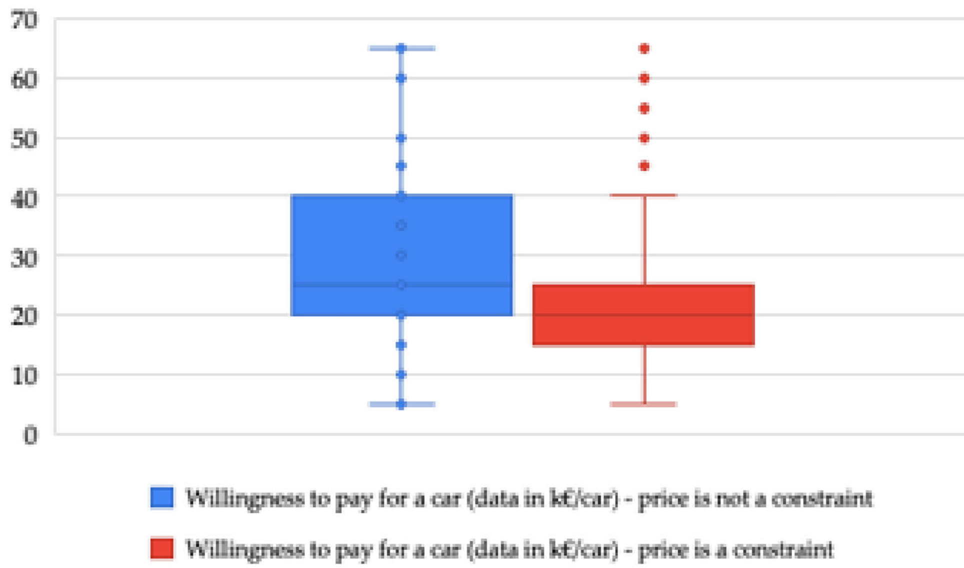


Fig. 10 Willingness to pay for a car (data in k€/car)—the following average values are obtained: 29,515 €/car if price is not a constraint and 21,525 €/car if price is a constraint

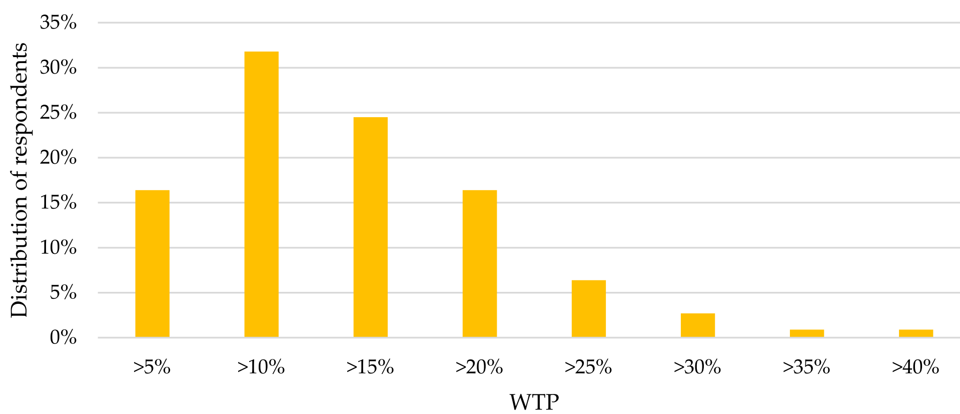


Fig. 11 Premium price recognized by respondents for an electric car

Electric Vehicle or Internal Combustion Engine Vehicle: Consumer Analysis

The fourth section aims to confront the consumer with a choice between the two alternatives concerning the entire sample of respondents. The first question, using the Likert Scale (1–5), asks what type of car will be purchased in the next 7 years—Fig. 12.

The sample surveyed gives a slight preference to the electric car (3.1) over the internal combustion car (2.8).

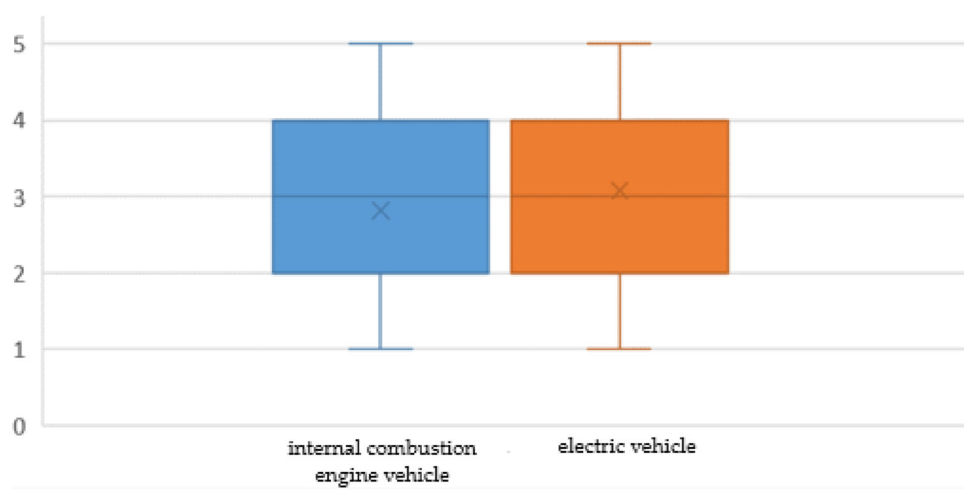


Fig. 12 Future purchase propensities toward the two different types of cars—the following average values are obtained: 2.8 for internal combustion engine vehicle and 3.1 for electric vehicle

However, the value that confirms what has emerged so far, which a strong perplexity about electric cars with a summary judgment is testifying to a rather neutral degree. Analysis by age shows that the greatest propensity to purchase combustion vehicles is among younger people (range 18–24 presents a value of 3.2). The value is very peculiar since they are the only ones by age group that present a higher value than the EV. In this case, the highest value (equal to 3.25) is recorded for the 35–54 age group (Fig. S12).

In the next stage of the section, consumers were also faced with a purchase choice. The first question compared four vehicles, two electric vehicles (EVs) and two internal combustion engine vehicles (ICE vehicles), in which price is a constraint—Fig. 13:

- "EV 1" costs 3000 € more than ICE vehicles and thus has a 9% higher premium price. In addition, it has lower battery charging time than EV2.
- "EV 2" costs 12,000 € more than ICE vehicles and thus has a 44% higher premium price. However, it has much more significant technical performance than EV1 in terms of distance traveled at full capacity and acceleration.
- "ICE vehicle 1" characterized by a lower price and a longer travel distance than EVs. It also has an acceleration value similar to EV1.
- "ICE 2 vehicle" has the same features as the ICE 1 vehicle, and it is added that consumers value EVs but would not buy them because of their price.

It should be noted that the premium price set at 9% was found to be close to that obtained from the previous phase of the questionnaire (14%).

The results confirm that for consumers at the time of purchase, the price parameter is paramount, taking precedence over vehicle performance. In fact, most of the sample choose ICE vehicles (56.9%). Two distinct categories emerge among them. The first concerns that it appreciates EVs but is held back by its price (38.6%). The second, on the other hand, indicates a clear preference toward ICE Vehicle (18.3%). Among those who choose electric there is a greater preference toward the higher performance vehicle, even if it has a higher cost (25.3% vs 17.8%).

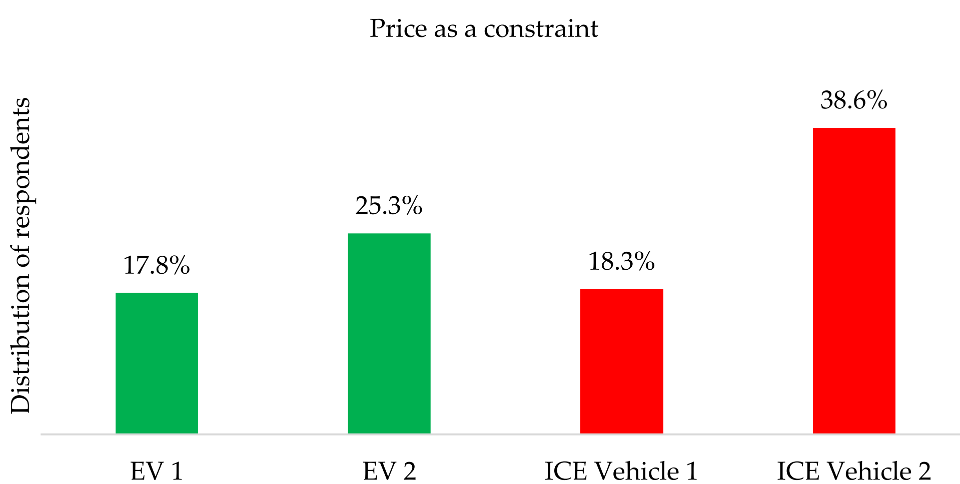
The second question considers that the vehicles cost the same amount and the following characteristics are noted—Fig. 14:

- "EV1*" has lower battery charging time than "EV2*" that instead has better both distances traveled at full capacity and acceleration.
- "ICE vehicle 2*" is different from "ICE vehicle 1*" as the consumer prefers the convenience of not having to recharge the car and having to manage autonomy compared to EVs.

When price is not an issue, most consumers pour into choosing EV 2* (70.3%). However, another result also emerges. In fact, there is still a segment of consumers who prefer the ICE vehicle. A portion of these do not consider themselves ready in handling the charging of the EV (11.3%), while the other prefers in all cases to opt for the ICE vehicles (10.5%). An online survey does not capture the reasons for this revulsion, which could be associated with the obstacles that typically characterize new products (electric could be seen that way). Thus, there is a 35% reduction in consumers opting out of ICE vehicles, but even in the absence of the price constraint, there remains a 22% share who continue not to choose EVs.

There was a wish to go into greater detail regarding the analysis of consumers' purchase choice. An initial analysis that was carried out included a reduced sample of consumers, from 241 to 47. These 47 consumers were selected

Fig. 13 Consumers' car purchase choice—price as a constraint



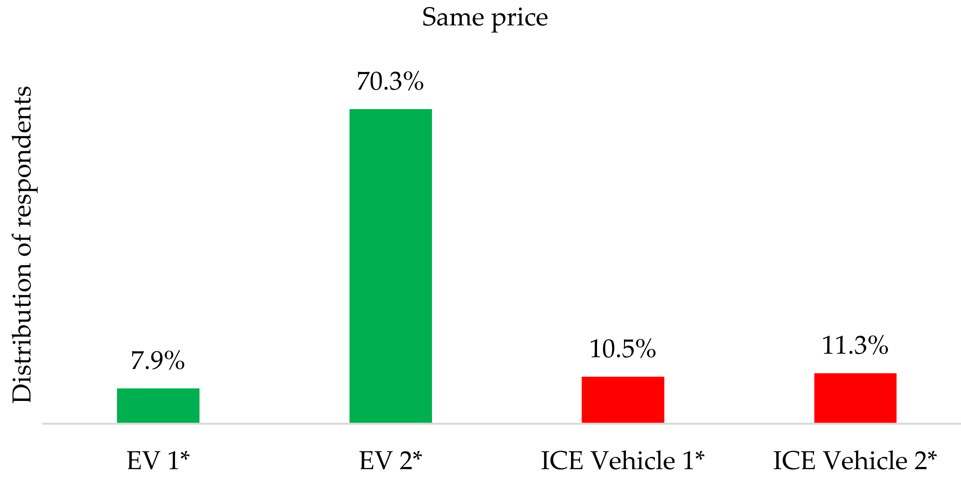


Fig. 14 Consumers' car purchase choice—same price

on the basis of responses to section two of the questionnaire, the one in which knowledge about EVs and the characteristic that these cars rely on renewable sources was analyzed. Those who provided the following values were chosen: (i) customer's knowledge in EVs (4 or 5); (ii) decarbonization impact charging the vehicle only with green energy (4 or 5); and (iii) decarbonization impact charging the vehicle with fossil fuels and green energy (1 or 2)—Fig. 15.

Despite the fact that this cluster of consumers is aware of the benefit of EVs and how to use them to extract the maximum emission reduction potential, the ICE vehicle is still preferred for the vast majority of consumers (60%), which represents an increase from the sample as a whole (+ 3%). The difference from the sample as a whole appears to be a decrease in the choice of EV 2, in favor of the ICE vehicle. The result then is that the most informed and aware consumers would also seem to be the most price-conscious. Thus, it appears from this information that those who know that electric is sustainable if it is powered by renewable sources and have knowledge on the subject tend to choose ICE vehicles since under current conditions the choice of electric does not equate to environmental protection. Analyzing, again for the sample reduced to 41 respondents, the case in which price is not a relevant variable, it is possible to analyze how we still maintain a group of consumers who continue to prefer ICE vehicles (17%), which nevertheless represents a reduction compared to the sample as a whole (– 5%). This result confirms the previous point, as increased knowledge leads to the

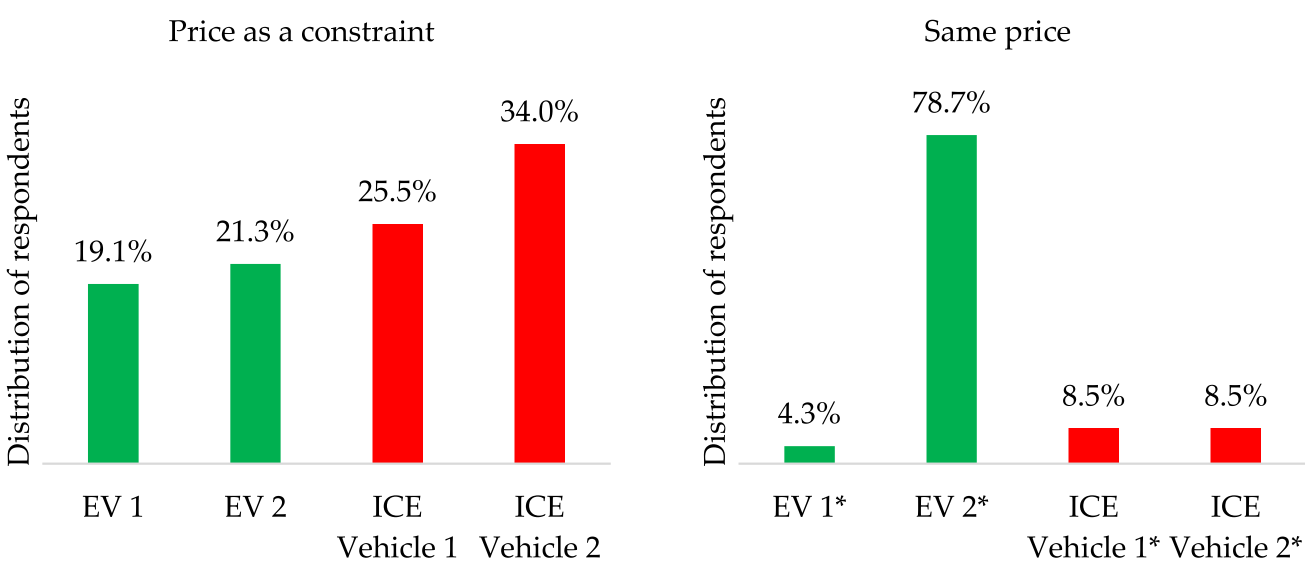


Fig. 15 Consumers' car purchase choice referred to cluster of 47 consumers

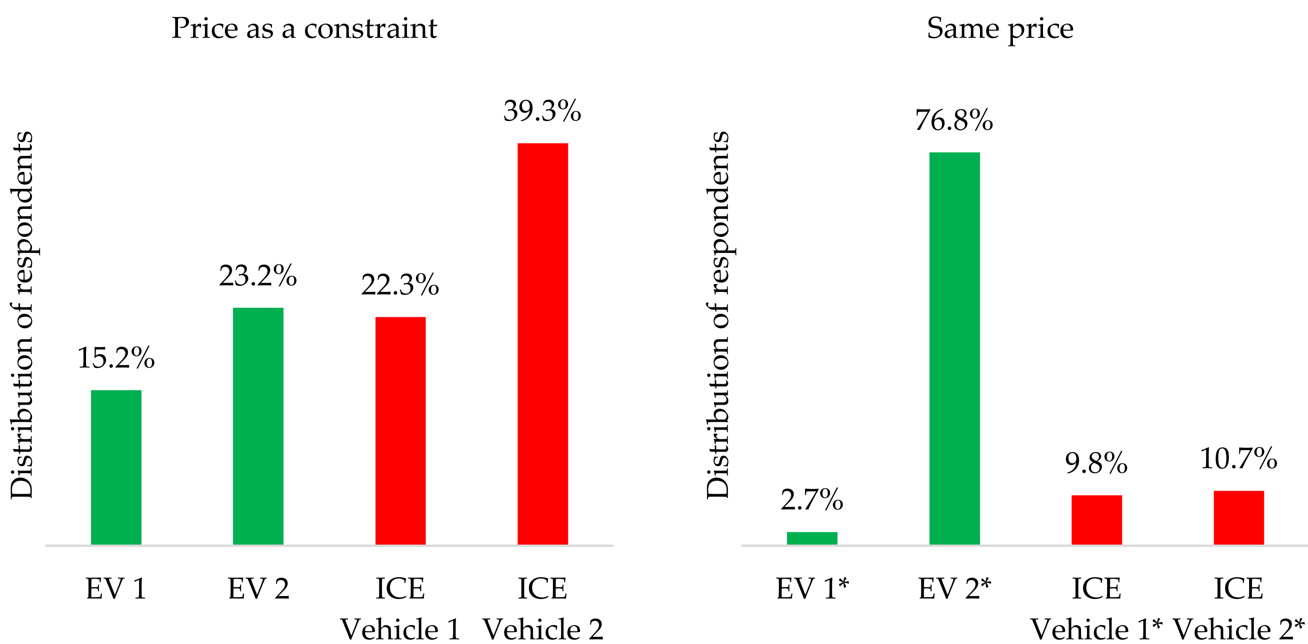


Fig. 16 Consumers' car purchase choice referred to cluster of 112 consumers

conclusion that at levelized prices, consumers not only reduce their choice of ICE vehicles, but also consistently opt toward the better performing EV 2* (+ 8%).

A second analysis is geared toward increasing the sample of people taken in the analysis. If in the previous analysis, only informed people were selected; now people with neutral knowledge are also included, thus obtaining a sample of 112 respondents. Those who provided the following values were chosen: (i) customer's knowledge in electric vehicles (3 or 4 or 5); (ii) decarbonization impact charging the vehicle only with green energy (3 or 4 or 5); and (iii) decarbonization impact charging the vehicle with fossil fuels and green energy (1 or 2 or 3)—Fig. 16.

In the price-constrained scenario, including people with a neutral level of knowledge in the cluster increased the relative choice of EV 2 compared to the sample of 41 respondents (+ 2%) but still lower than the overall sample. There is also a decrease in the choice of EV 1 (– 4%) and an increase in ICE vehicles (+ 2%). In the scenario where price is not a relevant variable, those who choose ICE vehicles increase (+ 3.5%) compared to the 41-person cluster but still lower than the global sample. Again, the choice of EV2 (– 2%) exceeds the previous cluster but greater than the global cluster.

In order to complete the overview, the paper proceeds to a third analysis on these consumer choices between EVs and ICE vehicles—Fig. S13. We consider EVs to be a sustainable choice even if powered by fossil fuels. Then, we consider a cluster of 18 respondents, i.e., those who assigned 4 or 5 to the three questions in Sect. 2, a statistically less significant sample than the previous ones. However, a comparison with the overall sample shows that only 44.5% still choose ICE vehicles (– 12%); there is a tendency to prefer EV 2 more with 33.3% (+ 8%), while in the absence of price limits, it is recorded that EV 2* is still preferred but there is a significant increase for EV 1*. These data show a gap on the degree of knowledge that is evidenced in a nonlinear choice, where price is a constraint people opt for the more expensive vehicle; otherwise, they tend toward a lower-performing choice. This is a sample that probably a priori considers electric—a correct choice even if fossil-fueled and does not present much attention to choose processes when comparisons are found.

Consumer Enablers toward Electric Vehicle Purchase and Sustainable Electric Mobility

In the fifth section of the questionnaire, the objective was to compare the values provided by consumers against what the experts proposed. Figure 17 proposed the data related to electric vehicle purchase, while Fig. 18 those related to sustainable electric mobility transition.

Consumers appear to agree with the experts that purchase price is the criterion that most influences them in purchasing an electric car. The data emerging from this question corresponds to the previous ones from the consumer analysis, in which other technical features around a car, such as battery range, charging time and infrastructure, also appear to play a relevant role. These could also be seen as interrelated variables, in the presence of cars with a large range which would obviously decrease the need for a widespread charging infrastructure and vice versa. Also

Fig. 17 Ranking of factors in accordance with consumers—purchase of an electric car

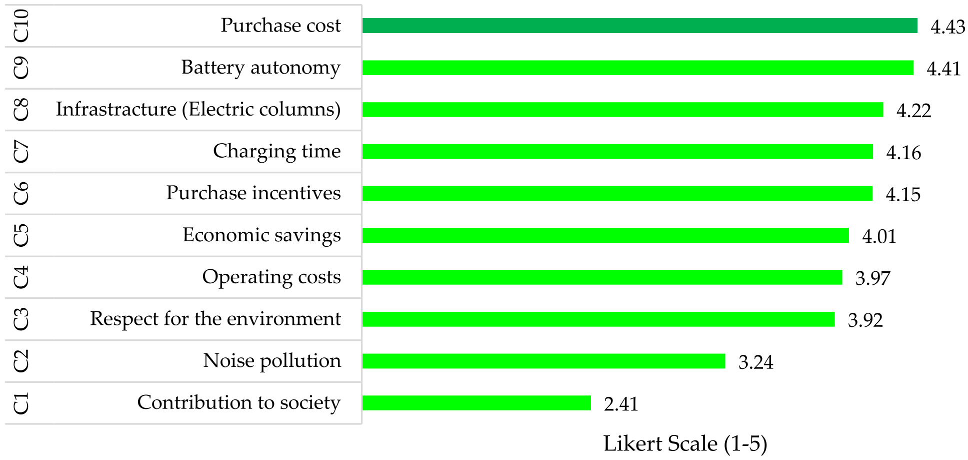
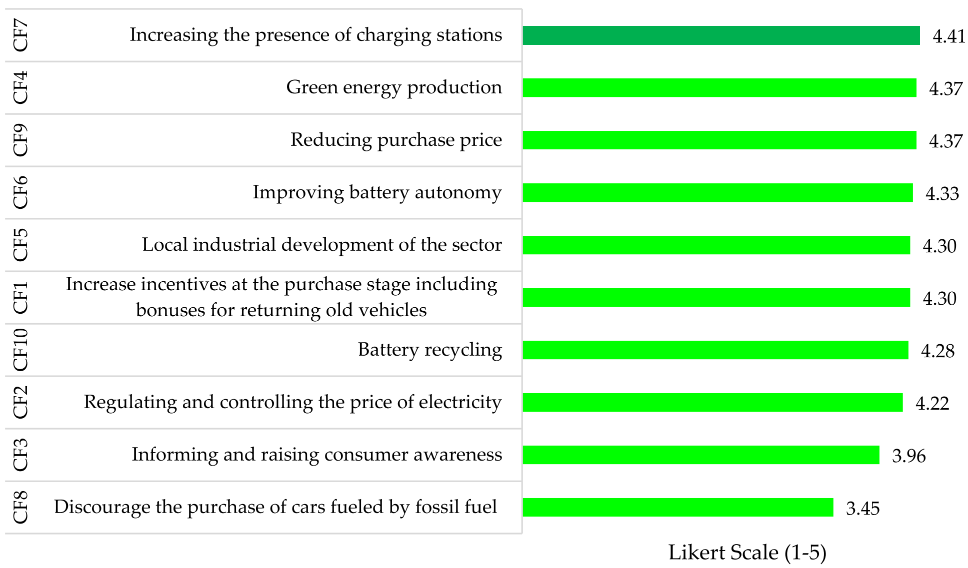


Fig. 18 Ranking of factors in accordance with consumers—green transition in electric mobility



important for consumers turns out to be the economic incentive at the time of purchase, since it is closely related to the purchase price. The ranking is closed by the environmental criteria since as analyzed earlier consumers do not evaluate the environmental impact when choosing a car, but evaluate price, then technical features and only some at the end CO_2 emissions and noise pollution. Social data are even less considered. It is the only criterion that is ranked "a little" and is a significant 2.0 (considering the 1–5 range of the Likert Scale) away from the first in the ranking. Thus, the range that is obtained with the Likert scale is not always less numerically significant than that obtained with the AHP. Similarly, if the value of contribution to society is excluded and that of noise pollution, the gap between the other eight criteria is in the range of about 0.5 (4.43 vs. 3.92).

Regarding the question on enabling factors toward a sustainable transition in electric mobility, different results emerge with the experts. In fact, the criterion "increasing the presence of charging stations" that was penultimate for experts occupies the first position for consumers. It seems to emerge that consumers look more closely at everyday needs. In second place, we find the criterion of green production, which, on the other hand, had been awarded as most relevant by the experts. This is crucial to ensure maximum reduction of CO_2 emissions by electric cars. For the remaining criteria, an identical ranking position never occurred. Reducing the purchase price and improving battery range, which occupy a relevant position for consumers, highlight that the perspective that has emerged from consumers is the absence of an overview, which limits the full understanding of development of the sector. Indeed, these are the criteria that are most relevant to everyday life. Again, it emerges that the gap between the first and penultimate criteria appears to be small at 0.45 (4.41 vs. 3.96).

This analysis shows that there is a knowledge gap, as not all consumers understand that an electric vehicle is always sustainable. People look a lot at the presence of charging stations so as to save time, but although renewable sources have a high position, they occupy second place. It is assumed that this can also be explained by those who consider an EV sustainable even if it is powered by fossil sources. The lower knowledge on sustainability is then expanded by the lower weight associated with battery recycling compared to the second place recorded by experts. It should be said that the consumers did not do a pairwise comparison, so they analyzed the variables individually, and the range of difference between the parameters is much smaller. The first seven criteria actually tend by approximation all to 4.5. However, it is evident how consumers' thinking is not fully informed. Thus, the social data on the industrial development of the sector is not surprising in this direction, confirming the point made in the previous point. It is given a similar value as the battery. An additional finding that confirms the knowledge bias is the following: There is a tendency to want to reduce the purchase price of these vehicles (probably through subsidies), but if you combine this policy choice with providing a bonus for dated vehicles, you consider it less valuable.

Discussion

The results of this work, related to RQ1, confirm the relevance of the first two criteria (purchase cost and battery autonomy) already proposed in the literature (D'Adamo et al., 2023), while slightly less importance is given to infrastructure. In fact, it is assumed that this aspect tends to decrease as several initiatives are being developed in this direction (Huang et al., 2022). Regarding the purchase price, a number of measures have been introduced in Italy at both the national and regional levels to reduce the initial cost. In addition to this, other economic incentives have been introduced to reduce the total cost of ownership, including exemption from payment of road tax for five years upon purchase (thereafter, tax reduced to one-fourth of the internal combustion equivalent) and possibility of access to restricted traffic zones. These concessions aim to make the total cost of ownership of the EV, thus the cost of the vehicle over its lifetime, comparable to that of a conventionally powered vehicle, despite the fact that the purchase price is higher to date and is one of the main barriers to purchasing an electric car (Franzò et al., 2022). It is therefore also necessary to inform and raise awareness among consumers, as the enabling factors for the green transition may be primarily monetary (Colasante et al., 2022) or also related to personal and social norms (Niamir et al., 2020).

Another reason for the low uptake of electric cars lies in the fear that the car will only travel a few kilometers due to the limited battery range and the still-poor charging infrastructure. However, the average daily mileage of the latest electric car models highlights significant improvements (Abid et al., 2022). As highlighted above, the economic side plays a key role; however, experts favored the cost required to purchase an EV and not the potential benefits. Certainly, incentive policies can reduce these costs, but they should have their own justification for the purpose of welfare to civil society. However, it is often incentive policies that determine the sustainable development of an industry (De Santis et al., 2022; Srivastava et al., 2022). At the same time, economic benefits are manifested if the energy is self-generated; otherwise, there is a risk of manifesting not economic savings but a higher cost given trends in electricity prices (Colasante et al., 2022). Furthermore, the infrastructure aspect differs in that appears to be still underdeveloped. The charging network, both public and private, is of paramount importance as the infrastructure is an indispensable functional component on par with traditional gas stations (LaMonaca & Ryan, 2022).

The positive externalities that are potentially created by the use of an EV lie in its respect for the environment and contribution to society, which, however, according to experts are a factor that is marginally considered by consumers. This is quite worrying and leads to the need to have to inform and raise consumer awareness of the negative externalities of everyday mobility. At the same time, the communications of policy makers should also be improved (Kim et al., 2022). However, the issue of sustainable education is essential to foster stakeholders' engagement. Similarly, recharging time is not significant; according to experts, it is much more relevant to have a battery with a larger capacity, which allows the consumer to carry out daily dynamics without having to stop and recharge the car. With a sufficiently large battery capacity, the car could be charged overnight, and therefore the speed of charging is not relevant (Ye et al., 2022). Finally, the least important factors are noise pollution and operating costs. In particular, the latter factor shows a reduction in significance compared to the literature (D'Adamo et al., 2023), probably determined by a direct comparison with respect to investment (purchase) costs.

The findings of this work, related to RQ2, confirm the relevance of the first three critical factors (CF4, CF5 and CF10) that had already been proposed in the literature (D'Adamo et al., 2023). However, a fourth element (CF1) is added to these, but this result depends on the combination of two previously considered factors. Electric cars are proposed as a driver of sustainable mobility; however, electric mobility is sustainable when fuel is considered to be obtained totally from renewable sources. Literature showed that the emissions associated with such a vehicle were 5 gCO_2eq/km, and the same value associated with CNG vehicles was powered by biomethane (DENA, 2011). In contrast, vehicles associated with the European energy mix about a decade ago had a value of 75 gCO_2eq/km reported. The current situation does not see totally green European countries, so this aspect is emphasized by the experts. So, it is pointed out that EVs to really cut emissions need to be powered through renewable energy.

Sustainability concerns not only economic and environmental aspects, but also social ones. The electrical sector is changing the automotive industry, requiring as much new professionalism as new raw materials. This aspect is reflected in two other very relevant critical factors. Industrial development of the sector is needed to maintain jobs so as not to create social unsustainability. Therefore, there is a need to generate learning programs for those currently working in this sector and to make use of new professionals. The absence of an industrial economy leads to a weakening of a country's economic system and the risk of facing speculative market turbulence. In addition, batteries have the advantage of storing energy but nevertheless, the issue of their recycling is an aspect to be paid attention (Sathish Kumar et al., 2023). Moreover, this aspect also risks fostering speculative aspects or geopolitical risks, since their resources are mainly located in certain areas of the world. Therefore, it becomes strategic first to ensure that technologies exist that can recover critical materials and components found in these products (Ippolito et al., 2023; Rosa & Terzi, 2016), and then resources from end-of-life vehicles need to be acquired in order to have resources that these countries would not otherwise have. However, while incentives play a key role, it is believed that the suitable solution for mobility conversion requires a combined policy intervention. It is necessary to provide incentives for the purchase of EVs but linked to bonuses that can be given if old cars are scrapped. Recycling of some components of cars are able to genre industrial ecosystem in which opportunities are manifold and circular economy practices totally become part of the automotive business (Cozza et al., 2023; Yuik et al., 2022).

In the direction of modernizing the vehicle fleet, we also need to discourage the purchase of non-new-generation fossil fuel vehicles (Leach et al., 2020). The European direction toward that view all need to be observed that some heat engines could be powered by renewable sources. This opens up the need for further analysis. Here, a gap emerges in this work that does not evaluate a comparison of different sustainable modes in the automotive sector, which are clearly not only achievable through EVs.

Two critical factors that emerged relevant in RQ1 receive less attention in RQ2 (reducing purchase price and improving battery autonomy). This turns out that was already present in the previous work (D'Adamo et al., 2023), so in this analysis, it was explored with experts whether a potential cause was the redundancy of factors in both RQs. The conclusion was that these aspects are very relevant at the stage of consumer purchase of an electric vehicle, and they are less so for the green transition of electric mobility. A similar argument is proposed for the presence of charging stations. Finally, another comparison with previous research work (D'Adamo et al., 2023) shows that purchase price and consumer awareness are the critical factors that receive the least importance, in favor of the combined policy intervention mentioned above. Electricity price regulation, probably considered more of a macroeconomic issue, closes the ranking.

These responses of RQ2 highlight that unlike the previous one (RQ1), a trade-off among several items is more required, and therefore a flexible solution to the sustainable mobility of the future is in demand. In fact, electric cars have advantages but to date do not perfectly hinge all the requirements. Likewise, this vision changes according to the territorial reality considered (Molla et al., 2023; Zahraee et al., 2018). The challenge of sustainable mobility can be met through two basic requirements:

- Flexibility in decision making that can combine resilience and sustainability.
- Stakeholder engagement.

Regarding RQ3, this work confirms how the price variable of EVs determines a key role in the purchase phase, and great importance is placed on the presence of charging stations (Almansour, 2022). In several parts of the questionnaire, a clear knowledge gap emerges. In fact, in some cases, it is not clear that a vehicle is sustainable just because it is electric. Clearly, this gap can only be overcome through knowledge and with stakeholder engagement (D'Adamo et al., 2023). The point that emerged from RQ2 turns out to be confirmed because sustainable change happens when there is awareness, and the consumer adapts his or her needs to the needs of ecosystems as well. Likewise, one thinks with a mindset that does not only involve one's personal interests. Thus, it is necessary to be not ideological but pragmatic. When there is a high cost, some citizens are unable to purchase a given sustainable product. Analysis of the work shows that there is a significant 25% variation on the purchase price depending on whether the price is considered a limitation or not. It also emerges that there is a share of consumers fond of using internal combustion vehicles, which turns out to be the choice in different purchase contexts, and it emerges that only half of the respondents recognize a premium price to a sustainable car. In this regard, it is worth noting the characteristics of this sample: i) environmentally conscious and ii) proper knowledge. This confirms the need to explore these concepts (Yeğin & Ikram, 2022). The propensity to purchase a car in the future in the coming years shows that the difference between those who plan to purchase EVs and those who internal combustion vehicles does not appear to be significant. In this perspective, a flexible approach could be precisely obtained from rental cars that could push consumers to try new products (Gulzari et al., 2022).

Conclusions

The issue of sustainability is changing all existing models, as climate change is confronting humankind with an objective situation: ecosystems are experiencing a period of crisis. It therefore seems clear that actions are necessary because future generations must not give up opportunities. Europe aiming to be climate neutral is an ambitious and correct goal. However, the choices made should move toward pragmatic and not ideological sustainability. That is, the concept of sustainability covers not only the environmental, but also the economic and social spheres. The 2035 changes for the automotive sector move toward the right goal of decarbonizing the transportation system, but some concerns emerge. In fact, there is a need to relocate from a social point of view people who are likely to be unemployed, and from an economic point of view, some products (e.g., electric cars) might be purchasable only by those with significant incomes. In this way, poorer people might be asked to pay a higher price tomorrow.

The key word in this context could be flexibility, which allows for continued maximization of production from renewable energy sources, making the electric vehicle effectively green. However, this is not enough, as there is a need for research and development to give support to battery recycling but at the same time to create local industrial development that counteracts social unsustainability from a labor employment perspective. The needs expressed by experts do not find a similar sharing of thought with consumers. The characteristic of the need for charging stations is considered by them to be the most relevant. However, the questionnaire brought out some sustainability bias; first of all that for some people, an electric vehicle is sustainable even if it is powered by fossil fuels. Another finding is how the very young in the near future would tend more to buy an internal combustion engine than an electric vehicle. In this direction, the knowledge provided during the university course needs to be strengthened. Another aspect to highlight is the choice of a suggested policy for the future: an incentive that could support the development of electric vehicles but overcoming the critical issues highlighted above. Such a choice could also include the recycling of old vehicles to achieve a flexible industrial ecosystem. In fact, flexible management through this policy instrument could reduce the impact of purchase cost, which is the main hindering factor in purchasing such products (a view shared by consumers and experts) combined with green and circular practices that combine renewable production with reuse/recycling/remanufacturing. The willingness to pay extra for an electric vehicle exists for only less than half of the surveyed sample, and there are also consumers who have no intention of giving up internal combustion vehicles. This work therefore calls for the need to develop life cycle analyses of these products and to include externalities in this computation. Similarly, sustainable alternatives to each other in the transportation sector are not directly compared, but it seems important to involve stakeholders in the decision-making process based on the role of flexibility in the automotive sector where there is no single dominant technological model.

Funding Open access funding provided by Università degli Studi di Roma La Sapienza within the CRUI-CARE Agreement. The author(s) received no financial support for the research, authorship and/or publication of this article.

Declarations

Conflict of Interest The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

Ethical Approval Given that the research is a non-experimental voluntary survey, no ethical approval is necessary. Furthermore, the self-administered survey that is non-experimental in nature was conducted under complete anonymity for the participants. No personal or sensitive information that can be used to identify the respondents were collected. Besides, the consent of the respondents to partake in the online survey were sought before the survey was executed by including an electronic informed consent in the online survey form.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40171-023-00349-w.

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Key Questions

1. What are the future rules of flexibility as important strategy for expanding customization, addressing specific mobility market demands and keeping throughput as high as possible?
2. Flexibility and sustainability strategies will increasingly converge in a more competitive and uncertain future?
3. Flexibility has always been a key element for more efficient productions, what is the exact consumer's perception of the importance of flexibility in electric mobility?

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