Is Perceived Climate Friendliness Driving EV Adoption? Exploring Consumer Knowledge at Different Stages of the Vehicle Purchasing Process

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Abstract

Electric vehicles can significantly contribute to decarbonizing transport – but does that really matter to consumers? Based on a survey in Switzerland, one of the fast-growing European EV markets, we find that moving closer to the purchase decision the share of well-informed adopters increases, but their climate optimism decreases.

Keywords: Electrical Vehicles in Switzerland, Perceptions of Climate Friendliness, Emission Break-Even Mileage, Lifecycle Analysis, Health Action Process Approach (HAPA)

Part 1: Case Study on Electrical Vehicle Adoption in Switzerland

Decarbonization of transport is central for fulfilling climate goals:

Electrifying individual transport with electric vehicles (EV) and renewable energy (RE) can be a key element in reaching climate objectives. Similar to many other industrialized nations, Switzerland, in its Nationally Determined Contribution (NDC), commits to reducing greenhouse gas emissions (GHG) by 2030 to "*at least* 50% below 1990 levels" (NDC, 2020). In 2019, the transport sector was the biggest emitter of greenhouse gas (GHG) emissions in the country with 14.9 million tCO_2equiv. (32%), ahead of buildings (24%), industry (24%) and agriculture (14%). Within the domestic transport sector, road transport is responsible for almost all GHG emissions (14.6 million tCO_2equiv.) (Federal Office for the Environment (FOEN), 2021). Battery electric vehicles (BEV) are a readily available technology to decarbonize the transport sector. By now, consumers can choose from a wide range of different models from various manufacturers (Gersdorf et al., 2020). For some use cases, studies estimate a cost advantage of EVs over internal combustion engine vehicles (ICEV) in terms of lifecycle cost despite their higher upfront cost (Miotti et al., 2016). Unlike lifecycle emissions, lifecycle costs are difficult to determine because gasoline and electricity prices are volatile, whereas the emission intensity of the power grid and gasoline combustion can be predicted more easily (Verma et al., 2022). Yet, despite the estimated cost advantage and product availability, the current speed at which Swiss consumers adopt EVs remains insufficient to meet Swiss climate objectives.

Adoption of electric vehicles on the rise:

In 2020, the Swiss Road Traffic Office registered 336'800 new motorized vehicles across all vehicle segments in Switzerland. The two largest vehicle segments encompassed 238'700 new passenger cars and 32'430 new cargo vehicles (Federal Statistical Office, 2022). Here we focus on the passenger segment. In 2020, the new registrations in this segment plummeted by 23% compared to the 2019 level due to the outburst of the COVID-19 pandemic. However, in the same year, the number of new electric passenger cars on Swiss roads continued to rise to 19'800 vehicles (+49.8% compared to 2019). This EV growth was fueled by 19'800 BEV and 14'400 PHEV registrations. By the end of 2021, overall, new car registrations had not recovered from the COVID-19 shock yet, and new electric vehicle registrations continued to rise, with the growth rate of BEV overtaking PHEV (Federal Statistical Office, 2022). In Q4 2021, 19.5% of all new car registrations were BEVs; and 10.0% were PHEVs (Swiss Federal Office of Energy, 2022).

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Reality has overtaken policy targets for electric vehicle adoption

Many European countries have adopted policy goals for the complete phase-out of new ICE vehicle registrations or sales, including Norway (2025), Sweden, Iceland, Ireland, the Netherlands, Slovenia (2030), Denmark and the United Kingdom (2035), France, and Spain (2040) (Wappelhorst, 2021; Wappelhorst & Cui, 2020). Unlike these countries, Switzerland has not adopted any national policy goal for the phase-out of ICE registrations or sales. Instead, the federal transport ministry initiated, in 2018, the "Roadmap Electromobility", a consortium of 50 public and private organizations. The aim was to increase the combined share of BEV and PHEV in all new passenger car registrations to 15% by 2022. Switzerland has passed this threshold already in Q3 2020, and efforts to introduce a new target for 2025 have not been successful yet (Swiss E-Mobility, 2021). Furthermore, Swiss eMobility, an association initiated by the Touring Club Switzerland (TCS) with a broad network of private-sector members across Switzerland, has raised ten demands in its "e-agenda 2021". When it comes to "emission-free individual mobility", Swiss eMobility demands that all new passenger car registrations be emissions-free by 2035 (Grossen & Hannesbo, 2021).

Role of beliefs concerning e-mobility

As highlighted by theories of consumer behavior, outcome expectations (i.e. perceived advantages and disadvantages of a product) are a major predictor of consumer attitudes towards a product. Attitude influences purchase intention, which in turn influences the actual purchase decision (Ajzen, 1991).

Perceived advantages and disadvantages of EVs over ICE vehicles are increasingly discussed by the general public. For example, news outlets such as Swissinfo, Handelszeitung, NZZ have published news series including "Mythbuster" to address common misconceptions concerning e-mobility. Likewise, automotive manufacturers have engaged in similar endeavors (e.g. Skoda's storyboard, Audi's e-Irrtümer).

The most common perceived concerns about electric vehicles deal with their lifecycle costs, lifecycle emissions, maximum range, charging times, battery ageing, availability of public charging, electricity grid impact, and environmental footprint of battery production.

Some consumers suspect that EVs may not reduce environment pollution because battery production and electricity generation may also cause pollution (Axsen et al., 2012). Such a belief could potentially decelerate vehicle electrification and jeopardize the emission goals in the transport sector. Environmental concern has been concluded the most studied factor towards EV adoption (Chu et al., 2019). However, other factors, such as mileage and refueling cost, might play a larger role in the purchase decision (Graham-Rowe et al., 2012).

Given the central role that beliefs play in the formation of EV purchase intention and purchase behavior, understanding potential EV users' beliefs concerning climate-friendliness of e-mobility helps design effective decarbonization policies for the transport sector.

Therefore, based on a consumer survey fielded in Switzerland in September 2021, we first assess the gap between experts' and the general public's views on emission break-even mileage of electric versus combustion vehicles. Then, we investigate potential drivers of heterogeneous beliefs concerning EV's climate-friendliness in the general public, and in particular the relationship between the perceived environmental friendliness of EVs (proxied by CO_2 break-even mileage perception) and purchase intentions.

Part 2: Estimating the climate friendliness of electric vehicles

Emissions for Electric Vehicles along their Lifecycle

In the production phase, EVs tend to accrue higher emissions than ICE vehicles due to the energy-intensive raw material extraction and production of the lithium-ion battery. In the use phase, EVs are characterized by lower emissions. The magnitude of their environmental advantage in the use phase depends on the carbon intensity of the electricity consumed at the point and time of charging. In the end-of-life (EOL) phase, EVs and ICE vehicles have similar emissions depending on recycling and reuse of the battery. As a result, an emission break-even mileage indicates what range an EV must drive to reach emission parity with a similar-sized ICE vehicle.

The emission break-even mileage has decreased continuously over the last years due to an increasingly energy-efficient production of lithium-ion batteries and a decreasing emission intensity of the electricity grid that results from large-scale RE deployment.

Diverging Experts' estimates of the Emission Break-Even Mileage

Various authors have calculated the emission break-even mileage for specific and stylized car models in Switzerland using the recent Swiss electricity mix. Generally, there is a wide range of estimates for that break-even point depending on the model assumptions (Bauer et al., 2015)(Bauer et al., 2015). A comparison of the emission intensity of battery electric driving in Switzerland (kg CO_2equiv. per km) across six different studies revealed that almost all estimate variability resulted from different assumptions about the battery production and EOL, while all authors used (almost) the same assumptions for road-associated emissions, grid emission intensity, and vehicle-associated emissions. Across the studies, the battery-associated emissions ranged from 20% to 60% of all BEV lifecycle emissions (Althaus & Bauer, 2011).

A recent study conducted by PSI & TCS suggested that the break-even mileage for mid-size cars was 26'851 km in 2020, with higher estimates for small cars and luxury cars. Other sources indicate that the emission break-even mileage might be as low as 10'000 to 20'000 km in 2022. Estimates are very sensitive to the chosen car model and the assumptions about the carbon intensity of lithium-ion battery manufacturing, which tends to decrease with mass manufacturing and decarbonization of the electricity mix (Ellingsen et al., 2016). A recent study even suggests that BEVs have a lower footprint in the production phase than ICE vehicles (Wolfram et al., 2021). Hence, there is a consensus that a large-scale replacement of ICE vehicles with EVs would ultimately reduce CO_2 emissions over the entire life-cycle of the car, and a majority of the literature assumes that EVs have higher initial emissions in the manufacturing phase which are then at some point overcompensated by lower emissions in the operating phase. Based on the review of existing studies and Swiss e-mobility experts' recent statements, we assume that a reasonable assumption for this point, the current emission break-even mileage, ranges between 20'000 and 30'000 km for passenger cars in Switzerland as of 2021.

Part 3: Analyzing Perceptions on Climate Friendliness of Electric Vehicles

General public's beliefs on Emission Break-Even Mileage:

We measured perceptions of climate-friendliness of EVs in Switzerland based on the responses of a consumer survey fielded in September and October 2021. The main sample ("representative survey") consists of 1'054 Swiss residents aged between 16 and 74 years residing in the German- and French-speaking region of Switzerland. It is representative in terms of gender, age, education and political orientation. In addition, the same questionnaire ("boost survey") was answered by 250 "early electrifiers", defined as people who, at the time of the survey, were owners of photovoltaic (PV) and/or EV, or intended to buy PV and/or EV within the next three years.

Among other questions, respondents were asked: "*For the CO_2 footprint of a car, production, transport, operation and recycling must be taken into account. After which distance travelled (in kilometers) do you think the CO_2 footprint of an electric car is better than that of a car with a combustion engine in Switzerland?*" We use responses to this question to measure citizens' beliefs on climate-friendliness of EVs in Switzerland.

We measured respondents' purchase intentions using a survey item inspired by Schwarzer's Health Action Process Approach (Schwarzer et al., 2008). Respondents were asked "Do you own or can you imagine owning an electric vehicle in the future?" Table 1 provides an overview of the possible answers to this question and their respective stage in the HAPA process.

Table 1: Allocation of stages in EV purchasing decision process and HAPA process

HAPA stages:	**Survey question: "Do you own or can you imagine owning an electric vehicle in the future?"**
Non-Intenders	"No, I haven't thought about it yet."
Intenders	"No, I don't own an EV but could imagine to purchase one in (select a year). – selected year must be between 2021 and 2024
Actors	"Yes, I already own an EV – and I purchased it in (select a year)" – selected year must be after 1990

In the representative sample, we identified 42 owners of an EV (4.0%) and 121 potential adopters (11.5%) who intended to purchase an EV within in the next three years. In the boost sample, we identified 36 actual owners (14.4%) and 105 potential adopters (42.0%).

The Health Action Process Approach for Adopting Electrical Vehicles

According to the Health Action Process Approach (HAPA), the process for changing one's behavior consists of at least a motivation and a volition phase (Schwarzer et al., 2008).

In the motivation phase, "non-intenders" become "intenders" by forming an intention to adopt a certain behavior. The precursors for forming a new intention encompass task self-efficacy, outcome expectancy, and – to a lesser extent – risk perception. In other words, individuals that form an intention to adopt a behavior change their beliefs in their capacity to execute behaviors to produce specific performance attainments (Bandura, 1997), they have a strong expectation of a specific outcome, and a good perception of relative risks associated with and without the behavior change. The intention-behavior gap refers to the phenomenon that once an individual has formed an intention, the intended behavior is not guaranteed, but depends on the volition phase.

In the volition phase, "intenders" become "actors" by translating their intention into action initiations and maintenance. The precursors are action planning and action control. In other words, individuals who initiate and maintain actions based on their intentions have planned when, where, and how they will act, and they have control mechanisms including self-monitoring at their disposal (Schwarzer et al., 2008)

While Schwarzer initially developed the HAPA model to predict and promote behavior changes in the health domain, such as abandoning unhealthy behaviors (e.g. quitting smoking) and adopting healthy behaviors (e.g. sports), other authors have applied the HAPA model successfully to other domains, such as sustainable consumption and the decision to invest in renewable energy (Hübner et al., 2012).

Key findings:

Figure 1 provides an overview of the perceptions of the emission break-even point between EVs and ICE vehicles prevalent in the Swiss population by HAPA groups. We find a relationship between the perceived climate friendliness of EVs and the adoption stage in the purchasing decision process (HAPA groups).

For the ***overall population***, we observe that the majority (54%) are EV optimists who hold slightly more positive beliefs of the climate friendliness of EVs than what current studies suggest is a realistic estimate – noting that these EV optimists might be ahead of their times if the production of EVs and the power grid continues to become greener. In contrast, 40% of respondents are EV pessimists. EV pessimists' estimates tend to be further off from the reasonable estimate than EV optimists'. Only 6% of the Swiss population provide answers within the 20'000 to 30'000 km range that appears to be the currently realistic estimate of the emissions break-even point.

For ***non-intenders***, who had not thought about purchasing an EV at the time of the survey, we observe by far the highest share of EV optimists (65%); and one of the lowest shares of EV pessimists (26%); and only few EV realists (4%). Non-intenders tend not to be well-informed, but their deviation is more tilted towards positive opinions on the climate friendliness of EVs.

For ***intenders***, who were planning to purchase an EV at the time of the survey, we observe significantly fewer EV optimists (42%), more EV realists (8%), and more EV pessimists (50%) than in the general population.

For ***actors***, who owned an EV at the time of the survey, the share of EV optimists was lowest (35%), the share of EV realists highest (14%), and the share of EV pessimists rather high (51%). Those who have moved from intention to action are the best informed segment, and to the extent that members of this group do not hold realistic beliefs, they are more likely to underestimate the climate friendliness of EVs.

Overall, the results show that non-intenders start out with fairly optimistic opinions about the climate friendliness of EVs. As consumers move from intention

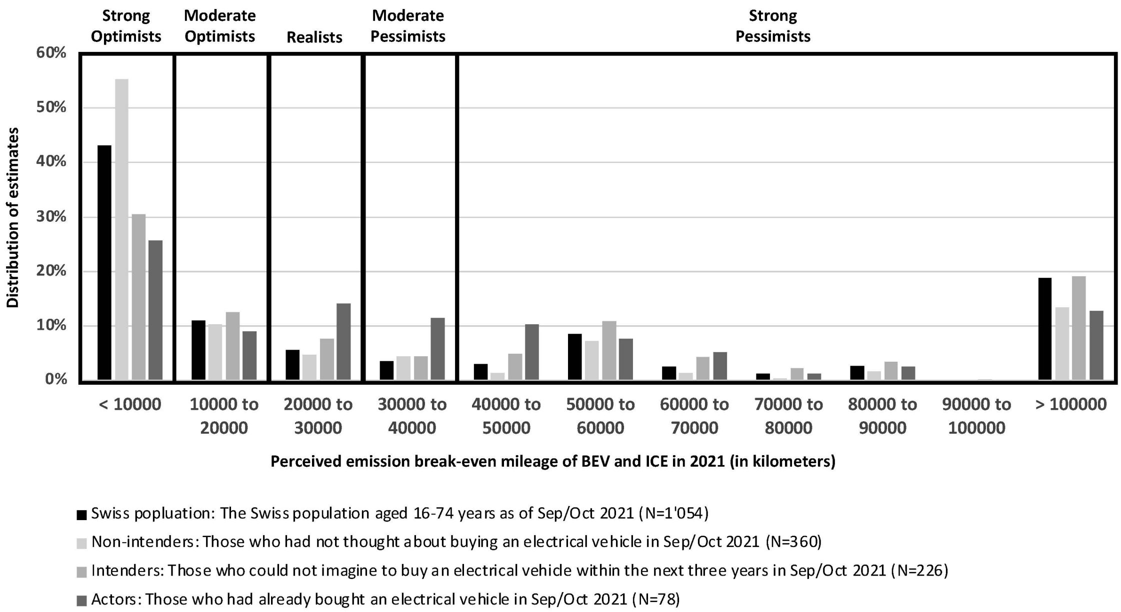

Figure 1: Perceptions of Emission Break-Even Mileage by HAPA groups

to action, they become better informed and somewhat less optimistic. Interestingly, this erosion of optimism regarding the climate friendliness of the product does not prevent them from making the purchase decision, perhaps suggesting that EVs are increasingly bought for other reasons than climate (alone).

Conclusion

We presented a case study of electrical vehicle adoption in Switzerland, conducted a literature research on the relative climate advantage of EVs compared to ICE vehicles, and analyzed the perceptions of the emission break-even point of EVs prevalent in the Swiss population at different stages of the purchasing decision process based on the HAPA model.

We find a relationship between the perceived climate friendliness of EVs and the stage in the purchasing decision process. At the pre-intention stage, people overestimate the climate friendliness of EVs and are poorly informed. As they enter the intention and action stage, they become less optimistic about the climate benefits of EVs and better informed. The results show that the erosion of EV climate optimism does not deter potential EV buyers from buying an EV, suggesting that EVs are bought out of other motives than just lowering emissions. The results corroborate the finding of other studies that information campaigns focusing on the environmental benefits of EVs alone are insufficient in accelerating EV adoption.

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