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| Institution: Oxford Brookes University |
| Unit of Assessment: 4 - Psychology, Psychiatry and Neuroscience |
| Title of case study: Assessing the viability of electric vehicles for daily use |
| <p>1. Summary of the impact</p> <p>Harris, Burgess, Bunce, Mansbridge and King have identified critical facilitators and barriers to widespread daily EV use through their industry-led, problem-based research into drivers' real-world long-term experiences with electric vehicles (EV). Their findings have had impact in 3 distinct areas. First, their work has been used by the UK Government to construct policy to support integration of EVs into the national fleet, as well as informing realistic expectations of successful integration. Second, their work directly influenced development of EVs, accelerated their route to market, and has resulted in specialised support for EV drivers and their vehicles. Third, their work has informed energy suppliers of the support required for drivers to charge their vehicles both at home and also away from home as part of a wider public charging infrastructure.</p> |
| <p>2. Underpinning research</p> <p>Researchers: Professor Margaret Harris (PI), Dr. Mark Burgess (Reader), Dr. Louise Bunce (Post-Doctoral Researcher) Sarah Mansbridge & Naomi King (Research Assistants)</p> <p>Finite fossil fuels, climate change, and government targets to reduce carbon emissions have stimulated technological innovation from car manufacturers to produce electric vehicles (EVs). The UK Government has committed to reducing carbon emissions by 34% by 2020 and 80% by 2050. It established demonstrator trials in order for the UK to become a leader in the development and manufacture of low carbon vehicles. For these carbon reduction and car manufacture targets to become a reality, key players in the transport system need reliable data to inform their decisions of how to produce cars, infrastructure and policies that support successful commercialisation of EVs and consequently aid the reduction of carbon emissions. Harris et al.'s research in the BMW MINI E international trial (Grant no.TP11/LCV/6/I/BF, 'User Perceptions of the BMW MINI E', £147,775) and the TSB UK Ultra-Low Carbon Vehicle Demonstrator Trial (Grant no.PO000805, 'The Expectations and Experiences of Ultra Low Carbon Vehicle Drivers', £640,075) provided robust data from real-world sustained usage of EVs that demonstrated the degree to which EVs are viable for daily use.</p> <p>In recognition of their multi-method and theoretical expertise in problem-based psychological research, Harris et al. were invited by BMW to design data collection methods and analyse drivers' expectations and experiences in the UK segment (May 2009 – March 2011) of their international MINI E trial, the world's largest single-manufacturer trial in collaboration with university researchers. Unlike previous EV research (short-term EV exposure/surveys of non-EV drivers), the BMW trial involved systematic international (UK, USA, Germany, France, Japan, China) research in which we worked closely with colleagues from Technical University Chemnitz, Germany, to develop methods of data collection and to investigate drivers' expectations, motivation, adaptation, journey patterns, range and charging experiences, environmental attitudes, and purchase intentions over a 6 month period of use. These collaborative analyses established robust patterns of expectations and experiences across MINI E drivers of each nation. For the UK trial, Harris et al. selected applicants, contributed questions, and added interviews to the pre-post questionnaire/interview methods of the 120 private and corporate UK drivers. Analyses of data revealed consistency across nations and revealed that EVs are viable for everyday life with the majority of barriers relating to psychological factors rather than practical ones. The strength and impact of the findings the researchers presented to BMW and the TSB Head of Transport led to an invitation to submit a proposal to conduct similar research in the UK Ultra-Low Carbon Vehicle (ULCV) Demonstrator Trial (July 2010 – December 2012). This was awarded in May 2010.</p> <p>For the ULCV Demonstrator Trial, Harris et al. designed pre-post questionnaire/interview methods of data collection/analysis to assess 352 drivers of EVs and plug-in hybrid vehicles. This trial was the world's largest multi-manufacturer, multi-location trial and was constructed to aid the UK Government in the design of their ultra-low emission vehicle strategy. Eight regions hosted 19 car manufacturers and 349 vehicles were driven 1.5 million miles in 276,000 journeys and charged 51,000 times. Harris et al. collaborated with engineers from Cenex (Centre of Excellence for Low</p> |

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Carbon and Fuel Cell Technologies) to integrate their analyses of drivers' data with Cenex's analyses of objective information gleaned from EVs' on-board data loggers (e.g., measuring mileage, energy consumption, time to charge). This integration of person-oriented and machine-oriented data is unique in trials of EVs.

The final report was delivered to the UK Government in December 2012 and identified a steep learning curve in EV drivers' *primary adaptation* [Refs 2,4]. All drivers rapidly mastered unfamiliar components and developed routines that aided the integration of EVs into their lives. While they worried about limited range, facing those worries led drivers to have mastery experiences that enhanced self-efficacy in EV usage, leading drivers to become positive models to non-EV drivers [Ref 4]. Only 33% of drivers deliberately challenged the vehicles' range limit. Doing so resulted in a higher level of adaptation (*secondary adaptation*) that enabled drivers to understand how to drive with optimal efficiency [Ref 2].

Application of self-determination theory showed corporate drivers to have a different motivational profile to private drivers (who were early adopters, intrinsically motivated to trial new technology). Interviews showed that corporate drivers demonstrated the same learning curve as private drivers if they were induced to identify with their company's carbon reduction targets. If not, they did not adapt well and could become negative models for others [Ref 4]. This information is important as the corporate fleet represents 50% of UK vehicle sales and is a key target for future EV integration. Analyses indicated that the highly-rated EV performance shattered existing EV stereotypes and contributed to EVs being seen as a viable transport alternative for non-EV drivers [Refs 1,2,3,4]. EVs drivers' daily mileage was comparable to that of normal cars and 79% of drivers could complete trips without an extensive public charging infrastructure (PCI) [Ref 2]. However, 71% of private drivers and 92% of corporate drivers indicated that PCI is essential for widespread EV adoption [Refs 2,5]. 80% of trial drivers would replace a vehicle with an EV, 50% intended to do so at the completion of the trial, but only 30% would own only an EV [Ref 2].

3. References to the research

1. Burgess, M., Harris, M., Mansbridge, S., Lewis, E., Walsh, C. & Carroll, S. (Sept, 2011). *Initial Findings from the Ultra-Low Carbon Vehicle Demonstrator Programme: How Quickly Did Users Adapt?* URL: http://www.innovateuk.org/_assets/pdf/press-releases/ulcv_reportaug11.pdf
2. Carroll, S., Walsh, C., Burgess, M., Harris, M, Mansbridge, S., King, N. & Bunce, L. (Sept, 2013). *The Ultra-Low Carbon Vehicle Demonstrator Programme: Assessing the Viability of Electric Vehicles in Daily Life.* URL: <https://www.innovateuk.org/documents/1524978/2138994/ULCV%20Demonstrator%20final%20report>
Please note: This report was delivered to the UK Government in December 2012, but was published alongside the strategy document which it informed in September 2013.
3. Burgess, M., King, N., Harris, M. & Lewis, E. (2013). *Electric Vehicle Drivers' Reported Interactions with the Public: Driving Stereotype Change?* Transportation Research Part F: Traffic Psychology and Behaviour, 17, 33-44. DOI: 10.1016/j.trf.2012.09.003
Submitted to REF2014, Oxford Brookes University, UoA4-Psychology, Psychiatry and Neuroscience, REF2. JM Burgess, Output identifier 9217.
4. Everett, A., Walsh, C., Smith, K., Burgess, M. & Harris, M. (2010). *Ultra Low Carbon Demonstrator Programme.* Proceedings of the 25th World Battery, Hybrid and Fuel Cell Electric Vehicle Symposium and Exposition, Shenzhen, China. Available on request.
5. Everett, A., Walsh, C., Smith, K., Burgess, M. & Harris, M. (2011). *Ultra Low Carbon Demonstrator Programme: Charging.* Proceedings of the Hybrid and Electric Carbon Vehicle Conference, 11, Warwick, UK. Available on request

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4. Details of the impact

Our research was specifically commissioned to elucidate drivers' expectations and experiences with EVs in order to inform the UK Government's strategy for ultra-low emission vehicles in the UK. The aim of that strategy is to have a UK car fleet with zero emissions by 2050. Our research in the BMW international MINI E trial helped to demonstrate that drivers' expectations and experiences are robust *across nations*. Our research in the Technology Strategy Board (TSB) UK trial shows that those findings are robust *across car manufacturers*. Therefore, our social-psychological research into drivers' use of EVs provides a firm foundation for government policy makers, car manufacturers, and energy suppliers seeking to convert EVs from promising prototypes to viable fully market-ready products.

Findings were disseminated widely to:

Government departments and agencies (Technology Strategy Board, Dept. for Transport, Business Innovation and Skills, Dept. of Energy and Climate Change, The Office for Low Emission Vehicles)

Car manufacturers (BMW, Mercedes Smart, Tata, Ford, Lightning Car Company, Westfield Sports Cars, Mitsubishi, Jaguar Land Rover, Toyota, Microcab, Allied Electric Vehicles, Delta Motorsport, Ecotricity Cars, Peugeot, Smith Electric Vehicles, Liberty Electric Cars, AVID, Nissan)

Energy suppliers (Scottish and Southern Energy, EDF Energy)

In addition, academic journal articles and conference presentations have disseminated results to the wider community and the research has been reported in national media, including BBC News, national newspapers and automotive websites.

Impact on Policy and Economic Development: Significantly, the research has shown the UK Government that EVs are a viable proposition for daily use by private and corporate drivers in the UK today, and have indicated ways in which usability could be improved further [Refs 1,2,4,5,6].

Mr. Norman Baker, MP, Minister of Transport, said,

"This in-depth study provides important evidence to support the Government's policy which is set out today in the Ultra-Low Emission Vehicles Strategy. People find electric vehicles easy and fun to drive. In addition, they are less polluting and a vital part of the UK's transition to a low-carbon sustainable transport system" [a].

Mr. Phil Smith, Chair of the TSB, indicated that,

"The UK is committed to a low-carbon economy, and transport is a key area where change will be needed. This study shows how people will welcome and readily adapt to well-thought-out and effective innovation in this" [b].

The Head of Low Carbon Regulation, R&D and Procurement at OLEV said that

"the finding that drivers used their at-home charge points for 97% of their charging time" led to the OLEV strategy to commit to providing *"a national package of up to £37 million through to May 2015 to support the installation of charge-points in homes, residential streets, railway station and public sector car parks and rapid charge-points to facilitate longer journeys"* [c]

As a result of the research, Government is aware that drivers expect EVs to be priced at comparable levels to normal cars, and to receive further financial incentives. This has ramifications for ensuring that EVs are introduced at an appropriate price (and for the continuation of the EV purchase supplement), and for follow-on benefits such as congestion charge waivers [d].

Impact on EV Car Development: The results on drivers' range requirements, levels of adaptation and driving styles have informed car manufacturers' decisions regarding the required battery capability of their EVs, drivers' prior expectations, anticipated mobility needs, expected vehicle cost, the learning curve of adaptation to EVs, and the way these vehicles should look relative to normal cars [Refs 1-6]. We had an especially close relationship with BMW. The Project Leader (User Research, BMW) indicated that the unique theoretical underpinnings of the research enabled BMW to understand the need *"to establish a situation in which fleet car users identified*

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with the green agenda of their company” in order to achieve optimal adaptation and that “*on a theoretical level, the differentiation between primary and secondary adaptation resolved a paradox that was not explainable before*” and that “*in order to make EVs a success story, customers should be encouraged to achieve secondary adaptation*”, making “*these results highly relevant for sales and aftersales processes and long-term customer satisfaction*” [e].

The findings prompted BMW to develop the new position of EV Mobility Consultant and to construct salesrooms that are specific to EVs. General Manager of BMW UK’s Project i stated that the research had “*been invaluable in helping our understanding of how people really respond to electric cars*” and that this information puts them in a “*strong position to provide a well-rounded product and service proposition*”. Indeed, she also explicitly stated that Harris et al.’s findings “*informed the development of the 2011 BMW ActiveE*” and that “*the biggest beneficiary will be the BMW i3, the first purpose-built EV from the BMW Group, due in 2013*” [f].

Impact on Energy Provision: Energy suppliers are particularly concerned with assessing drivers’ ease of use of private and public charging points and concerned with determining the degree of public charging infrastructure required to support a new market of EVs. The Head of Sustainable Transport at Scottish and Southern Electric has said that the findings have “*been invaluable for us in forecasting the impact of EV charging on the network and understanding the underlying behaviours of EV owners when recharging at home. This has helped when talking to EV charging equipment manufacturers in designing charging equipment that is functional and easy to use. It has also provided valuable insights into the utility of public charging infrastructure and the types of locations that would meet the requirements of future EV owners as the market develops*” [g].

In addition, energy suppliers and consultants are also using the results on drivers’ preferred charging times to inform their development of charging posts and to increase the predictability of public charging sites being available for use for mid-journey recharging [Refs 4,6]. These factors are helping to make further improvements to the provision of public charging infrastructure that would enhance the experiences of EV drivers.

5. Sources to corroborate the impact (indicative maximum of 10 references)

- a. Mr. Norman Baker, MP, Parliamentary Under Secretary of State for Transport, quoted in press release from Technology Strategy Board, 4th September 2013, <https://www.innovateuk.org/documents/1524978/1866950/Low%20carbon%20cars%20a%20dream%20to%20drive>
- b. Phil Smith, Chair of the Technology Strategy Board, quote taken from speech given at the Low Carbon Vehicles 13 conference at Rockingham, 5th September 2013, and reproduced in TSB article, <https://www.innovateuk.org/-/91-per-cent-of-trial-drivers-endorse-electric-cars>
- c. Corroborative statement author 1. Statement from Head of Low Carbon Vehicle Regulation, R&D and Procurement at the Office for Low Emission Vehicles.
- d. Office for Low Emission Vehicles (2013) Driving the Future Today: A Strategy for Ultra Low Emission Vehicles in the UK (Published September 2013 at a delayed strategy launch event. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/239317/ultra-low-emission-vehicle-strategy.pdf)
- e. Corroborative statement author 2. Project Leader, User Research, BMW AG/Germany
- f. Corroborative statement author 3. Letter from General Manager, Project i, BMW to Brookes Vice-Chancellor, 9th January 2012. Also cited here: <http://www.hls.brookes.ac.uk/research/low-carbon-vehicles/research-impact>
- g. Corroborative statement author 4. Email from Head of Sustainable Transport at Scottish and Southern Energy.