Schweizerische Eidgenossenschaft
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Federal Department of the Environment, Transport, Energy and Communications DETEC

Swiss Federal Office of Energy SFOE
Energy Research and Cleantech Division

Interim report dated 30. September 2020

Fostering the Transition Towards More Fuel-Efficient Cars

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Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Institute of Science, Technology and Policy
Institut für Wissenschaft, Technologie und Politik

Date: 30 September 2020

Location: Bern

Subsidiser:
Swiss Federal Office of Energy SFOE
Energy Research and Cleantech Section
CH-3003 Bern
www.bfe.admin.ch

Co-financing
ETH Zürich
Rämistrasse 101 CH-8092 Zurich
www.ethz.ch

Subsidy recipients:
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SFOE contract number: SI/8100087-00-01-05

Zusammenfassung

In diesem Forschungsprojekt untersuchen wir politische Präferenzen und Kaufentscheidungen im Bereich des motorisierten Individualverkehrs, der Personenwagen. Die Autobranche ist eine der Hauptquellen von Treibhausgasemissionen, in der Schweiz sind die Emissionen von Personenwagen im Vergleich zu 1990 gewachsen und in der Schweiz neu immatrikulierte Fahrzeuge stossen im europäischen Vergleich, Jahr für Jahr, am meisten CO_2 Emissionen (pro km) aus. Dadurch hat der Sektor Verkehr bis heute ein hohes Dekarbonisierungspotenzial. Die momentan in der Schweiz auf dem Markt befindlichen Fahrzeugmodelle, insbesondere Elektrofahrzeuge (EV) und darunter im speziellen rein batterieelektrisch betriebene Fahrzeuge (BEV), haben das Potenzial diese Emissionen zu senken. Die Nachfrage nach diesen Fahrzeugen steigt mittlerweile zwar, aber von einem niedrigen Niveau aus. Ein Grund für die geringe Nachfrage nach diesen, im Betrieb emissionsfreien, Fahrzeugen, könnten die geringen politischen Anreize in der Schweiz und ihren Kantonen sein. In diesem Projekt haben wir (mittels eines Umfrageexperimentes) untersucht, welche politischen Anreize für Elektrofahrzeuge von Verbraucher:Innen gefragt sind. Wir haben dazu exklusive Umfragedaten von einer Zufallsstichprobe Schweizer Autobesitzer:Innen gesammelt, um ihre politischen Präferenzen und ihre Kaufabsichten in Bezug auf Elektrofahrzeuge zu untersuchen. Mittels eines randomisiert-kontrolliertem Feldexperimentes haben wir untersucht, wie die Bereitstellung von Informationen und eine 48-stündige Probefahrt mit einem rein batterieelektrisch betriebenem Fahrzeugen den Informationsstand zu Elektroautos und die Kaufabsichten dazu beeinflussen. Die Informationen haben das Wissen zwar erhöht, aber vor allem die Testfahrt hat sehr stark positive Effekte auf Kaufintentionen gezeigt. Auf Grund der Corona-Pandemie und dem damit einhergehenden Lockdown, haben wir unsere nächste und letzte Befragung auf Oktober 2020 geschoben. Diese Befragung wird über die bisherigen zwei Umfragen hinaus auch erheben, wie sich die Kaufabsichten, mittels Anschaffung von Elektromobilen, materialisiert haben. Überdies planen wir die Ergebnisse aus den vorherigen Befragungen in Bezug auf die grosse Nachfrage nach mehr öffentlicher Ladestationen mittels einem Umfrageexperiment zu diesem Thema genauer zu untersuchen. Wir haben bereits mehrere Studien publiziert oder in den Publikationsprozess gegeben und die Zeit genutzt um weitere Publikationen vorzubereiten. Dieses Projekt zielt darauf ab, eine Lücke in der evidenzbasierten Forschung zu politischen Präferenzen nach der Erprobung von neuen Technologien zu schließen, um die Entwicklung von Politiken in diesem Bereich zu unterstützen.

Summary

In this research project we investigate political preferences and purchasing decisions in the field of motorised individual transport, i.e. passenger cars. The car industry is one of the main sources of greenhouse gas emissions. In Switzerland, emissions from passenger cars have increased compared to 1990, and new cars registered in Switzerland emit the most CO2 emissions (per km) in a European comparison, year after year. As a result, the transport sector still has a high decarbonisation potential today. The vehicle models currently on the market in Switzerland, in particular electric vehicles (EV) and, in particular, purely battery electric vehicles (BEV), have the potential to reduce these emissions. Although demand for these vehicles is now increasing, it is starting from a low level. One reason for the low demand for these vehicles, which are emission-free in operation, could be the low political incentives in Switzerland and its cantons. In this project we have investigated (by means of a survey experiment) which political incentives for electric vehicles are in demand by consumers:Inside. We collected exclusive survey data from a random sample of Swiss car owners to analyse their political preferences and purchase intentions for electric vehicles. Using a randomised controlled field

experiment, we examined how the provision of information and a 48-hour test drive with a vehicle powered solely by batteries influence the level of information on electric cars and the purchasing intentions. Although the information has increased knowledge, the test drive in particular has shown very strong positive effects on purchase intentions. Due to the corona pandemic and the associated lockdown, we have postponed our next and last survey until October 2020. In addition to the two previous surveys, this survey will also determine how purchase intentions have materialised through the purchase of electric vehicles. Furthermore, we plan to investigate the results of the previous surveys in more detail with regard to the great demand for more public charging stations by means of a survey experiment on this topic. We have already published or submitted several studies to academic journals and used the time to prepare further publications. This project aims to fill a gap in evidence-based research on policy preferences following the experience with new technologies to support policy development in this area.

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Abbreviations

BEV	Battery Electric Vehicle
EV	Electric Vehicle
GHG	Greenhouse Gas
ICEV	Internal Combustion Engine Vehicle

1 Introduction

1.1 Background information and current situation

The sector with the highest emissions in Switzerland is currently the transport sector (BAFU 2020) and transport emissions rose by 5 % points since 1990. Transport emissions stem mainly from passenger transport, in 2018 75% of transport emissions stemmed from passenger transport. One area, notoriously high emitting of greenhouse gasses (GHG) is private road transportation, i.e. cars. Switzerland has the highest emissions per km in its newly registered car fleet when compared to other European countries (BFE 2020a; EEA 2020). Together, this shows the enormous decarbonisation potential from passenger transport.

One possible solution to decrease the passenger transports' GHG emissions would be the widespread purchase and use of Electric Vehicles, especially battery electric vehicles. In 2019, for the first time, the share of BEVs from the stock of all swiss cars surpassed one per cent (1.6%) (BFE 2020b). Meanwhile, there are currently many different EVs on the road, however, consumer interest in BEVs is just starting to show on the mass market. By mid-2020, approx. 29'000 registered BEVs in Switzerland are only held by around 28'000 households, out of around 3.8 Mio Swiss households or around 2.6 Mio car holding households (BFS 2020b, 2020a; Bundesamt für Statistik BFS and Bundesamt für Raumentwicklung ARE 2017).

The challenges to the mass-adoption of new technologies, such as BEVs, is usually driven by consumers' lack of knowledge about new technologies (Axsen, Langman, and Goldberg 2017; Krause et al. 2013; Roberson and Helveston 2020; Wang et al. 2018) as well as misperceptions (Lane and Potter 2007) around these technologies. Often EVs are not shown to potential customers at dealerships (Lynes 2018; Matthews et al. 2017). Together, these lead to (perceived) obstacles of BEV purchase such as higher purchase prices, short ranges and long recharging times, safety or environmental concerns, limited all-wheel-drive selection (Coffman, Bernstein, and Wee 2017; Daramy-Williams, Anable, and Grant-Muller 2019; Li et al. 2017; Liao, Molin, and van Wee 2017; Rezvani, Jansson, and Bodin 2015; Singh, Singh, and Vaibhav 2020). Whereas the previous literature provides ample evidence about these factors inhibiting mass adoption of BEVs, most research on this topic uses conventional surveys and often relies on very specific survey populations, which hardly can represent the average consumer.

1.2 Purpose of the project

This research project aims to understand which private and public sector initiatives could help to achieve decarbonisation of individual motorized transport. Especially, we investigate the shift from internal combustion engine vehicles (ICEV) to BEVs. Switzerland is an ideal country for investigating this as Switzerland is of high income (IMF 2018) and environmental concern (Diekmann and Franzen 2019), two factors previously identified of positively related with EV purchasing interest (Sierzchula et al. 2014). Moreover, energy is already largely from renewables (mostly hydropower) and the legislation ("energy strategy") will replace all remaining non-renewable energy sources, including nuclear energy, with renewables by 2050, following recent legislation (SFOE 2018).

1.3 Objectives

Many countries, such as e.g. Norway, enacted many different policies to promote the acquisition and use of BEVs (Hardman 2019; Hardman et al. 2017; Rietmann and Lieven 2019; Sierzchula et al. 2014; Zhang et al. 2014). In Switzerland, only the import tax reduction, as well as CO2 targets for car importing companies, are in place overall. Some cantons enacted financial benefits for EV purchase lately, such as Tessin, Thurgau or Valais. Other cantons, such as Zurich, offer a temporary reduction of street usage fees for EV users. Through the direct-democratic nature of the Swiss democracy, this project aims to understand which policies, to foster the transition towards more BEVs on Swiss roads, would be accepted by Swiss car holders. We chose Swiss car holders as a population that would or could be very much affected by these new vehicles policies.

Besides EV policy support, we also aim at researching how two particular policy measures would alter EV knowledge and purchase interest: a 48 hours test drive with a BEV and detailed, comprehensive information on BEVs. We expected greater effects of the test-drive as previous literature showed that experience matters for stated interest in EVs (Graham-Rowe et al. 2012; Schneider, Dütschke, and Peters 2014), however findings were mixed so far (Bühler et al. 2014; Jensen, Cherchi, and Mabit 2013; Skippon et al. 2016). In our field experiment, we found a significant positive effect of test-drives on EV purchase interest, while the information treatment alone, was able to increase the knowledge participants had about EVs. In the next survey wave, we aim to find whether treatment effects (e.g. from the information only treatment) arise over time or if treatment effects, from the treatment with test-drives, last and materialized in EV purchases.

Next, we aim to build our previous knowledge on BEV policy preferences in Switzerland (Brückmann and Bernauer 2020), where we found the highest support for many public charging infrastructures. In our next survey, we plan a survey-embedded experiment on which EV recharging stations Swiss car holders (both with and without EV) would like to use for recharging away from home.

2 Procedures and methodology

In this research project, we used a random sample of Swiss car holders from the Swiss cantons of Aargau, Schwyz, Zug, and Zurich (see annual report of 2018 and 2019). Addresses were provided from the respective cantonal car registries. This provided us with the opportunity of a very large and reliable sample, that we first invited to a baseline survey in mid-2018 (Brückmann and Bernauer 2020). Out of 20’000 registered car holders (without any BEV), we received answers from 4,148. Survey participants were then randomly assigned to one of three experimental treatment groups: (1) providing detailed information on BEVs, relating to car attributes that buyers typically pay attention to; (2) provision of the same information on BEVs, plus test-driving of such a car; (3) a control group with neither (1) nor (2). After the second survey (see annual report of 2018), 2283 respondents agreed that we can survey them again, for the third time.

In 2018, we also gathered data on a census of registered BEV holders (see annual report of 2018 for a more detailed description). 1093 are available for a second survey. We will invite them alongside with the conventional car holders to participate in a last panel survey wave.

We plan to survey both populations at the same time, with a questionnaire that allows for the new acquisition of an EV by the ICEV sample as well as the possibility of EV sale by the EV sample. This allows us to follow respondents’’ car purchase behaviour over more than 2 years. All respondents will

take part in the EV charging station choice experiment. The experiment is a choice experiment, meaning that respondents have to decide on which charging station they plan to charge, given a scenario, where people have to charge their BEV with a depleted battery. Charging stations will be characterized by their price and source of electricity, surrounding as well as charging time and (possible) waiting time until the charging station becomes available. Respondents' prior experience with BEVs (holding them, testing them through our experiment or no experience) will likely explain part of the variance in BEV charging station choice.

3 Activities and results

This year's activities can be divided into three parts: Publishing results from the first survey waves, as well as preparing further publications and designing the last survey wave.

We published results from the first survey wave (including both, the ICEV as well as the BEV holder survey) regarding policy preferences for EV policies in Environmental Research Letters. This is a high-impact gold standard open-access journal. Building upon the preliminary results (see e.g. annual report 2018) we found overall strong support for pull measures, that is public charging infrastructure provision as well as subsidies for EVs. We add to previous literature, by focussing on how the information on the cost implications of these policies changes the picture of public support. The relatively high level of support, especially for many more public chargers, stays rather high if funding options are presented alongside. The different funding options were: increased car vignette price, increased income tax, malus for inefficient cars as well as governmental savings. Especially among EV holders, the support for more charging stations is overwhelming. Ambitious pull measures to decarbonise transport are therefore possible, especially when more and more people adopt EVs (Brückmann and Bernauer 2020).

Using data from the first wave, Thomas Bernauer and Gracia Brückmann, are currently preparing an in-depth comparison about the BEV and the ICEV holding population, based on data from the first survey wave. While there is a large and increasing number of survey-based studies examine preferences concerning electric vehicle adoption (Coffman, Bernstein, and Wee 2017; Daramy-Williams, Anable, and Grant-Muller 2019; Li et al. 2017; Liao, Molin, and van Wee 2017; Rezvani, Jansson, and Bodin 2015; Singh, Singh, and Vaibhav 2020) there are yet very few systematic studies based on representative samples of BEV owners as such. Using only a representative sample of the population or car holders does not allow a reliable characterization of the EV holding population. Therefore it would not be possible to e.g. characterize BEV usage and recharging behaviour. The reason this would not be reliably possible is the small number of BEV holders within the whole population. In Switzerland, in BEV ownership share is around 0.62% in 2019 (BFS 2020b). From a random sample of N = 1000 car holders, the baseline probability would be around 6-10 BEV holders. Therefore we intentionally invited a census of BEV holders to take part in this survey (see annual report of 2018). Main findings of BEV holders show that most (77.5%) BEV holders drive below 20'000 km p.a. with their BEV and a nearly equal share of BEV owners intents to buy again a BEV as their next car. Recharging often takes place at home, over-night, at varying battery levels until it is fully-charged and mostly (56%) one to three times a week.

Gracia Brückmann used data from the experiment (see annual reports of 2019) between wave one and wave two of the ICEV holders panel, to write her single-authored paper, a mandatory part of her dissertation. The lack of BEV adoption by the mass public can be explained, inter alia, due to the lack

of experience and knowledge. In her paper, she analyses a randomized-control trial on whether information on BEVs and experience with BEVs (i.e. a 48h test-drive) can alter attitudes towards BEVs. The large random sample (n=1'189) of conventional car holders is randomly partitioned into three groups: test-drive with information treatment group, information treatment group and a control group. The experimental treatment with test-driving was not mandatory, therefore some respondents did not want to test-drive and others could not get a test-drive due to out-of-capacity, an instrumental-variable approach (intention to treatment) is utilized to estimate LATEs (Local Average Treatment Effects). This method follows Angrist, Imbens, and Rubin (1996). The main dependent variables of interest were the objective knowledge and awareness about BEVs as well as BEV purchase intentions. The information treatment alone as well as the treatment with test-drives have significantly increased knowledge and awareness about BEVs. However, purchase intentions are largely and statistically significantly driven by the treatment with test-drives. Comparing the effects of the test-drive treatment shows that they are much stronger as common predictors of EV purchase intentions, such as household income, technology interest or house ownership. Together, these results show that policy and industry interest could align and test-drive a BEV could be promising for increasing knowledge about this technology as well as purchase interest.

Our plan for the last survey wave is to survey both populations at the same time. We plan a very short survey, as this is what they agreed to when we asked them in previous survey waves. A joint questionnaire will allow us to assess the new acquisition of EVs by members of the ICEV sample as well as of the EV holder sample. At the same time, it also allows for the possibility that any EV is sold. We will also assess knowledge about BEVs and opinions about BEV policies, again, to assess the difference between treatment groups of the experiment, between the first two panel waves. To answer questions, such as, if higher BEV purchase interest translated into BEV purchase after the treatment, we will analyse on those who had been in the respective sample.

The survey is planned with the following elements:

1. Welcome page with informed consent
2. Mobility demographics (i.e. access to which cars, if there are EVs acquired or sold, reasons for discarding a BEV (if applicable))
3. Intention to buy any new cars in the future (and if so, what kind of cars)
4. Choice experiment on charging behaviour and pre-reserving public charging station spots
5. Personal evaluation of BEVs environmental impacts and own BEV knowledge
6. Personal attitudes towards certain BEV policies
7. The expected resale value of BEVs and factors influencing this expectation
8. Own energy production through photovoltaics
9. Thank you and end of the survey

4 Evaluation of results to date

So far, our results indicate strong support for certain actions, that could be taken to increase BEV uptake. Politically, more charging stations on public parking spaces (such as “Blaue Zone”) are widely

supported and these investments could even by financed by e.g. an increase in motorway vignette prices (Brückmann and Bernauer 2020).

Also, our results indicate that more information on BEVs leads to higher BEV awareness, such as about actual BEV ranges as well as public charging spots. While results from the information treatment alone have not been associated strongly with higher purchase intentions for BEVs, we are confident that test-drives do so. This is a very surprising finding, as previous studies not always reached this conclusion. We are especially confident that our results can be generalized to a broader population, as we used a random sample and randomly assigned treatments. Both have not always been the case in previous studies.

Sadly, our project had been delayed because of the severe accidental injury of one project member as well as the COVID-19 pandemics with the lockdown. The lockdown relentlessly changed mobility behaviour (more home office, hardly any leisure trips) and car purchases during this time were strongly inhibited. Therefore, we had to delay the start of our last survey wave, as we decided in close communication with SFOE. However, in the current state, we are very confident that this project already provided valuable rigorous results and will continue to do so.

5 Next steps

We plan to carry out a last panel survey wave, analyse the data, publish further papers and finalise the final report to successfully finish this project.

For the last survey, we plan to examine whether treatment effects from the field-experiment, carried out between ICEV survey panel wave one and two are stable over time, materialize in BEV purchases or arose over time. We also dig deeper into EV policy preferences depending on prior BEV purchases. Lastly, we plan on investigating optimal public BEV charging station provision.

We plan to publish the papers mentioned above and below, as well as, at least one more academic paper based on the results from this last survey wave with ICEV and BEV holders.

All information together will be synthesized in a final report for the SFOE. Alongside, we plan the successful finish of Gracia Brückmann's doctoral thesis as well as an outreach activity of this project.

6 National and international cooperation

Together with two collaborators from the ETH Zurich's ISTP and chair of Planning Landscape and Urban Systems, Fabian Willibald and Victor Blanco, Gracia Brückmann submitted an article to Transportation Research Part D. In their paper entitled "Battery Electric Vehicle adoption in regions without strong policies" they use data from the first survey waves on Battery Electric Vehicle holders as well as the random sample of ICEV holders and merge it with spatial data from the respondents' home addresses, especially charger density and population density in their respective ZIP codes. Thereafter, a generalized linear mixed-effects logistic model is used to find drivers for early adoption of BEVs. Mainly, this is driven by technological affinity as well as high income, green party preferences

and single-family house ownership. No significant effects from home locations' population or charging station density were found. These findings imply that increased interest in technology was decisive for early BEV adoption and might be politically stimulated. We already revised the article once and resubmitted it. The final decision is still outstanding as the paper is again under review.

7 Publications

Brückmann, Gracia, and Thomas Bernauer. 2020. "What Drives Public Support for Policies to Enhance Electric Vehicle Adoption?" *Environmental Research Letters* 15(9).

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9 Appendices