Factors and Policies Affecting Electric Vehicle Uptake

Presentation for AUT Ventures Webinar Series: Business Strategy for EV Fast Charging Stations

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cognitus economic insight

About the Author

Dr Richard Meade is Principal Economist at Cognitus Economic Insight, Senior Research Fellow at Auckland University of Technology, and Vice President Auckland of the Law & Economics Association of New Zealand. His initial career was in investment banking, with Credit Suisse First Boston.

Richard has completed studies on the effects of disruptive new technologies, players and business models in both transport and electricity sectors, and on the socio-economic impacts of climate change policies. He has been active in electricity sector research, consulting and/or transactions since 1988.

Richard holds a PhD in Industrial Organisation and Regulation from Toulouse School of Economics. He has taught environmental economics at Auckland University of Technology and University of Auckland, industrial organisation at University of Auckland, and corporate finance at Victoria University of Wellington.

Important Notice

Abbreviations

BEV	Battery electric vehicle
CV	Conventional vehicle – see also ICV
EV	Electric vehicle
FCEV	(Hydrogen) fuel cell electric vehicle
ICV	Internal combustion (engine) vehicle – see also CV
PHEV	Plug-in hybrid electric vehicle

Outline

Background

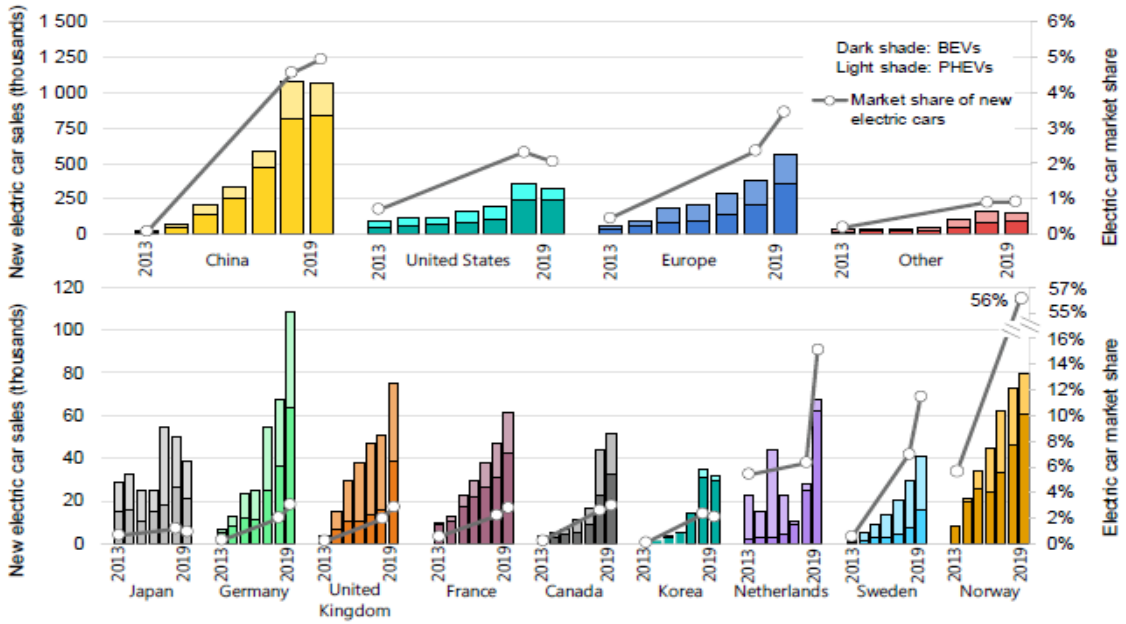
- Decarbonising transport sectors is an urgent policy aim shared by many countries – for local air pollution reasons, but also to meet global climate change objectives and commitments:
  - It is even more urgent for New Zealand, since our electricity is already more than 80% renewable, and hard-to-reduce agricultural emissions (mainly methane) account for half of our GHG emissions.

- Switching from internal combustion vehicles (ICVs) to electric vehicles (EVs) holds much promise, but also involves many significant challenges.

- This webinar provides an evidence-based and economically-informed discussion of the issues in switching from ICVs to EVs:
  - Particular focus is on policies that can be used to encourage EV uptake – in transport, but also in allied sectors like electricity.

Background (cont'd)

Figure 1.2 Passenger electric car sales and market share in selected countries and regions, 2013-19



Note: Regions and countries in this figure represent the largest electric vehicle markets and are ordered by size of their conventional car market.

Sources: IEA analysis based on country submissions, complemented by ACEA (2020); EAFO (2020c); EV-Volumes (2020); Marklines (2020); OICA (2020); CAAM (2020).

The worldwide market share of electric cars reached a record high of 2.6% in 2019, expanding in all major markets except Japan, Korea and United States.

Source: IEA (2020), Figure 1.2.

Background (cont'd)

- In this webinar we start with the pros and cons of EVs:
  - A major question is whether EVs are the most efficient way to decarbonise transport – what about hybrids, or hydrogen?
  - This includes a discussion of other issues and challenges with EV uptake – e.g. electricity sector issues
- Then, supposing EVs are the best way forward, we discuss global lessons about the non-policy factors affecting EV uptake.
- Attention then turns to the global lessons regarding policies for encouraging EV uptake, with a brief discussion of New Zealand's approach.
- We finish with conclusions, and "homework" questions.

My Background

- I have been active in electricity sector research, consulting and/or transactions since 1988 (including through a first career in investment banking).
- This overlaps with my wider consulting and research in the economics of competition and regulation:
  - Reflected in my PhD in industrial organisation and regulation from Toulouse School of Economics – my focus was on utility sectors like electricity.

Click image to download

My Background (cont'd)

- Since 2015, among other things, I have been heavily involved in policy and research thinking about regulatory and competition questions in transport and energy, including those relating to "disruption":

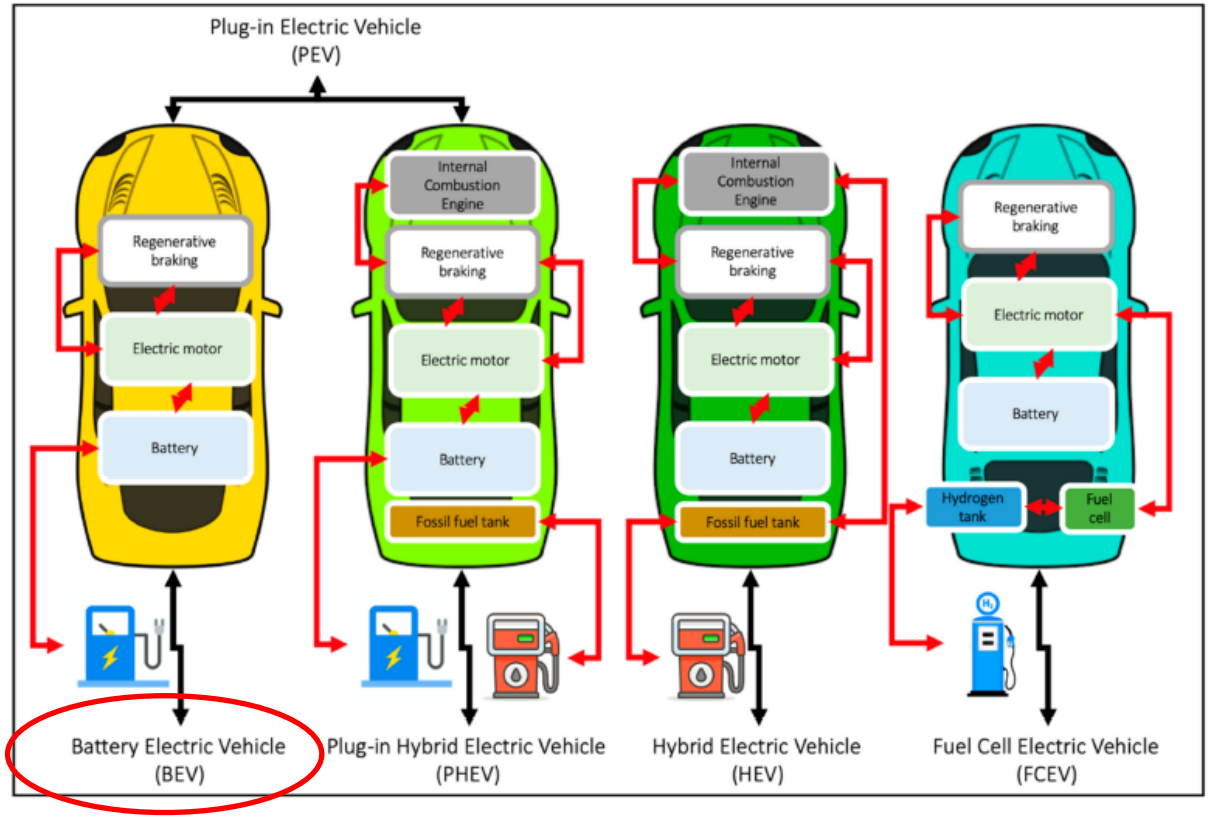
Outline

Section

1. Background and Summary
2. Why (Not) EVs?
3. Factors Affecting EV Uptake
4. Policies to Encourage EV Uptake
5. Conclusions
6. “Homework” Questions

Why (Not) EVs? – What are EVs?

- Our focus is mainly on battery EVs (BEVs):



Source: Foley et al. (2020), Figure 1.

Why (Not) EVs? – The Positives

- An obvious appeal of BEVs is that they produce no GHG emissions when converting stored electrical energy into motion:
  - This translates into low vehicle running costs per km – also improving the economics of ride sharing and public transport;
  - Low running costs are improved even more by BEVs having fewer mechanical issues than ICVs (though batteries eventually need replacing …).

- Policymakers anxious to reduce GHG emissions (or to improve local air quality) naturally seize on the potential of BEVs to decarbonise and clean up passenger and goods transport:
  - If we could convert the existing ICV fleet to BEVs, then all other things equal we could substantially reduce GHG and other vehicle emissions …

Why (Not) EVs? – The Positives (cont'd)

- A less-recognised potential benefit of electrifying the vehicle fleet is:
  - BEVs are essentially "batteries that move";
  - With vehicle-to-grid (V2G) capabilities now more common in BEVs, this offers potential synergies – not just extra burden – for electricity systems.

- Examples include BEVs:
  - Complementing solar photovoltaic (PV) systems – improving their economics by storing PV generation for when it can best be used;
  - Supporting electricity distribution systems – providing network reinforcement services (though also creating increased demands …);
  - Alleviating equity issues arising from high-income PV owners shifting electricity network fixed costs onto low-income consumers (Hoarau and Perez (2019)); and
  - Providing low-cost "second life" batteries for PV owners.

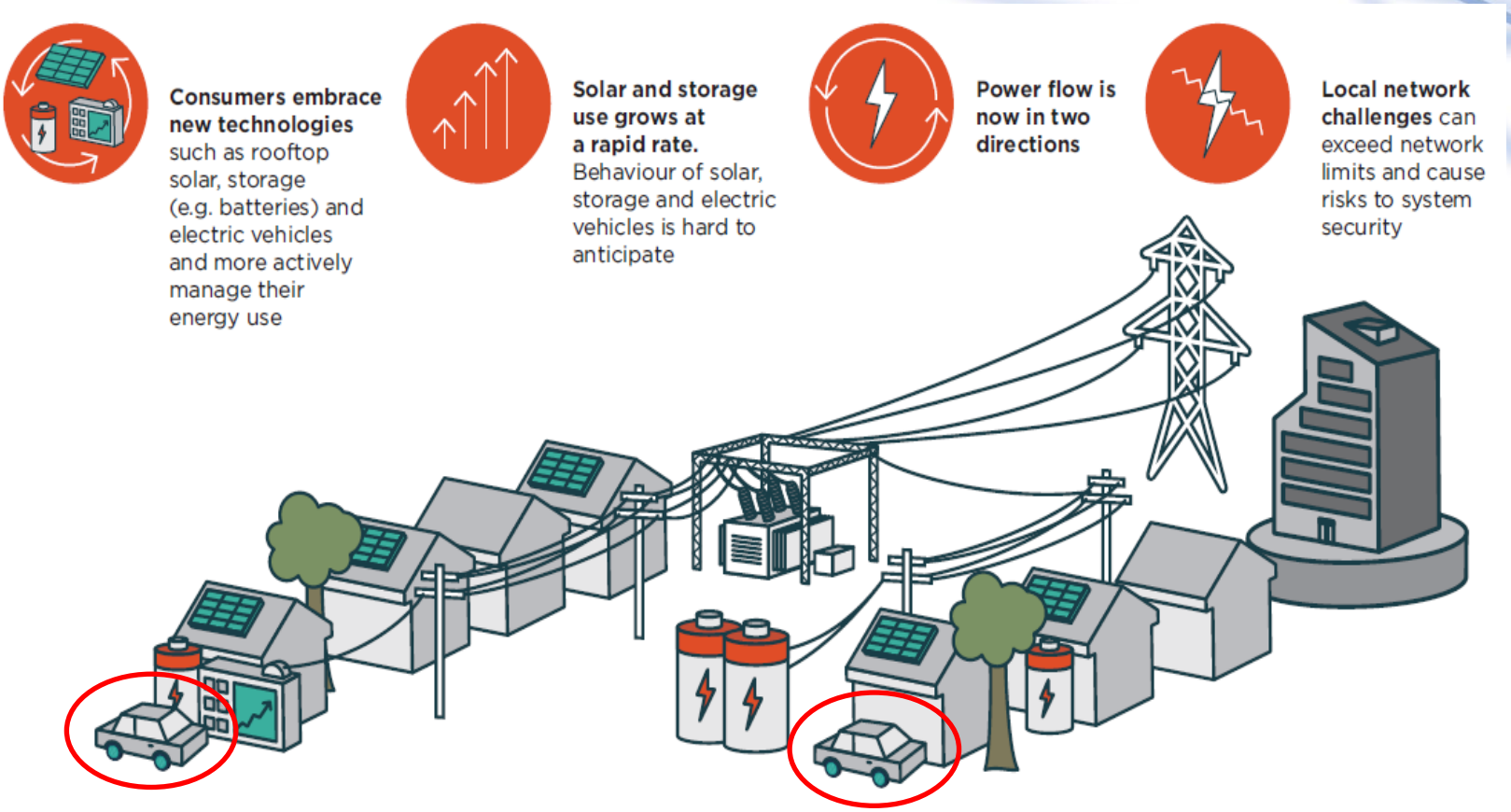
Why (Not) EVs? – The Positives (cont'd)

BI-DIRECTIONAL CHARGING IS GOING TO CHANGE THE WAY WE THINK ABOUT WHAT A CAR IS (IMAGE: SUPPLIED).

More than a set of wheels: How electric vehicles could soon power your home

Source: New Nissan Leaf allows V2G bi-directional charging, www.thespinoff.co.nz, 19 September 2019.

Why (Not) EVs? – The Positives (cont'd)



BEVs will become integral components of electricity systems …

Source: Adapted from Energy Networks Australia (2020), Figure 3.

Why (Not) EVs? – The Positives

- There are possible "virtuous circles" with increasing EV uptake:
  - More EVs on the road improves the economics of privately-funded EV charging and servicing infrastructures;
  - Greater EV demand will induce greater investments by manufacturers in:
    - Improved battery technologies;
    - Vehicle ranges appealing to a wider range of consumers;
  - Increased EV manufacturing will increase scale economies, and improve quality and features through learning by doing; and
  - Convincing consumers and manufacturers that EVs will achieve critical mass reassures both groups that it is worth investing in EVs and not other technologies.

Why (Not) EVs? – The Negatives

- There are some important negatives to acknowledge:
  - Foremost is BEVs' limited travelling range relative to ICVs.
- However, BEVs are also very costly to buy compared to ICVs, and:
  - While day-to-day running and maintenance costs are relatively low, battery replacement is costly, and depreciation is high (including due to rapidly evolving technologies).
- BEVs have additional "time costs" and "fuss" relative to ICVs:
  - Recharging BEVs can be more frequent and time-consuming than refuelling ICVs;
  - How BEVs are recharged can affect battery performance and longevity – active "battery management" is required …

Why (Not) EVs? – The Negatives (cont'd)

GET THE BEST OUT OF A BATTERY

Looking after your battery will help to maintain capacity for many years.

- **Only recharge the battery when needed.** Many EV owners find they only need to charge every few days.
- **Limit exposure to extreme heat or cold.** In very hot weather (over 30 degrees C), park and charge in the shade or in a garage. In freezing temperatures, follow battery care instructions in the manual. Some batteries have thermal management systems that use a small amount of energy to protect the battery by regulating its temperature.
- **Check fast charging advice.** Frequent fast charging may decrease battery capacity over time, but it depends on the EV model and the climate it is operating in. The EV manual or manufacturer should provide more details.
- **Follow the manufacturer's servicing recommendations.** EVs should always be serviced by a qualified technician.
- **Don't store with a fully charged battery.** If your EV won't be used for a long time, follow the battery care instructions in the manual.

ASSESS THE BATTERY BEFORE YOU BUY

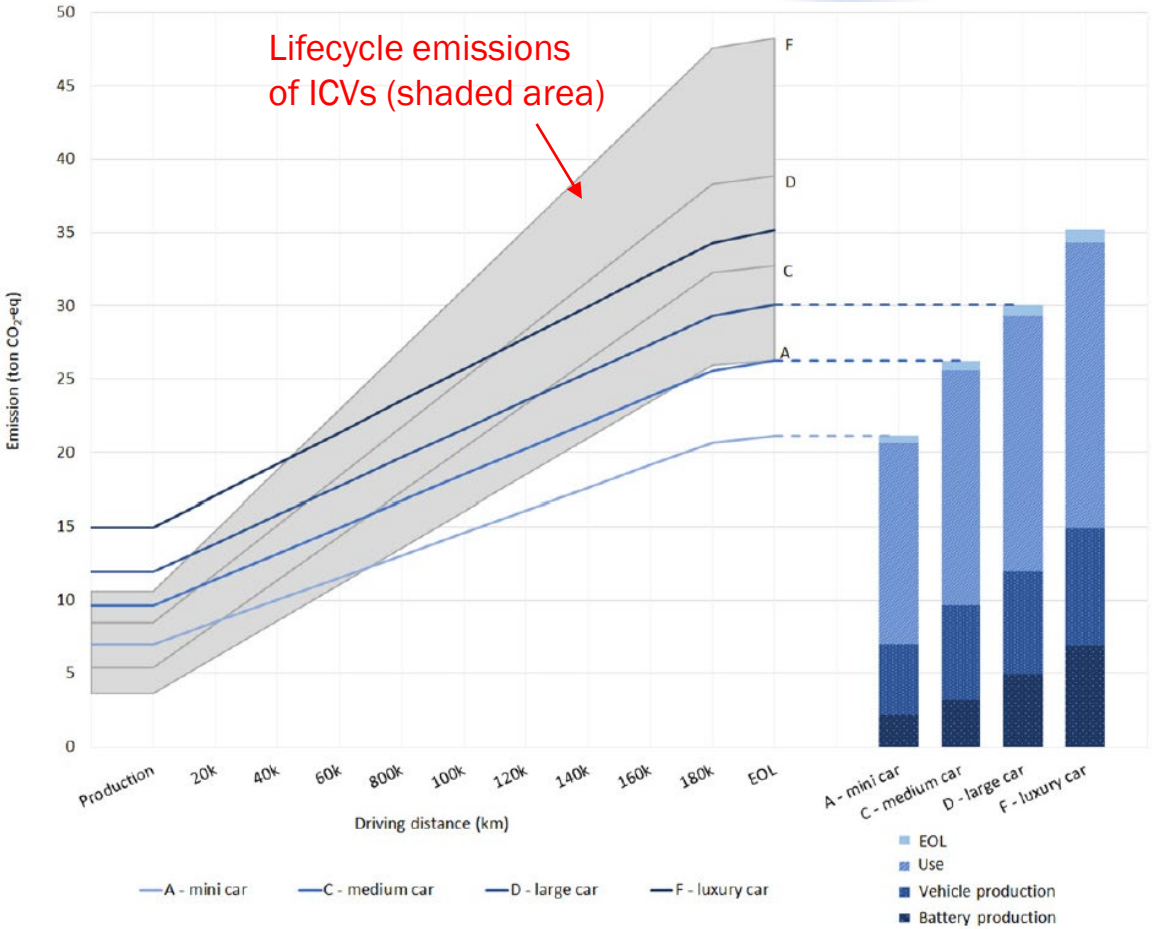
If buying a used EV, it's important to get the battery properly checked.

Source: https://genless.govt.nz/moving/lower-energy-transport/electric-vehicles/range-and-batteries/.

Why (Not) EVs? – The Negatives

- Just how “green” an EV is hinges on two key issues.
- First, how renewable is the electricity that is used to recharge the BEVs?
  - GHG emissions from BEV usage can still be less than those of ICVs even when the electricity generation mix includes fossil fuels;
  - Relatedly, how do the electricity transmission and distribution losses compare with those of ICV fuels?
- Second, significant GHG emissions and other environmental and social costs are associated with EV battery manufacturing (and end-of life) …

Why (Not) EVs? – The Negatives (cont'd)



Source: Ellingsen at al. (2016), Figure 2 – using European average electricity fuel mix.

Why (Not) EVs? – The Negatives (cont'd)

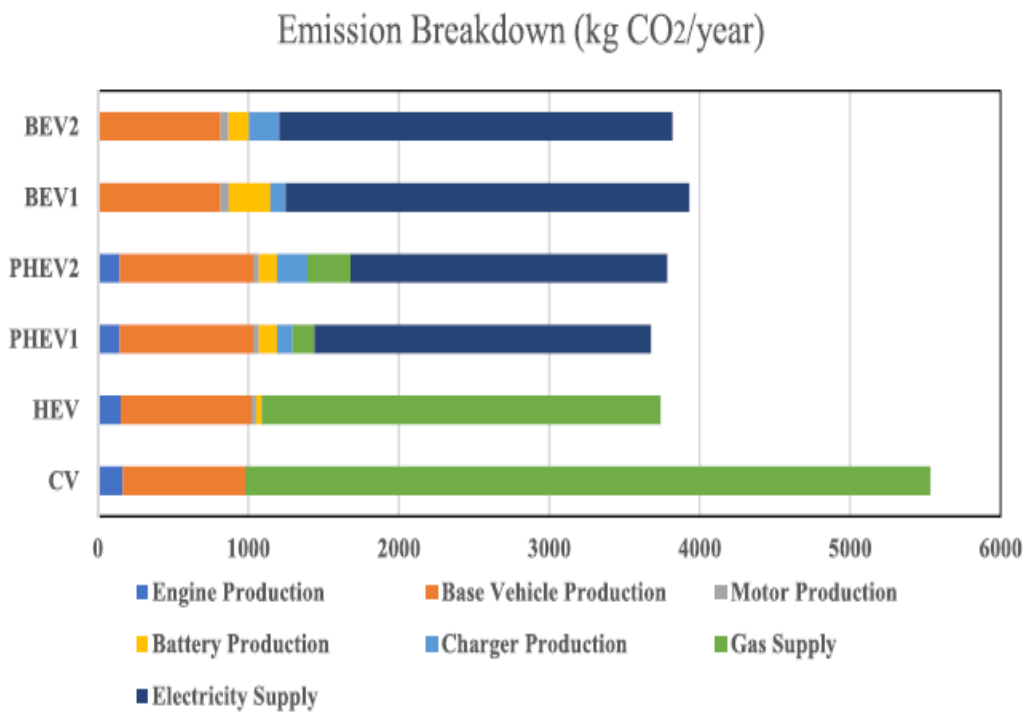


FIGURE 7 Emission breakdown for various lifecycle stages of alternative vehicles under optimal conditions for vehicles with 10,000 vehicle miles traveled (VMT) a year [Colour figure can be viewed at wileyonlinelibrary.com]

Source: Ahmadi et al. (2018).

Why (Not) EVs? – The Negatives (cont'd)

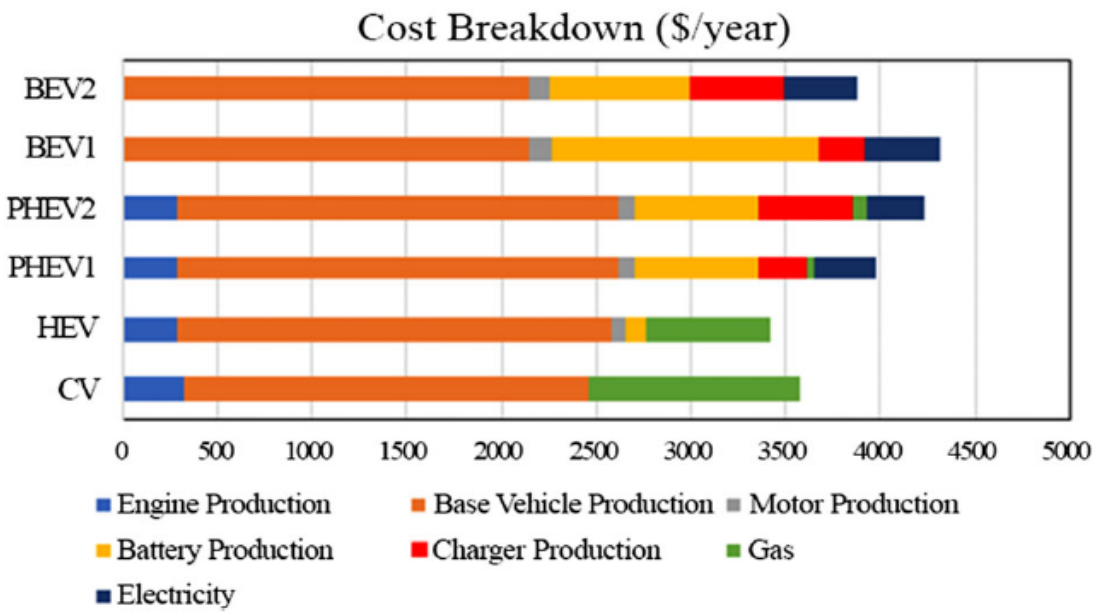


FIGURE 8 Emission breakdown for various vehicles under optimal conditions (10,000 mile/year) [Colour figure can be viewed at wileyonlinelibrary.com]

Source: Ahmadi et al. (2018).

Why (Not) EVs? – The Negatives

- Incompatible EV batteries and chargers are reminiscent of how inconvenient cell phone recharging used to be …

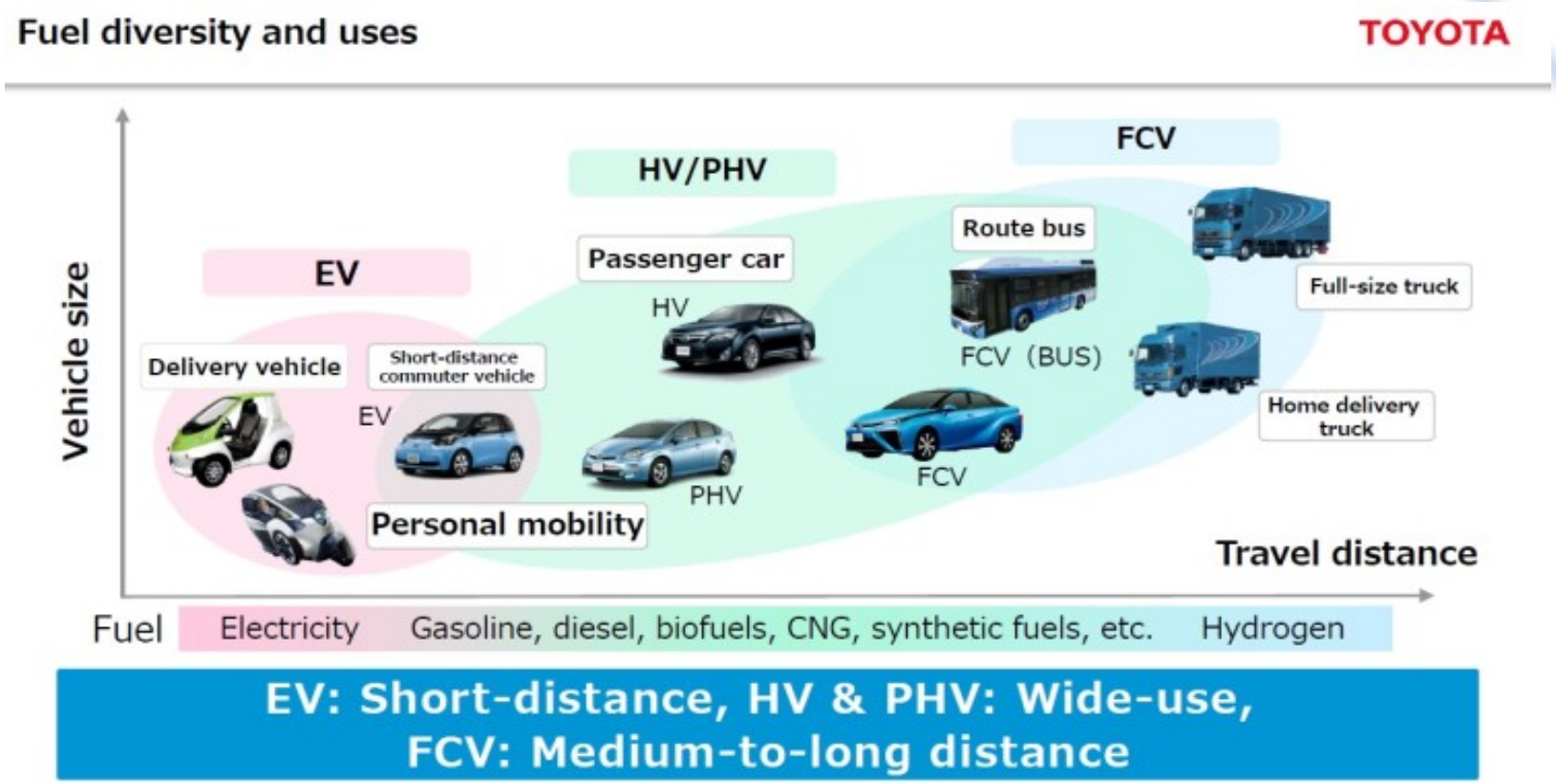
Why (Not) EVs? – The Negatives (cont'd)

- Importantly, significant EV uptake will require upgrades to both:
  - Renewable generation capacity – perhaps through PV uptake;
  - Local network capacity – fast-chargers especially place significant demands on network capacity:
    - Active peak demand management will be critical to avoid or defer network upgrades.

- Even more important – whole new recharging infrastructures are required to resolve "range anxiety" issues – who builds, where?

- Another fundamental question before committing to BEVs – first new technologies are often not the best, and different new technologies might better cater to different market segments …

Why (Not) EVs? – The Negatives (cont'd)



Source: http://insideevs.com/toyota-to-sell-30000-hydrogen-fuel-cell-cars-annually-by-2020/.

The Uber Driver's "Weapon of Choice" – What Should We Learn from This?

Outline

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3. Factors Affecting EV Uptake
4. Policies to Encourage EV Uptake
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Factors Affecting EV Uptake – Introduction

- Here we focus on non-policy factors affecting BEV uptake:
  - Policies affecting BEV uptake are covered in the next section.
- The discussion draws heavily on published research identifying and synthesising the key lessons from countries with experience of significant EV uptake:
  - New Zealand is not one of them – in 2018 only 0.23% of the light vehicle fleet was fully electric, with 0.92% petrol/electric hybrid (www.transport.govt.nz).
- Key sources are Foley et al. (2020), and Broadbent et al. (2017).
- But first, some general ideas …

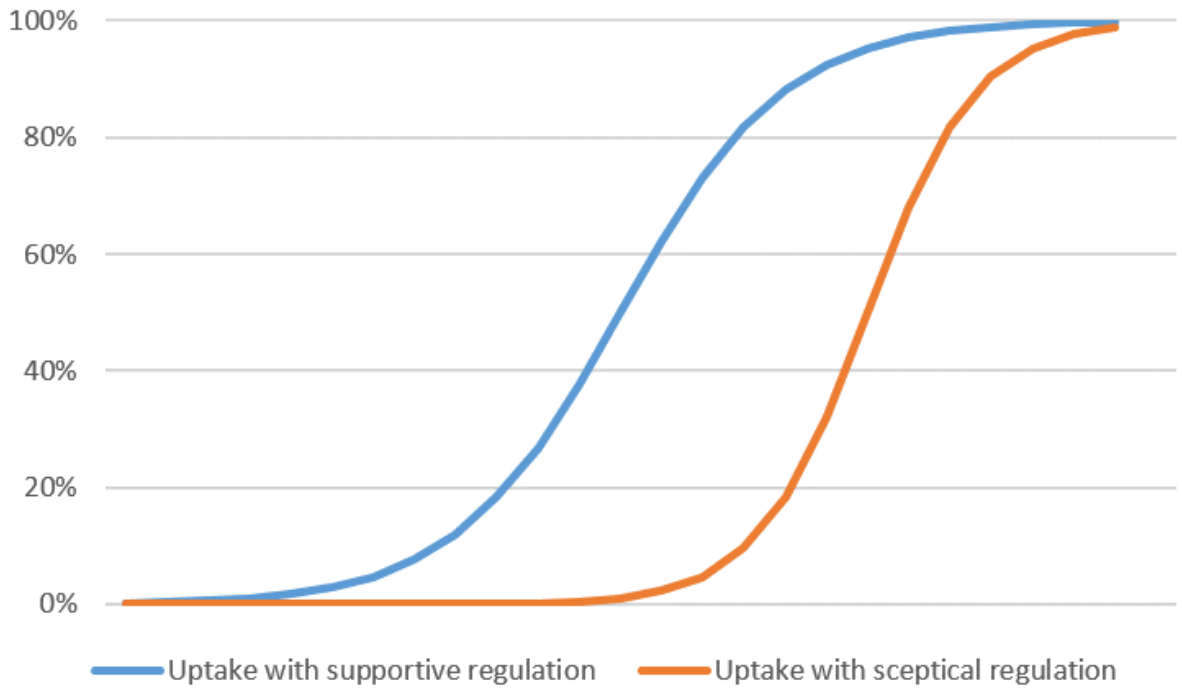
Factors Affecting EV Uptake – In General

- EV uptake reflects the combined decisions of:
  - Consumers – including consumers' peers;
  - Infrastructure providers – especially providers of recharging infrastructure, but also electricity generators and distributors;
  - Manufacturers and repairers – of EV-related equipment;
  - Researchers – i.e. those undertaking battery R&D; and
  - Governments and regulators – changing the relative benefits and costs of competing transport solutions through taxes, subsidies, standards, public transport choices, urban design, etc.

- Don't forget – ICV manufacturers and providers of legacy infrastructure (e.g. fuel companies) – and providers of alternative clean vehicle technologies! – also make key strategic decisions affecting EV uptake:
  - E.g. by designing and pricing their products and services more competitively as consumers start switching to EVs.

Factors Affecting EV Uptake – In General (cont'd)

- Even status quo regulation is a choice about the nature and pace of uptake of new technologies and business models – the question is whether it is a conscious one (or a good one)?



Source: Meade (2018), Figure 1.

Factors Affecting EV Uptake – Lessons

- Upfront purchase cost is the biggest barrier to uptake:
  - This favours business customer uptake over private/residential uptake.

- Close behind is "range anxiety" – consumers' fear of finding themself out of charge, and not having a way to recharge.

- Relatedly, (smart) access to recharging capacity is critical – fundamental "chicken and egg" problem:
  - Consumers won't buy EVs without recharging infrastructure already in place;
  - But private recharging providers face little incentive to build costly infrastructure without certainty of consumer uptake.

Factors Affecting EV Uptake – Lessons (cont'd)

- Consumers face significant informational hurdles, and risks, when adopting EVs – e.g. regarding:
  - Actual "greenness" and other "ethical" features of EVs relative to ICVs – lifecycle especially;
  - EV performance relative to ICVs – including range;
  - Recharger access/convenience/compatibility;
  - Battery status, management, replacement cost/ability, and end-of-life costs/benefits – especially if buying used EVs;
  - Total costs of ownership – over EV lifecycle, including likely resale (of vehicles, and used batteries) → especially given rapidly evolving EV and rival clean vehicle technologies.

- Research on PV uptake suggests "peer effects" – i.e. learning about peers' experiences with new technologies – can be valuable for addressing such hurdles and risks (e.g. Palm (2017)).

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Policies to Encourage EV Uptake – Introduction

- Various countries have actively encouraged EV uptake – Norway being the "poster child":
  - After 20 years of active support for BEV uptake, new car sales in Norway are now dominated by BEVs, though total fleet share is still only c. 18%!

- Nonetheless, the experiences of these countries offer lessons for which policies do – and do not – make a difference in affecting consumers' decisions to switch from ICVs to BEVs.

- Policies are only one key ingredient in encouraging uptake:
  - E.g. complementing vehicle manufacturer commitments to offer only hybrid/fully-electric vehicles from certain dates, etc.

Policies to Encourage EV Uptake

- From Broadbent et al. (2017) on the general roles of EV policy:

  "suitable policies, … implemented well, could be seen as a necessary co-condition of market formation. Such measures could assist diffusion of innovations and address market failures that inhibit the adoption of innovative products such as BEVs and PHEVs. Market failures can include (a) incomplete markets from inadequate customer information; (b) failure to consider costs of negative externalities …; and (c) lack of necessary co-conditions." [emphasis added]

- Broadbent et al. (2017) punchline – EV uptake in 30 countries was positively correlated with financial incentives, charging infrastructure availability, and local vehicle production:
  - Though chargers per head of population was assessed as most important – charger availability three times more effective than subsidising vehicle purchase (Yu at al. (2016)).

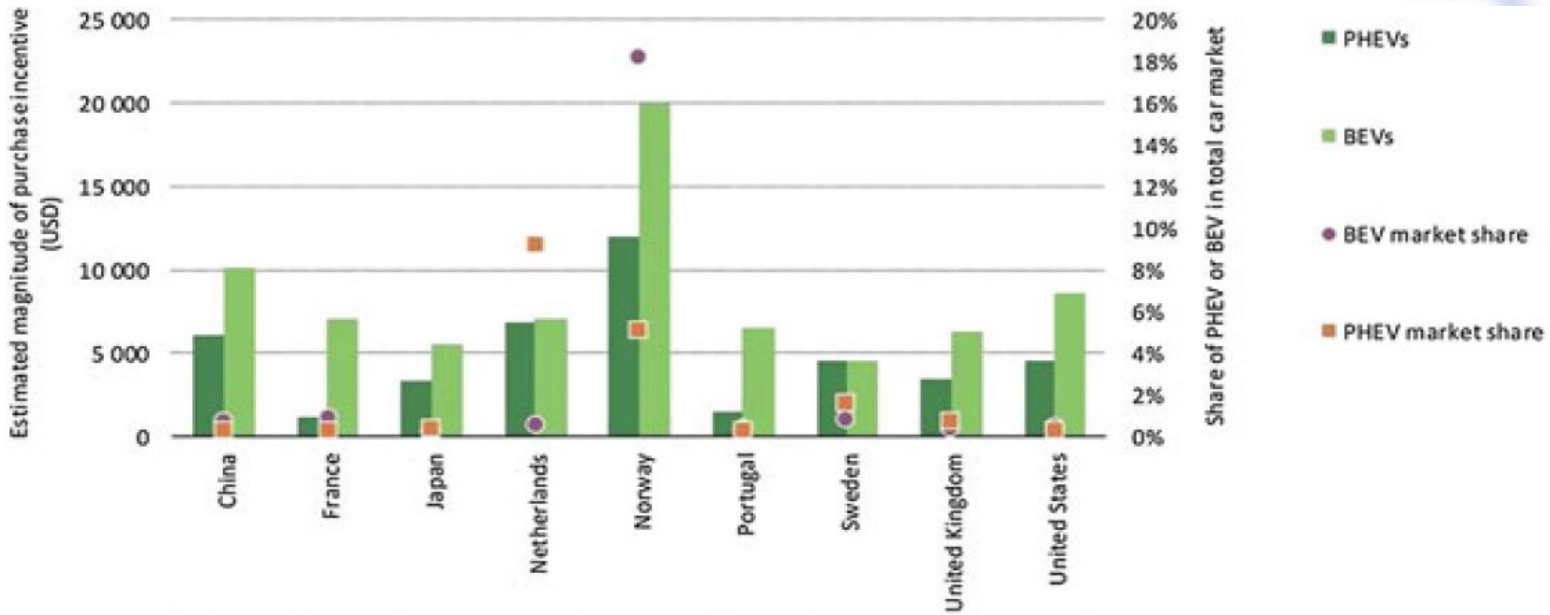
Policies to Encourage EV Uptake – Subsidies

- Unsurprisingly, financial incentives have played a key role in encouraging BEV uptake, especially those that make BEVs no more expensive to purchase than ICVs, though not decisively!
  - Important equity concern – "subsidies for the rich" to buy new cars.

- Theoretical modelling by Yu et al. (2016) indicates that subsidising EV purchase encourages uptake through multiple channels:
  - **Direct** – making EVs cheaper makes them more affordable;
  - **Indirect** – but greater EV uptake also improves the profitability of private investments in recharging infrastructure, which then makes EV adoption even more attractive to car buyers.

- Broadbent et al. (2017) stress that upfront credits are more effective than delayed credits.

Policies to Encourage EV Uptake – Subsidies (cont'd)



Note: estimates for the Netherlands are calculated as the difference between the tax paid by a BEV and a PHEV emitting 50 g CO_2/km and the average of the tax paid by a gasoline and a diesel car emitting 130 g CO_2/km. Incentives in Norway are based on an average electric car cost (before VAT) of USD 30 000.

FIGURE 2 Purchase incentives and market shares for BEVs and PHEVs, 2015 (Source: IEA, 2016a, p. 16. © OECD/IEA (2016) *Global EV Outlook 2016 Beyond one million electric cars*, IEA Publishing. Licence: www.iea.org/t%26c)

Source: Broadbent et al. (2017), Figure 2.

Policies to Encourage EV Uptake – Subsidies (cont'd)

- Norway's incentives were not confined to purchase subsidies, and included "soft incentives" like:
  - Deployment of recharging infrastructure – Norway has the highest number of rechargers per million population;
  - Free battery recharging;
  - Free parking in public car parks;
  - Exemption from road and public ferry tolls; and
  - Free BEV access to bus lanes.

- While purchase incentives make BEVs more affordable at the outset, these soft incentives reduce ongoing direct costs of travel (e.g. tolls, fuel, parking) as well as ongoing indirect costs (e.g. travel times and parking times):
  - Toll exemptions were especially effective soft incentives, following purchase incentives and recharger availability.

Policies to Encourage EV Uptake – Government Procurement and Business Fleets

- A major difficulty in encouraging EV uptake is that many car buyers cannot afford new vehicles, and rely instead on second hand vehicle purchases:
  - Offers explanation for "attitude-action gap" – many consumers indicate willingness to pay for EVs, but in practice are reluctant to pay more than negligible premiums to secure EV benefits.

- Government procurement of EVs – supported by policies encouraging businesses to update their vehicle fleets with EVs – has multiple benefits:
  - It generates a local supply of used vehicles (of known provenance); and
  - It generates user experience of EVs without requiring purchase.

Policies to Encourage EV Uptake – Other EV-Specific Policies

- Other EV-specific policies for encouraging uptake include:
  - Bans on sales of new ICVs beyond certain dates;
  - Fleet emissions standards; and
  - Consumer information services – e.g. as to vehicle attributes, location and status/availability of rechargers, total costs of ownership, and availability of incentives.

- To the latter could be added certification/standards for reducing "adverse selection" issues re used EVs, second-hand batteries, vehicle/battery recycling options, recharger access, repairs, etc:
  - More generally, policies reducing consumer risk/uncertainty re EV ownership could be critical – e.g. guaranteed buy-backs for used EVs/batteries, government commitment to roll out rechargers, etc.

Policies to Encourage EV Uptake – ICV Sunsets

- Many car manufacturers have committed to discontinuing ICV production beyond a certain date, or to sell a significant proportion of new vehicles based on clean technologies.
  - Relatedly, many governments have also provided long-term signals to consumers about the "direction of travel" by announcing bans on sales of new ICVs after certain dates.

- Such "**soft sunsets**" on ICVs face government commitment problems – i.e. later governments might abandon them:
  - Worse still, they could create "backfire effects" – e.g. car owners holding onto old ICVs longer until they can afford EVs;
  - More useful (but politically more sensitive) would be "**hard sunsets**" on ICVs – e.g. "no ICVs at all beyond [2050] …"

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P.S. – Regulating Uptake?

- A very salient regulatory choice is whether to mandate BEVs, hydrogen fuel cell EVs (FCEVs), neither, or both:
  - BEVs need investments in vehicles, renewables, network reinforcement, and charging and servicing infrastructures;
  - FCEVs need investments in vehicles, clean hydrogen production, and distribution and servicing infrastructures.

- Another consideration – "Big Oil" likely to see a greater role for itself in a hydrogen-based solution, and hence might find it profitable to support such a decarbonisation solution (vs oppose a BEV solution) …

P.S. – Regulating Uptake? (cont'd)

- Investments in either technology are less attractive, and enjoy lower scale economies and uptake, in a world where there is the competing technology:
  - N.B. they are both worth less, and enjoy lower scale economies and uptake, in a world with increased investments in public transport (and/or reduced investments in roads);
  - N.B. they are both worth more (etc) in a world where ICVs face a hard sunset …

- Due to scale economies (for producers), and network effects (for producers and consumers), there is a case for reducing competition for the market by mandating a technology:
  - Would require a clear "social bargain" about the risks …

Policies to Encourage EV Uptake – New Zealand's Approach

- New Zealand policymakers are reluctant to "pick winners":
  - Throwback to high-profile failures of major government investments in the 1970s and 1980s ("Think Big" projects, which often became "white elephants").

- New Zealand's "balanced" and "market led" approach to EVs reflects this, promoting EVs but also (e.g.) hydrogen:
  - Government EV incentives are very much "soft";
  - Because car sales taxes are relatively low (15% GST, vs Norway's 25%), there is less scope to reduce them to offer meaningful purchase incentives;
  - Equity issues will loom large – most New Zealand car buyers cannot afford new cars, even with subsidies.

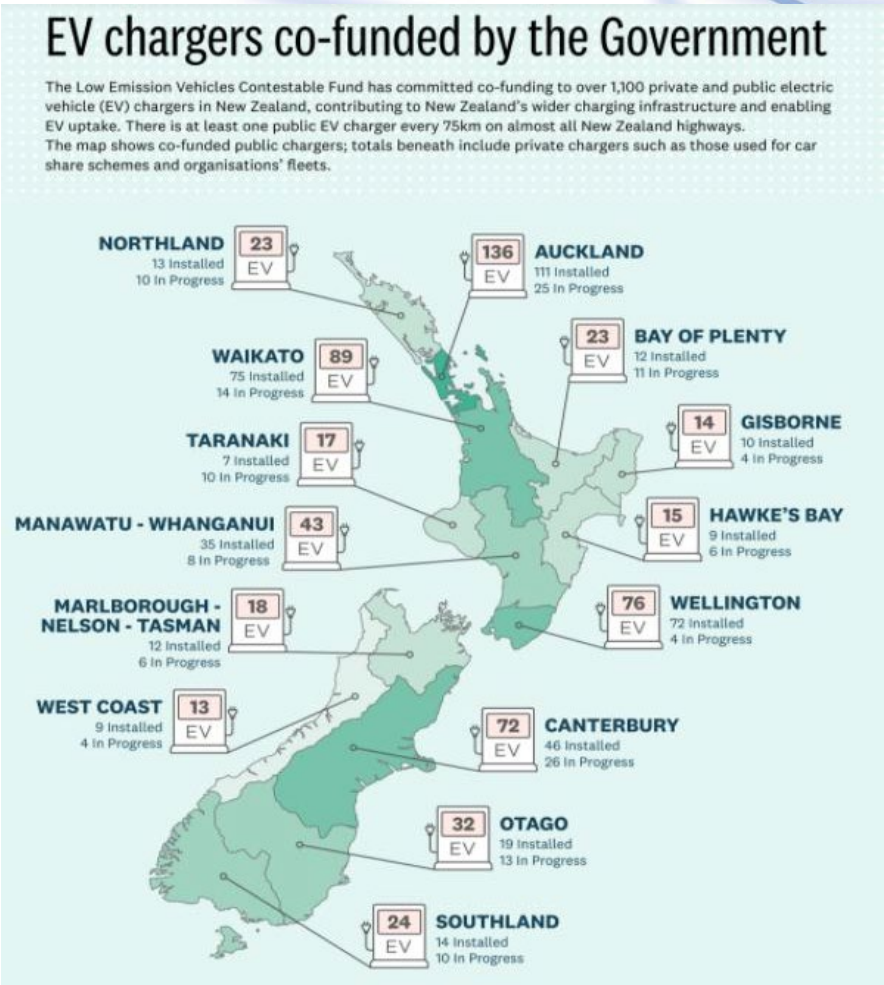
Policies to Encourage EV Uptake – New Zealand's Approach (cont'd)

- Electric Vehicles Programme introduced May 2016:
  - Road user charge exemptions for EVs (which don't pay fuel taxes to support roading);
  - Exploring public-private bulk-buying of EVs;
  - Coordinate any government rollout of rechargers, information and guidance;
  - $1m/year for information campaigns, and $6m/year contestable fund for low-emission vehicle projects;
  - Possible future access to bus lanes and high-occupancy vehicle lanes;
  - Tax changes to ensure EVs not disadvantaged (versus advantaged);
  - Coordinating central/local government and business.

Policies to Encourage EV Uptake – New Zealand's Approach (cont'd)

- Low emissions vehicle contestable fund introduced August 2016 – for projects showcasing EVs' potential – including government co-funding of chargers.

- Note that many chargers rolled out initially by customer-owned electricity distribution companies:
  - Complemented by private charger providers.



Policies to Encourage EV Uptake – New Zealand's Approach (cont'd)

- Other policies and initiatives include:
  - In January 2021, the government signalled it will introduce Clean Car Standard – a CO_2 emissions standard for imported new and used light vehicles;
  - Ministry of Transport is developing a Transport Emissions Action Plan – for reducing transport emissions, as part of an Emissions Reduction Plan for the 2022–25 emissions budget;
  - A goal that, where practicable, the government vehicle fleet will be emission-free by 2025-26;
  - Climate Change Commission (2021) recommending:
    - Ban on new ICVs by 2035;
    - Feebate or subsidy for EVs – despite major left-hand drive, used vehicle supplier Japan prioritising hydrogen and hybrids!!!; and
    - Charging infrastructure plan.

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Conclusions

- Major coordination and adverse selection problems, and risks/uncertainties, lie at the heart of EV uptake:
  - For consumers interested in EVs, access to rechargers is a key "chicken and egg" dilemma, made worse by high purchase prices and informational issues;
  - For consumers interested in clean transport but unconvinced about EVs, even bigger coordination problems arise – e.g. possibility of hydrogen or other technologies proving superior.

- Policies to resolve these problems and risks/uncertainties are critical complements to other policies that improve the price-competitiveness and affordability of EVs (supposing EV uptake is the preferred route to decarbonising transport).

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“Homework” Questions

- Please note – these questions are intended to be discussed by you with colleagues (nothing should be handed in for marking!).
- What is Indonesia’s aim in encouraging EVs? – reducing GHG emissions from transport efficiently, or at any cost?
- Might there be lower-cost ways of achieving emissions reductions in transport – e.g. hybrids?
- How “green” is Indonesia’s electricity supply? – are better emissions reductions achieved by EVs, or by alternatives (e.g. FCEVs?):
  - Can EV uptake policies be used to support PV uptake and vice versa?
- What investments in renewables and distribution would be required to support significant uptake in Indonesia?

“Homework” Questions (cont’d)

- Could Indonesia rapidly electrify smaller vehicles (e.g. electric two- or three-wheel vehicles) while decarbonising larger vehicles through hybrids or other technologies?
- How can complementary policies such as in active and public transport, and urban design, be used to limit growth in private vehicle usage?
- How would investments in charging infrastructure (and in required generation and distribution) be funded? – could government take a lead, or will private investment be timely enough to support uptake?
- What mix of financing and soft incentives might be necessary and (politically) supportable in Indonesia to encourage EV uptake in an inclusive/equitable way?

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