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Electric vehicle law and policy: a comparative analysis

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Law and policy initiatives to encourage the uptake of electric vehicles are examined in an international context. The efforts of several jurisdictions to overcome barriers to a more rapid uptake of electric vehicles are examined: Norway, California, Germany, New Zealand, Australia and France. Price support is found to be essential as long as electric vehicles are more expensive than internal combustion vehicles. However the impact of fuel efficiency standards is greater than is sometimes appreciated, especially if reducing greenhouse gas emissions and increasing energy security are key benefits in electric vehicles. Other measures are also examined. It is concluded that electric vehicle policy may diverge at key points from transport policy and from climate change policy. Care is needed to design laws and measures that will be effective from those different policy points of view, and that will promote social equity at the same time.

Keywords: electric vehicles; electromobility; transport policy; climate change policy

Introduction

Excitement about electric vehicles is understandable. They are intriguing technically. Compared with internal combustion vehicles, they offer impressive acceleration, fuelling at home, lower fuel costs, lower maintenance costs, less noise and less vibration. They are attractive in respect of pollution, greenhouse gas emissions, and fuel efficiency. They open up exciting ways of preserving the mobility that people value highly while responding to some of the adverse effects of transport. In the ‘first age’ of electric vehicles (EVs) in the late nineteenth century they were even serious competitors with internal combustion vehicles (ICVs), but their numbers declined as ICVs improved, petrol became cheaper, and long-distance road travel increased.[1] The ‘second age’ began in the 1960s with increasing concerns about the environment and oil prices, but electric batteries did not improve greatly. The current ‘third age’ is driven by concerns about greenhouse gas (GHG) emissions and other pollutants, and benefits from technical advances especially with batteries. EVs lend themselves to the technology that is emerging to produce connected and autonomous vehicles. But significant barriers remain, above all price, and EVs have not yet entered the mass market.

[1] National Research Council, Committee on Overcoming Barriers to Electric-Vehicle Deployment, *Overcoming Barriers to Deployment of Plug-In Electric Vehicles* (2015) p 8. Unless noted otherwise, in this article EVs are passenger on-road cars and sport utility vehicles that derive all (pure or battery EV) or some (plug-in hybrid EV) of their power from the electricity grid. Electrically-assisted bicycles are a whole other story; there are 230 million of them in China, and they are becoming very popular elsewhere.

This article examines law and policy efforts to encourage the uptake of EVs. While EVs have significant public benefits in most situations, the benefits should not be overstated; electric vehicles are still vehicles, and many of the most important policy levers for EVs also promote improvements in the conventional vehicle fleet. The article particularly inquires into the extent to which divergences appear between EV policy and policy for transport and for climate change. It finds that those divergences are more significant than is generally understood, particularly in relation to fuel efficiency standards. Important issues appear in the social equity of policy choices, and the efficiency of different policies to bring about the improvements we need in transport and climate change laws and policies. The article provides a global overview of research knowledge about EV policy measures, and draws on the particular experience of several relevant jurisdictions.

The benefits of electric vehicles; with a note of caution

The public benefits that EVs offer are considerable. The overall lifecycle benefits of EVs in comparison with ICVs have been found to be substantial in relation to energy, greenhouse gas emissions and environmental impact, under New Zealand conditions, even allowing for differences in the materials and manufacturing methods used.[2] We can look at these benefits separately, starting with greenhouse gases and climate change.

Transport emissions are a major source of anthropogenic greenhouse gases, 23 per cent of global carbon dioxide (CO_2) emissions.[3] The transport sector, which is mostly motor vehicles, is a large one and in many countries its emissions are growing rapidly. The use of EVs will generally displace the use of ICVs that produce GHG emissions; but the value of the displacement depends on how the electricity fuel is produced. For the OECD as a whole, the proportion of renewables in electricity production is 22 per cent; Australia 14.9, the United States 12.9, California 24, and Germany 32.4.[4] (Happily in Germany and California the proportion is increasing.) Some countries have a high proportion of renewable generation, making them prime candidates for switching to EVs. Iceland has 100.0 percent renewables, Norway 97.7, and New Zealand 79.1. Carbon emissions of battery EVs using European grid-mix electricity are about half of average European vehicle emissions.[5] The climate benefits of EVs could increase dramatically over time, from over 125 million tons CO_2 per year in 2030 to over 1.5 billion tons CO_2 per year in

[2] Arup and Verdant Vision, *Life Cycle Assessment of Electric Vehicles* (Energy Efficiency and Conservation Authority, 2015).

[3] J D Miller and C Façanha, *The State of Clean Transport Policy: A 2014 Synthesis of Vehicle and Fuel Policy Developments* (International Council on Clean Transportation [ICCT], 2014) p 6.

[4] International Energy Agency (IEA), *Renewables Information* (2015), Table 3, OECD: Share of electricity production from renewable sources (%), 2014 provisional figures; and https://www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/erneuerbare-energien-in-zahlen (retrieved on 9 July 2016).

[5] P Wolfram and N Lutsey, *Electric Vehicles: Literature Review of Technology Costs and Carbon Emissions* (ICCT Working Paper 2016-14, 2016). EVs may have significant but manageable effects on electricity systems, especially if time of charging can be controlled: for example, see New Zealand Centre for Advanced Engineering, “Electric Vehicles: Impacts on New Zealand’s Electricity System” (Technical Report 2010). However the topic lies outside this article.

2050.[6] EVs allows the global fleet to achieve approximately 40 per cent lower carbon emissions than a highly efficient ICV fleet (and 70 per cent lower carbon than a business-as-usual fleet) in 2050. The greatest EV climate benefits will first be reaped in Europe and parts of the United States, but in the longer term in China and other emerging markets.

Energy efficiency is directly linked to climate change mitigation, but has numerous advantages of its own, in reducing energy costs and reducing the adverse effects of energy supply activities and infrastructure. EVs are about four times as efficient as conventional ICVs at using the energy delivered to the vehicle to overcome vehicle road load.[7] EVs also generally improve energy security, because they shift from petroleum to electricity, which in most countries is produced more locally, is less subject to currency fluctuations, and is more stable in price. For many people, EVs represent a very welcome cushioning from the volatility of oil prices and currencies.

Air pollution from motor vehicles is another problem; it causes premature mortality, extra hospital admissions, and restricted activity. In New Zealand, its estimated annual total social cost is NZD 942 million, about NZD 214 per person.[8] It is estimated that in the United States road transportation emissions in 2005 caused 52,800 early deaths due to increased $PM_{2.5}$ exposure and 5,250 due to increased ozone exposure.[9] Traffic noise also has long-term effects on well-being and health; exposure can lead to high blood pressure, various types of heart disease, disturbed sleep and lower cognitive functioning.[10]

However the air quality benefits of switching to EVs will depend on the general quality of a nation's vehicle fleet and what an EV replaces. For example, in respect of particulate emissions from vehicles, EVs may be no better than well-regulated modern passenger ICVs, because non-exhaust sources (ie wear of tyres, brakes and roads, and resuspension of road dust) account nearly all the particulate matter produced by the car; and because heavier cars produce more of these emissions, and EVs are about 24% heavier than their ICV equivalents.[11]

In truth, EVs do not solve all problems. EVs are still motor vehicles. They need highways and cause congestion, so promoting them will not reduce travel times or solve problems of

[6] N Lutsey, *Global Climate Change Mitigation Potential from a Transition to Electric Vehicles* (ICCT Working Paper 2015-5, 2015).

[7] N Lutsey, *Transition to a Global Zero-Emission Vehicle Fleet: A Collaborative Agenda for Governments* (ICCT, 2015) p 7.

[8] G Kuschel et al, *Updated Health and Air Pollution in New Zealand Study*, Vol 1: Summary Report (2012) pp iv-v.

[9] S Barrett, R Speth, S Eastham, I Dedoussi, A Ashok, R Malina and D Keith, "Impact of the Volkswagen Emissions Control Defeat Device on US Public Health" (2015) 10 Environmental Research Letters 11405. The authors note the range of estimates from different assessment approaches.

[10] L den Boer and A Schroten, *Traffic Noise Reduction in Europe: Health Effects, Social Costs and Technical and Policy Options to Reduce Road and Rail Traffic Noise* (CE Delft, Delft, 2007) estimate the social costs of traffic noise in the EU to be at least €40 billion per year.

[11] V Timmers and P Achten, "Non-exhaust PM Emissions from Electric Vehicles" (2016) 134 Atmospheric Environment 10. Their review shows that 90% of PM_{10} and 85% of $PM_{2.5}$ come from non-exhaust sources; and that EVs are approximately 24% heavier than ICV equivalents. Note that particulate emissions from vehicles do not include GHGs or other gases, and do not include emissions from the fuel supply system such as electricity generation.

urban form. They may compete with public transport for policy effort and public funds, and perpetuate old transport practices.[12] One recent study suggests that the overall external costs of EVs in Germany are little better than those of ICVs if one includes the costs of accidents, air pollution, climate change, noise, and congestion.[13] The advantages are argued to depend strongly on the electricity generation portfolio and potentially the charging strategy.[14] A valuable framework for thinking about transport policy and the place of EVs in it is 'avoid, shift, and improve' putting an emphasis first on 'avoid' policy to slow travel growth, such as through city planning, 'shift' which moves travel to more energy efficient modes such as public transport, active transport (walking and cycling), and 'improve' reducing the energy consumption and emissions of all travel modes.[15] EVs only address 'improve.' Electricity as a fuel has adverse effects on the environment even when generated from renewable energy sources such as hydro, geothermal, and wind power.

Barriers to the uptake of electric vehicles

In spite of their advantages, on a global scale not many EVs are being bought. The total global passenger EV fleet in 2015 was estimated at 1,200,000 vehicles, out of a total fleet of 1,200,000,000 vehicles; one light vehicle in a thousand.[16] A target of 20 million EVs by 2020 set by the Electric Vehicles Initiative looks unreachable,[17] and various government targets aggregating 30 million EVs by 2025 is equally unrealistic.[18] The market share of EVs in sales has reached one per cent only in Netherlands, Norway, Sweden, and the United States. Norway stands out at over 20 per cent, and, in the US, California at 4 per cent.[19] However growth will happen; Lutsey estimates that even allowing for supply constraints the market share of EVs could reach 10 to 15 per cent of sales in leading markets by 2025.[20] EVs may gradually become common without policy action, as technology and prices improve, but there is a distinct public benefit in making the transition more rapidly, especially when there is real urgency about reducing GHG emissions.

Why is the uptake of EVs slow? In general the main barriers for the introduction of EVs as a mass market product today are as follows.

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[12] D Rees, 'Could Electric Cars be Bad for the Environment?' blog post 5 November 2014, www.energycultures.org.nz.

[13] P Jochem, C Doll and W Fichtner, "External Costs of Electric Vehicles" (2016) 42 Transportation Research Part D 60.

[14] A Abdul-Manan, "Uncertainty and Differences in GHG Emissions between Electric and Conventional Gasoline Vehicles with Implications for Transport Policy Making" (2015) 87 Energy Policy 1.

[15] IEA, *Energy Efficiency Market Report 2014*, p 60, citing Deutsche Gesellschaft für Internationale Zusammenarbeit, 'Sustainable Urban Transport: Avoid-Shift-Improve (A-S-I)' (Eschborn, 2004).

[16] Wolfram and Lutsey, above n 5. The figures exclude buses and two-wheeled vehicles.

[17] IEA, *Global EV Outlook 2015*.

[18] Lutsey, *Global Climate Change*, above n 6.

[19] Miller and Façanha, above n 3 p 26; 'Norway to Review Electric Car Subsidies as Sales Soar' Reuters, 20 April 2015.

[20] Lutsey, *Global Climate Change*, above n 6.

(i) The higher capital cost of EVs in comparison with ICVs.[21] This is an obstacle even though costs are coming down, and even though the total cost of ownership over the lifetime of the vehicle is often less than that of an ICV.[22] Furthermore, advances in the fuel efficiency of ICVs reduce relative attractiveness of EVs.[23]

(ii) The shorter driving range of an EV in combination with times required to charge the vehicle,[24] although in fact the great majority of daily car trips are well within EV driving ranges.[25]

(iii) The need for a better-developed charging infrastructure.[26]

(iv) The incomplete internalization of the negative external effects of ICVs by policy action. Without effective action on the GHG emissions and air pollution caused by ICVs, in the form of price measures or regulatory requirements, the comparative benefits of EVs are insufficiently valued.

Element Energy Ltd's thorough British study determined the barriers to EV uptake in similar terms:[27]

- EVs have a high price premium over non-EVs.
- Supply of EV models is limited, in terms of vehicle segments and brands.
- Consumers are concerned by the short range and long charging times of EVs.
- The majority of private vehicle buyers are not currently receptive to EVs.

Other reasons may be minor in their impact but they may accumulate in public thinking; concerns about safety, standardization of charging systems, maintenance, and retention of

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[21] Lutsey, *Transition* above n 7 p 9 cites a cost differential of US $8,000-$16,000. This is consistent with the National Research Council, above n 1, p 112) and European findings of a net difference for mid-sized cars of €18,000: F Kley, M Wietschel, and D Dallinger, 'Evaluation of European Electric Vehicle Support Schemes' p 75 in M Nilsson, K Hillman, A Rickne and T Magnusson, eds, *Paving the Road to Sustainable Transport* (2012). Wolfram and Lutsey, above n 5 estimate that power train costs for PHEVs will drop about 50%, for battery EVs 60%, and 70% for hydrogen fuel cell EVs.

[22] Battery costs, which can be half of an EV's cost, have dropped from US $900/kWh in 2007 to $380, and still dropping: S Nyquist, 'Peering into Energy's Crystal Ball' McKinsey Quarterly July 2015. Wolfram and Lutsey above n 5 estimate them to be €250/kWh in 2015 and likely to drop to €130-€180 in 2020-2025. The National Research Council, above n 1 p 113, concludes that the decline in EV production costs is likely to occur gradually, and may not be sufficient by itself to ensure widespread adoption of EVs.

[23] Deloitte Touche Tohmatsu Ltd, *Unplugged: Electric Vehicle Realities Versus Consumer Expectations* (2011) available www.deloitte.com, p. 16.

[24] An international survey shows that the vast majority of consumers expect EVs to recharge in less than two hours. 37% of the Japanese consumers saw a maximum of 30 minutes charging time as acceptable: Deloitte, above n 23 p 8. However such responses are likely to be strongly affected by the framing of the question.

[25] IEA / Electric Vehicles Initiative, *Global EV Outlook* (2013) p 26. See also National Research Council above n 1 p 2; Deloitte, above n 22 p 6.

[26] IEA, *Global EV Outlook* above n 25 p 25; J Perdiguero and J L Jiménez, 'Policy Options for the Promotion of Electric Vehicles: a Review' (Institut de Recerca en Economia Aplicada Regional i Pública, 2012) p 7 et seq.; S Lemon and A Miller, *Electric Vehicles in New Zealand: From Passenger to Driver?* (Christchurch: Electric Power Engineering Centre, 2013) p 5.

[27] Element Energy, *Pathways to High Penetration of Electric Vehicles* (Report for Committee on Climate Change, 2013) p 21; S Steinhilber, P Wells and S Thankappan, 'Socio-Technical Inertia: Understanding the Barriers to Electric Vehicles' (2013) 60 Energy Policy 531.

value. We proceed to examine the policies that different jurisdictions have adopted in order to address these barriers.

International comparisons

We will examine the EV policies of Norway, California, Germany, New Zealand, Australia and France, selected for their usefulness as examples and in light of the authors' expertise. Norway has the world's highest percentage of EVs in its fleet and has a high percentage of renewable production of electricity. California has a long history of effective policies to tackle traffic and pollution problems and then climate change. Germany and France have set a strong policy direction to decarbonize their transport systems, with different levels of success, and at the same time are major car manufacturers. Australia and New Zealand are smaller countries, one of them generating most of its electricity from coal, the other like Norway mostly from renewables; but neither has yet made great progress in decarbonizing its transport system.

Norway

Norway's EV history began in the 1970s when prototypes of EVs and propulsion systems were developed by private enterprise with financial support from the Research Council of Norway.[28] The first vehicles were tested and the first EV incentives were introduced in the 1990s. From 1999 to 2009 EV car production in Norway ('Kewet') and a Norwegian EV industry cluster evolved. In 2009 the government organization Transnova was established to support testing and demonstration of new technologies that could reduce GHG emissions from the transport sector. Transnova gave financial assistance to establish charging stations on a wide scale and to start test and demonstration facilities. Transnova also supported 'Grønn bil' an organization promoting EV usage in municipalities and fleets. After having reached 0.4 per cent of the total fleet of passenger vehicles (approximately 10,000 vehicles) in 2012, the number of EVs passed 50,000 in April 2015, with EVs being one-fifth of all sales.[29]

Norway's central government presently supports EVs with the following measures.[30]

- 'EL' number plates for privileges like using bus lanes and for awareness generally.
- Exemption from the initial vehicle registration tax. EVs do not pay this initial fee anyway (unless they are heavy ones) because the computation of the tax takes account of weight, combustion engine power, and CO_2 and NO_X emissions.
- Exemption from VAT tax (usually 25 per cent) on the purchase of an EV.
- Lowest fee band for the annual licence.
- Fringe benefit tax (on employee benefits) half the usual rate.
- Slightly higher mileage allowance where one is payable by an employer.

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[28] E Figenbaum and E Kolbenstvedt, *Electromobility in Norway: Experiences and Opportunities with Electric Vehicles* (Oslo, Institute of Transport Economics, TØI Report 1281/2013, 2013) p I to III; U Tietge, P Mock, N Lutsey and A Campestrini, *Comparison of Leading Electric Vehicle Policy and Deployment in Europe* (ICCT white paper, 2016) p 47.

[29] Lutsey, *Transition*, above n 7 p 12; 'Norway to Review Electric Car Subsidies as Sales Soar' Reuters, 20 April 2015.

[30] Figenbaum and Kolbenstvedt, above n 28, p 24.

While some of these measures, like the exemption from the initial vehicle registration tax, can be characterized as the absence of an environmental charge, others, especially the VAT and fringe benefit tax measures, are clearly subsidies for purchasers. In addition there is a range of local incentives, such as access to bus lanes, road toll exemption, free road ferry tickets, and free parking. The incentives that are thought to have been most effective are the VAT exemption, access to bus lanes, and free use of toll roads and ferries.[31] High petrol and diesel prices also play their part.

Norway has set more stringent GHG emission standards for vehicles than the EU. The present objective for new passenger vehicles is that the average CO_2 emissions from new cars will be reduced to 85 g/km by 2020.[32] EVs and hydrogen vehicles are identified for special attention, but some of the policy measures, such as the initial vehicle registration tax, and high petrol and diesel prices, benefit ultra-efficient ICVs as well as EVs. Most recently the government has been considering amendments to the car tax system to base it more on emissions levels rather than engine power.[33] This leading jurisdiction has therefore set EV policy as a part of climate and transport policy.

A recent Norwegian survey showed that reduction of the EV purchase price is the strongest incentive, but there are distinct groups of owners to whom other incentives matter, especially priority of access to bus lanes.[34] Geographical, age, gender and education distinctions can be discerned in the groups, but income levels do not predict which incentive is most powerful, perhaps because price incentives are strong enough to make EVs an alternative to ICVs almost regardless of budget. Interestingly, the study reports intense political debate about removing EV access to bus lanes because it delays public transport. This may be a sign of social tensions to come in transport, calling for great care to prevent EV policy from appearing to favour the well-to-do early adopters of the new technology.

California

California has long exercised leadership in the United States on air pollution and GHG emissions from motor vehicles, and on energy policy generally. EVs are no exception, generally under the rubric of zero emissions vehicles (ZEVs) which refrains from making choices between different technologies. The Air Resources Board has worked on ZEV since 1990, and in 2010 it required manufacturers to sell an increasing percentage of ZEVs in California, 14 per cent for model years 2015 to 2017.[35] This use of direct regulation to mandate EVs may be unique. The 'Transit Fleet Rule' requires bus operators to reduce pollution and GHG emissions. The *2013 ZEV Action Plan* identified actions that different agencies would take to complete necessary infrastructure, improve consumer awareness and demand, and increase fleet uptake, in order to reach a target of 1,500,000 ZEVs by

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[31] Figenbaum and Kolbenstvedt, above n 28 p. VII, Table S. 1.

[32] Figenbaum and Kolbenstvedt, above n 28 p 23; Tietge et al above n 28 p 7.

[33] H Stolen, 'Volkswagen Scandal may Lead to Rethink of Norway's New Car Tax' (Reuters, 29 September 2015).

[34] K Bjerkan, T Nørbech, M Nordtømme, "Incentives for Promoting Battery Electric Vehicle (BEV) Adoption in Norway" (2016) 43 Transportation Research Part D 169.

[35] 13 CCR §1962.1 and §1962.2; Lutsey, *Transition*, above n 7 p 15.

2025.[36] Fiscal incentives (up to $2,500 for EVs, $5,000 for fuel cell vehicles), carpool lane access and extensive charging infrastructure development have also played their part. Five out of the top seven EV-deployment cities in the United States are in California or states that have adopted the ZEV program.[37]

What is striking about these California ZEV initiatives, apart from their ambition, is how they fit within a very comprehensive energy policy framework. The centrepiece is the *Integrated Energy Policy Report*, a statutory responsibility of the California Energy Commission since 2002. Its 2014 version focuses on transportation and its role in meeting state climate, air quality and energy goals.[38] An important part of the policy work that it coordinates is the Alternative and Renewable Fuel and Vehicle Technology Program, funded with up to $100 million annually. The Low Carbon Fuel Standard began in 2011. For decades, the Air Resources Board has exerted strong pressure on motor vehicle pollution, and from 2004 its standards have controlled GHG emissions as well. The Board is responsible for the Cap-and-Trade Program under the California Global Warming Solutions Act of 2006,[39] which was launched in 2013, and which included transportation fuels in 2015. The 2006 Act sets an ambitious target of limiting California's GHG emissions at 1990 levels by 2020, and requires continuing reductions beyond then.

The vehicle fleet of California is also affected by federal laws and policies. The *EV Everywhere Grand Challenge* of 2012 focuses on cutting battery costs, cutting drive system costs, and reducing vehicle weight.[40] It includes expenditure on charging infrastructure and education. The goal is by 2022 to produce EVs that are as affordable as today's ICVs. The most significant federal measure for EVs is a federal income tax credit for purchasers of EVs, ranging between $2,500 and $7,500 depending on battery size, and restricted to the first 200,000 vehicles sold by each manufacturer in the United States.[41] However the credit is not refundable, so it is little benefit to people who have low tax liabilities.[42] The American Recovery and Reinvestment Act of 2009, which put the credit in place instead of one that also benefited hybrid vehicles, also authorises substantial EV loans, grants and tax credits to the automobile industry.

Just as in California state law and policy, these federal policies and provisions that address EVs directly must be seen in the broader policy context of transport, climate, and pollution. The most important feature is fuel and GHG efficiency standards. The corporate average fleet efficiency (CAFE) standards have improved energy efficiency to reduce

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[36] Available www.opr.ca.gov. See Miller and Façanha, above n 3, p 27.

[37] N Lutsey, S Searle, S Chambliss, and A Bandivadekar, *Assessment of Leading Electric Vehicle Promotion Activities in United States Cities* (ICCT white paper, 2015) p 41.

[38] California Energy Commission, *Integrated Energy Policy Report: 2014 IEPR Update* (Publication CEC-100-2014-001-CMF, 2015).

[39] California Health and Safety Code § 38500 et al (AB 32, 2006), 17 CCR § 95801.

[40] US Department of Energy, *EV Everywhere: Grand Challenge Blueprint* (2013).

[41] 26 USC § 30D; Congressional Budget Office, *Effects of Federal Tax Credits for the Purchase of Electric Vehicles* (Washington, September 2012) p 3.

[42] The Congressional Budget Office, above n 41 p 25, estimated that for 2011 only about 20% of potential tax filers had a tax liability of at least $7,500 (the maximum EV credit) and only about 40% had a liability of at least $2,500 (the minimum), so 60% of them can see no benefit from the tax credit subsidy.

dependence on foreign oil, and have mitigated local air pollution since the 1970s.[43] The standards are imposed on manufacturers and importers, in respect of the average performance of all the regulated vehicles that they manufacture for sale in the United States in a year. That gives them flexibility and the ability to sell inefficient vehicles as well as efficient ones. The standards under the Energy Policy Conservation Act initially covered passenger cars but not minivans, pickup trucks and sports utility vehicles, sales of which boomed in the 1980s; those vehicles were only brought under the regulations under an 'attribute based' system in 2009. The agencies set standards for different classes of vehicle for each model year eighteen months in advance. After much struggle, including the court case *Massachusetts v Environmental Protection Agency*,[44] the system was extended to GHG emissions. In 2012 a national standard was agreed to simplify the carmakers' duties under the Clean Air Act emissions controls, the CAFE standards, and California's GHG controls, but with progressively more ambitious targets.[45]

An emissions control defeat device was discovered by the EPA and the California Air Resources Board in Volkswagen diesel engine models 2009-2015. The electronic control software produced real-world nitrogen oxides (NO_x) emissions 10 to 40 times above the compliance levels achieved under test conditions. While it was not the first time a car manufacturer had resorted to illegal deception, the Volkswagen case was a major challenge to American and European pollution laws, and in itself had a significant impact on public health.[46] It is likely to result in tougher monitoring, better testing methods that reflect on-road results, and more pressure on diesel technology – all of which are likely to favour EVs by comparison.

Germany

Action in Germany to promote EVs proceeds against the background of the effective regulation of GHG emissions in the European Union. CO_2 emission standards for motor vehicles were introduced in 2007, have become steadily more stringent, and put significant pressure on the quality of the ICV fleet.[47] (CO_2 emissions are directly related to fuel efficiency.) Further strengthening of the standards has been decided on, coming into effect in 2020. Relatively high fuel prices also play their part.[48] However the stringent European CO_2 controls have led to more reliance on diesel engines with their particulate and NO_x problems.[49]

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[43] 42 USC § 32902 et seq, 49 CFR § 501 et seq; J S Martel and K K White, 'Motor Vehicles and Transportation' ch 14 p 325 in M B Gerrard, ed, *Law of Clean Energy* (American Bar Association, 2011).

[44] 549 US 497 (2007); J Freeman, 'The Obama Administration's National Auto Policy: Lessons from the "Car Deal"' (2011) 35 Harvard Env L Rev 343.

[45] OECD, *Climate Change Mitigation Policies and Progress* (2015) p 76.

[46] Barrett Speth et al, above n 9.

[47] EU standards are described below under the heading Efficiency Standards: Fuel Efficiency or GHG Emissions Regulation.

[48] Lutsey, *Transitions*, above n 7 p 13.

[49] C Schmidt, "Beyond a One-Time Scandal: Europe's Ongoing Diesel Pollution Problem" (2016) 124 Environmental Health Perspectives A19, doi 10.1289/ehp.124-A19.

In 2009, Germany took action on EVs more specifically by adopting the *National Electromobility Development Plan* which set a goal of becoming a lead market and lead manufacturer, with the goal of 1,000,000 electric vehicles on the road by 2020.[50] The important *Energy Concept* policy statement of 2010 added a goal of 6,000,000 vehicles by 2030.[51] The Electromobility Plan established the National Platform for Electromobility (NPE) with experts from industry, science and society in seven working groups, on drive technologies and vehicle integration, battery technology, charging infrastructure and power grid integration, regulation, standardization and certification, materials and recycling, training and qualifications, and general framework.[52] The results from these working groups were brought together in a 'systemic approach.' It addresses Vehicle Technology, Energy and Environment, Charging Infrastructure and Urban Planning as well as Intermodality. In addition, education, standards and information and communication technology are seen as crucial preconditions for the system. The NPE's specific vision is formulated as to create a robust 'electric mobility system' until 2020 that enjoys widespread public acceptance, guarantees high availability, reliably meets individual mobility needs (private and commercial transport) and facilitates the marketing of technologically sophisticated and profitable products.[53] The country has placed more focus on research and development and public-private partnerships and less on per-vehicle consumer incentives.[54]

Since April 2012 the 'systemic approach' on the federal level has been accompanied by four testing regions as showcases for electric mobility within the federal states of Baden-Württemberg, Berlin/Brandenburg, Lower Saxony, and Bavaria.[55] In 2014, 90 projects combining a total of 334 individual initiatives were funded in the showcase regions, the Federal Government contributing €157 million.[56] The approach emphasizes testing and demonstrating electric mobility in everyday life, with a special focus on linking EVs and the electricity system by using information and communication technology in the transport system.[57]

Currently the following legal incentives for EVs are in force in Germany.

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[50] 'Nationaler Entwicklungsplan Elektromobilität der Bundesregierung' (1.8.2009) available in English http://www.bmub.bund.de/. Generally see Tietge et al above n 28 p 10.

[51] Federal Ministry of Economics and Technology (BMWi), *Energy Concept* (2010 with amendment in 2011) available in English www.germany.info p 24.

[52] 'Nationale Plattform Elektromobilität' (NPE) available www.bmub.bund.de (retrieved 17.4.2015) and 'Vision and Roadmap of the National Electric Mobility Platform' September 2012, available www.bmwi.de (retrieved 17.4.2015).

[53] NPE, *Progress Report 2014 – Review of Pre-Market Phase*, available in English: http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/NPE_Progressreport_2014_engl.pdf (retrieved on 8.11.2015) p 16.

[54] Lutsey, *Transitions* above n 7 p 13.

[55] See http://www.schaufenster-elektromobilitaet.org/programm/ (retrieved on 17.4.2015).

[56] NPE, *Progress Report 2014*, above n 53 p. 39.

[57] IEA, *Hybrid and Electric Vehicles: The Electric Drive Gains Traction* (May 2013) available www.ieahev.org, p. 120.

- EVs are exempted from the motor vehicle tax for ten years when licensed before the end of 2015 and for five years when licensed from 2016 until the end of 2020.[58]
- This exemption is accompanied by a fifty percent tax reduction on the purchase price for all EVs.[59]
- The Federal Ordinance on the licensing of motor vehicles allows interchangeable licence plates for ICVs and EVs, among other vehicles. This instrument is intended to facilitate the ownership of an EV as second vehicle.[60]
- Electricity used in public transport is subject to an electricity tax reduction.[61]
- Due to changes within the Energy Law framework in 2016, operators of charging points are no longer to be considered as energy suppliers but rather as final consumers not having to face energy suppliers' tax obligations.[62]
- Furthermore, the German government recently introduced a moderate fiscal incentive of €2,000 when buying a pure EV and of €1,500 when purchasing a hybrid EV.[63]

A new Electromobility Act was enacted in June 2015.[64] It authorizes municipalities to grant privileges to EVs (and hybrid and fuel-cell vehicles) for parking and bus lanes, and for those vehicles to be specially identified in their registration numbers. In addition, a draft Ordinance on Charging Infrastructure was presented in October 2015.[65] Its objective is to harmonize charging infrastructure standards in Germany to grant national and European interoperability according to recent European legislation.[66] The operators of public charging infrastructure will be obliged to report the start and finish of infrastructure operations to the Federal Network Agency.

In September 2016 Germany's Federal Council sent a note to the European Council with regard to a strategy to move towards "low emission mobility".[67] The press coverage particularly concentrated on the intention to make use of fiscal instruments within the EU so that by 2030 only zero emissions vehicles would be registered. Nevertheless, the recent

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[58] Section 3b of the federal motor vehicle tax law (Kraftfahrzeugsteuergesetz).

[59] Section 9 para. 2 of the federal motor vehicle tax law (Kraftfahrzeugsteuergesetz).

[60] Annex 4 section 2a of the federal ordinance on the licensing of motor vehicles (Fahrzeugszulassungsverordnung), see Mayer and Warnecke, 'Legal questions on individual electric mobility in road traffic' (Rechtsfragen individueller Elektromobilität im Straßenverkehr), Kommjur (Journal for the Communal Lawyer) 2013, 361, 365.

[61] Section 9 para. 2 of the federal electricity tax law (Stromsteuergesetz).

[62] Section 3 no. 25 of the federal energy tax (Energiewirtschaftsgesetz) and section 1a para. 2 of the federal ordinance on the implementation of the federal electricity tax law (Stromsteuer-Durchführungsverordnung).

[63] See Directive for promoting the marketing of EVs dated 29 June 2016 (Richtlinie zur Förderung des Absatzes von elektrisch betriebenen Fahrzeugen (Umweltbonus), Bundesanzeiger vom 1.7.2016, p. 1) – and http://www.bafa.de/bafa/de/wirtschaftsfoerderung/elektromobilitaet/index.html (retrieved on 2.11.2016).

[64] Elektromobilitätsgesetz, dated June 5th, 2015 (BGBl. - Federal Gazette - I p. 898).

[65] See http://www.bmwi.de/BMWi/Redaktion/PDF/V/verordnung-ladeeinrichtungen-elektromobile-kabinettbeschluss,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf (retrieved on 8.11.2015).

[66] Directive 2014/94/EU on the deployment of alternative fuels infrastructure, [2014] OJ L307/1.

[67] BR-Drs. (Federal Council Gazette) 387/16. The Federal Council (Bundesrat) represents Germany's 16 Federal States.

legislation and policy measures do not foresee major subsidies or economically relevant direct aid for EV purchasers, and that is thought to be the reason for the small uptake of EVs – only 24,000 vehicles reported at the end of 2014[68] – even though recently the numbers have risen; 25,502 pure EVs and 130,367 hybrids in early 2016).[69]

New Zealand

Road transport GHG emissions in New Zealand have grown three times as fast as overall national emissions.[70] The country's population density is low and the use of public transport in major cities is low by international standards. Renewable energy sources, especially hydro, have always dominated New Zealand's electricity supply, and the proportion of renewables is approaching 80 per cent.[71] Geothermal and wind energy account for most recent and anticipated additions to generation capacity. EVs would not stress this system; even if EVs were 80 per cent of the vehicles entering the fleet by 2040, EV charging is likely to be no more than 8 per cent of total electricity demand.[72] Most light vehicles are parked at home overnight with access to an electrical outlet.[73] Electricity companies are interested in EVs as a new market; fortunately, most of them already offer time-of-use pricing plans which may be enough to manage peak demand without regulation.[74] EV sales are growing, but the numbers are still minute; by June 2016 the light electric fleet had reached 1512 vehicles, one car in 2300.[75]

In May 2016 the Government announced an EV policy package.[76] It set a target of doubling the number of EVs in New Zealand every year, to reach approximately 64,000 by 2021, about two percent of the light vehicle fleet. The package announced the extension (to the end of 2021) of an existing exemption from the road user charges that are normally payable by the owners of non-petrol vehicles in order to fund road construction

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68 B Parkin and D Tschampa, 'Merkel Backs Incentives in 1 Million Electric Cars Push' (2 December 2014) www.bloomberg.com. In CO_2 emissions Germany is also said to be performing poorly in EU terms: European Federation for Transport and Environment, *CO_2 Emissions from New Cars in Europe: Country Ranking* (2014).

69 See http://www.kba.de/SharedDocs/Pressemitteilungen/DE/2016/pm_08_16_bestand_01_16_pdf.pdf?__blob=publicationFile&v=8 (retrieved on 3.11.2016).

70 *New Zealand's Greenhouse Gas Inventory 1990-2013*, above n 5.

71 Ministry of Business, Innovation and Employment, 'New Zealand Energy Quarterly' March 2015.

72 New Zealand Centre for Advanced Engineering, 'Electric Vehicles: Impacts on New Zealand's Electricity System' (Technical Report 2010).

73 New Zealand Centre for Advanced Engineering, ibid, p 21.

74 Electricity Authority, 'Implications of Evolving Technologies for Pricing of Distribution Services' (Consultation paper, 2015).

75 Ministry of Transport, *Quarterly Vehicle Fleet Statistics*, April-June Quarter of 2016.

76 S Bridges "Govt driving the switch to electric vehicles" (press release, 5 May 2016). See B Barton, "Electric Vehicles Policy Announcement" [2016] NZLJ 268. For most purposes it replaces the modest statutory target in *New Zealand Energy Efficiency and Conservation Strategy 2011-2016* (Ministry of Economic Development) p. 19: M Eusterfeldhaus and B Barton, 'Energy Efficiency: A Comparative Analysis of the New Zealand Legal Framework' (2011) 29 JERL 431.

and maintenance.[77] For a typical car driver driving 14,000 km the charge is $812 per annum. The package also announced an extension of the exemption to heavy electric vehicles, until December 2025. This is unusual because bus and truck EV technology is generally less advanced than for light vehicles. Road controlling authorities will be able to allow EVs to use bus and high occupancy vehicle lanes, and to designate parking for EV charging points. Bulk purchasing, an information campaign, and a contestable fund for innovation are proposed. The package proposes a review of tax and like liabilities. The fringe benefit tax is calculated on a vehicle's cost price or market value,[78] so it probably over-taxes EVs that have a higher initial price and lower lifetime cost.

The package made no announcement about introducing fuel efficiency standards. A proposal for such standards was considered in 2008, but was dropped after a change of government.[79] However standards may be considered in the revision of the National Energy Efficiency and Conservation Strategy under the Energy Efficiency and Conservation Act 2000. At least under that Act there exists a public awareness measure in the Energy Efficiency (Vehicle Fuel Economy Labelling) Regulations 2007.

As for motor vehicle air pollution, regulation under the Land Transport Act 1988 follows the Australian Design Rules, which mainly follow the European Union's regulations with a lag of four or five years.[80] On the whole, Australia and New Zealand's vehicle exhaust emission rules are aligned with other OECD countries.[81]

Overall, the hope for exponential growth in New Zealand EV numbers is ambitious, and the policy measures are not particularly forceful. The electricity generation mix makes EVs an attractive proposition, and electricity companies are in a position to exploit market opportunities. The private sector is installing a network of high-speed charging stations well ahead of demand, and work such as bulk purchasing to increase customer choice and reduce prices is likely to have some effect. How rapidly the mass market will change is unclear. The turnover of cars in New Zealand is unusually slow; the average age of the light vehicle fleet is 14.2 years, and many vehicles are imported as used cars, from Japan in particular.[82] Even though potential purchasers in New Zealand feel more positive about EVs than in the United Kingdom, they are concerned about upfront costs and range.[83]

Australia

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[77] Road User Charges (Exemption Period for Light Electric RUC Vehicles) Amendment Order 2016, made under the Road User Charges Act 2012.

[78] Income Tax Act 2007 Schedule 5.

[79] B Barton and P Schütte, *Electric Vehicle Policy: New Zealand in a Comparativ Context* (CEREL Research Report, 2015) p 29.

[80] The policy is to implement new standards at the same time as Australia or 2 years after Japan or Europe, as appropriate: *Regulatory Impact Statement: 2012 Amendment to the Land Transport Rule: Vehicle Exhaust Emissions 2007*, p 3.

[81] Miller and Façanha, above n 3, pp 14-17, 38-40, 56.

[82] Ministry of Transport, *Annual Fleet Statistics 2015* p 13.

[83] R. Ford, J. Stephenson, M. Scott, J. Williams, D. Rees and B Wooliscroft, *Keen on EVs: Kiwi Perspectives on Electric Vehicles, and Opportunities to Stimulate Uptake* (2015, Centre for Sustainability, University of Otago).

Light vehicle GHG emissions have been Australia's fastest-growing emissions, up 47.5 per cent since 1990.[84] The uptake of EVs has been slow; sales in 2014 were 948 out of 1.08 million new vehicles sold. There is no national policy framework, but there has been some state and local support for charging infrastructure, free charging, and modest registration discounts.[85] ClimateWorks proposes a series of policy measures to ensure that the benefits of EVs are recognized, and that EVs are encouraged with awareness measures, upfront purchase incentives and operating incentives like access to priority lanes. Barriers to EVs can be removed, notably the fringe benefit tax (as in New Zealand) and the luxury car tax that penalizes expensive cars.

Australia has had vehicle air pollution rules in place since the 1970s.[86] As noted above, the Australian Design Rules track those of Europe.

The absence of vehicle fuel efficiency standards is an important part of the background. Australia, along with New Zealand, is one of the few developed countries not to have such standards in place. They are particularly important in a state such as Victoria, where most electricity is generated from brown coal and where EVs may have worse overall emissions than ICVs for some time to come.[87] There is a voluntary scheme, but without regulation the average CO_2 emissions of new Australian cars is 45 per cent worse than European requirements.[88] The federal government decided against compulsory light vehicle emission standards in 2014,[89] even though fuel efficiency presented the lowest cost opportunity to reduce emissions across the economy, and average car owners would recover the additional costs within three years through fuel savings.[90]

However in February 2016 the government established a Ministerial Forum on Vehicle Emissions to revisit emissions standards and consider the options.[91] Later in 2016 the Climate Change Authority recommended that carbon dioxide emissions standards be introduced for light vehicles and considered for heavy vehicles as well. It noted that Australia was unusual in not having such standards already.[92] As to EVs, the Authority provided figures that show that EVs only have a modest advantage over ICVs under the current electricity generation mix. It observed that direct EV financial incentives would

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84 Climateworks, *The Path Forward for Electric Vehicles in Australia* (2016) pp 7, 13, 27, 28.

85 ClimateWorks, above n 84 p 13.

86 Motor Vehicle Standards Act 1989 (Cth) and Vehicle Standard (Australian Design Rule 79/04 – Emission Control for Light Vehicles) 2011. See Climate Change Authority, 'Light Vehicle Emissions Standards for Australia' 2014, p 26.

87 ClimateWorks, above n 84 p 19.

88 M L James, *Vehicle Fuel Efficiency Standards* (Parliamentary Library, Canberra, 2013) p 5.

89 Climate Change Authority, *Light Vehicle Emissions Standards for Australia* (Canberra, 2014); Energeia, *Review of Alternative Fuel Vehicle Policy Targets and Settings for Australia* (prepared for the Energy Supply Association of Australia, 2015).

90 ClimateWorks, *Improving Australia's Light Vehicle Fuel Efficiency* (Briefing Paper, 2014).

91 Commonwealth of Australia, *Vehicle Emissions Discussion Paper* (February 2016).

92 Climate Change Authority, *Towards a Climate Policy Toolkit: Special Review on Australia's Climate Goals and Policies* (August 2016), p 117. At p 123 it projects 2025 new ICV passenger vehicle average emissions of 160 g CO_2/km, and a Nissan Leaf EV's emissions under a 'business as usual' electricity grid of 140 g CO_2/km – little better.

likely be an expensive method of emissions reductions, and recommended research into the best roles of public and private providers in delivering recharging infrastructure.

France

France is among leaders in Europe for EV sales.[93] The government adopted a 14-point plan for EVs in 2009.[94] It included policies and incentives to install seven million charging points (public and private) by 2030. Policy is now embodied in the general framework of the Energy Transition for Green Growth Law of 2015.[95] It requires half of all new national government vehicle purchases to be low-emissions vehicles, and 20 per cent of local government vehicles. Research and development by car manufacturers was supported.

The most notable policy measure is the bonus-malus or feebate scheme that applies to initial vehicle registrations. The fee side ranges from €150 to €8,000, and the rebate from €150 to €6,300.[96] Battery EVs qualify for the highest bonus of €6,300 and plug-in hybrids for €4,000. A motor vehicle dealer can advance the bonus to reduce the purchase price directly. Annual vehicle ownership taxes are also determined by the vehicle's CO_2 emission value, and EVs are exempt from company car tax for the first two years.[97] The benefits of the bonus-malus scheme are enhanced if a car buyer also scraps a diesel car registered before 2001; he or she can reap a total benefit of €10,000.[98]

The bonus-malus scheme produced an immediate reduction in France of 6 per cent in CO_2 emissions in new cars, almost twice that in the rest of the EU, and significant reductions have continued. There is evidence that the bonus-malus scheme is less vulnerable to gaming for tax purposes than an emissions standard system.[99] The scheme is effective in promoting EVs. Its parameters are periodically updated. We consider bonus-malus or feebate schemes further below as an example that other countries could follow.

The different policy options for electric vehicles

On the basis of these examinations of the EV policies of different countries, it is possible to turn to consider different policy instruments in turn. There is a growing body of studies from around the globe that assess the effectiveness of government policies on EVs. They tell a strong and consistent story about the barriers to EV uptake and the success of policy measures to overcome them. In a recent literature review, Nic Lutsey of the International Council on Clean Transportation (ICCT) identified the best-practice design principles that

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[93] Lutsey, *Transition*, above n 7 p 13.

[94] Tietge et al, above n 28 p 28.

[95] La loi n° 2015-992 du 17 août 2015 relative à la transition énergétique pour la croissance verte, available www.legifrance.gouv.fr.

[96] National Research Council, above n 1, p 136. The legal basis of the bonus-malus scheme is the Code général des impôts, art 1010 bis and 1011 bis.

[97] Tietge et al, above n 28 p 30.

[98] Tietge et al, above n 28 p 30.

[99] P Mock, *Optimizing to the Last Digit: How Taxes Influence Vehicle CO_2 Emission Levels* (ICCT, 2015).

emerge.[100] The consensus he found is that, although regulatory standards for fuel efficiency are necessary, along with research and development, they are insufficient without complementary policies and incentives:

- Fiscal incentives to defray the incremental upfront cost; non-fiscal incentives such as preferential road, parking and lane access to provide benefits to vehicle users.
- Engagement with electricity utilities for EV charging rates and infrastructure; utility involvement in EV financing and vehicle-to-grid technology.
- Deployment of public and workplace charging networks
- Placement of EVs in car-sharing fleets, and encouragement of longer-range EVs.
- Information and awareness actions.

Similarly, Element Energy Ltd, in a study for Britain's Committee on Climate Change, concluded that a high uptake of EVs requires:[101]

- Continuing and sustained improvements in the supply of EV models, with tighter CO_2 emissions standards as the decisive driver for supply;
- Consumer awareness and acceptance;
- Charging infrastructure promoted as to household units, and in the longer term a national network of public charging points; and
- A level of equivalent value support (financial or otherwise) in the order of £2,500 per EV, for 2020-2030.

Likewise, the International Energy Agency (IEA) considers that the keys to global EV growth are:

- lowering the initial vehicle cost,
- developing electricity storage and fuelling technologies, and
- co-ordinating infrastructure investment.[102]

A detailed study of European EV policies comes to similar conclusions.[103] One can also draw on a statistical analysis of American cities which shows that EV uptake is strongly correlated with charging infrastructure, incentives, and city-level actions, but with significant variations and uncertainties; in Los Angeles, carpool or bus lane access seems important; in Portland, charging infrastructure seems key; while in Atlanta, subsidies are dominant.[104] Another literature review of American policy measures emphasizes that EV adoption is greatest when multiple measures are used in parallel, that measures to reduce the upfront cost help EV uptake, and that other support such as emission testing exemptions, low-carbon fuel policies and awareness actions are important.[105] Charging infrastructure and a good availability of EV models are also significant.

This international research and experience shows consistency about the policy priorities. We can proceed to consider the main policy options in greater depth.

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[100] Lutsey, *Transition*, above n 7, pp 21-25, 32.

[101] Element Energy, above n 27, p 124-127.

[102] IEA, *Energy Efficiency Market Report 2014*, p 73.

[103] Tietge et al, above n 28.

[104] Lutsey Searle et al, above n 37.

[105] Y Zhou, T Levin and S Plotkin, *Plug-In Electric Vehicle Policy Effectiveness: Literature Review* (Argonne National Laboratory ANL/ESD-16/8, 2016).

Price support to address the cost of electric vehicles

As we have seen in different countries, price support, fiscal incentives, or subsidies are generally regarded as important to produce any significant uptake of EVs, in order to deal with the price barrier. Price measures can be justified on economic grounds to correct for the negative externalities of ICVs.[106] In theory taxes on fuels and prices on carbon might be more efficient but in fact the upfront purchase price of a vehicle weighs heavily on consumer choices. Because the capital cost premium is the most significant restraint on mass EV adoption, financial incentives or value support are effective and essential.[107] In some countries large fiscal incentives have been offered. Norway offered €11,500 per battery EV (about 55 per cent of the vehicle base price), and the Netherlands €38,000 for a large company-owned plug-in hybrid EV (about 75 per cent).[108] Unsurprisingly those massive incentives led to rapid growth in the EV share in vehicle sales, nearly 6 per cent and nearly 5 per cent respectively. California shows a major response too. More surprisingly, in Sweden and the United Kingdom, with incentives of 35 per cent and 50 per cent of vehicle base price respectively, EV sales barely budged from zero. Germany, as we have seen, has only moderate fiscal incentives and has also seen much less EV growth than other leading countries in the past. Mock and Yang conclude that fiscal incentives are powerful mechanisms, but are not the only factor that influence EV market growth.

A number of studies show convincingly that EV price support or incentive measures need to be well designed in order to produce results.[109] First, they need to be big enough to make a difference; small subsidies will benefit purchasers but will not change their behaviour. Secondly, incentives need to be available immediately at the time of sale; consumers have a short pay-back outlook on the investment. (For example, sales tax waivers work much better than income tax credits.[110]) Thirdly, incentives need to be in place for long enough to send a clear message to automakers and importers. Fourthly, incentives should be linked to the relevant externality, such as the vehicle's CO_2 emissions, and should apply to the entire vehicle fleet and not only to EVs; conventional ICVs cannot be put to one side. Purchase incentives should be stronger for battery EVs than for plug-in hybrids, and stronger where an EV purchase is linked to the retirement of an old vehicle.[111] Ideally price incentives should be in place both at the time of purchase

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[106] S B Peterson and J Michalek, 'Cost-effectiveness of plug-in hybrid electric vehicle battery capacity and charging infrastructure investment for reducing US gasoline consumption' (2013) 52 Energy Policy 429 at 437.

[107] Element Energy above n 27 p 127. On the impact of public incentives, see Brook Lyndhurst Ltd, *Uptake of Ultra Low Emissions Vehicles in the UK* (for the Department of Transport, 2015) p 31.

[108] P Mock and Z Yang, *Driving Electrification: A Global Comparison of Fiscal Incentive Policy for Electric Vehicles* (ICCT, 2014) pp ii, 15, 19; Tietge et al above n 28 p 68.

[109] Lutsey, *Transition*, above n 7 p 23; National Research Council, above n 1 p 119; Element Energy above n 27; L Jin, S Searle and N Lutsey, *Evaluation of State-Level U.S. Electric Vehicle Incentives* (ICCT, 2014); J R DeShazo, "Improving Incentives for Clean Vehicle Purchases in the United States: Challenges and Opportunities" (2016) 10 Rev Env Economics and Policy 149.

[110] K Gallagher and E Muehlegger, 'Giving Green to Get Green: Incentives and Consumer Adoption of Hybrid Vehicle Technology' (2011) 61 J Env Ecs & Management 1. Most purchasers expect to recoup the initial price premium of an EV within three years: IEA, *Global EV Outlook*, above n 25 p. 30.

[111] DeShazo above n 109.

and throughout a vehicle's lifetime.[112] Fifthly, price incentives need to be used in combination with other policy instruments, as well as embracing a wide variety of technologies.[113]

The effects of taxation also need to be taken into account.[114] We have noted the delivery of EV subsidies through tax credits in the United States, and reductions in taxes on EVs in Norway and France, but we have also seen that the structure of fringe benefit taxes in Australia and New Zealand discourages EV purchases. The United Kingdom's company car tax, which varies substantially by CO_2 emissions, shows one path for reform.[115]

Incentives should be designed with a view to social equity and distribution; if they are clumsily designed they will be regressive and only help the well-to-do buy EVs.[116] There is no point, and a good deal of harm, in allowing public funds to be disproportionately transferred to wealthy new car buyers who would have purchased clean vehicles anyway. Even apart from social equity, emission reductions will be greater if incentives reach low-income consumers, because they tend to drive more polluting vehicles, drive them further, and exhibit less propensity to buy clean vehicles.[117]

Overall, policymakers have much evidence that the question of vehicle price cannot be ignored, and that price support incentives are essential and effective. They also have cogent evidence about the design of incentives. It is likely, for example, that the American federal tax rebate is not as effective or fair as it should be, and it is likely that purchasers are not greatly motivated by New Zealand's road user charges exemption because it does not provide an immediate reduction in price and is available for a limited time only.

Efficiency standards: fuel efficiency or GHG emissions regulation

EVs look like a viable option only if the adverse effects of ICVs are controlled, so we need to consider the regulatory pressure on all kinds of vehicle. The great majority of the world's vehicle sales – eighty-five per cent – are subject to efficiency standards, whether

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[112] H He and A Bandivadekar, *A Review and Comparative Analysis of Fiscal Policies Associated with New Passenger CO_2 Emissions* (2011, ICCT) pp 8-9.

[113] IEA, *Tracking Clean Energy Progress* (2012) p 44.

[114] European Federation for Transport and Environment, above n 68; C Brand, J Anable, M Tran, "Accelerating the Transformation to a Low Carbon Passenger Transport System: The Role of Car Purchase Taxes, Feebates, Road Taxes and Scrappage Incentives in the UK" (2013) 49 Transportation Research Part A 132.

[115] S Potter and A Atchulo, "A Review of Ten Years of CO_2-based Company Car Taxation: Impact and Potential" (Universities Transport Studies Group Annual Conference 3-5 January 2013, Oxford) available www.open.ac.uk.

[116] M Nilsson and B Nykvist, "Governing the Electric Vehicle Transition – Near Term Interventions to Support a Green Energy Economy" (2016) 179 Applied Energy 1360. An early inquiry into the distributional questions is P Wells, "Converging Transport Policy, Industrial Policy and Environmental Policy: The Implications for Localities and Social Equity" (2012) 27 Local Economy 749.

[117] DeShazo, above n 109.

in the form of fuel efficiency, fuel economy, or GHG emissions.[118] Russia, Australia and New Zealand are exceptions from this general pattern; even Saudi Arabia is adopting a standard.[119] These standards have proved to be highly cost-effective in cutting CO_2 emissions and producing fuel savings. Between 2000 and 2010 they improved new vehicle fuel efficiency by 20 per cent in OECD countries and 10 per cent in other countries.[120]

We have seen these standards in the laws of several jurisdictions. The American 'CAFE' standards – corporate average fuel efficiency standards – are among the pioneers, introduced to tackle air pollution in California but now also part of the response to climate change. In the European Union, the CO_2 standards that were put in place for cars in 2009 set an overall fleet average target for 2015 of 130 g/km, which accelerated reductions considerably; in 2006 the average was about 160 g/km.[121] It is expected that the standards that have been agreed on to take effect in 2020 will produce a 25 per cent reduction in fuel consumption, and that the fuel savings will actually be larger than the cost of compliance, resulting in net savings of between €80 and €295 per ton of CO_2 avoided. Both the American and European standards are very cost-effective and are credited with putting significant pressure on the ICV fleet.[122] The regulatory pressure on ICVs makes EVs a more attractive option for suppliers and for purchasers.[123] Efficiency standards have been found to be a key driver for the deployment of EVs in the United States and Europe.[124]

However there is some complexity in the relationship between efficiency standards and EV uptake. One feature of efficiency standards that is crucial, but in our view insufficiently understood, is that they operate as averages. They require each manufacturer or importer for each model year to sell a fleet of vehicles that, when measured overall, meets the regulatory standard. The positive side of this averaging is that it gives the vendors flexibility to continue to offer low-efficiency vehicles, provided that they are balanced with high-efficiency ones. But it may reduce the power of efficiency standards to increase EV numbers. In Europe, although increasingly stringent CO_2 regulation incentivizes EVs, the automakers already have dozens of ICV models that meet the 2021 emission standard, so they do not need to produce EVs to meet it.[125] Similarly in the United States, the Congressional Budget Office concludes that the federal tax credits for

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[118] Miller and Façanha, above n 3. We follow their use of the term 'efficiency standards' to refer collectively to targets for fuel consumption, fuel economy, and CO_2 or GHG emissions: p 4. The standards are directly related in their effect.

[119] 'Proposed Saudi Arabia CAFE standard for new LDVs 2016-2020' www.theicct.org, 18 December 2014.

[120] IEA, *Energy Efficiency Market Report 2014*, pp 70-71.

[121] ICCT, *EU CO_2 Emission Standards for Passenger Cars and Light-Commercial Vehicles* (Policy Update January 2014).

[122] As to the USA: D. Kodjak, *Policies to Reduce Fuel Consumption, Air Pollution, and Carbon Emissions from Vehicles in G20 Nations* (ICCT, 2015) p. 19; Lutsey, *Transition*, above n 7; National Research Council, above n 1 p 116. As to Europe: ICCT, *EU CO_2*, above n 121; OECD, above n 45 p 77. The current EU Regulations, including the tightening of the standards in 2020, are Regulation (EC) 443/2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles, [2009] OJ L140/1, as amended by Regulation (EU) 333/2014 to define the modalities for reaching the 2020 target to reduce CO_2 emissions from new passenger cars, [2014] OJ L103/15.

[123] Miller and Façanha, above n 3, pp 26 and 53.

[124] Kodjak, above n 122 p 19; Element Energy, above n 27, pp 81 124-27; Tietge et al, above n 28 p 7.

[125] Tietge et al, above n 28.

the purchase of EVs may produce little or no reduction in gasoline consumption or GHG emissions because with CAFE standards the vehicle suppliers can match the greater EV sales numbers with greater numbers of low-economy vehicles.[126] The inference is that vehicle efficiency standards may not on their own ensure the mass-market adoption of EVs, and, equally, that price support for EVs may not reduce GHG emissions.

In turn, that presses us to ask what really matters, the GHG reductions, or the EV sales? We suggest that the answer is both. ICVs will be part of the vehicle fleet for a very long time and it all needs to be as efficient and low in emissions as possible; and that efficiency standards are the best means to that end. Equally, looking further ahead, we need to promote technology diffusion for EVs and other ultra-low emissions vehicles that will be required for an entirely new kind of mobility future.

The averaging characteristic of efficiency standards has another consequence for countries like Australia and New Zealand that do not have such laws. In those countries, a car manufacturer can sell as many of its low-efficiency models as it likes, even though the sales in other countries are limited. This contrasts with absolute standards for product quality or performance, where one country can free-ride on the regulatory efforts of another. In fact very few countries are promoting EVs without fuel efficiency measures to shape the composition of the overall vehicle fleet.

Price on carbon

Also relevant are measures that put a price on GHG emissions, in the form of a carbon tax or emissions trading scheme. We have already noted arguments that conceptually carbon pricing and pollution pricing are more directly targeted at the negative externalities.[127] However there seems to be a good case for policy action on both vehicle purchase decisions and subsequent vehicle use decisions. The two activities are quite different and different policy instruments are needed to influence them. It is not a case of unnecessary duplication. There is firm evidence that carbon pricing on its own is not enough to overcome all barriers to cost-effective energy use actions.[128]

A general price on carbon is used alongside vehicle efficiency standards in California, British Columbia and Quebec. In other cases, such as New Zealand, and carbon price exists but is probably too small to influence decisions; the Emissions Trading Scheme charge is about 2 cents per litre of fuel.[129] In Europe, motor vehicle fuel is not subject to the EU Emissions Trading System, so the case for action on vehicle fuel efficiency is even stronger.

Feebates

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[126] Congressional Budget Office, above n 42 p 12.

[127] DeShazo, above n 109.

[128] L. Ryan, S. Moarif, E. Levina, R. Baron, *Energy Efficiency Policy and Carbon Pricing* (IEA, 2011); IEA, *Energy Efficiency Market Report 2014*, p 70.

[129] Ministry of Business, Innovation and Employment, Importer Margins up to the week ending 24 June 2016.

Feebates are interesting as a policy instrument that can address both the price barrier and fuel efficiency at once. Feebates are generally recognized in the literature of environmental economics and policy,[130] and in relation to motor vehicles the best example is the French bonus/malus scheme, noted above. A feebate rates each model for its GHG emissions or efficiency performance, usually at the point of initial import or manufacture, so that better vehicles get rebates and worse ones must pay fees.[131] The reward is tangible and immediate. A true feebate is self-financing; fees received from above the 'pivot point' are balanced by the rebates paid below it. (The pivot must therefore be reset periodically as technology changes and as ambition grows.) Revenue neutrality is attractive politically; a feebate is not a subsidy or a tax. It is likely to be attractive in terms of social equity; it is less likely than most systems to put good quality vehicles out of the reach of poor families. A feebate is technology-neutral; it influences the purchase of ICVs and EVs alike, and encourages hybrids, fuel cells, and hydrogen vehicles as well. It will generally give EVs favourable ratings especially where electricity generation is low-carbon.

Feebate principles can also be applied to vehicle use, such as in Germany's annual vehicle registration fee, connected to engine capacity as well as CO_2 emissions. In theory it sends a larger price signal than the French feebate, but it may have less consumer impact because it is spread out over time.[132] The United Kingdom has a similar arrangement for its annual vehicle excise duty.[133] The United States has a 'gas guzzler' tax but it applies to only a small fraction of the vehicle fleet.[134] The feebate model seems very suitable for a country like New Zealand, which does not yet have fuel efficiency standards or substantial price subsidies, and sees many of its vehicles imported by small companies.

Charging facilities

Among the barriers to the uptake of EVs are their short driving range in comparison with ICVs and the need for a better-developed charging infrastructure, even though most of the car trips that people make actually are well within EV driving range. Most EV charging can be done at the owner's residence, using ordinary electrical outlets for a full charge overnight.[135] However there is also a role for a network of public charging facilities that provide a rapid recharge. Such facilities are important for people who cannot readily charge at their residence, and for long-distance travellers; but they are also vital to displace the "range anxiety" that has been found to weigh on the decisions of potential purchasers.[136] The practical and psychological importance of charging is suggested by an American study showing a correlation between the number of a city's public chargers per

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[130] T T Tietenberg and L Lewis, *Environmental and Natural Resource Economics* (10th ed, 2015) p 437. For an early study as to EVs, see A Ford, 'Simulating the Controllability of Feebates' (1995) 11 System Dynamics Review 3.

[131] J. German and D. Meszler, *Best Practices for Feebate Program Design and Implementation* (ICCT, 2010); Element Energy above n 27 p 97 also emphasizes feebates.

[132] German and Meszler, above n 131 pp 18 and 28; European Federation for Transport and Environment, above n 68 p 11; Tietge et al, above n 28 p 11.

[133] Tietge et al, above n 28 p 21.

[134] German and Meszler, above n 131 p 30.

[135] National Research Council, above n 1, pp 82-87

[136] National Research Council, above n 1, p 47.

capita with its EV share.[137] We have noticed that Portland, Oregon, is distinctive in achieving high EV numbers of EVs with high levels of public charger availability but low levels of subsidy.

Whether government support is needed to develop a charging infrastructure may vary from place to place. California, France, Germany, Norway, and other jurisdictions have been active providing such support. Some municipalities, cooperatives and companies may promote EV car-sharing schemes such as the one in Paris.[138] However in other places, such as New Zealand, private enterprise seems to be providing charging ahead of demand. There is evidence that early EV adoption does not depend on the government to provide large-scale access to a national public charging infrastructure.[139] Where government action is clearly needed is legislation to give local government and other authorities the mandate and powers to authorize EV charging facilities on public road space. The German statute of 2015 provides an example. Regulation is also required for charger plug and communication protocols.[140]

Public awareness and ancillary regulation

Research shows that consumers and fleet managers are not well informed about EVs, and that a number of perceptual factors contribute to consumer uncertainty and doubt about them, particularly the total costs of ownership over time, battery durability, and the driving range concern that we have just considered.[141] Educational and information measures are therefore essential. Fiscal incentives on their own are not sufficient to ensure uptake.[142] On the other hand it is unlikely that public awareness measures are enough on their own to outweigh high EV purchase prices, limited driving range, and limited variety of models, especially where ICVs do not face significant regulation of fuel efficiency or GHG emissions.[143]

In New Zealand the Energy Efficiency and Conservation Authority produced an online tool for fleet purchasers to compare the total cost of ownership of EVs and other vehicles. Large fleet procurements can spur EV sales by leading public opinion and accelerating economies of scale. The German government intends to replace its existing vehicle fleet with EVs, and the French government is coordinating the purchase of 50,000 EVs.[144] The special number plates for EVs in Norway improve public awareness, identifying EVs and giving preferential rights as to bus lanes, parking, road charges and ferries. Benefits of this kind, mainly non-financial ‘perks,’ are likely to encourage EVs, and do not impose

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[137] Lutsey Searle et al, above n 37 p 34.

[138] IEA, *Energy Efficiency Market Report 2015*, p 169.

[139] Element Energy, above n 27, p 126.

[140] National Research Council, above n 1, p 33.

[141] Lutsey, *Transition*, above n 7, p 24; National Research Council, above n 1, p 51.

[142] Tietge et al, above n 28 p 68.

[143] Element Energy above n 27; Lutsey, *Transition*, above n 7, p 23.

[144] Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, press release ‘Bundesumweltministerium ist Vorreiter bei der Beschaffung von Elektrofahrzeugen’ 14 February 2014; IEA, *Global EV Outlook* (2013) p 33.

obvious fiscal costs. They are also measures that a municipality can implement without waiting for central government action.[145]

Industry policy

Brief mention should be made of the strategy that we have noted in some countries with large automotive industries, investing substantially in supply-side innovation, especially by providing automakers with research and development funding. France, Germany and the United States are examples. Such countries often also put public funding into the demand-side environmental policies that encourage the diffusion and uptake of EV technology.[146]

Conclusion

It is clear that EVs offer public benefits in relation to climate change, air pollution, energy efficiency and energy security – even though the incidence of the benefits is not the same everywhere. It is also evident from the literature that policy action is essential to obtain any significant uptake of EVs beyond a business as usual rate. We have seen that a number of policy actions and legal measures have a proven track record, backed up by a strong consensus in the research and analysis. For example, it is very likely that the price barrier is not overcome by subsidies that are too small and too gradual. The literature also shows that non-price barriers such as information and availability are important. So too are unintended barriers such as road use rules that can impede the development of charging infrastructure. Policy actions need to be well designed, and often they need to be used together, working on different decision points and different aspects of human behaviour.

Two insights emerge from this analysis that are more novel and perhaps contentious. The first is that EV policy and transport policy diverge at key points. Electric vehicles are still vehicles. They do not reduce journey times, the number of cars on the road, or the demand for new roading. They produce about as much particulate matter air pollution as ICVs. EVs themselves need to evolve, for example by making reductions in vehicle weight. If EVs are understood still to be vehicles, we see that public effort and resources invested in them may not be the best investments that society can make in transport; public transport, shared transport and active transport, for example, may produce better results. EV initiatives should find their place within the "avoid, shift, improve" framework. An undue focus on EVs may unduly perpetuate longstanding but outmoded conceptions of vehicle use and ownership. Electrification needs to find its place in relation to connected and autonomous vehicles – CAVs – that are likely to be EVs but with self-driving capabilities that may transform human mobility, and suddenly seem to be emerging as a reality.

The second insight is that EV policy and climate change policy also diverge at key points. A switch from petroleum to electricity as a fuel will reduce GHG emissions under most generation mix scenarios. EV policy measures need to be coordinated with a shift towards

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[145] Lutsey, Searle et al, above n 37.

[146] J Wesseling, "Explaining Variance in National Electric Vehicle Policies" (2016) Environmental Innovation and Societal Transitions, in press.

renewable energy production, carbon pricing and other GHG measures. We have seen that efforts to promote EVs are undercut if ICVs are not exposed to the real cost of their negative externalities. However the swiftest cheapest reductions in GHG emissions from road transport may not come from EVs, but from better ICVs, vehicles using biofuels or hydrogen fuel cells, or from public and active transport. We find a particular divergence in relation to fuel efficiency standards. Generally, fuel efficiency standards support EVs because they require improvements in the vehicle fleet as a whole. However, carmakers need not use EVs to meet the rules, and even when they do they can add equivalent numbers of high-emissions vehicles at the other end of the efficiency spectrum. In neither situation does an emphasis on EVs, such as price support, shift GHG emissions. The inference would be that EV subsidies are unnecessary if our concern is with GHGs and we have good fuel efficiency standards in place.

These insights seem to bring us to the familiar policy criteria of efficiency and equity. Efficiency causes us to ask whether EV-specific measures, such as auto industry research and development support, price incentives or bus-lane privileges, are the most cost-efficient way to obtain benefits in transport management or in GHG emission reductions. Whether they are good value for money in the use of public funds and resources is a proposition that needs to be justified. The fact that EV policy diverges from transport policy and climate change policy is apparent. It has often been said that policymaking should avoid picking winners and favouring one technology in addressing a general problem.[147] On the other hand, as we have noted it may be desirable, even essential, to support the longer-term emergence of EVs as a technical option, even though it is an expensive one in the short term.

The equity criterion seems very relevant as well; it causes us to ask whether a measure such as EV price support is a regressive subsidy, if it fails to change behaviour and merely redistributes income towards purchasers who are already affluent. Equity tensions will also appear dramatically if bus users complain that EV users entitled to use bus lanes are slowing down public transport. Social equity therefore presents a real challenge to policy makers.

On the whole it is reasonably clear that EVs have a role in transport and greenhouse gas emission reductions in a sustainable society, and the sooner that they can make their contribution in substantial numbers, the better. It will take careful policymaking and law reform to ensure that they do so.

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[147] M J Trebilcock and J S F Wilson, 'The Perils of Picking Technological Winners in Renewable Energy Policy' p 343 in G Kaiser and B Heggie, eds, *Energy Law and Policy* (Toronto: Carswell, 2011).