

Using Citizen Science to Promote Electric Vehicle Uptake in New Zealand

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Presented at EVS 31 & EVTeC 2018, Kobe, Japan, October 1 - 3, 2018

ABSTRACT: Encouraging uptake of electric vehicles (EVs) in New Zealand requires extraordinary efforts to overcome barriers of misconceptions amongst potential purchasers and absence of strong financial subsidies and regulatory incentives to buy EVs. ‘*Flip the Fleet*’ (www.flipthefleet.org) is a citizen science approach to better inform public and businesses of EV practicality, financial rewards, environmental and social benefits. Owners of over 1000 EVs upload monthly data from their CAN bus and dashboard, report charging events, repairs and maintenance. Social research provides the human dimension of EV ownership and aids media outreach. Scientific analysis builds trust and reduces uncertainty amongst prospective buyers.

KEY WORDS: citizen science, diffusion of innovation, financial & environmental performance, battery longevity

1. INTRODUCTION

Flip The Fleet (FtF) is a Citizen Science approach gathering monthly data which is openly shared from around 10% of all EV vehicles currently in New Zealand to build trust and credibility. The data summaries and analysis are becoming more widely cited in social media to answer questions and reduce uncertainty amongst prospective buyers.

In this paper we first provide background on the particular opportunities and constraints on EV uptake in New Zealand. We then illustrate the strengths and limitations of *FtF*'s data stream by presenting analysis of participation rates and reactions of participants, together with some important outcomes for EV owners and wider society. We end by asking whether citizen science and *Flip the Fleet* will accelerate EV uptake in New Zealand.

2. ROLE OF CITIZEN SCIENCE

2.1. Induced Diffusion

Rogers⁽¹⁾ emphasises the role of communication channels in hastening uptake. Internet and a citizen science approach is ideal

for drawing together the information from otherwise dispersed and loosely organised innovators and early adopters.

Data are uploaded to a communal database from private owners and business fleets and the software instantly graphs the results, shows trends and compares each participant's results with others. Uptake will be faster, and a “critical mass”, where EVs will “sell themselves” without added investment in advocacy and education, will be reached earlier in the diffusion curve (Fig. 1).

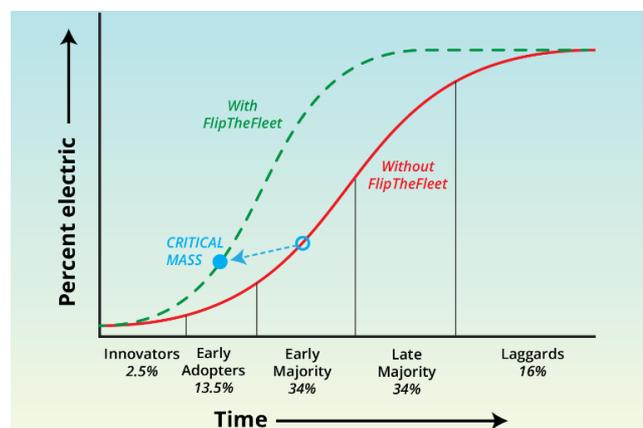


Fig.1 E. Rogers (2003) Diffusion of Innovations model

The objective of *Flip the Fleet*, and the associated network, is to accelerate the rate and reach of diffusion by gathering the information from innovators and early adopters and spreading the lessons to prospective purchasers.

2.2. Influencing Vehicle Purchasing Decisions

A decision to buy an EV depends partly on the EV's financial, environmental and convenience benefits, driving pleasure and the fit of the vehicles' capabilities to the purchasers' purposes. Much of this conference highlights brilliant technological advances of EVs created through tremendous skill and commitment of scientists and the electric automotive industry. But the Diffusion of Innovations model emphasises that these technological innovations alone may not be sufficient to ensure rapid uptake of EVs. Rather, acceptance of new technology is a highly social process that can only be accelerated with considerable investment in communication and trust building.

FtF can only achieve its primary goal, to accelerate EV uptake, by combining science with a meaningful marketing campaign. The latter uses social media networking to advocate EVs in intimate places and times where mainstream media will not reach, and mainstream media for broader outreach.

Our aims are to (i) empower EV owners to better advocate for their neighbours, colleagues, fellow ratepayers and business shareholders to operate EVs, (ii) build confidence amongst potential purchasers by sharing real data in local New Zealand conditions, (iii) provide a learning platform for EV owners to optimise their charging patterns, financial benefits and battery care, and (iv) eventually provide a fine-grained and national database and sampling platform to support research on policy and business initiatives to accelerate EV uptake throughout New Zealand.

2.3. Key Criteria for Citizen Science

The following design imperatives were identified as important for building enduring participation by EV owners⁽²⁾:

- Clearly define a simple goal and communicate it clearly
- Make the data useful and personal
- Recruit expertise for science and communication
- Trial systems thoroughly first
- Constantly evaluate for continuous improvement
- Build a team and sense of 'EV club' membership
- Secure adequate funding

- Allow for participants' different skill and commitment
- Don't over-complicate the analysis and communication
- Make it fun
- Share data while protecting privacy of participants
- Provide rapid feedback to participants
- Check and demonstrate science quality
- Take action with the results

3. NEW ZEALAND LIGHT ELECTRIC VEHICLE SCENE

3.1. Background

In 2011-2012 two prominent Japanese manufacturers introduced new 100% battery EVs into the New Zealand market. Uptake was slow with price a major barrier. By 2015 used imports from Japan and the UK were becoming more readily available providing high quality vehicles at affordable prices.

In June 2017, the New Zealand Government set a target of 2% of the fleet to be electric by 2021 (red line in Fig, 2).

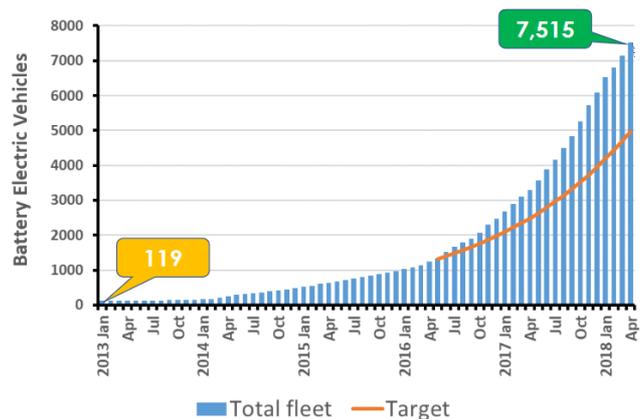


Fig. 2 New Zealand Electric Vehicle Fleet

A New Zealand Government sponsored Life Cycle Analysis⁽³⁾ was released in 2015 which confirmed the environmental benefits of EVs. The report considered potential battery replacements required due to high average age of light vehicles (relative to OECD) being 13 years. Retirement occurs at an average age of 20 years.

3.2. New Zealand Climate, Geography and Electricity

The islands that make up New Zealand are large, population density low, and lack of charging is a disincentive for some potential EV purchasers. Establishing sufficient rapid (DC) charging stations has been an enormous challenge. DC charging stations are now widely deployed with a target of one every 80 km of key highways and tourist routes by the end of 2018.

Investment has been by power line companies and the nationwide provider ChargeNet (a strong EV advocate). An emerging priority is to fill in the charging network to keep up with demand and relieve congestion⁽⁴⁾.

Renewable power generation from hydro, wind and geothermal provided 81.4% of electricity over the 12 months to 24 June 2018⁽⁵⁾, enhancing the environmental benefits of EVs and driving the New Zealand government to promote their use for achieving zero net carbon economy by 2050⁽⁶⁾.

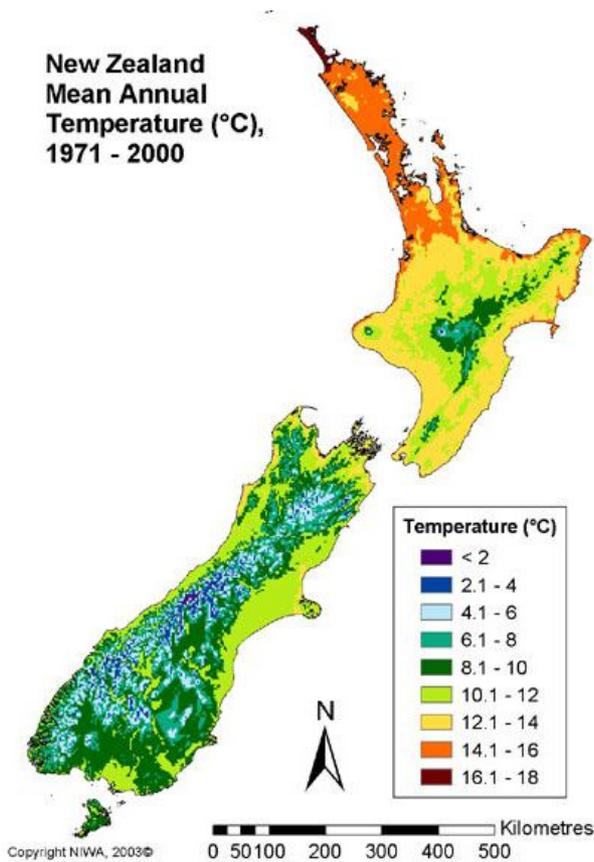


Fig. 3 Map of New Zealand⁽⁷⁾

New Zealand has a temperate climate that helps reduce temperature stress on EV batteries allowing for reasonable life between replacements. Cooler temperatures in winter increase energy demands for cabin heating and range reduction is a consideration but is balanced by the lack of excessive summer temperatures.

3.3. Government investments to incentivise uptake

There are currently no purchase incentives. An exemption from Road User Charges is in place until 2% of the fleet is electric. Access to priority lanes for EVs is available in some cities.

The New Zealand Government provides marketing support and research to encourage uptake. Their Low Emission Vehicles Contestable Fund⁽⁸⁾ assists community organisations and businesses to invest in infrastructure and demonstration projects that make EVs more visible. They have partly funded *FtF*, and 49 other projects including heavy vehicles, delivery vans and EV courtesy cars as at June 2018.

The Better NZ Trust, an EV community initiative with volunteer and government support, arranges many community led events across the country⁽⁹⁾ including a national roadshow called *Leading the Charge*. During the 2018 road trip⁽¹⁰⁾ over 800 test drives were given for prospective purchasers across New Zealand.

FtF is dedicated to quantifying and communicating the benefits of EVs, and tearing down the barriers to uptake that have been identified by regular surveys by the Energy Efficiency & Conservation Authority (Fig. 4).

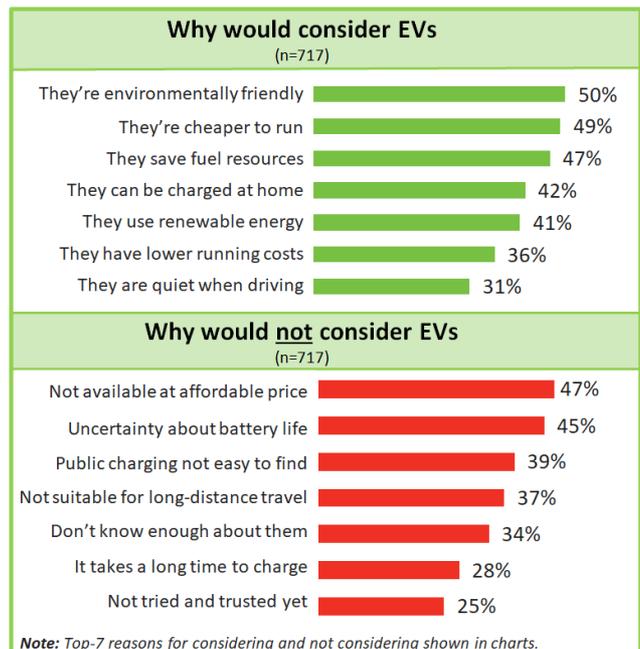


Fig. 4 Ipsos: EECA Consumer Monitor, Q3 Jan-MAR 2018⁽¹¹⁾

3.4. Cars Available and Support

An increasing number of new cars are being sold with manufacturer warranties, but without purchase incentives the high prices limit penetration outside corporate fleets. Cost effective quality used imports provide a critical role building the total fleet which means concerns over items such as battery life and support need to be answered to build the required confidence. There is currently limited manufacturer support for used imports.

4. FLIP THE FLEET DATA

4.1. Participation: growing a coalition of citizen scientists

FtF was publically launched in June 2017 after a year of developing the software and testing systems with EV owners. By the end of June 2018, there were 975 EVs enrolled in the system, mostly owned privately by families, but including vehicles from business and institutional fleets. Vehicles from manufacturers in Japan, Korea, USA, Europe and the UK, with the addition of some conversions to EV, are represented. The geographical spread across New Zealand is dominated by the larger cities but there are a growing number from regions throughout New Zealand.

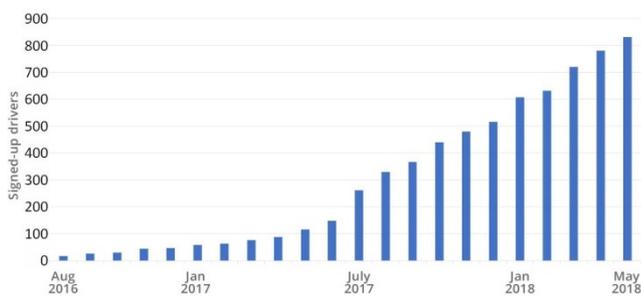


Fig.5 Number of EVs registered with *Flip The Fleet*

4.2. EV Performance Indicators: trends and benchmarking

Between 8 and 20 metrics are uploaded from each EV at the start of each month, depending on the model of EV and tiered levels of technical expertise selected by each participant. Basic parameters gathered include distance travelled over the past month, a sample of individual trip distances, average speed, average energy efficiency, costs for maintenance and charging events and battery state of health. The software then calculates and reports key outcomes about distances travelled, costs incurred for electricity and estimates the fuel and GHG emission avoided, battery longevity and return on investment, both for each EV and for each business's fleet where appropriate.

The performance of each car is benchmarked against other vehicles in the common pool, but each participant can choose to filter the data to show reports of their car versus similar models, or in the same region. Surveys show that this anonymised benchmarking is greatly appreciated by the participants and that many of them use it for learning and research about how to get more out of their EV⁽¹²⁾.

4.3. Battery State of Health

A key benefit of *FtF* to the wider New Zealand public has been the ability to disseminate some of the collected data, in near-real-time, to prospective buyers. State of Health (SoH) of the most popular EVs in New Zealand is one such metric, that is often referenced by both prospective buyers and sellers of EVs when evaluating the vehicle's value.

These data have shown that the 24kWh variant of a popular EV is on average meeting the manufacturer expectation of 80% SoH at 5 years (Fig. 6), thus building confidence for prospective buyers and providing guidance on typical values for a given age of car.

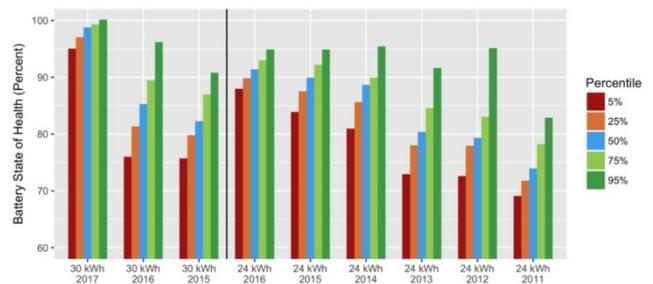


Fig. 6 Battery State of Health for popular EV

Data collected from *FtF* participants has shown that the opposite can also be true. A report released by *FtF* in March 2018⁽¹³⁾ showed highly accelerated decay in the reported SoH in the majority of the 30kWh variants of the same EV model compared to the 24kWh (Fig. 7).

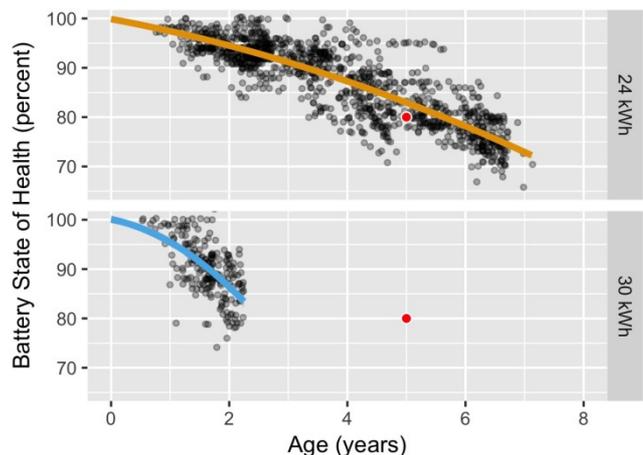


Fig. 7 Reported Capacity Loss of Popular EV

The red dots indicate the manufacturer expectations of SoH at 5 years. We are aware of testing for actual capacity which indicated reporting errors not reflecting actual capacity. As of June 2018 no remedy was available in New Zealand. An

unexpected “consumer watchdog” and advisory service emerged as *FitF* fielded increasing numbers of requests for help and information from the public.

4.4. Energy Efficiency

Owners can compare average efficiency to the national EV fleet’s distribution. Seasonal variations with colder temperatures during winter (July) can be seen, and the team can measure comparative efficiency for EVs driven by different models, in urban compared to rural areas, and in flat compared to more hilly terrain.



Fig. 8 Average efficiency per month for a participant’s car (bars), and benchmarks for comparing against the national fleet (lines)

4.5. Monthly Savings

By factoring in the cost of electricity and estimating the cost of fuel and repairs and maintenance avoided, each contributor can see their monthly savings and compare it to the fleet statistics, or other EV models (Fig. 9).

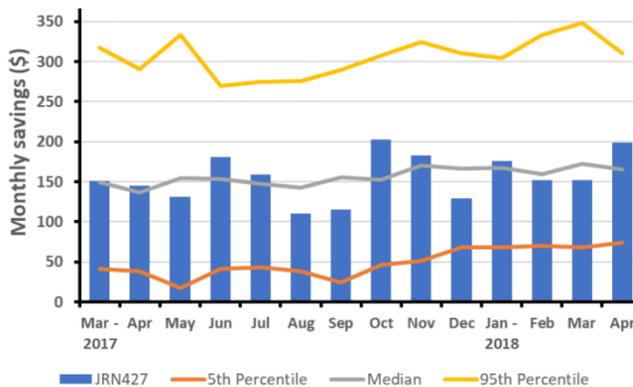


Fig. 9 Monthly savings for car and fleet

4.6. Maintenance Costs

Owners are surveyed each month for running costs including tyre replacements. The sample size at time of writing is $n = 3195$ from 492 popular BEV and $n = 428$ from 39 popular PHEV. The New Zealand Automobile Association (AA) analysis is included

in Fig. 10. This information helps inform prospective buyers with what others are actually spending,

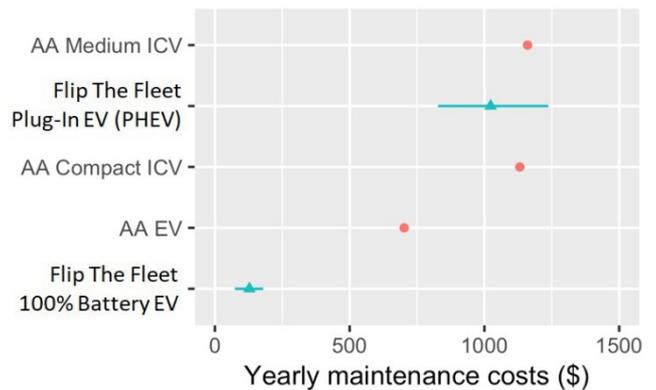


Fig. 10 Repairs, maintenance and tyre costs for EVs, Plug-in Hybrids (PHEV) and Internal Combustion Vehicles (ICVs).

4.7. Automated data uploading

FitF has worked closely with a local IOT device manufacturer to develop a small OBD2 reader equipped with a cellular modem to upload data every 5 minutes from popular EV models to servers for analysis. Parameters include energy consumption and speed, battery health, and battery temperature during charging, travel and rest. These are currently being installed in 44 cars to provide significantly more data than is available from the monthly readings. Automated data upload is an important facility to enable business fleets to participate due to their lack of time to add data manually.

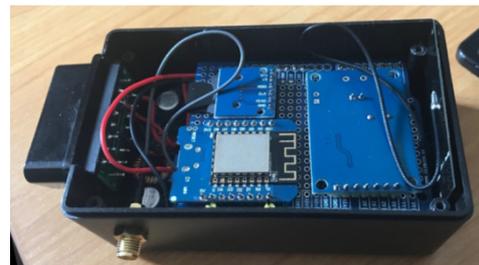


Fig. 11 OBD2 Reader, GPS and Cellular Modem

5. MONTHLY OPINION SURVEYS: A HUMAN STORY ALONGSIDE THE NUMBERS AND FACTS

Some people use numbers and science for decision making, others prefer a more intuitive approach or the testimony of family, friends or colleagues that they trust. Uncertainty about new technology and the high expense involved make many potential buyers extremely wary of EVs. *FitF* therefore deploys formal questionnaires and qualitative analysis of comments provided by its participants to capture the experiences of early adopters, their overall satisfaction with the vehicles, lessons they have learned

about how to get the most out of the vehicles, and most of all, what they are feeling. We have a simple rule: the main survey question emailed to the participants each month must be answerable in 5 seconds.

The main question nearly always provides five potential answers to choose from a Likert scale. If the respondent wishes, they can provide open comments to tell us why they chose their answer. We are usually swamped with several hundred comments each month which we sort and analyse to tell the story of early adopters. The second rule is that the respondents must have a report on the collective results within a week of the survey closing - prompt and full feedback is important to show the participants that we care and are listening to their feedback, which in turn keeps them responding next month.

Their personal comments and knowledge is then woven with statistical analyses of their monthly performance indicators to create a monthly media release to carry the messages to the wider public. We also use the opinion surveys to design the EV marketing campaigns. For example, a recent survey showed that most people bought their EV for environmental and financial benefits (Fig. 12), so most of the advocacy centres on these themes in the meantime.

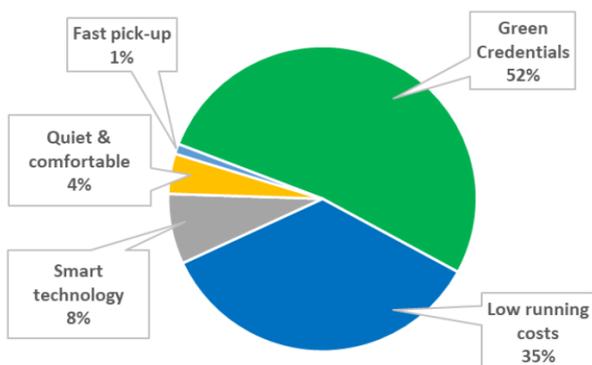


Fig. 12 "1-Click Survey" April 2018, n=391 - My most important reason for buying Battery Electric Vehicle was its ...

When unexpected results are revealed the news is still accepted as necessary: "However, *FTF* also published some enlightening data that cast a shadow on an aspect of EVs that newcomers are most worried about i.e. batteries. This is expected to decelerate uptake. That can't be helped – there is a moral obligation to publish the data, regardless of whether it's good or bad for uptake"

6. DISCUSSION: WILL *FLIP THE FLEET* ACCELERATE EV UPTAKE IN NEW ZEALAND?

The intent is to facilitate an increase in early adopters removing uncertainty for prospective buyers and sharing reliable information. A survey in May 2018 was asked to rank the statement "*Flip the Fleet* project will accelerate EV uptake in NZ". Over 80% of 398 respondents thought that it would succeed (Fig. 13). The remainder were unsure or were sceptical that information alone could make much of a difference⁽¹⁴⁾.

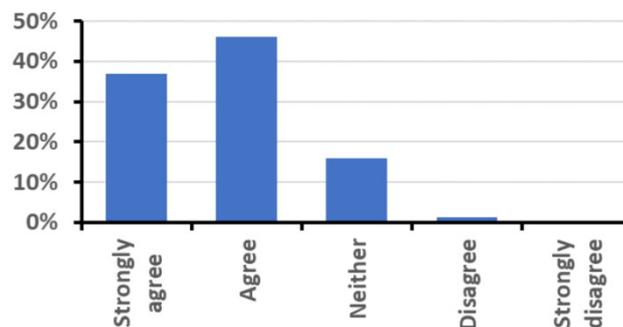


Fig. 13 1-Click Survey "project will accelerate EV uptake in NZ", May 2018.

It is common to see comments in social media⁽¹⁵⁾ referencing the benchmarking charts (Fig. 6 & 9) when questions are raised about whether a specific car being considered for purchase has acceptable 'State of Health' (SoH). For example: "Here's all the data you need on expected battery degradation. If dealer has a car not matching this I would be very careful if claimed SoH is accurate".

Others sign-up to *FitF* after purchasing and report that the information provided to the public was invaluable e.g. one respondent to an opinion survey said "I used the data available from *FitF* when deciding to purchase my car. The data gave me confidence that the real-world range was suitable for my commute, and that the battery degradation with age/use was acceptable to me".

Many of the people who sign-up to *FitF* state that they heard about the project from mainstream and social media that was generated from the database and opinion surveys. Car dealers report a highly informed clientele that bring *FitF* charts to the negotiating table.

FtF team has discovered some general lessons about citizen science:

- It is time consuming and challenging
- Finding funding is difficult
- Professional scepticism that citizen science is not “real research”
- It can provide a fast and penetrating data stream
- It’s personally transformative for the participants and coordinators alike
- It can greatly assist sustainability transformations!

A large part of the apparent success of *FtF* is based on trust in our objectivity, scientific approach and financial independence⁽¹⁶⁾. Trust helps in two ways: by keeping the existing EV owners interested and engaged enough to continue contributing data and recruiting their friends to join up; and by attracting media to seek an evidential basis to underpin their print, radio and TV stories.

7. CONCLUSION

Participation in *Flip The Fleet* and Citizen Science builds and reinforces the pride felt by early adopters of EVs. It also provides an authoritative and collective EV owners’ voice to help promote an exciting new technology that will soon revolutionise our mobility and business for the benefit of people, their purses and the planet.

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