

Understanding sustainable mobility: *The potential of electric vehicles*

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Abstract— Rising awareness of the environmental impacts of dominant mobility practices lead to the development of the sustainable mobility paradigm. This paradigm advocates three features of a mobility system: 1. A reduced need to travel, 2. Modal shift towards more sustainable options, and 3. Reduced vehicle kilometres travelled. In this paper, two sets of data are presented to explore the potential of electric vehicles to contribute to a more sustainable mobility system. First, data from an international Delphi of transport experts shows how a sustainable future can be characterised by different features: efficient internal combustion engine vehicles, electric vehicles, and reduced personal car ownership. Thus electric vehicles are presented as both an opportunity and a threat in relation to sustainable mobility. A second body of empirical material is drawn from interviews with electric vehicle owners, and discusses the drivers and barriers to ownership. Interestingly, participants suggest changing mobility practices associated with electric vehicle ownership, evidenced by decreasing kilometres travelled. The paper concludes by suggesting that there may be potential for electric vehicles to contribute to a sustainable mobility future through modified mobility practices and renewable energy sources in New Zealand.

Keywords—sustainable mobility; electric vehicles; future transport; New Zealand

I. INTRODUCTION

The ‘new mobilities paradigm’ emerged in response to earlier failings to adequately incorporate social features in travel and transport research [1]. This paradigm is concerned with a diverse array of accounts of movement, migration and transport [2]. These mobilities operate at a range of spatial scales; from bodily movements through to global migrations. As a result, this research field is intrinsically connected to global, national, regional and local transportation systems and mobility flows. This includes daily mobilities through to tourism and long term migration. Increasing reliance on air and road travel to achieve these mobilities links this field to the sustainability agenda.

Rising awareness of the impact human actions are having on the global climate as a result of CO₂ emissions, has led some commentators to speculate about future directions for mobility [3], [4], [5]. Alongside concerns about the

environmental impact of current mobility patterns, is the recognition that private car dependence has become increasingly entrenched in developed (and increasingly the developing) nations’ psyche. This transport-led future has been enforced by car dependency and the decentralisation of cities [6].

The sustainable mobility paradigm has been proposed in response to concerns of the wide ranging negative outputs of current mobility systems, including climate change, social exclusion, resource consumption and air pollution. It calls for “a radical change in the way in which travel decisions are made” [6:77]. The approach is developed around three needs, 1. To reduce the need to travel and consequently lead to less trips, 2. To encourage modal shift towards more sustainable options, and 3. To reduce the length of trips. Two approaches to achieving more sustainable mobility could arguably be through technological innovation such as Electric Vehicles (EVs) and behaviour changes leading to increased energy efficiency.

In New Zealand, transport is the largest energy consuming sector at 39% of all energy. Of this, light vehicles consume 59% [7]. New Zealand also has the third highest rate of private vehicle ownership and use in the OECD [8]. Furthermore, after agriculture, transport is the largest producer of greenhouse gas emissions in the country accounting for 9.3 million tonnes of carbon dioxide annually [9].

New Zealand is particularly suited to EVs due to the large amount of energy (70%) generated by renewables compared to other countries. This means that even accounting for the electricity required to charge an EV, there is a corresponding saving of 170 grams of carbon dioxide emissions compared to an average fleet vehicle. This could amount to a reduction in emissions of two tonnes per vehicle per year. The average NZ household produces eight tonnes of emissions per year from electricity and transport, therefore this could amount to a significant saving [7].

In this paper, we will explore how electric cars are perceived as one of the components of future sustainable mobility by a global panel of transport experts, before focusing on the perceptions of New Zealanders regarding uptake of EVs to achieve the required transition. Data from two research workstreams of the Energy Cultures and GREEN Grid research programmes will be presented.

II. METHODS

The empirical material presented in this paper draws from two interrelated research projects. Both research projects employ interpretivist research methodologies. Through this perspective there are many different interpretations of reality, therefore the research sought not for a representative sample, but for a range of perspectives from the research participants.

The first is an international Delphi project on future transport. Emerging in the 1950's, the Delphi Technique has undergone several transformations, being used for military research, as a business forecasting tool, and for complex social issues. There is no single, fixed definition for the Delphi, and this allows it to be a versatile research technique [10]. The Delphi is an iterative process which involves the recruitment of an 'expert panel' who respond to a series of questionnaires, through which ideas and responses are developed through several rounds. The international Delphi on future transport employed 30 global experts from a wide range of disciplines including material and battery technologies, behavioural science and economics. This paper will be reporting on findings from Round 1, which gathered qualitative data from 22 open questions exploring themes of risks of Business-As-Usual (BAU), drivers and barriers to innovations, and global trends and possible discontinuities in the transport system. The questionnaires were administered through the Qualtrics website; 23 responses were received. The data were analysed by two research team members using NVivo10 software, and explored for emergent themes.

The second research project explores household appetite for adoption of new energy technologies, including EVs. The preliminary results reported in this paper explore the factors influencing individual's decisions to purchase EVs and how the uptake of these new appliances and technologies might impact future demand. An ongoing set of semi-structured interviews with individuals around New Zealand who have EVs are being conducted. The interviews are conducted face to face at the participant's home, or via telephone. The interviews are audio-recorded and fully transcribed. The transcriptions are then thematically coded. These interviews are designed to investigate the enablers and barriers of adoption of EVs. A preliminary analysis of an initial set of three interviews is reported in this paper.

III. RESULTS OF AN INTERNATIONAL DELPHI ON FUTURE TRANSPORT

The Delphi study identified various different 'futures' for the global transport system, and different interpretations of BAU. Each requires different degrees of change to behaviours, technological innovations, policy and regulations and social norms. BAU could include the continuation of unabated private mobility, with private vehicle ownership in the form of increasingly efficient Internal Combustion Engine Vehicles (ICEVs), or EVs. In contrast, another perspective portrayed a sustainable future with reduced dependence on personal vehicles (both electric and ICEVs), instead relying on shared

transport (public transport and shared vehicle ownership models) and active transport.

A. Drivers of Change

Our international Delphi panel identified a range of occurrences which could threaten the continuation of the current ICEV-reliant transport system, and thereby drive a transition towards a more sustainable structure of mobility. The availability and cost of fossil fuels, including variability in pricing was seen to be a large driver, particularly in relation to increasing government desire to gain energy security. Where fuel distribution channels were perceived to be vulnerable (such as for New Zealand) a greater imperative to transition towards more sustainable sources of energy were voiced. This could drive the change towards EVs in countries where the electric supply is secure and renewable.

Technological developments in non-transport related fields were also seen to be driving change, although this change is away from the personal vehicle ownership model. This was most evident in terms of Information Communication Technologies (ICTs), which were proposed as methods through which transport and traffic management could become more efficient, to make public transport more attractive through real-time scheduling information, and also to provide travel substitution opportunities thereby reducing vehicle kilometres travelled and the number of trips – a feature of Banister's sustainable mobility paradigm.

The state of current transport infrastructure was also perceived by the Delphi panel to be a potential driver of change away from private car dominance due to the saturation of the current system. This declining functional performance of the transportation system could contribute to changing perceptions of the private automobile – both ICEVs and EVs, and a desire to use alternative transport modes (such as public transport), as well as resulting in diminishing social and economic returns on the current transport system.

B. Innovations: An Opportunity and Threat

Contestations arose amongst the Delphi panel when discussing possible innovations to move away from BAU. This was largely due to the complex array of definitions of BAU: for some this means more sustainable forms of personal vehicles - moving from ICEVs to EVs and hybrid vehicles, or the introduction of more efficient ICEVs. For other participants, however, moving away from BAU involves reducing reliance on private vehicles, and focusing instead on active and public transport modes. Consequently, many innovations were seen to be both facilitating BAU as well as driving a sustainability transition. One example of this is the increasing fuel efficiency of ICEVs which was seen to be promoting auto-dominance and perpetuating private car ownership. Likewise, the EV was perceived to be both an innovation facilitating a shift away from BAU, towards a more sustainable fuel source, as well as an innovation continuing BAU through perpetuating private car ownership.

Nevertheless, a wide range of technological, fuel and social innovations which could facilitate a shift away from BAU were identified by the Delphi panel. Technological innovations include; (semi) autonomously guided vehicles, 3D printing, ICT and wireless high speed internet access. While for fuel-based innovations, fuel economy standards and second generation biofuels were dominant. In terms of social innovations, panel members articulated social change related to technical innovations such as the Internet and smart phones, facilitating changing practices which in turn affect norms.

C. Drivers and Barriers to the Uptake of Innovations

The international Delphi participants perceived cost and price to be central to the uptake of innovative technologies including EVs. A further example of this is related to the financial incentives related to fuel efficiency gains. Social drivers to uptake innovations were argued to be behaviour change associated with peer norms, peer pressure and the neighbourhood effect, as well as an increasing social conscience about both environmental and health impacts of the current transportation model – this could result in increased uptake of EVs which have lower emissions and reduced contributions to air pollution. Early adopters in particular could drive this effect, as they would be more likely to lead the uptake of a new technology. Panel members suggested that policy could be a strong driver for technological innovation and uptake, but that this requires political will.

Indeed, a lack of political will was identified as being the main barrier to the uptake of innovations through policies and practices which perpetuate BAU and fail to incentivise new innovations which could contribute to a more sustainable mobility system. Fear of the unknown and risk aversion from both political and social perspectives can reinforce the status quo and contribute to inertia, particularly around technologies such as the EV where range-anxiety and uncertainty around maintenance could hinder uptake. Systemic lock in related to access, structural car dependence, lack of incentives and political/ economic instruments, can provide further barriers to the uptake of innovations. Social perceptions of freedom and control related to owning a personal vehicle can prevent a future with less personal transport and more shared transport – but still allows for efficiency gains and EVs to prosper, however Delphi panel members suggested that often the public (with the exception of early adopters) perceives new technology to be inferior which could present a significant hurdle to overcome.

Overall, the international Delphi paints a complex picture of future transport, built upon wide ranging assumptions about the direction transport should be taking – whether that is with or without personal vehicles is a key question. The complexity of this process was succinctly depicted in this quote from a Delphi panel member:

“Answering this survey was a huge personal (emotional) and intellectual struggle. There are simply too many interdependencies. The physical and social arrangements of how we live and work – separately from transport systems alone – will greatly affect transportation...”

IV. RESULTS FROM EV INTERVIEWS

All interviewees were owners of EVs.

A. Motivations for Uptake of EVs

Participants indicated a range of motivations for purchasing EVs. One participant stated that their household had been on the path to higher efficiency vehicles for many years, progressively getting smaller cars, moving from petrol to diesel and towards EVs. For this participant, an EV was part of a larger, conscious pathway towards energy efficiency. Environmental concerns were a major factor driving uptake of EVs for all participants; and within this a key theme was to reduce dependence on fossil fuels.

Running costs of EVs was another theme emerging from the interviews. Even though EVs are expensive relative to ICEVs in upfront costs, the comparatively low daily running costs were a major factor, with EVs perceived to be providing good value for money.

“Cost me \$22,000, I’ve had it for 5 years and I’m sure I’ll have it for another 5, that’s only 2 grand a year and it’s cost me nothing to run” (Participant 2)

Being an early adopter of technology was also a factor for some participants, who are likely to be attracted by the novelty of new items to the market.

“I was keen to be one of the first in New Zealand to get one of these, the early adopter approach I guess” (Participant 1)

One participant had a large network of other EV users and stated that they tended to fall into one of two groups. Either they were environmentally conscious and were concerned about fuel efficiency or they were individuals with high net worth and were concerned with high performance.

“High net worth individuals are buying these because of performance, not necessarily running costs...probably one of the biggest drivers is performance e.g. the Tesla roadster will beat most Porsches and Ferraris” (Participant 1)

B. Barriers to Uptake of EVs

The range or distance an EV can achieve without charging was seen as a significant barrier to purchasing an EV. Participants mentioned how they like to drive outside of the urban region on weekends and holidays. Trips to the beach, mountains or across country are often not viable with a purely electrically powered vehicle due to lack of charging points available in New Zealand.

The high cost of purchasing an EV in New Zealand was seen as another major barrier to uptake. Participants stated that even with the fuel savings an EV or a hybrid would bring, at this stage those savings alone were not enough of an incentive to purchase.

C. Changes in Behaviour

Participants mentioned that they had changed their travel practices since they had bought an EV such as making fewer trips, or ensuring the trips they do make achieve as much as possible. This suggests a synergy between the mobility practices of EV owners and Banister's sustainable mobility paradigm and could indicate the potential for EVs to act as a conduit to reducing vehicle kilometres travelled whilst continuing private car ownership.

"I'm more conscious of the trips I do because I think more about if I have to get an extra top up charge during the day" (Participant 1)

D. Incentives

Incentives were already attracting individuals towards EVs, but participants indicated that more could be done. Energy companies offering reduced rates during the evening incentivise EV users to charge their vehicles at night, when it is also the most convenient time to charge.

"[Energy company] are offering a 30% discount if I charge my car between 11pm and 7am" (Participant 1)

Participants felt that there should be governmental involvement in providing support for EVs. These incentives took many forms such as tax breaks, better charging infrastructure, public charging facilities or purchase incentives. They stated that changes such as these would encourage greater uptake of EVs in New Zealand.

"People need to be putting a lot of pressure on the government to look closely at where we have to be moving fast" (Participant 3)

"The government seems to be very focused on oil, gas and coal and not on renewables, they're not interested in carbon taxes...until they start showing interest in those areas, you're not going to see as fast uptake here as in other countries....incentives include free public charging, the ability to drive in bus lanes...exemptions on taxes for cars" (Participant 1).

In sum, interviews participants indicated a range of motivations and barriers to uptake of EVs. Drivers include financial, environmental and self-identity incentives, whilst barriers include range anxiety and the relatively high cost of EVs in New Zealand in comparison to ICEVs. However, interestingly, the interviews provided evidence of changing travel practices since owning an EV; this could indicate a

potential opportunity for more sustainable use of private vehicles in the future, as suggested by Bannister (2008).

V. CONCLUSIONS

This paper has presented data from an international Delphi with global transport experts and semi-structured interviews with EV owners. Framed by the sustainable mobility paradigm, the Delphi data has shown the range of ways a sustainable future can be perceived: increasingly efficient ICEVs, EVs and hybrid vehicles, or a future with reduced personal vehicle ownership.

Owners of EVs stated that their travel behaviours had been modified as a result of owning an electrically powered vehicle, and that this had contributed to reduced kilometres travelled, and more efficient travel practices – key features of sustainable mobility. Thus while EVs may perpetuate personal car ownership, they could still contribute to more sustainable future mobilities, and help increase public awareness to sustainable behaviours.

New Zealand has the potential to be a leader in terms of transport carbon emissions reductions - if it can increase uptake of EVs - as a result of high domestic renewable energy production. The research presented in this paper indicates that EVs are currently adopted due to environmental concerns and as a result of social desire to be an 'early adopter of technology' rather than for economic reasons. To fulfil its potential in terms of transport emissions reductions, New Zealand needs to provide better charging infrastructure and provide greater financial incentives to increase uptake of EVs.

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