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Electric Mobility: Inevitable, or Not?

A report for the Platform for Electromobility

PLATFORM
FOR
electromobility

Element Energy

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Executive summary

The European Union has set targets to become carbon neutral by 2050 and achieve a 55% reduction on 1990 emissions by 2030. To meet these targets, passenger cars – which today represent around 12% of EU CO₂ emissions¹ – must rapidly decarbonise. Cars introduced to the market from the mid-2030s are expected to remain in the stock until 2050, so actions to increase the uptake of zero-emission vehicles must be taken today. Though the sales of zero-emission vehicles have been increasing, with only 8.9% of new car registrations in 2021² there is a long way to go.

This study focuses on the purchase behaviour of new car buyers. In June 2021 Element Energy conducted a survey of 14,052 new car buyers in seven European markets (Figure 1) covering 80% of new car registrations across Europe (EU + EFTA + UK). At the core of this survey was a consumer choice experiment, which provided insights into the purchase decisions of survey respondents. This is the largest choice experiment conducted with new car buyers in Europe to date. From this survey and subsequent modelling work, four key conclusions can be drawn.

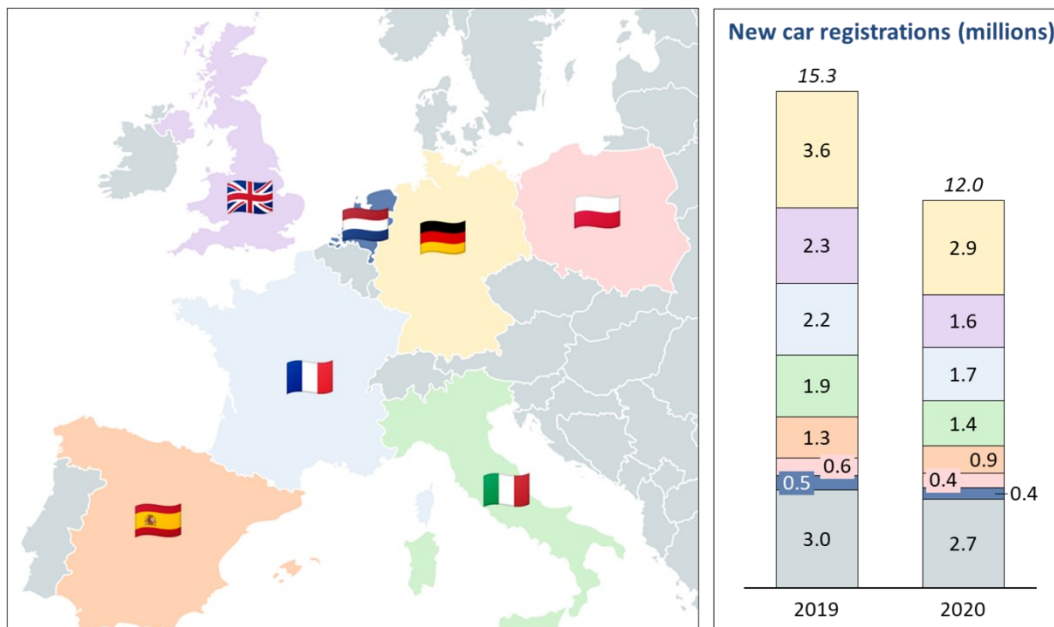


Figure 1: The seven markets in scope of this study (left) cover 80% of new car registrations (millions) across the EU + EFTA + UK (right)³.

1. The transition to electric mobility is now inevitable

Using the choice experiment responses of new car buyers to project vehicle sales out to 2050, it is expected that battery electric vehicles (BEVs) will become the most demanded powertrain across Europe from 2025 (Figure 2). Rapid growth in demand for BEVs is the result of the expected reduction in BEV purchase prices over the coming decade, driven by falling production costs of lithium-ion batteries as manufacturing plants scale up, recouping of research and development costs by vehicle OEMs, and the introduction of lower specification, more affordable BEVs to the market.

¹ European Commission, CO₂ emission performance standards for cars and vans, [Link](#) (accessed 30 November 2021)

² European Alternative Fuels Observatory (EAFO), EU + EFTA + UK + Turkey.

³ ACEA, Motor vehicle registrations in the EU, by country and per vehicle type, 2020, [Link](#).

Upfront cost was identified as the most influential factor in consumer powertrain decision, with running cost, driving range, and access to charging secondary factors in the decision. Figure 2 compares demand for new car powertrains under the baseline and a scenario where BEVs achieve purchase price parity with petrol internal combustion engine vehicles (ICEs) by 2028⁴. This early purchase price parity scenario assumes that the widespread adoption of dedicated BEV manufacturing platforms unlocks cost savings of around 20% by 2030, but purchase price reductions could also be achieved through the introduction of lower specification, entry-level cars. Achieving purchase price parity as soon as possible is critical to achieving a rapid transition to zero-emission powertrains, with all consumers overwhelmingly choosing BEVs over the alternatives if upfront costs are similar.

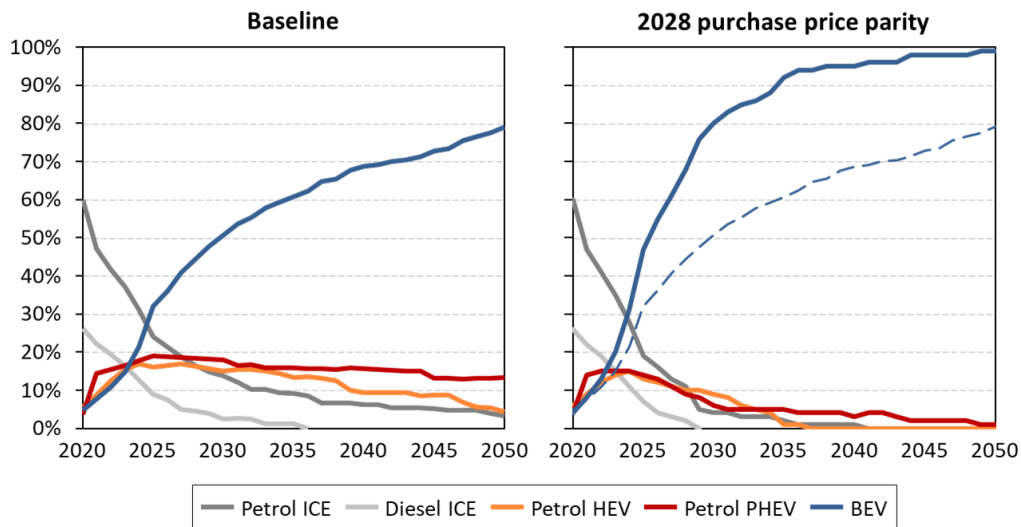


Figure 2: Demand for BEVs increases substantially with dedicated BEV platforms. Baseline BEV uptake is shown in dashed blue (right).

Governments can hasten the transition to BEV dominance by encouraging and supporting vehicle manufacturers to produce low cost BEVs, as well as applying higher registration taxes to ICE vehicles, such as is done in the Netherlands and Norway today. Policies designed to reduce the upfront cost of BEVs should ensure purchase price parity is achieved across the price spectrum and for the lowest income consumers. So long as a sufficient supply of BEVs is available, the transition to electric mobility is now inevitable.

2. Consumers will not view e-fuels as a compelling alternative to BEVs

Even under optimistic scenarios for future synthetic fossil fuel (e-fuel) costs, ICE vehicles running on e-fuels are not a compelling alternative to BEVs in the eyes of consumers. As outlined above, consumers in 2021 have already embraced the transition to electrified mobility and would preferentially choose an electric vehicle (EV) over an ICE alternative if they were the same price. However, the running costs of an e-fuel powered ICE are not the same as a BEV – even if no fuel duty is applied to already ambitious projections of e-fuel costs⁵, requiring synthetic fuels be produced using solar power in the Middle East, the total cost of ownership of an ICE using e-fuel is 23% higher in 2030 than an equivalent BEV⁶.

⁴ The baseline scenario represents a realistic, but conservative projection of future BEV purchase prices, where small cars achieve price parity 2030, but medium and large cars retain a purchase price premium over Petrol ICEs.

⁵ Frontier Economics for Agora Energiewende (2018): *The Future Cost of Electricity-Base Synthetic Fuels*. [Link](#)

⁶ Element Energy for BEUC (The European Consumer Organisation) (2021), *Electric Cars: Calculating the Total Cost of Ownership for Consumers*. [Link](#)

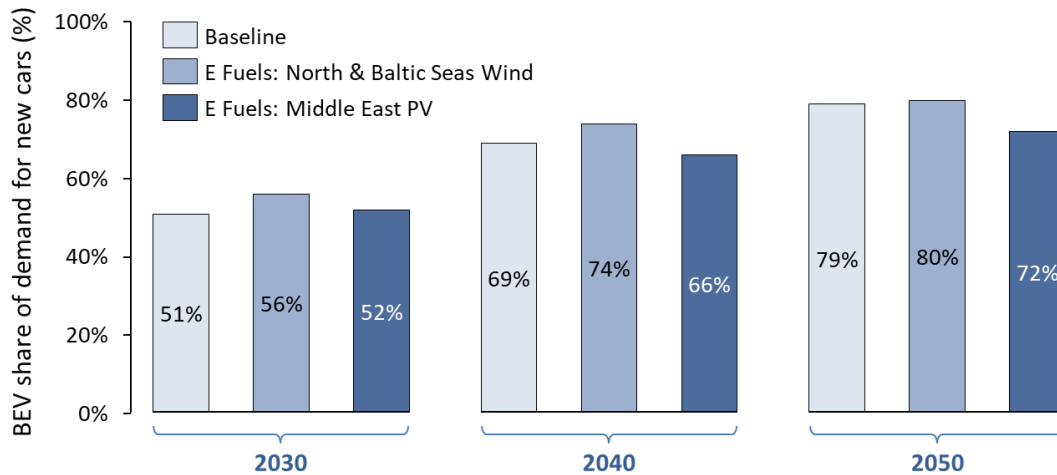


Figure 3: BEV demand under scenarios where cheap e-fuels are introduced.

As a result of these high costs, consumers overwhelmingly choose to purchase BEVs (Figure 3). The introduction of e-fuels increases vehicle running costs to all consumers, providing new car buyers a greater incentive to switch to BEVs and hitting the poorest in society the hardest. E-fuels do not benefit consumers, and governments should instead focus investment towards achieving the near-term purchase price parity of mass-market BEVs.

3. Public charging infrastructure does not limit demand for BEVs today, but deployment should keep up with sales

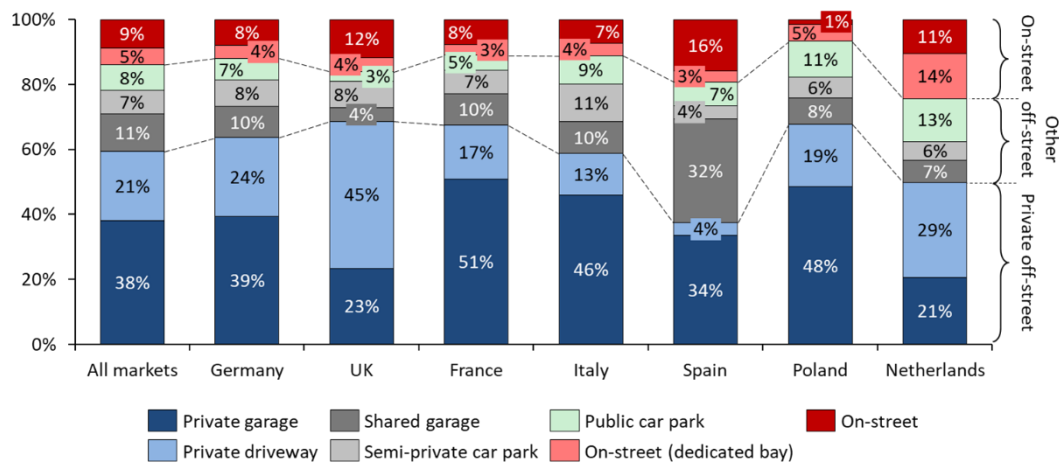


Figure 4: The location where survey respondents currently park their cars (14,052 respondents, 23,967 cars).

Today, perceived access to charging does not significantly impact purchase decisions. However, if charge point deployment does not keep pace with EV uptake, we would expect this to change rapidly. Consumers without access to home charging are on average 12% less likely to purchase a BEV than those with home charging, though for most new car buyers in Europe this is not a problem – 85% of new car buyers have access to off-street parking, with 59% having access to private off-street parking (Figure 4).

As a result of the high access to off-street parking amongst European new car buyers improving access to public charging ahead of demand does not, by itself, unlock significant additional BEV demand (Figure 5). However, in markets such as Spain where currently both

access to off-street parking and access to public charging is low, deployment of public charging infrastructure is key to unlocking latent BEV demand. Not having access to either a private charge point or reliable public charging infrastructure is a significant barrier to EV adoption, and consumers who would otherwise willingly purchase an EV are likely to purchase an ICE alternative until better access to charging is made available.

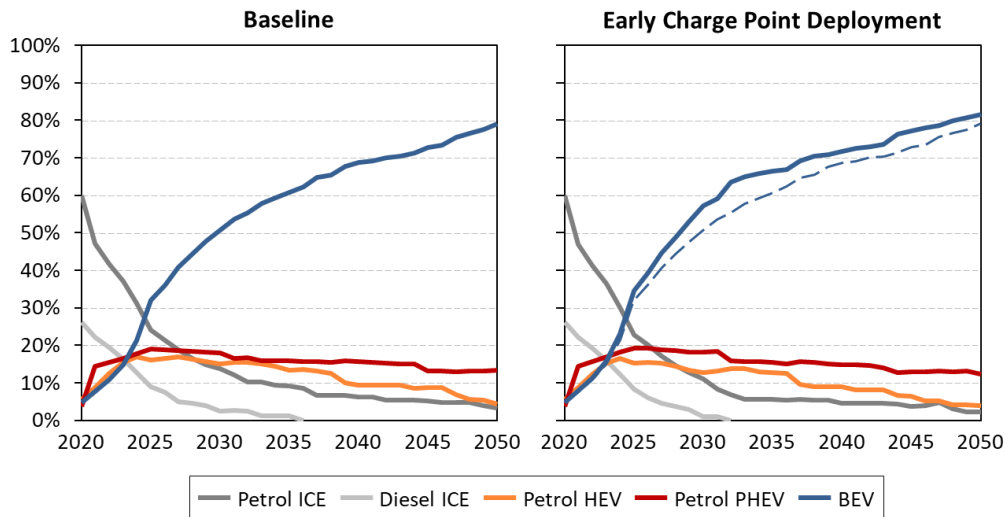


Figure 5: Demand for BEVs increases only slightly if access to public charge points is guaranteed from 2030. Baseline BEV uptake is shown in dashed blue (right).

4. BEVs are the preferred powertrain of today’s consumers

All of the six consumer groups identified from the 14,052 survey respondents would preferentially choose an EV over an ICE if all else were equal⁷, with 73% of private consumers choosing a BEV as their preferred powertrain (Figure 6). Comparing these results to similar studies conducted by Element Energy in the UK in 2015 and 2011 it is clear there has been a profound change in the preferences of consumers, shifting from the dominant powertrain of choice being an ICE vehicle to a mix of plug-in hybrids (PHEVs) and BEVs. It is expected that this trend towards EVs will continue as governments continue to signal their intentions to phase out ICE vehicles and EV technology improves and becomes more widespread.

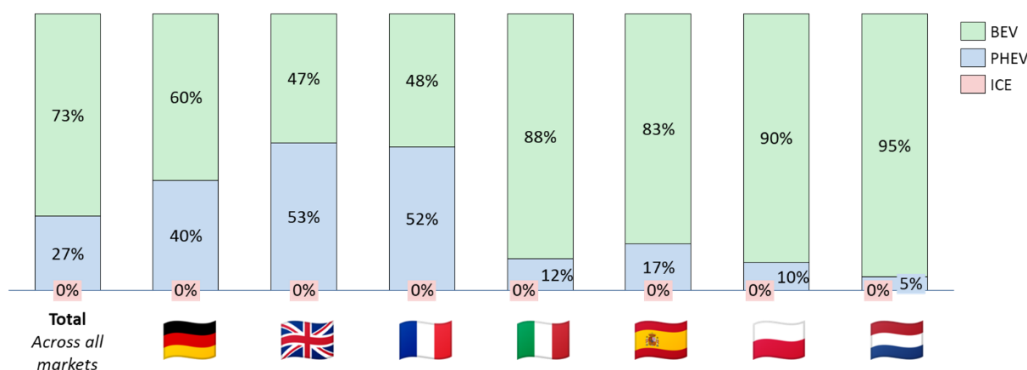


Figure 6: First choice powertrain if all else is equal for European consumers in 2021.

⁷ Upfront purchase price and running cost are equal between powertrains, consumer has perceived access to home and public charging, PHEV range is 80 km, BEV range is 500km.

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Element Energy is a strategic energy consultancy, specialising in the intelligent analysis of low carbon energy. The team of over 90 specialists provides consultancy services across a wide range of sectors, including low carbon transport, the built environment, carbon capture and storage, industrial decarbonisation, smart electricity and gas networks, energy storage, and renewable energy systems. Element Energy provides insights on both technical and strategic issues, believing that a technical and engineering understanding of real-world challenges supports strategic work. As of July 2021, Element Energy is part of ERM Group.

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Acronyms

ACEA	European Automobile Manufacturers Association
BEUC	The European Consumer Organisation
BEV	Battery electric vehicle
BNEF	Bloomberg New Energy Finance
ECF	European Climate Foundation
EFTA	European Free Trade Association
EU	European Union
EV	Electric vehicle
FCEV	Fuel cell electric vehicle
FCH JU	Fuel Cell and Hydrogen 2 Joint Undertaking
HEV	(Full) Hybrid electric vehicle, non-plug in
ICCT	International Council on Clean Transportation
ICE	Internal Combustion Engine
OEM	Original equipment manufacturer
PHEV	Plug-in hybrid electric vehicle
PLN	Polish złoty
PV	Photovoltaic (solar)
TCO	Total cost of ownership
TEN-T	Trans-European Transport Network
T&E	Transport and Environment
WLTP	Worldwide harmonized light vehicles test procedure
YTD	Year to date
ZEV	Zero-emission vehicle

1 Introduction

This report presents the results of the largest consumer survey focusing on European new car buyers' attitudes towards electric vehicles (EVs) to date. The findings presented provide a quantitative insight into the purchase decisions of private new car buyers, and this report explores how this improved understanding of consumer purchase decisions will impact on projections of future EV uptake in Europe. Passenger cars are key to decarbonising the European transport sector as they represent around 12% of the EU's total CO₂ emissions⁸. As such, understanding what influences a consumer's new car purchase decision is paramount to designing policy that will achieve Europe's goal of reaching Net Zero emissions by 2050.

1.1 Background and context

In 2021, the European Commission adopted a proposal to amend Regulation (EU) 2019/631⁹ to strengthen CO₂ emission performance standards for new cars and vans sold in the EU up to 2050. This amendment would require that new cars sold in 2030 have average CO₂ tailpipe emissions per kilometre 55% lower than 2021 levels, and all new cars registered from 2035 onwards have zero tailpipe emissions, building on 2019 regulation that set targets of 15% and 37.5% reductions in 2025 and 2030 respectively from 2021 levels.

The actions of some original equipment manufacturers (OEMs) to date (including actions to meet the 2020/21 CO₂ standards) have been relatively slow and several OEMs have focussed primarily on improving the efficiency of internal combustion engine vehicles and hybridisation¹⁰. This poses an issue as manufacturers will eventually reach physical limits and deploying further efficiency improvements will be either uneconomic or impossible. Attention must therefore shift towards developing and selling greater volumes of zero-emission vehicles to ensure long-term net-zero emission targets can be achieved. This will require the eventual phase out of all non zero-emission powertrain technologies.

Battery electric vehicle (BEV) sales have seen a sharp rise during 2021, accounting for 8.9% of European car sales, compared with 5.7% in 2020¹¹. However, due to the coronavirus pandemic, overall vehicle registrations in Europe fell by ca. 24.5%¹² between 2019 and 2020. It is unclear to what extent current momentum in electric vehicle (EV) sales will continue. This will largely depend on: (1) the pace of technology development; (2) policies introduced at European & national levels; and (3) consumer attitudes and purchasing behaviour.

While the first two elements are generally well studied and understood, the topic of consumer attitudes and preferences has not received as much attention. To address this shortfall and explore the relative influence of the three above factors, this study has carried out primary research on consumer attitudes towards different car powertrains, across multiple European countries. This has been used to model uptake of different car technologies out to 2050, under several scenarios.

⁸ European Commission, *CO₂ emission performance standards for cars and vans*, [Link](#) (accessed 30 November 2021)

⁹ [Regulation \(EU\) 2019/631](#) with proposed amendment [2021/0197 \(COD\)](#)

¹⁰ Transport & Environment (2021): *Electric car boom is at risk*. [Link](#)

¹¹ European Alternative Fuels Observatory (EAFO), EU + EFTA + UK + Turkey

¹² ACEA, EU + UK + EFTA + Turkey YoY 2019 and 2020. [Link](#)

1.2 Importance of new car buyer purchasing decisions

This research focuses solely on new cars buyers. First owners, who typically only own a vehicle for the first few years of a vehicle's lifetime, determine the market stock of all passenger cars, and control which vehicles are available for used car buyers. As such it is the choices of new car buyers which will determine the timeline of the transition to electric vehicles. This is particularly relevant as the upfront purchase prices of BEVs, which are currently ca. 30% higher than a petrol internal combustion engine vehicle (ICE) in 2021, is a challenge to consumer uptake, with BEVs typically offering best financial value to subsequent owners, due to the much lower running costs. A medium sized BEV bought new today will save a total of €9,000 for its eventual second & third owners compared to a Petrol ICE over its lifetime¹³.

Though EVs are expected to achieve total cost of ownership (TCO) parity with legacy powertrains within the next decade¹³, as outlined in this report consumers do not make purchase decisions on a purely TCO basis. Rather, purchase price, running cost, powertrain, driving range, access to charging infrastructure, and less tangible factors such as an aversion or interest in new technologies, all contribute to the overall perceived utility of the vehicle, with different weightings for different consumers.

1.3 Countries in scope

New vehicle sales for the seven European countries in scope are shown in Figure 7 for 2020, with the percentage of BEV sales given in each market. These countries make up ca. 80% of total new passenger car registrations across the EU + EFTA + UK. Germany is the largest market for new passenger car registrations, with BEV sales continuing to grow rapidly, from 7% of total sales in 2020 to ca. 11% in 2021 YTD¹⁴. While The Netherlands, in terms of new car registrations, is the smallest market in this study, it has the highest percentage mix of fully electric sales, with over 20% BEVs in 2020, with the absolute number of BEV sales being higher than in Italy, Spain and Poland combined.

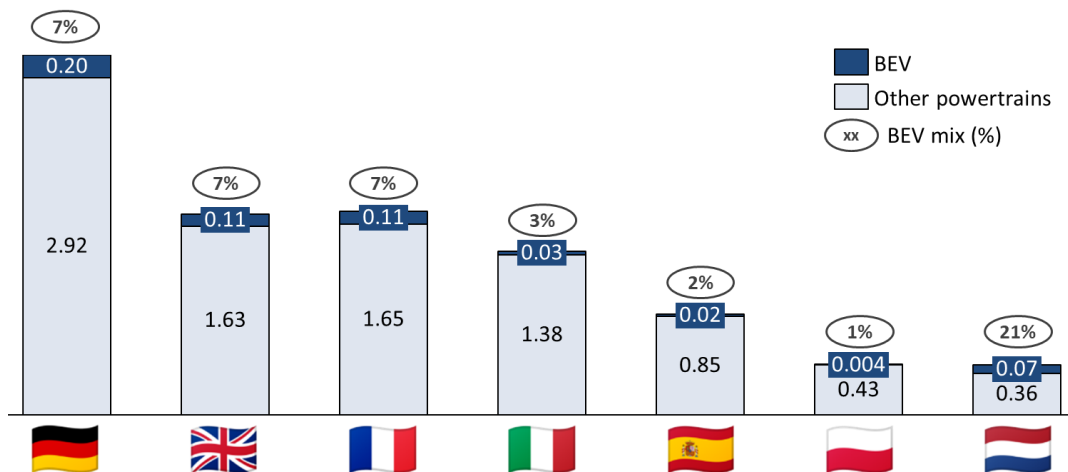


Figure 7: New vehicle registrations in 2020 (millions) for seven markets in project scope.

¹³ Element Energy for BEUC (The European Consumer Organisation) (2021), *Electric Cars: Calculating the Total Cost of Ownership for Consumers*. [Link](#)

¹⁴ [European Alternative Fuels Observatory \(EAFO\)](#) January to November 2021

1.4 Aims of this study

As policy discussions continue within Europe about the level of ambition required to achieve the targets set for new vehicle emission reductions and the mechanisms used to deliver on these targets, it is timely to assess how consumer purchasing behaviour will influence future powertrain demand. This report by Element Energy was commissioned by the Platform for Electromobility to understand how consumers make decisions and forecast the demand for different vehicle powertrains across seven European markets – Germany, UK, France, Italy, Spain, Poland, the Netherlands – which contribute to ca. 80% of European new passenger car registrations¹⁵ in 2020. Specifically, this study has:

- Developed and run a choice experiment to evaluate European consumer attitudes towards EVs. Unlike surveys that ask consumers to state their intention to buy an EV, a choice experiment measures the willingness to pay upfront for different attributes (low running costs, driving range, etc).
- Built a choice model to predict demand for different car powertrains out to 2050. Combining willingness-to-pay outputs from the choice experiment with projections of technology development enables the projection of consumer demand over the coming decades.
- Developed scenarios of EV consumer demand to illustrate the effectiveness of different policy interventions, and the impact of technology improvement.

1.5 Stakeholder engagement

A series of stakeholder workshops were held throughout this project from February – November 2021, where representatives from industry, trade unions, thinktanks, consumer organisations and e-mobility associations were invited to provide feedback on the consumer survey, modelling assumptions and discuss the project findings.

1.6 Report Structure

Section 2 outlines the consumer survey design and shows the results of the consumer segmentation and purchase behaviour. Section 3 details the demand forecast for different powertrains across the seven European markets in the project scope between 2020-50, alongside the modelling assumptions. Finally, section 0 brings all these findings together with a discussion of the policy and market implications.

¹⁵ ACEA (2020) *Motor vehicle registrations in the EU, by country and per vehicle type*. EU+EFTA+UK, [Link](#)

2 Consumer survey

2.1 Survey design

At the heart of this study is a survey of new and nearly-new¹⁶ car buyers across Europe, conducted in June 2021. The survey was completed by 14,052 consumers, with ca. 2,000 respondents from each of the seven study markets. 661 EV owners, representing ca. 5% of the sample, responded to the survey. The survey and choice experiment design represent an evolution on surveys used successfully by Element Energy in similar studies in the UK in 2011, 2015, and 2018. The market research consultancy Accent¹⁷ hosted and administered the survey on behalf of Element Energy and the Platform for Electromobility.

The survey included a choice experiment where respondents were presented with a series of hypothetical ICE, plug-in hybrid and battery electric cars, and were asked to choose their preferred option. By asking multiple questions and systematically rotating the attributes used to describe the vehicles, it is possible to build a statistical model of how survey respondents trade-off different attributes against each other: for example, do respondents value savings upfront more or less than annual running cost savings, and how much are consumers willing to pay for additional BEV driving range. A brief explanation of the theory behind choice modelling can be found in appendix 5.1. Survey respondents were each shown eight choice sets, like the example set shown in Figure 8, resulting in a total of 112,416 choice responses across the whole seven market sample.

	Petrol/ diesel car (A)	Plug-in hybrid electric car (B)	Battery electric vehicle (C)
Purchase price ¹	£10,000	£13,000	£13,000
Annual running cost ¹	£500 per year	£2,000 per year	£1,000 per year
Official driving range ¹	400 miles	20 miles in electric mode, 400 miles using petrol/diesel engine	300 miles
Access to private home charging ¹	Not applicable	No	No
Local and destination charge point coverage ¹	Not applicable	On residential streets ¹ and at driving destinations ¹	On residential streets ¹
Location of rapid charge points ¹	Not applicable	Not applicable	Within urban areas
Rapid charge point rate ¹	Not applicable	Not applicable	80 miles

If you could choose any of the three cars, which one would you choose?

Option A

Option B

Option C

Figure 8: An example of the choice sets presented to survey respondents.

Not all vehicle attributes are considered material to the purchase behaviour of consumers, and some attributes are not relevant to the powertrain choice. For example, the colour of the car will likely impact a purchase decision, but it is not related to the powertrain so is not relevant to this study. In this study the vehicle attributes investigated were upfront cost, annual running cost, all-electric driving range, access to home charging, access to slow public charging, access to rapid public charging, and the rate of rapid public charging expressed in range added in a 10- minute charge.

The attributes investigated in the choice experiment were included based on an analysis of similar studies (see appendix 5.2 for further details), previous experience by Element Energy, and discussions with stakeholders through workshops in early-2021. Of the

¹⁶ Nearly-new was defined as a car that has been registered for under 2 years. These consumers are expected to behave similarly to new car buyers.

¹⁷ <https://www.accent-mr.com/>

attributes investigated all except rapid charging rate were shown to have a material impact on consumer powertrain purchase decision.

In addition to the choice experiment the survey also included a series of attitudinal and demographic questions. Information was also gathered on respondents' current driving patterns and car ownership. These responses were used to segment consumers and provide useful qualitative insights which were used to better understand the quantitative results of the choice experiment. Attitudinal questions focused on attitudes towards owning and driving cars, attitudes towards new cars and technology, attitudes towards the environment, and prior knowledge of electric cars.

2.2 Consumer segmentation

No two consumers are alike and, when deciding what car to purchase, each individual will take account of different vehicle attributes before making a decision. Despite no two consumers behaving exactly alike, commonalities in behaviour can be identified across large groups of consumers, meaning that the variability in behaviour seen across the population can be described using only a handful of consumer segments. As such the purchase behaviour of new car buyers across seven European markets can be modelled using just a few consumer segments, rather than having to consider every new car buyer individually.

Table 1 summarises the consumer segments that were identified from the survey responses gathered during this study. From the 14,052 consumers surveyed, six distinct consumer segments were identified using k-means and hierarchical clustering algorithms on consumers' annual mileage, country, income, commuting pattern, experience of electric cars, and stated attitudes towards the environment, car usage, electric vehicles, and new cars and technology in general. Classification of consumers into *Enthusiast*, *Pragmatist*, and *Potential Rejector* consumer types was based on the observed purchase behaviour when shown theoretical showrooms of new cars in the near-term, which is discussed in more detail in section 2.3.

For each of the consumer segments identified, an EV was the preferred powertrain choice if all else is equal¹⁸, indicating that consumers have embraced the transition to electrified mobility. Survey respondents were not explicitly asked to state their preferred powertrain, rather this preference for EVs was determined through quantitative analysis of respondents' behaviour in the survey choice experiment. Compared to previous studies of new car buyers in the UK, the share of consumers exhibiting a preference for EVs has increased substantially. Figure 9 shows the first-choice powertrain for new car buyers in the UK across three similar studies conducted by Element Energy over the past decade. Since 2011 there has been a profound change in the preferences of consumers, shifting from the dominant powertrain of choice being an ICE vehicle to a mix of PHEV and BEVs. Indeed, no consumer segments identified in the 2021 study preferred an ICE vehicle as their first-choice powertrain, indicating that this profound shift towards EVs is prevalent across Europe.

From these studies it is difficult to identify the root causes of this change in powertrain preference, but it has been documented in academic research that negative biases against new powertrain technologies tend to reduce as the technology becomes more common¹⁹.

¹⁸ Running cost and upfront purchase price are equal, consumer has access to all charging types, PHEV range is 80 km, BEV range is 500km.

¹⁹ Axsen *et al.*, (2009), *Combining stated and revealed choice research to simulate the neighbor effect: The case of hybrid-electric vehicles*, Resource and Energy Economics, 31(3), pp. 221–238. doi:[10.1016/j.reseneeco.2009.02.001](https://doi.org/10.1016/j.reseneeco.2009.02.001).

Though this may explain why a negative bias against EVs is no longer observed, it does not explain why a positive bias *towards* EVs is observed in this 2021 survey of new car buyers. Further research would be required to say with any certainty what is causing this EV preference, but it is likely that announced policies such as ICE bans and EV targets, shifts in OEM advertising towards EVs, and increasing consumer concerns around environmental issues are all contributing factors.

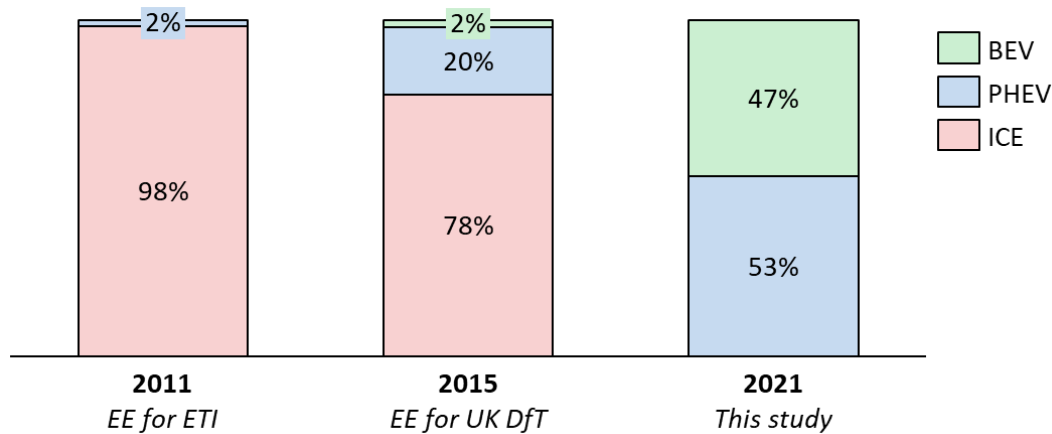


Figure 9: First-choice powertrain if all else is equal for consumers in the UK, 2011-2021^{20,21}. In each study between 2,002 – 2,700 consumers in the UK were surveyed.

BEVs are the first-choice powertrain for both *Enthusiast* and *Pragmatist* type consumers. For the two *Potential Rejector* consumer groups, PHEVs are their first preference; however, the two groups appear to prefer them for different reasons. *Uninterested Rejectors* appear dismissive of BEVs as they are not as concerned about the environment as other consumer groups. While they do not particularly value the environmental credentials of BEVs, they readily adopt BEVs once they become the cheapest option. *Unmet Needs* on the other hand have very positive stated attitudes towards the environment and EVs, however this is not reflected in their observed decision-making behaviour. Despite being presented with choice sets including cost competitive BEVs, they still chose a PHEV or ICE vehicle, indicating that they did not *believe* that BEVs will become cost competitive. This is the principal difference between this group and the otherwise similar *Cost Conscious Greens*. Though both consumer groups are cost constrained due to relatively low incomes, *Unmet Needs* appear to have a much higher reliance on their cars, reflected in their stated attitudes and high annual mileage, and this is likely the cause of the differences in behaviour between the two groups. The resistance to BEVs demonstrated by *Unmet Needs* will likely reduce as cheap BEVs become more common.

²⁰ Element Energy for Energy Technologies Institute (2011), *Consumer based uptake usage model*.

²¹ Element Energy for UK Department for Transport (2015), *Survey of consumer attitudes to plug-in vehicles*.

Table 1: Consumer segmentation of private new car buyers identified from survey of 14,052 new car buyers across Germany, UK, France, Italy, Spain, Poland, and Netherlands in June 2021. All consumer segments declared a similar share of urban vs rural driving, with a very slight skew towards urban driving.

	Enthusiasts		Pragmatists		Potential Rejectors	
	Trailblazers	Wealthy Adopters	Environmentalists	Cost Conscious Greens	Uninterested Rejectors	Unmet Needs
Relative income	High	Highest	High	Lowest	Medium	Low
Employment	Lowest (30%), high share of retired (40%)	High (80%)	High (80%)	Medium (50%)	Medium (60%), large share (25%) retired	High (70%)
Average age	56	43	40	41	47	36
Gender	High male skew	Slight male skew	50/50	High female skew	Slight female skew	High female skew
Parking type	47% private 70% off-street	56% private 79% off-street	64% private 81% off-street	53% private 72% off-street	61% private 80% off-street	59% private 76% off-street
Driving patterns	Average annual mileage 70% <u>never</u> commute by car	Average annual mileage 85% commute <u>>2x</u> a week by car	Very high annual mileage 80% commute <u>>2x</u> a week by car	Average annual mileage 60% commute <u>>2x</u> a week by car	Average annual mileage 40% commute <u>>2x</u> a week by car	Very high annual mileage 75% commute <u>>2x</u> a week by car
Attitude towards environment	Environmentally conscious	Environmentally conscious	Most environmentally conscious	Environmentally conscious	Relatively negative attitude towards environment	Very environmentally conscious
Attitude towards EVs	Embrace EVs	Neutral attitude towards EVs	Neutral attitude towards EVs	Slightly hesitant towards EVs	Hesitant towards EVs	Hesitant towards EVs; concerns around cost
Attitude towards new cars and tech	Uninterested	Very interested	Very interested	Neutral	Very uninterested	Interested
2021 powertrain preference²²	BEV > PHEV > ICE	BEV > PHEV > ICE	BEV > PHEV > ICE	BEV > PHEV > ICE	PHEV > ICE > BEV	PHEV > ICE > BEV
EV awareness	3% own EV, 63% considered buying EV	6% own EV, 71% considered buying EV	9% own EV, 71% considered buying EV	3% own EV, 66% considered buying EV	3% own EV, 53% considered buying EV	4% own EV, 69% considered buying EV
Global share	12%	27%	14%	20%	20%	7%

²² If all else is equal – running cost and upfront purchase price are equal, consumer has access to all charging types, PHEV range is 80 km, BEV range is 500km.

The share of each consumer group within the seven European markets studied varies at a national level, as detailed in Figure 10. Though each consumer segment is present in every market, indicating that there is no fundamental difference between consumers in different countries, the relative share of each segment varies greatly.

Unsurprisingly there is a high share of *Trailblazers* in the Netherlands, which is almost certainly related to the high share of EV sales to date. *Uninterested Rejectors*, the largest consumer segment in the three biggest markets (Germany, UK, France), display one of the lowest uptakes of EVs when presented with a realistic showroom of cars. This might explain why uptake of BEVs remains relatively low despite substantial TCO savings relative to ICE vehicles; for example, typical private first owners in France who choose a BEV over a Petrol ICE save ca. €7,000 over their ownership period (or €5,500 if comparing to a Diesel ICE)²³.

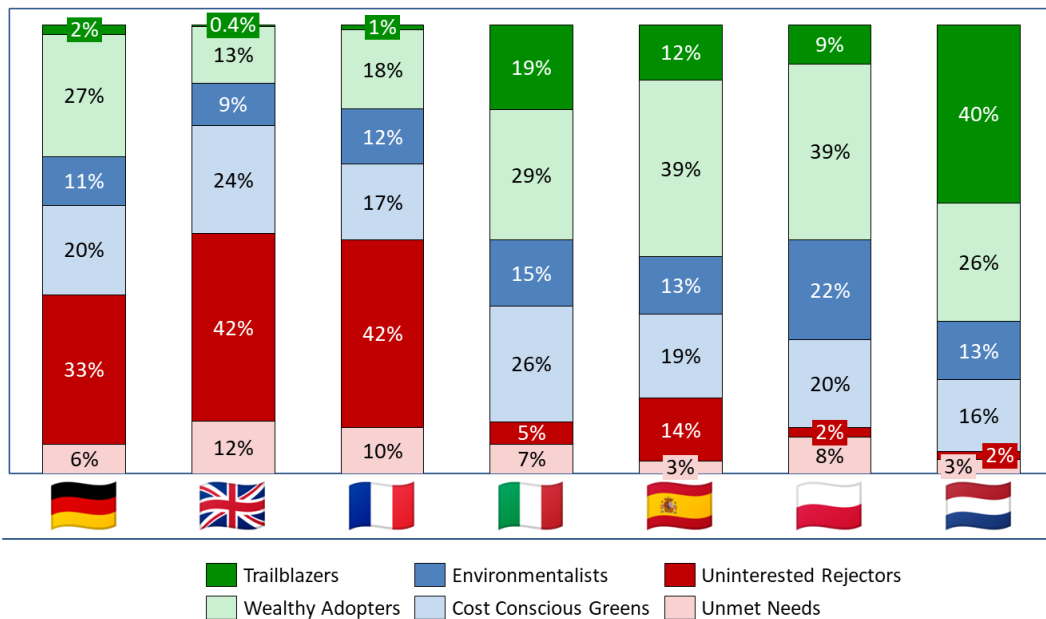


Figure 10: Share of private consumers within each of the seven markets studied. Each consumer segment is represented in every market, though the relative proportions vary substantially between countries

Whilst private consumers are the focus of this study, company car buyers represent a significant share of the market and so are accounted for in the modelling work. In the segmentation outlined in Figure 11, company cars are split into *User Choosers* and *Non-User Choosers*, capturing the different types of decision making when purchasing a company car. *Non-User Choosers* represent purchases made by fleet managers, with purchase decisions based on a total cost of ownership (TCO) assessment, whereas *User Choosers* are principally private consumers who are purchasing a car through their company, largely to take advantage of tax benefits. *User Choosers* are assumed to behave much like private consumers, but like *Non-User Choosers* they only consider BEVs if the real-world winter driving range meets their daily mileage requirements²⁴. The national share of *Non-User Choosers* is a function of the share of survey respondents who indicated they drove a car which their company chose. All company car buyers are assumed to consider the vehicle lease cost rather than the list purchase price, and *Non-User Choosers* will only consider an EV if they have guaranteed access to overnight charging; though this

²³ Element Energy for BEUC (The European Consumer Organisation) (2021), *Electric Cars: Calculating the Total Cost of Ownership for Consumers*. [Link](#)

²⁴ Energy Technologies Institute (2016-19), *Consumers, Vehicles and Energy Integration*

requirement is gradually removed by 2035 to simulate improving provision of public charge points.

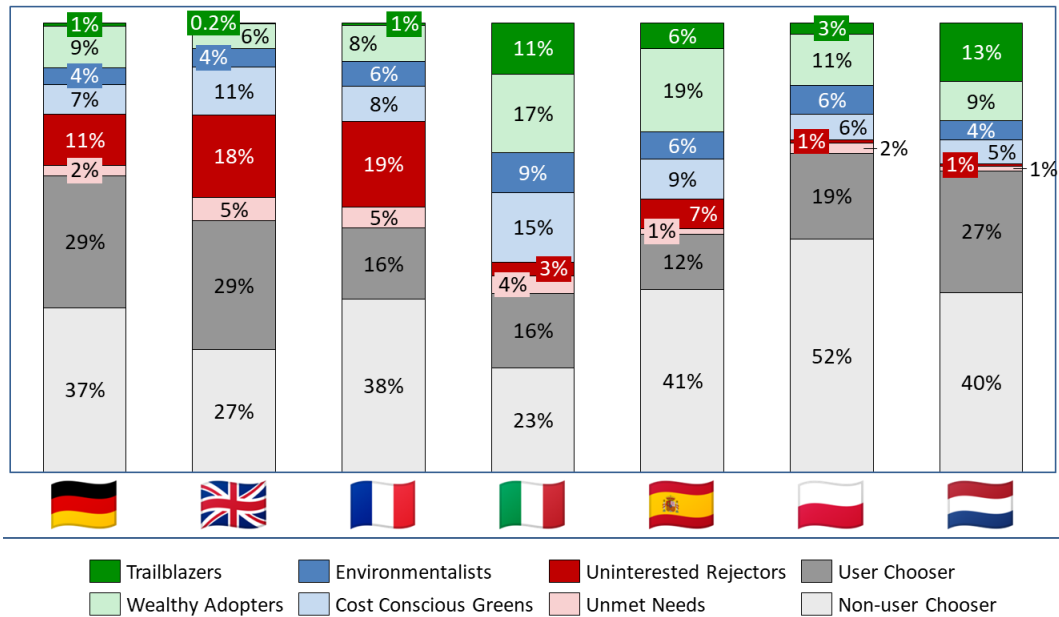


Figure 11: Company cars account for between 39 – 71% of new car registrations within the markets studied²⁵

2.3 Private consumer purchase behaviour

The results of the choice experiment conducted as part of this study shed light onto what influences the purchase decision of a new car. Specifically, as discussed in section 2.1 the choice experiment investigated the relative importance of upfront and ongoing costs and for EVs, the importance of all electric driving range and access to charging infrastructure. These attributes were identified as being of key importance through previous studies conducted by Element Energy in the UK, by an analysis of published literature, and through discussion with relevant stakeholders.

The choice model used in this study assumes that consumers decide which powertrain to purchase by comparing the utility of all the powertrains considered, choosing the vehicle with the highest utility. Each consumer group values vehicle attributes differently, with some consumers valuing annual running cost savings more than others for example. As such, if the consumer groups detailed in section 2.2 were all shown the same showroom of vehicles, different consumer groups might purchase different powertrains according to the priorities of that consumer group. This effect is detailed in Figures 12 - 14 which show the share of consumers choosing a BEV in a three-way choice between a reference ICE, PHEV, and BEV²⁶. In each figure a different attribute of the BEV is changed through a range of +/- 50% of the reference value, and the priority of each consumer is highlighted by the change in purchase decision across this range. The reference values used reflect an average medium

²⁵ Dataforce for Transport and Environment (2020), *Company Car Report*, [Link](#) – using latest data from 2019

²⁶ Reference vehicles have an upfront purchase price of €35,000 and annual running cost of €3,000. All electric driving range is 75 km for PHEVs and 450 km for BEVs. These values represent an average medium size vehicle sold in 2021, averaged across consumer segments and powertrains. BEVs and PHEVs are assumed to have access to home, slow public, and rapid public (BEV only) charging infrastructure.

size car available in 2021²⁶, though the specific values used in these charts are demonstrative only and are selected to represent realistic values consumers might see in a showroom.

Private consumer responses to changing BEV purchase price are outlined in Figure 12. Upfront purchase price is the most important attribute to all the private consumers identified, with variations in BEV upfront cost eliciting the most significant change in BEV demand of the vehicle attributes investigated. As would be expected, the lower the price of the BEV, the more consumers choose to purchase it over the alternative powertrains.

Different consumers respond at different rates to decreasing BEV prices. For example, both *Cost Conscious Greens* and *Trailblazers* show a sharp increase in BEV demand as purchase price falls. *Cost Conscious Greens* show a rapid transition between BEV avoidance and BEV demand as the upfront cost passes through purchase price parity (€35,000) with the ICE and PHEV equivalents. Given that *Cost Conscious Greens* have the second lowest income of all the consumer groups identified this suggests a high sensitivity to cost. *Trailblazers* show a similar response to decreasing purchase price, albeit with the transition from BEV avoidance to BEV demand occurring at a BEV price premium. This reflects *Trailblazers'* attraction towards BEVs and willingness to pay above and beyond the competition for BEV technology. Both *Rejector* type consumer groups show BEV demand increase only at significant purchase price discounts, reflecting their preference for PHEVs.

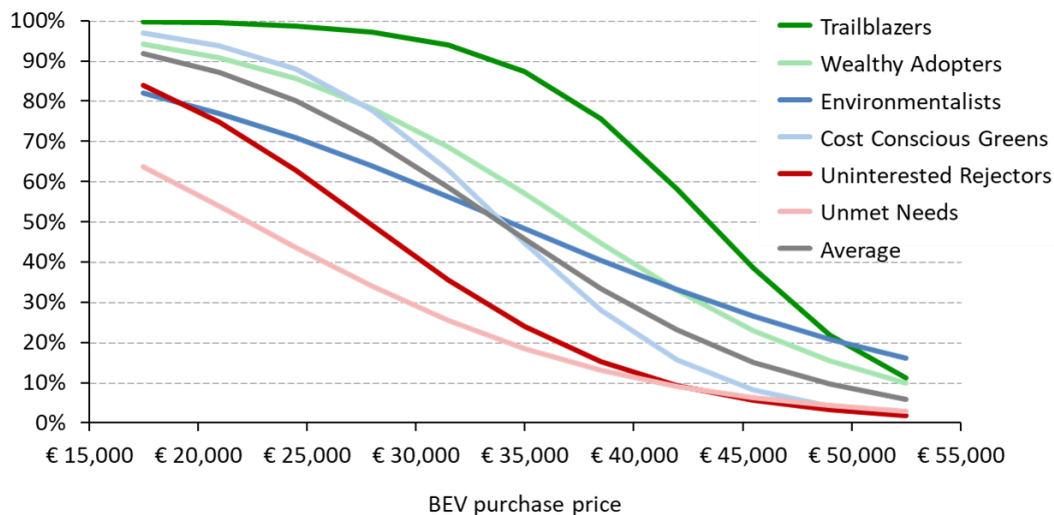


Figure 12: Share of consumers choosing to purchase a BEV at different purchase prices in a three-way choice between an ICE, PHEV, and BEV. Purchase price of ICE and PHEV kept constant at €35,000, with all other attributes kept at the reference value²⁶.

Varying BEV running cost through +/- 50% of the reference value results in a much lower change in BEV demand when compared to similar changes in upfront purchase price -see Figure 12. All consumers show higher demand for BEVs when the running costs are reduced below that of the alternative powertrains, with consumers willing to pay on average €4.2 upfront for a €1 annual running cost saving. This implies that an average private consumer is evaluating the total cost of ownership over a period of around 4 years. There is variation in consumers' willingness to pay upfront for annual savings however, with *Unmet Needs* – the consumer group with the lowest income – willing to pay only €2.6 upfront for a €1 annual saving, whereas the consumer group with the highest income, *Wealthy Adopters* are willing to pay €5.6 upfront per €1 saved in annual running costs.

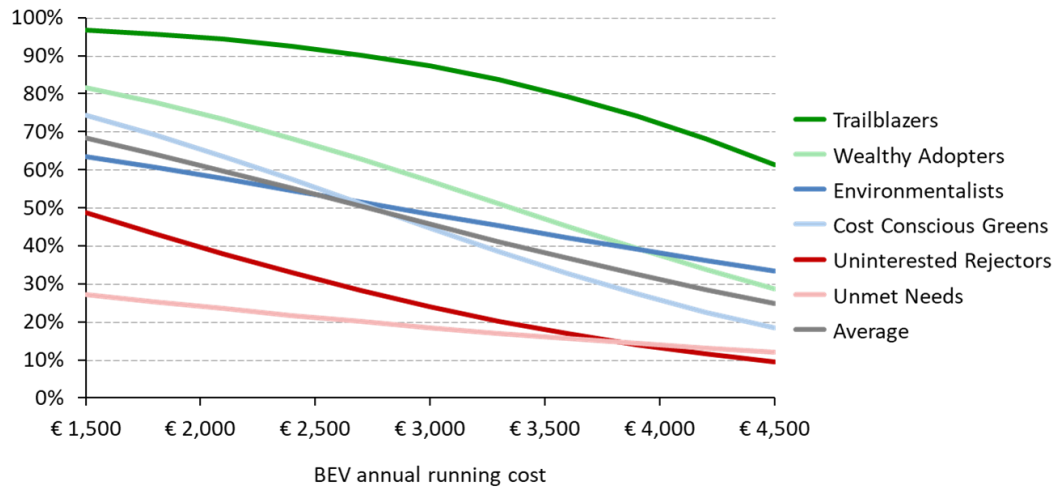


Figure 13: Share of consumers choosing to purchase a BEV with varying running cost in a three-way choice between an ICE, PHEV, and BEV. Running cost of ICE and PHEV kept constant at €3,000, with all other attributes kept at the reference value²⁶.

The variation in BEV demand observed in response to changing the BEV driving range, shown in Figure 14, indicates that most consumers are willing to pay for additional range. If the purchase price and running cost of all powertrains is equal, the range above which a majority of each consumer group would purchase a BEV is between 270 – 635 km, with the notable exception of *Unmet Needs*. *Unmet Needs* show a very low willingness to pay for additional driving range, implying that other vehicle attributes, notably upfront purchase price, are significantly more important to these consumers at the point of vehicle purchase.

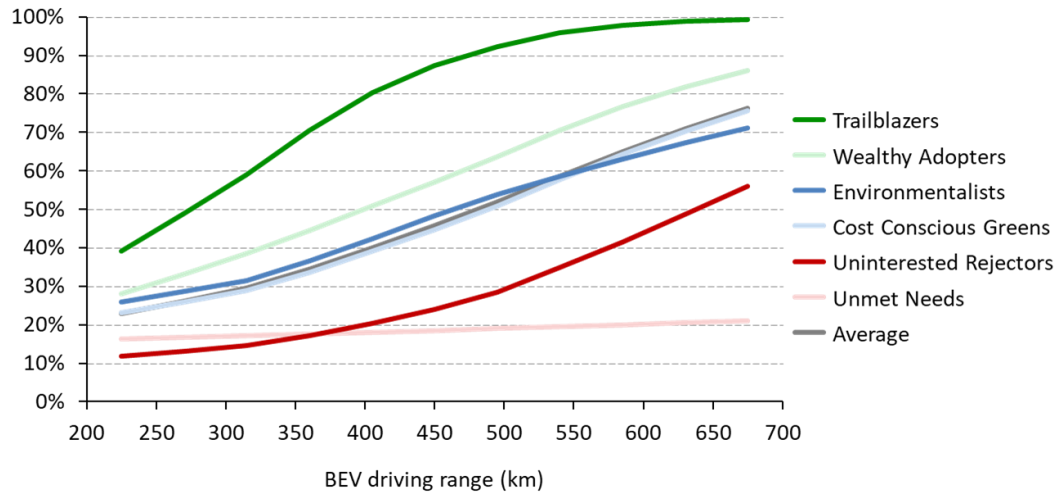


Figure 14: Share of consumers choosing to purchase a BEV with varying driving ranges in a three-way choice between an ICE, PHEV, and BEV, with all other attributes kept at the reference value²⁶.

In general, the private consumer groups identified were more willing to purchase a BEV if they had access to home charging. Figure 15 shows how consumer demand for BEVs changes with purchase price when consumers don't have access to home charging for either a BEV or PHEV.

At purchase price parity, consumers are on average 12% less likely to purchase a BEV without access to home charging. *Cost Conscious Greens*, *Unmet Needs* and *Wealthy Adopters* all show only a minor decrease in BEV demand without access to home charging, whereas *Environmentalists* show a decrease in BEV demand of 15 percentage points at

purchase price parity. Interestingly, *Uninterested Rejectors* are more willing to buy a BEV if they do not have access to home charging, because this consumer group considers access to home charging more valuable for PHEVs than for BEVs. This potentially reflects this consumer group's general preference for PHEVs, with their underlying aversion towards BEVs overwhelming the effect of BEV access to home charging.

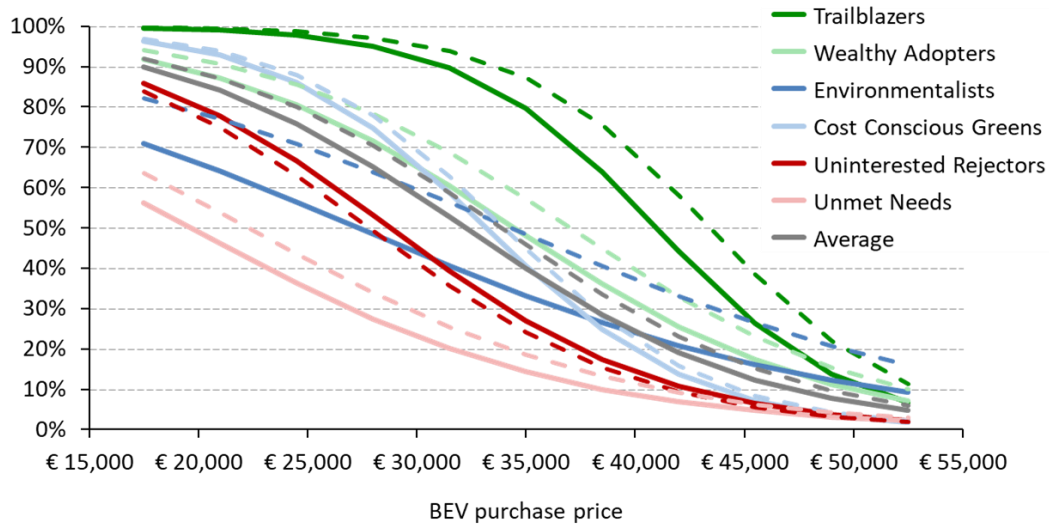


Figure 15: Share of consumers choosing to purchase a BEV without access to home charging at different purchase prices in a three-way choice between an ICE, PHEV, and BEV. Purchase price of ICE and PHEV kept constant at €35,000, with all other attributes kept at the reference value^{26,27}. BEV demand with access to home charging is shown as a dashed line.

Consumers valued public charging less than home charging, with slow public charging considered on average 50% less valuable for BEVs than home charging. For PHEVs only three consumer groups' purchase decisions were influenced by access to public charging infrastructure: *Cost Conscious Greens*, *Wealthy Adopters*, and *Trailblazers*. For access to rapid charging infrastructure, only *Cost Conscious Greens* and *Wealthy Adopters* showed any change in purchase behaviour. No consumers showed a change in purchase behaviour in response to different kW rates of rapid charging.

²⁷ Consumers don't have access to home charging for either the PHEV or BEV.

3 European EV uptake projections

Using the statistical model of consumer purchase behaviour developed using the results of the choice experiment and survey, consumers' future demand for powertrains can be projected. Element Energy's European Choice Model presents the modelled consumers with a showroom of available vehicles every year to 2050. Based on the behaviour of consumers determined by the choice experiment, sales shares of each powertrain – at a consumer, vehicle segment²⁸, and country level – can be determined. Future vehicle showrooms are determined using Element Energy's bottom-up car cost and performance model, with tax policies and grants applied to calculate the perceived upfront and annual running costs. Using historic new car sales data generously provided by ICCT²⁹ the uptake model is calibrated over a period of 10 years.

3.1 Key assumptions for baseline projections

The baseline modelled in this study assumes that EU CO₂ emissions standards for new vehicles, competition from OEMs, consumer demand, and pressure from policymakers and stakeholders continues to drive OEM investment in EVs. EV purchase prices are assumed to evolve as lithium-ion battery prices fall, tracking 2020 projections from Bloomberg New Energy Finance (BNEF)³⁰, with manufacturers assumed to achieve ICE-equivalent margins by 2030 as R&D and retooling investments are recouped. The vehicles presented to consumers in the uptake model are derived from bottom-up modelling by Element Energy last updated in Q4 2020 – further details on the modelling methodology can be found in the 2021 total cost of ownership report for BEUC³¹.

Tax policies are assumed to follow announced plans by national governments, with thresholds and rates held constant beyond the latest announcements. Vehicles are expected to continue improving in the future, so the absolute tax paid by consumers changes over time despite tax policies remaining constant. Grants in place to encourage uptake of zero-emission and ultra-low emission vehicles are assumed to remain in place until either the stated budget is exceeded, or policy end dates are reached.

Access to home charging is taken from the consumer survey results presented in section 2, with access of consumers with shared off-street parking tied to the rate of new-builds and renovations. Perceived access to slow public charging infrastructure increases over time, based on discussions with stakeholders. Perceived access to rapid charging in each country is based on survey respondents' stated requirement of highway charge point frequency to feel comfortable taking long journeys in a BEV, and the current density of rapid charge points on the TEN-T network³². The impact of increased charging infrastructure deployment is explored in section 3.3.3.

²⁸ Small, medium, large vehicle segmentation was used.

²⁹ ICCT (2020), *European Vehicle Market Statistics 2020/21*, [Link](#)

³⁰ 2021 BNEF battery price projections were not available when this study was prepared. The latest projections indicate a slowing of price reductions in 2021 due to increased raw material prices, with nominal 2022 prices expected to increase slightly. BNEF expect average lithium-ion pack prices to fall below \$100/kWh by 2024, two years later than expected in the 2020 survey. This could delay the BEV uptake presented here in the short-term, but it is not expected to impact the long-term trends. Battery prices will continue to fall as manufacturers increase production and competition drives investment.

³¹ Element Energy for BEUC (The European Consumer Organisation) (2021), *Electric Cars: Calculating the Total Cost of Ownership for Consumers*. [Link](#)

³² Transport and Environment (2020), *Recharge EU: how many charge points will Europe and its Member States need in the 2020s*. [Link](#)

3.2 Baseline results

In this Section, new car demand under baseline assumptions is forecast between 2020-50 for each powertrain, which includes an extended discussion of the country-by-country differences regarding the estimated future demand for BEVs across the seven European markets in scope.

3.2.1 Europe level uptake

Figure 16 shows the new car demand forecast for different powertrains under baseline assumptions, which have been discussed in Section 3.1, between 2020-50. Consumer demand for BEVs, which was ca. 5% of total demand in 2020, is forecast to become greater than that of any other powertrain by 2025, with demand for new BEVs expected to reach ca. 50% and 70% by 2030 and 2040 respectively. This shift in consumer demand is expected to occur rapidly, with BEVs becoming the 'normal' powertrain choice within the next decade. From 2027 no powertrain other than BEVs is expected to hold more than 20% of the market, with non-ZEV powertrains continuing to lose market share to BEVs out to 2050. These results refute the idea that European new car buyers do not want to buy BEVs, and demonstrate that if the price is right, BEVs will be naturally adopted by the vast majority of consumers.

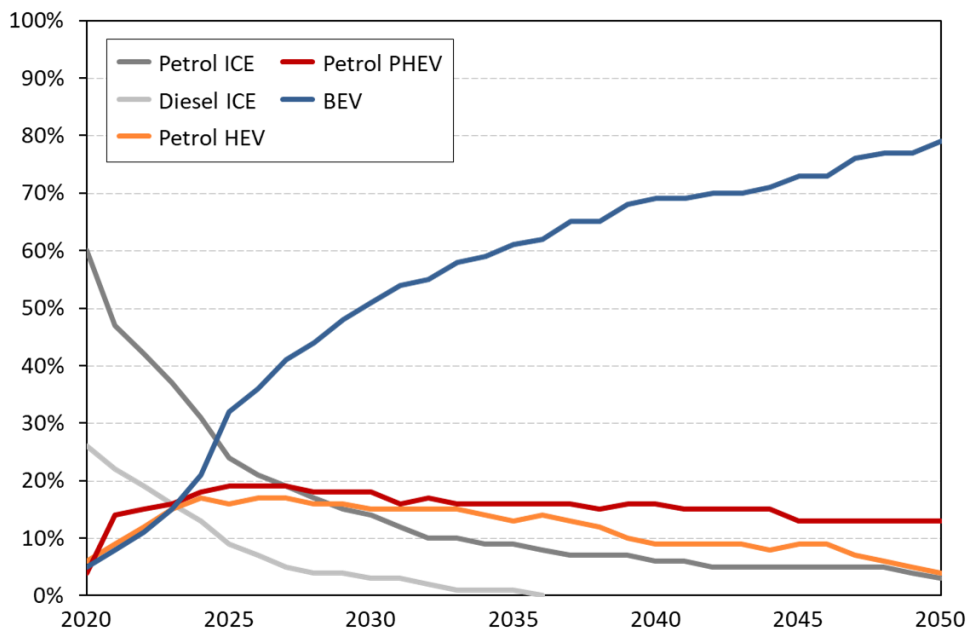


Figure 16: Combined share of consumer powertrain demand between 2020-50 for the seven markets studied (ca. 80% total EU + EFTA + UK car registrations)

As shown in section 2.3, upfront cost is the most significant driver of consumer purchase decisions. The price of lithium-ion batteries, the most expensive single component of a BEV, has fallen over the past decade, with the price of EV batteries in 2020 89% lower than they were in 2010³³. This downward trend is expected to continue, leading to a fundamental shift in the new car market. Bloomberg New Energy Finance projects that between 2020-2030 battery prices will decrease by 58%³⁴, enabling the production of cheap mass market vehicles which will directly compete with legacy powertrains. Although car OEMs are likely to retain a significant proportion of battery cost savings to recoup R&D costs and finance the retooling of manufacturing plants, lower battery prices and increased vehicle efficiency

³³ BloombergNEF (2020), *Electric Vehicle Outlook and Lithium-ion Battery Price Survey*

³⁴ Ibid.

will enable BEVs with longer ranges and competitive price points to be brought to market. Additional cost reductions will be unlocked by the growing prevalence of mainstream, lower specification models over the next few years, which will continue to drive down costs for new car buyers. New 2021 models, such as the Dacia Spring (with a WLTP range of 200km), offer very competitive upfront costs and cater for a mass market that buys smaller and cheaper vehicles. The introduction of Euro 7 requirements will also lead to moderate purchase price increases for ICE vehicles³⁵, further improving the business case for BEVs.

While short term growth in BEV demand is a result of purchase prices falling, growth from the 2030s onwards is driven by the removal from sale of poorly selling combustion engine powertrains by OEMs³⁶. Consumer demand for ICE vehicles is forecast to decline sharply between 2022 and 2030, with demand for Diesel ICEs reaching close to 0% in each of the seven focus markets after 2030. A small demand for Petrol ICEs persists in all markets except in the Netherlands after 2035, and remains at a low level across Germany, France, Spain, and Poland in 2050. Though this demand persists, as shown in Figure 18 it is driven by hesitancy towards EVs observed in *Potential Rejector* consumer groups today, rather than by cost. It is unknown how consumer preferences will evolve over time, however given the observed trend in consumer preference towards EVs in the UK over the past decade, it is likely that hesitancy towards BEVs amongst *Potential Rejector* consumers will be much lower by 2030. This could result in demand for Petrol ICEs collapsing further than shown in Figure 16.

Petrol hybrid electric vehicle (HEV) demand is forecast to peak in 2024 and to fall back below 10% by 2040. Though running cost savings give HEVs an advantage over ICEs, they cannot compete against BEVs, losing market share year-on-year towards BEVs. As with ICEs, demand for HEVs is driven by *Potential Rejector* consumers who show a bias against BEVs in 2021, exposing HEVs to potential shifts in consumer behaviour resulting in market collapse. Demand for HEVs is also found amongst *Non-User Choosers* as it is assumed under the baseline scenario that they do not consider PHEVs or BEVs unless guaranteed access to overnight charging is available. This is based on the share of new car buyers who have access to private off-street parking, which is around 59% across the markets studied. The requirement for guaranteed overnight charging is slowly removed by 2035, to represent growing confidence in the public charging network, however prior to 2035 this creates a major obstacle for *Non-User Choosers* adopting EVs, despite the significant cost savings they represent. Both PHEVs and BEVs experience growth in this consumer segment to 2035 driven by unlocking latent EV demand, but the majority share of this growth passes to BEVs.

Demand for PHEVs grows over the short term, driven by falling battery prices, before peaking in 2025 at ca. 20%. Though all the consumer groups outlined in Table 1 prefer PHEVs over ICEs, only the two *Potential Rejector* consumer groups would choose a comparable PHEV over a BEV. As such, demand for BEVs quickly outgrows increasing demand for PHEVs, with even a majority of *Uninterested Rejectors* shifting to BEVs from 2029 onwards. Only *Unmet Needs*, representing 7% of the market, choose PHEVs over BEVs in the long term. However, as discussed above the projected demand of both *Potential Rejector* consumer groups is strongly influenced by the hesitancy observed towards BEVs today. Should this hesitancy diminish as consumers become more exposed to BEVs, as has been seen over the past decade in the UK (Figure 9), demand for PHEVs amongst these consumers could collapse. PHEVs also experience strong demand from *Environmentalists*,

³⁵ Element Energy for BEUC (The European Consumer Organisation) (2021), *Electric Cars: Calculating the Total Cost of Ownership for Consumers*. [Link](#)

³⁶ Dates from which powertrains are removed from sale is a model output, assumed to occur once a powertrain has lost market share for 5 consecutive years and falls below 10% market share, tracked at the segment (small/medium/large) and country level.

with demand amongst this consumer segment rising to over 40% by 2025. This consumer group shows a significant preference towards PHEVs over ICEs today and this drives growth in PHEV demand over the short term. It is suspected this preference stems from the positive environmental marketing around PHEVs, though demand quickly shifts towards BEVs in the latter 2020s as BEV purchase prices fall.

This study has not accounted for the impacts of ICE phase-out targets announced by governments across Europe. It is not yet clear how these targets will impact the market – it is expected that these announcements will continue to increase consumer awareness of EVs and encourage investment by OEMs into BEV production, but the impacts on market demand in the run-up to phase-out dates is uncertain. Should demand for ICEs fall in the used-car market then it is likely that leasing companies will reduce their ICE offering in response to the increased depreciation of these vehicles. This could reinforce the transition to electrified mobility, though this is far from certain.

While future consumer demand does not necessarily directly lead to an equal corresponding uptake in vehicles sales, with OEM supply of BEVs increasingly the limiting factor to sales, the results of this modelling work demonstrate the inevitability of a mass transition of new vehicle sales in Europe from ICE vehicles to BEVs within the 2020s. This fundamental shift in consumer behaviour is a direct result of falling purchase prices – themselves a result of strong government targets and regulation – coupled with consumers’ desire for zero emission powertrains.

3.2.2 Country level breakdown

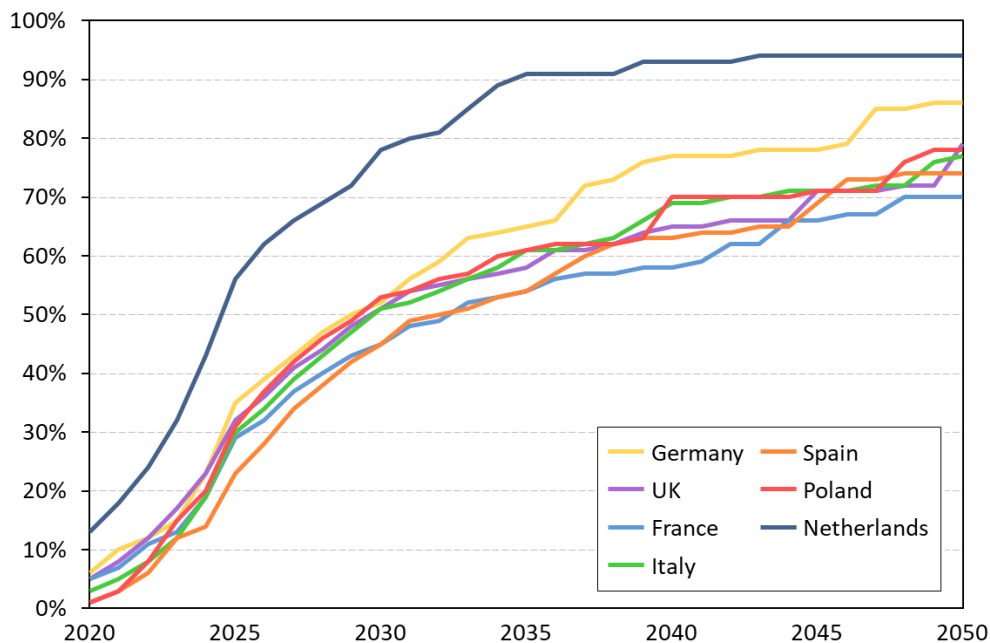


Figure 17: Consumer demand for BEVs by focus market between 2020-50.

Forecast BEV share of total new car demand is shown for the seven markets in scope in Figure 17 between 2020-50. All markets follow a similar trend, with demand for BEVs forecast to become greater than that of any other powertrain by 2025 and expected to reach between 54% and 91% of total new car demand by 2035 depending on the specific market. As discussed in section 3.2.1, short term growth is driven through BEV price reduction – stemming from falling battery prices and the entry of more mainstream, lower specification models – with longer term trends due to the withdrawal of combustion engine powertrains from the market.

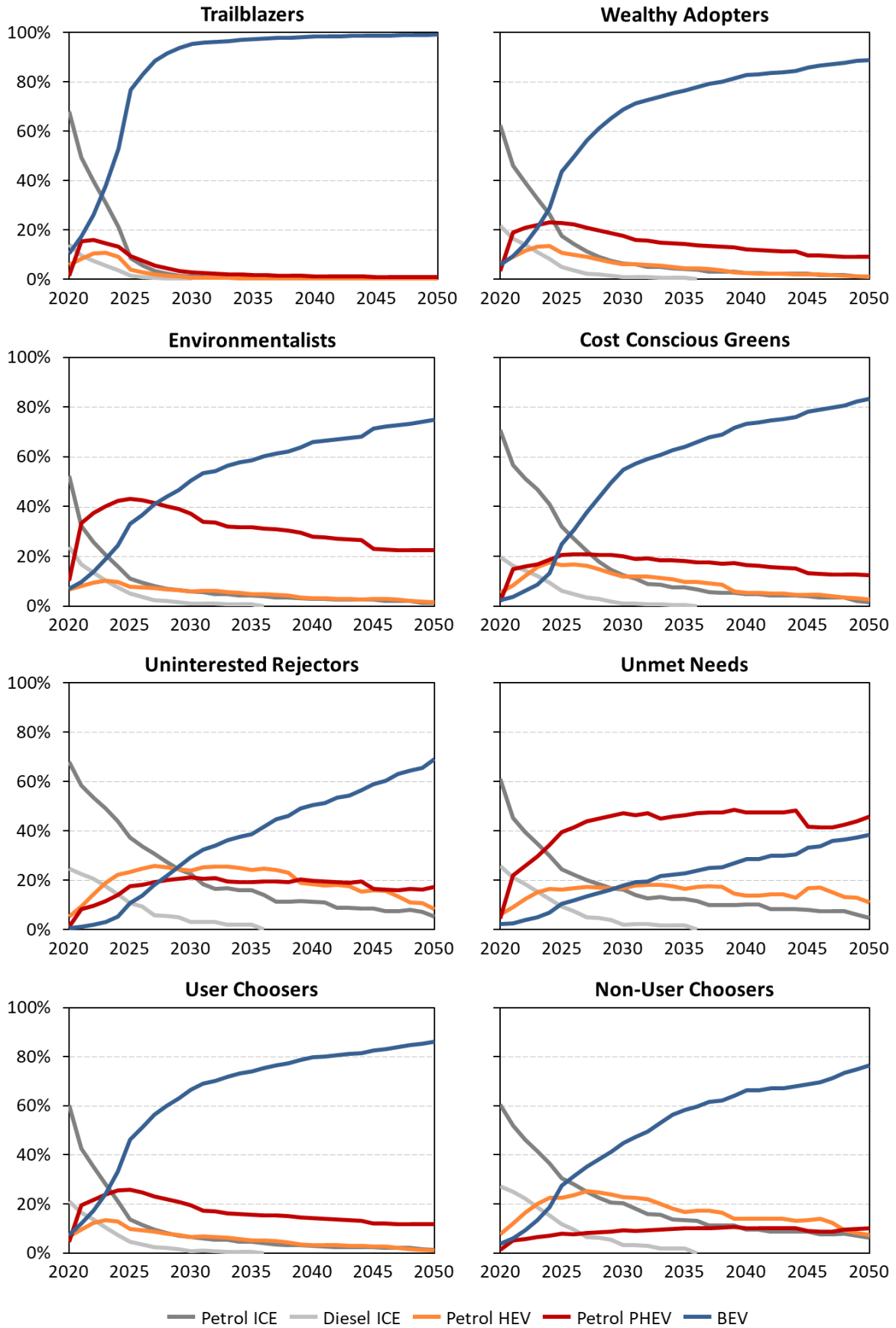


Figure 18: Baseline projections for new car demand across all 7 markets studied, broken down by consumer segment.

Germany

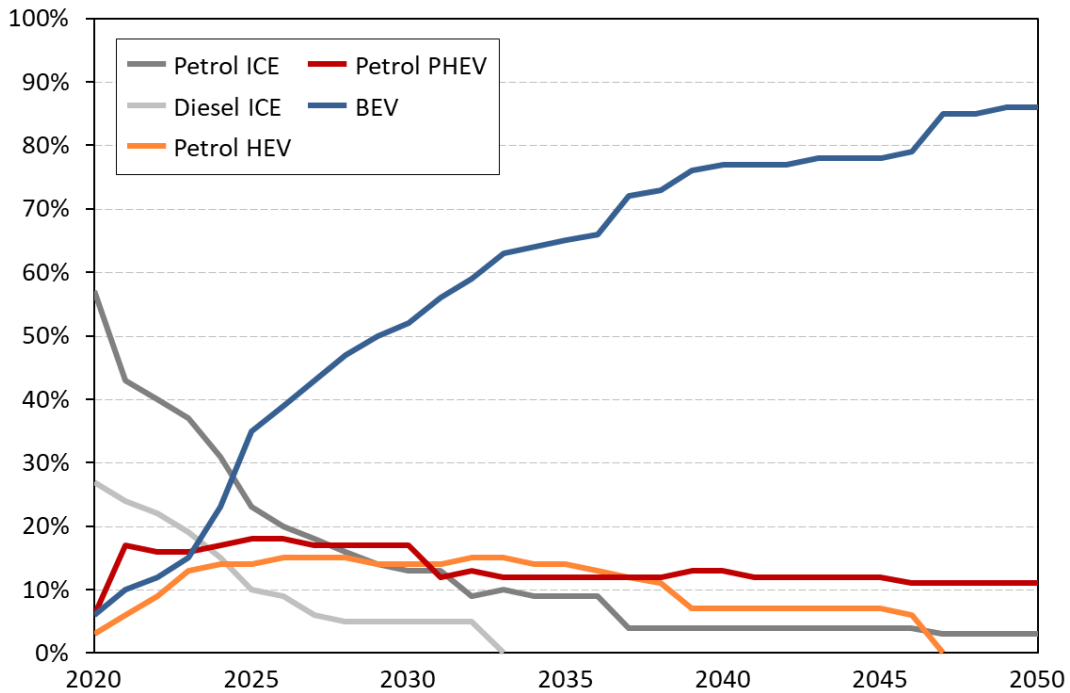


Figure 19: Germany sees strong growth in BEV demand, driven by high mileages, a large share of company cars, and the introduction of a carbon tax on fossil fuels.

Germany’s sharp growth in BEV demand is forecast to flatten slightly between 2022-24 as the new car purchase subsidies, which are currently the highest of all the seven countries considered, are modelled to exceed the budget allocated. However, long term consumer demand in Germany is the second highest out of the countries analysed in this study. This is due to a combination of different factors, including Germany having high average annual mileages (partly due to a large share – ca.66% – of new car buyers being company car drivers), which leads to a TCO advantage due to the running cost savings provided by BEVs. High domestic electricity tariffs are counteracted by increasing petrol and diesel prices due to the entry of a carbon tax of 25 €/ton in Q1 2021 (increasing petrol prices by ca. 7.5 cent/litre), which rises to 55 €/ton by 2025, increasing the running cost savings achieved by switching to BEVs.

United Kingdom

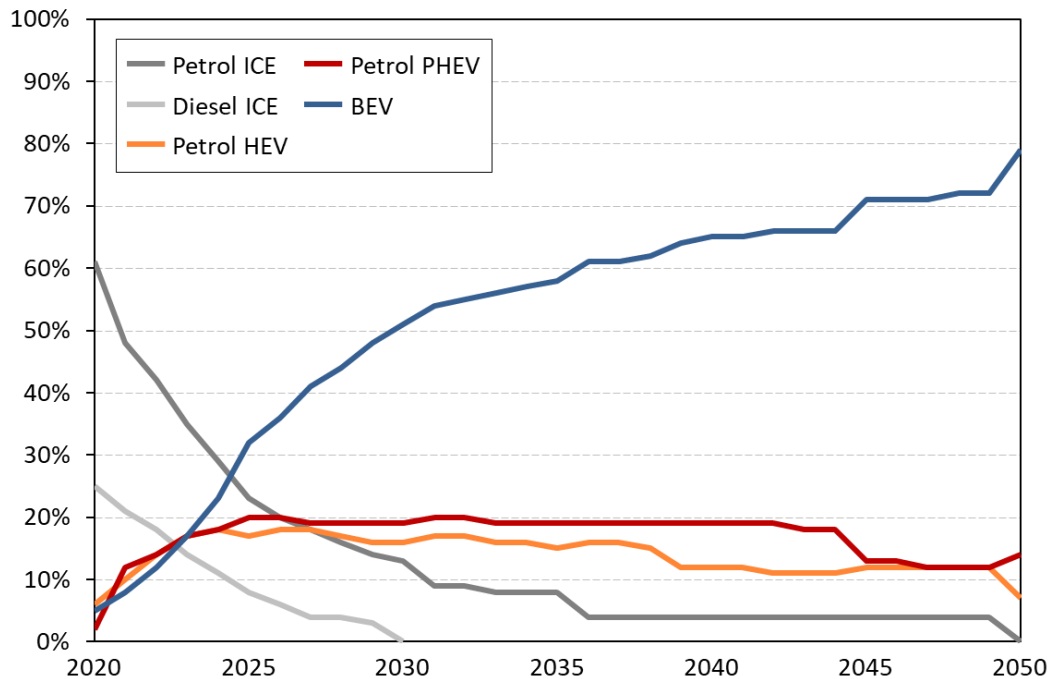


Figure 20: High rates of off-street parking and strong tax incentives drive UK demand for BEVs, though long term growth is limited by the high shares of *Potential Rejector* consumers.

The UK shows strong growth in the early 2020s despite the fairly limited grants available, due largely to a tax regime that heavily incentivises lower emission powertrains. Access to private off-street parking for new car buyers in the UK is the highest of all the markets studied, with 69% of survey respondents indicating they parked their car off-street on either a private driveway or in a private garage. Though private consumers do not assign significant value to home charging, valuing it at around €4,500, this likely contributes to the strong growth in BEV demand seen in the early 2020s. From 2030 onwards however growth in BEV demand in the UK slows relative to other markets. This is largely due to the structure of the UK private consumer segments, with the UK, like Germany and France, having a very high share of *Potential Rejector* consumers. These consumers also drive the long-term demand for PHEVs, though as discussed previously should these consumers adjust their attitudes towards BEVs as seen over the past decade in the UK, this demand for PHEVs could diminish in favour of BEVs.

The UK has a national target to phase out the sale of ICEs (including HEVs) from 2030, and of PHEVs from 2035. This policy is not included in the modelling shown here as the policy does not ‘ban’ the sale of these vehicles, and it is unclear how the policy will impact demand in the run-up to 2030.

France

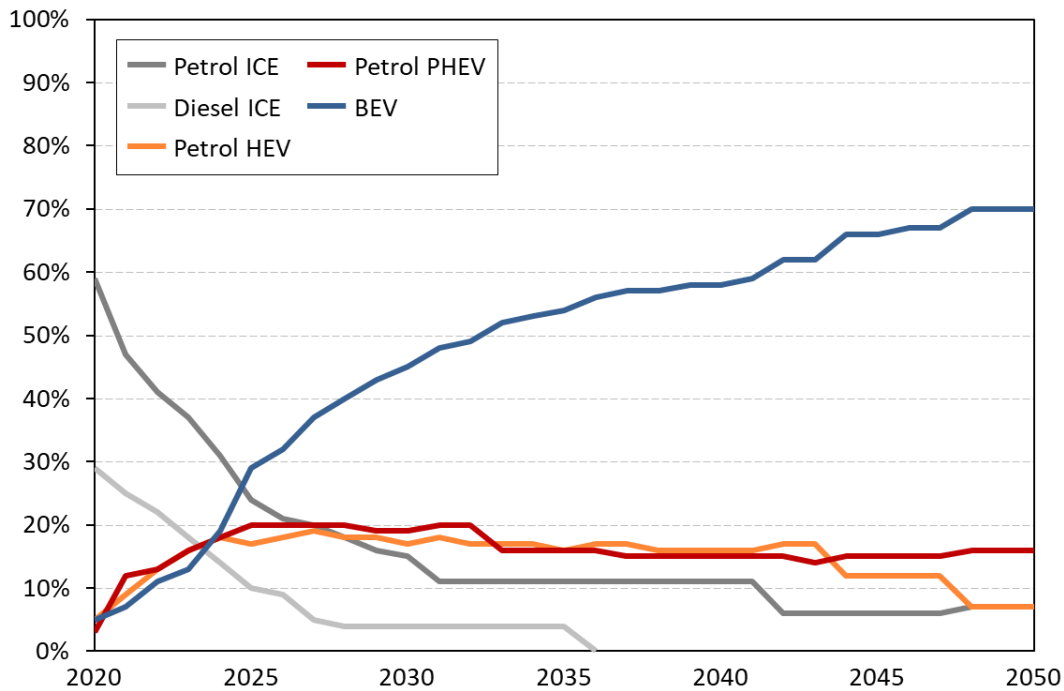


Figure 21: Generous subsidies drive growth in French BEV demand in the early 2020s, but ICE and hybrid vehicles remain in demand as tax policies do not significantly disincentivise the purchase of higher emission vehicles.

Despite relatively high BEV uptake in France in the early 2020s, which is driven partly from generous purchase subsidies available through the Bonus–Malus Scheme, with grants of up to €6,000 available at the end of 2021 for fully electric vehicles, long-term demand after 2025 is forecast to fall below other scope markets. This is a result of the company car benefit-in-kind (BIK) tax, which is applicable for ca. 54% of new registrations (see Section 3.2), not accounting for the CO₂ emissions of the vehicle, as seen in other markets such as the UK and Spain. This leads to a lower difference in the TCO between BEVs and competing powertrains for company car buyers as compared to similar markets. As such French company car buyers do not move to EVs as quickly as in other markets, as there is less economic incentive to do so. The consumer profile of France is similar to that of the UK, with both countries showing roughly equal shares of *Pragmatist* and *Potential Rejector* consumers, though France has a much higher share of *Non-User Choosers*. All else being equal, we would expect France and the UK to exhibit similar demand profiles, however, the high share of *Non-User Choosers* in France, who are particularly exposed to company car tax policies, means that France falls behind the UK in long-term BEV demand. Higher shares of small cars in France, where absolute differences in cost between powertrains is lower, also contribute to the reduced BEV demand seen.

In addition to the impacts on demand of cost and consumer preference, there are already over 5,000,000 French citizens living in a Low Emission Zone (Zone à Faible Emission, in Paris area, Lyon, and Grenoble). From January 2024, any diesel car entering these zones on a week day between 8am–8pm will receive a €68 fine. From 2030, all petrol cars will also attract a fine. A further seven Low Emission Zones are planned to open^{37,38}. It is not yet

³⁷ Official website of the City of Paris, *La Zone à faibles émissions (ZFE)*, (Updated 28/09/2021) (accessed December 2021), [Link](#)

³⁸ Official French Government website, *Les actions du gouvernement*, (accessed December 2021), [Link](#)

understood what impact this will have on consumers, but it is likely they will influence purchase decisions of consumers outside of the low emission zones, potentially resulting in the removal of diesel and Petrol ICEs from sale earlier than suggested in Figure 21.

Italy

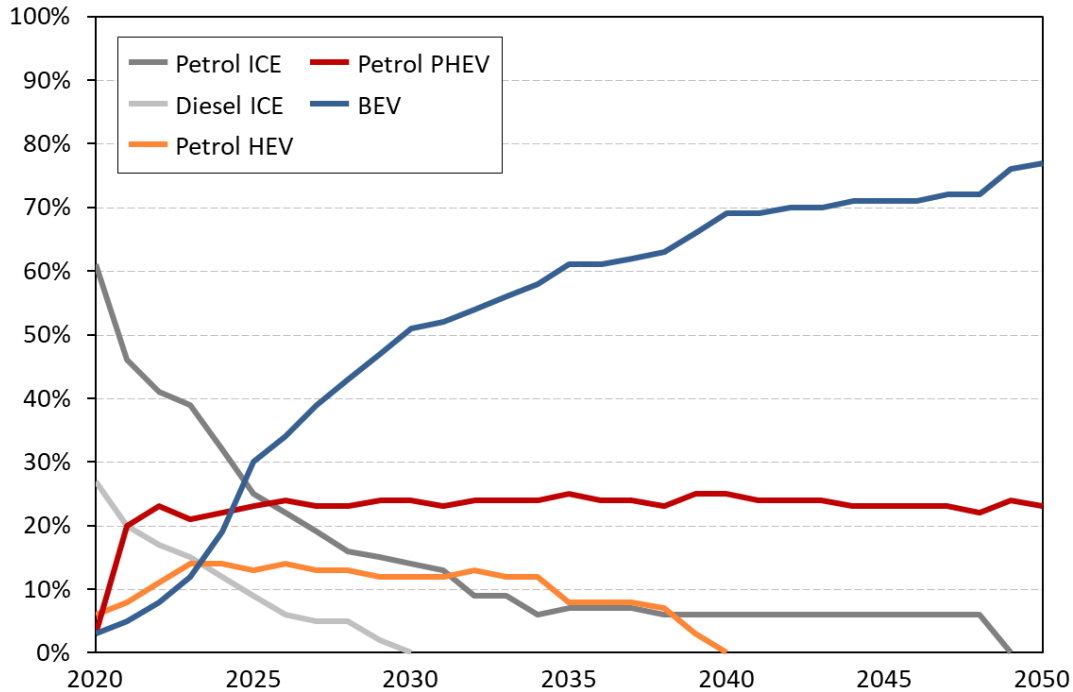


Figure 22: Lower annual mileages and a high share of private consumers delays BEV uptake in the short term, with a large *Enthusiast* segment driving long term growth

Italy has the lowest annual mileage of the markets studied^{39,40}, resulting in lower running costs relative to other markets. As such, there are less savings to be made by shifting from an ICE to an EV in the early 2020s. This reduces the short-term uptake of BEVs in Italy, with the highest growth seen in PHEVs. However, in the later 2020s as the purchase price gap between BEVs and ICEs diminishes, BEV demand jumps, reaching 50% by 2030. Markets where company cars make up a larger share of the market see earlier uptake of BEVs as *Non-User Choosers* use a TCO assessment when making a purchase decision, so running cost savings factor into the decision making process more than for private consumers. This is also the reason why PHEV demand remains at just over 20% to 2050 after climbing rapidly in the early 2020s. PHEVs do not offer significant TCO savings over other powertrains and so *Non-User Choosers* typically select BEVs and HEVs instead of PHEVs. The low share of company car buyers in Italy, and private consumers' observed preferences for PHEVs over ICEs sustains PHEV demand over the studied period. The low share of *Potential Rejector* consumers in Italy, <10% of the market, means that long-term demand consolidates around BEVs and PHEVs.

³⁹ Element Energy for BEUC (The European Consumer Organisation) (2021), *Electric Cars: Calculating the Total Cost of Ownership for Consumers*. [Link](#)

⁴⁰ Odyssee-Mure (2020), *Sectoral Profile – Transport*. [Link](#)

Spain

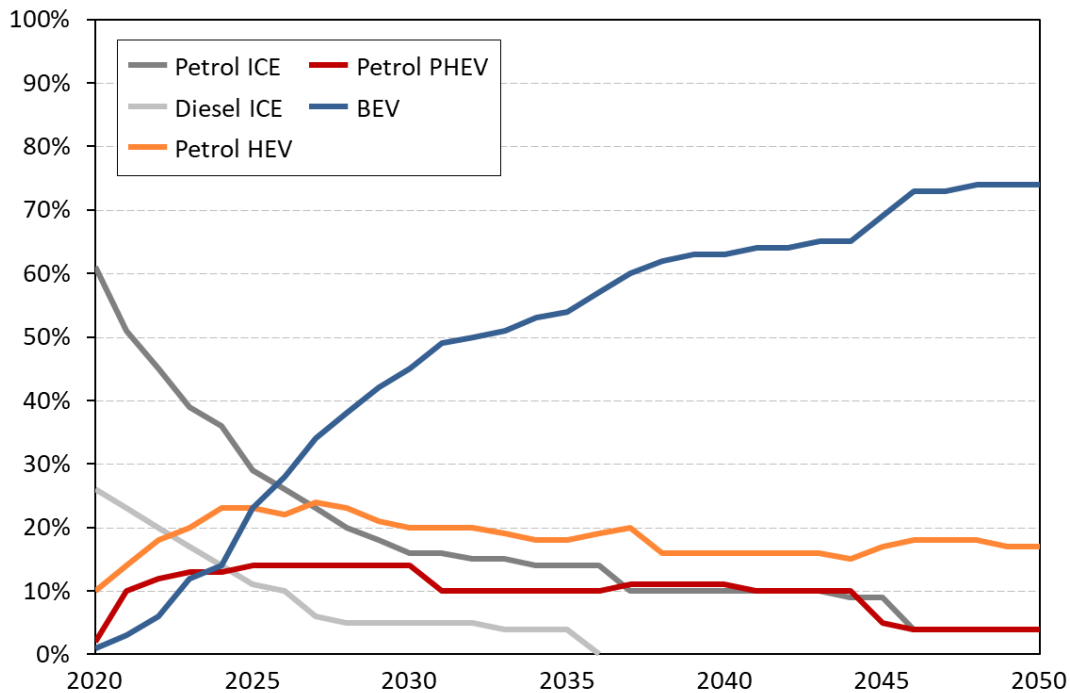


Figure 23: BEV uptake in Spain follows the expected reduction in BEV purchase prices, but limited access to private off-street parking inhibits growth and supports ca.20% demand for HEVs to 2050.

There is evidence in Spain that a lack of access to home charging is already limiting BEV uptake, with only ca. 37% new car buyers having access to private off-street parking according to the survey of new car buyers conducted as part of this study. Low access to private charging is compounded by a sparse public charging network, with Spain having one of the lowest densities of rapid charge points of the markets studied⁴¹. BEV uptake being limited by charge point provision is expected to continue through the short-term, with BEV demand in Spain only at ca. 30% in 2025, the lowest of the seven markets analysed in this research.

Figure 24 shows a sensitivity for Spain which compares a continuation of the status quo, with restricted EV charging access, to an “optimum” charging scenario where access to charge points does not negatively impact consumer decisions, due to very high availability. The difference in BEV demand between these cases is 4 percentage points in 2022, which increases to an additional 10 percentage points by 2025. This demonstrates the latent demand available in Spain, where consumers would naturally choose to buy a BEV over an alternative powertrain but are restricted due to poor charging access. There is a clear risk of heavily subsidising BEVs, with generous new car grants available in Spain, without supporting consumers with the necessary charging infrastructure.

⁴¹ Transport and Environment (2020), *Recharge EU: how many charge points will Europe and its Member States need in the 2020s*. [Link](#)

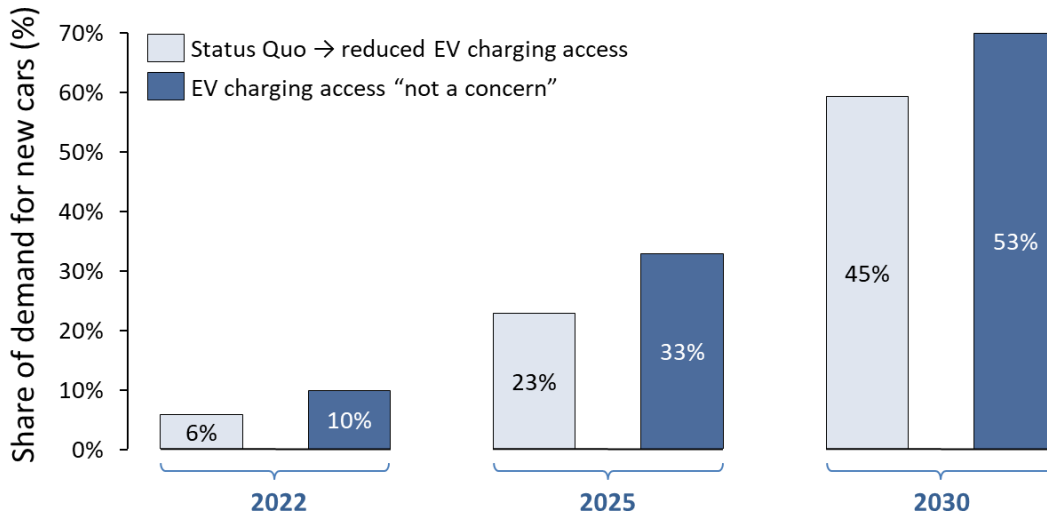


Figure 24: BEV demand in 2022, 2025 and 2030 for scenarios of (A) continued insufficient EV charging access, and (B) where EV charging access has no impact on consumer decisions.

Poland

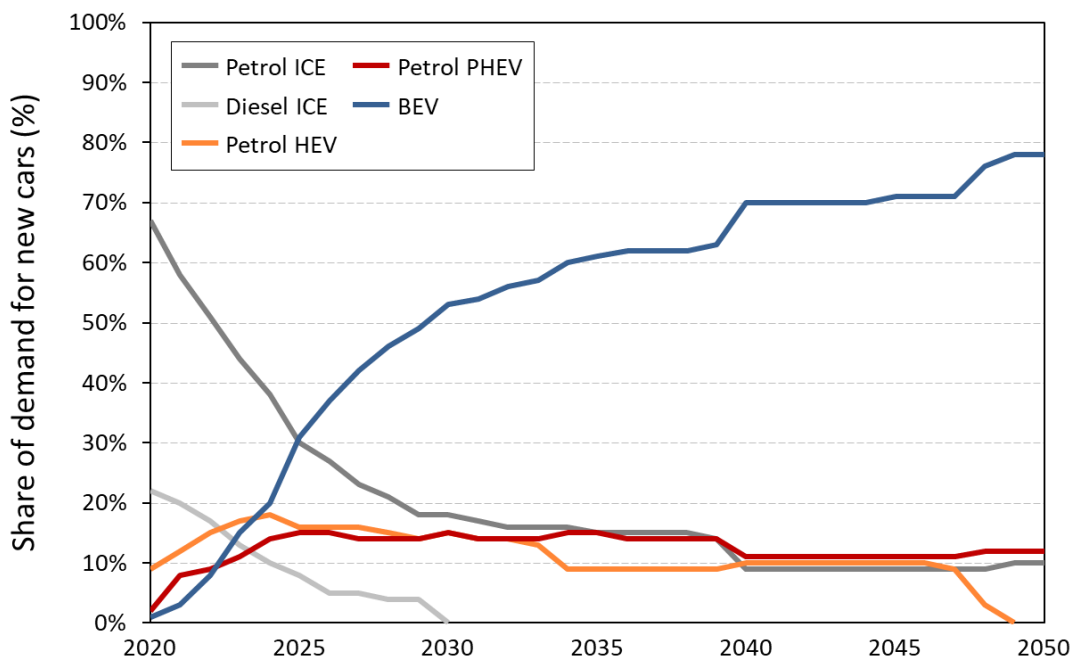


Figure 25: New purchase subsidies drive a sharp increase in demand over the early 2020s, with improving EV charging access being the key to unlocking latent demand.

New car sales in Poland differ from the other markets studied as a high proportion of the ‘new’ cars introduced to the Polish market are 2nd hand vehicles exported from other European markets⁴². For the purposes of this study, consumers were included in the survey if they were a buyer of a ‘new’ or ‘nearly new’ (less than 2 years old) car, so the behaviour captured accounts for both the buyers of both brand new and imported vehicles. BEV demand in Poland, which at 3% in 2021 was the lowest out of the markets considered in this

⁴² The ICCT (2020) - *Emerging electric passenger car markets in Europe: Can Poland lead the way?*. [Link](#)

research, is forecast to increase significantly in the 2020s. This low starting demand for EVs is due to Poland having lacked a widespread purchase EV subsidy to prior to 2021, meaning that high upfront costs have been prohibitive for all but the wealthiest consumers. The subsidy of 18,750 PLN (€4,100), increasing to 27,000 PLN (€6,000) for declared mileages over 15,000km⁴³, is forecast to help drive demand to ca. 8% in 2022 and increasing to over 31% by 2025. There is a secondary impact due to Poland having limited charging infrastructure, with the fewest rapid charge points of the markets considered⁴⁴. Though upfront purchase price is by far the most important aspect when consumers make a new car purchase decision, consumers value prior access to public charging infrastructure at between €1,000 - 2,000. As such, the expected long-term increase in charge point provision across Poland results in a steady increase in demand for BEVs.

Netherlands

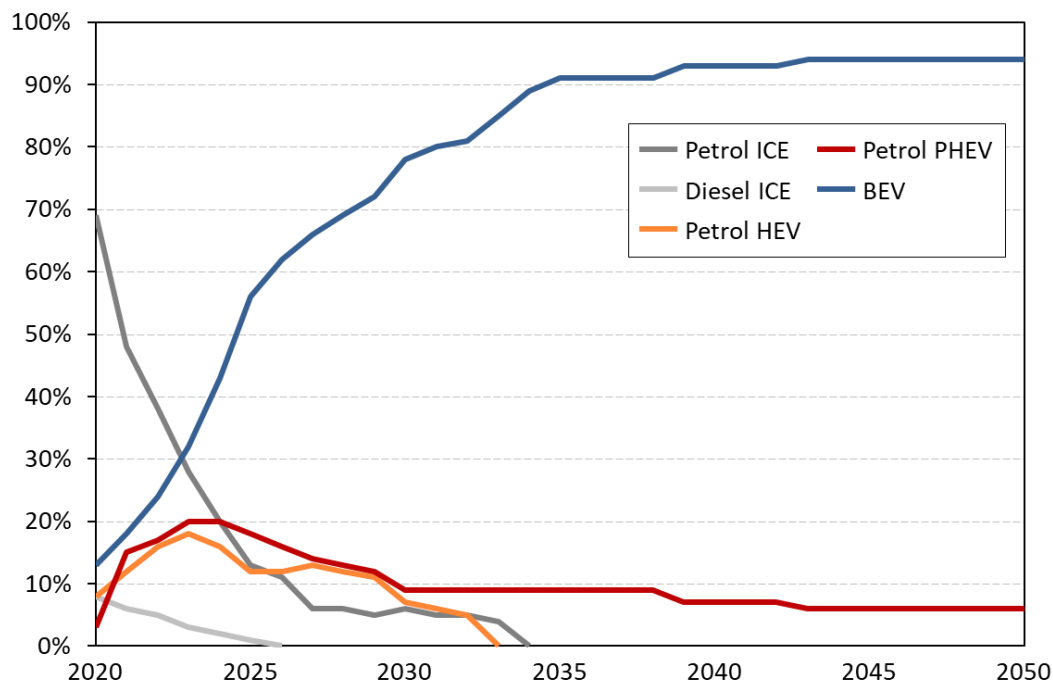


Figure 26: BEV uptake consistently higher than other European markets, with demand for ICEs forecast to drop out of the market before 2035

The Netherlands continues to have the highest share of BEV demand, driven by high registration taxes on the new sale of polluting ICEs with significant savings on the upfront costs for new car buyers that choose a BEV. This provides an example of how substantial (typically €000's), tiered CO₂-based registration taxes on new cars can have a significant impact on new buyer decision-making, who prioritise upfront costs over longer-term running costs. The Netherlands has a very high share of *Enthusiast* type consumers, with 40% of private consumers falling into the *Trailblazer* segment. As shown in Figure 18 this consumer group demonstrates rapid uptake of BEVs, as they assign significant value to BEVs and are very willing to pay for additional driving range, which is expected to increase over the next decade as battery prices fall. Furthermore, very few Dutch consumers fall into the *Potential Rejector* segments, meaning that there is a limited resistance to EV uptake amongst the consumer base.

⁴³ <https://www.gov.pl/web/elektromobilnosc/o-programie>

⁴⁴ Transport and Environment (2020), *Recharge EU: how many charge points will Europe and its Member States need in the 2020s*. [Link](#)

3.3 Sensitivity results

3.3.1 Hydrogen fuel cell electric vehicles

So far in this report discussion around the uptake of ZEVs in passenger cars has focused solely on BEVs, however there is another zero-emission powertrain which is being developed for road transport: hydrogen fuel cells. Fuel cell electric vehicle (FCEV) development has not kept pace with advancements in BEV technology with only two FCEVs – the Toyota Mirai and Hyundai Nexo – available for purchase in 2021, compared to over 50 BEVs available in Europe⁴⁵. In this regard, the market appears to have already decided which zero-emission powertrain will dominate passenger car sales over the coming decades, however it remains an open question as to whether consumers would prefer FCEVs over BEVs, should the vehicles come to market. Indeed, the latest proposed text for the EU Alternative Fuels Infrastructure Regulation⁴⁶ includes a requirement for Member States to ensure that by 2030 hydrogen refuelling stations accessible to light duty vehicles are present every 150 km on the TEN-T core and comprehensive network.

FCEVs were not included in the choice model presented to new car buyers as part of the survey for this study due to the dominance of BEV sales and OEM investment at present, but it is assumed that, aside from any new technology bias or consumer attraction to zero tailpipe emissions, consumers will perceive FCEVs in a similar light to ICEs due to the similarity of the user experience. Both PHEVs and BEVs on the other hand require a substantial change in behaviour because of slower charging (relative to ICE refuelling today) and lower driving ranges. As such, in the model FCEVs are introduced with zero consumer bias towards or against the powertrain. However, a 'hydrogen penalty' is added to account for limited availability of hydrogen refuelling stations⁴⁷, with the assumed number of refuelling stations following the FCH JU's 'Ambitious Scenario'⁴⁸ to 2040, increasing to 50% of all forecourts by 2050. This hydrogen penalty in 2025 is on average €5,200 – similar to the average consumers' willingness to pay for home charging at €4,600 – decreasing to €770 in 2040. According to Element Energy's bottom up cost modelling the price premium of a medium FCEV over a BEV decreases from €12,000 to €4,800 over the same period.

Figure 27 shows the projected demand of new cars by powertrain across the seven European markets studied if medium and large FCEVs are introduced en masse in 2025⁴⁹. FCEVs are not expected to exceed 10% market share before 2050, which is unsurprising given the anticipated price premium FCEVs will still hold over BEVs by this date – as outlined in section 2.3 purchase price is by far the most significant factor when a consumer is deciding which powertrain to purchase. It is simply not a financially viable decision to purchase a FCEV given the anticipated low costs of BEVs, with FCEVs not offering meaningful benefits to the consumer over an equivalent BEV.

The very limited projected demand for hydrogen fuel cell passenger cars reinforces what is already evidenced by the present market offering and focus of OEM investment – for passenger cars FCEVs do not offer a competitive alternative to BEVs. In light of this finding, it is difficult to recommend that policymakers invest public finances into supporting hydrogen

⁴⁵ [EV Database](#) (accessed 2 November 2021)

⁴⁶ COM (2021) 559: *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council*

⁴⁷ Greene (2001), *TAFV Alternative Fuels and Vehicles Choice Model Documentation*, ORNL/TM-2001/134, Oak Ridge National Laboratory

⁴⁸ Fuel Cells and Hydrogen 2 Joint Undertaking (2019), *Hydrogen Roadmap Europe: A Sustainable Pathway for the European Energy Transition*, doi:10.2843/341510

⁴⁹ It is assumed that small segment FCEVs will never be introduced to the market en masse

mobility for passenger cars. Support for FCEV infrastructure should instead be targeted at harder to electrify segments and duty cycles, where the faster refuelling and higher energy density of hydrogen may still offer a competitive advantage.

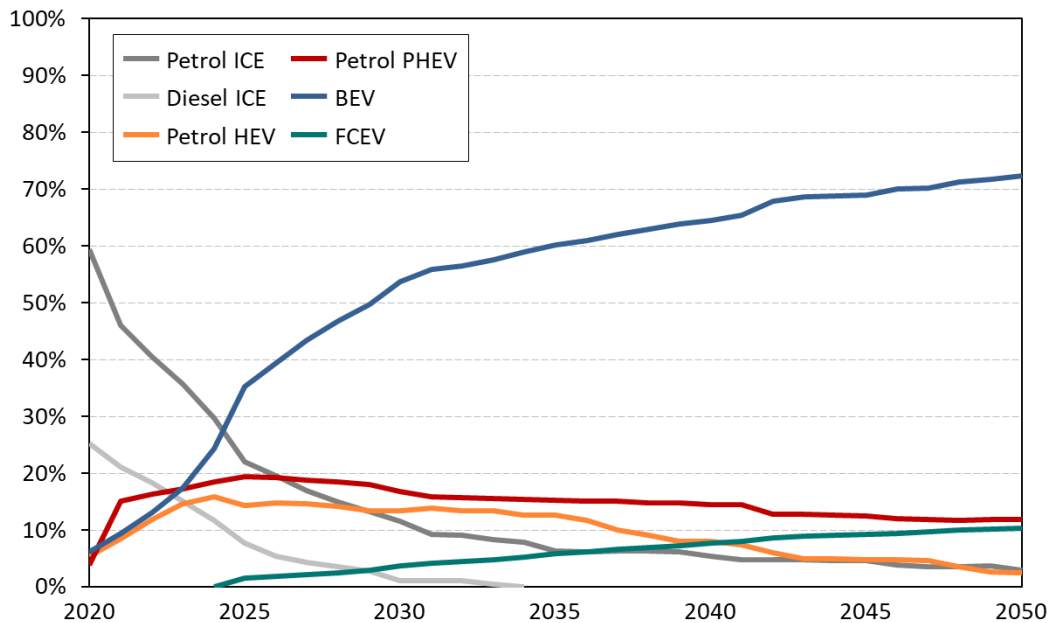


Figure 27: Projected demand for new cars across all 7 European markets studied if FCEVs are introduced from 2025 in the medium and large segments.

3.3.2 E-Fuels

The term ‘e-fuels’ covers a range of proposed carbon-neutral synthetic fuels made from renewable electricity. Hydrocarbons can be created by green hydrogen produced via electrolysis and carbon can be obtained via direct carbon capture. E-fuels covers a range of proposed fuels including synthetic methane, methanol, petrol, and diesel, that may be used to power internal combustion engines. Two different e-fuel scenarios have been modelled in this study⁵⁰:

- Middle East PV with no additional fuel duty – currently ca. 80% more expensive than petrol and does not reach price parity until 2037.
- North & Baltic Seas Wind with no additional fuel duty – this scenario is ca. 160% more expensive than petrol and does not reach price parity until after 2050.

To provide an economically viable case for consumers both scenarios would require substantial long-term government subsidies including the removal of fuel duty until e-fuels reach price parity with petrol, which is in 2037 under the most optimistic assumptions. In contrast, the significant running cost savings from the switch to BEVs would allow European governments in the long-term to reclaim lost fuel duty through additional taxation, while still providing savings for consumers. For both e-fuel scenarios there has been no increase in purchase price of the ICE vehicles to enable running on e-fuels.

Even in the most optimistic case, with Europe reliant on the Middle East for e-fuel production, on a first owner TCO basis e-fuel cost parity with petrol is not reached by 2030, which provides a very strong barrier to market entry without additional subsidies, beyond the

⁵⁰ Frontier Economics for Agora Energiewende (2018): *The Future Cost of Electricity-Base Synthetic Fuels*. [Link](#)

removal of fuel duty. Even as e-fuels approach price parity to petrol, in the most optimistic case, fully electric vehicles offer significantly better value for consumers: a BEV bought new in 2030 would save ca. 23% lifetime TCO over an ICE run on e-fuels (Middle East PV)⁵¹.

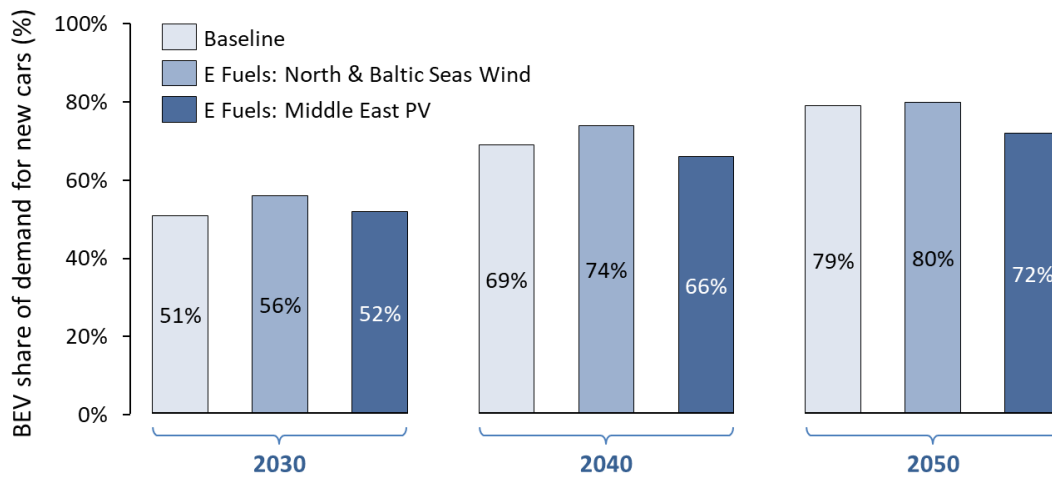


Figure 28: BEV demand in 2030, 2040 and 2050 for scenarios of (A) baseline: conventional petrol & diesel, and two e-fuel scenarios (B) North & Baltic Seas, (C) Middle East PV

Figure 28 shows the demand for BEVs in 2030, 2040 and 2050 for (A) baseline: using conventional petrol & diesel, and two e-fuels scenarios (B) North & Baltic Seas Wind and (C) Middle East PV. E-fuels are assumed to be blended into conventional fuels from 2025, reaching 100% mix by 2030.

In all scenarios, BEVs remain the “clear choice” powertrain for the vast majority of consumers. Demand for BEVs increases compared to the baseline in each year considered under the “realistic scenario” as premiums on e-fuels, despite heavy subsidies needed to remove fuel duty, make running costs higher than using conventional petrol and diesel. Under the most optimistic case where Europe imports e-fuel from the Middle East there is a small decrease in BEV demand, 3 percentage points and 6 percentage points in 2040 and 2050 respectively, with e-fuel (due to long-term subsidisation from the removal of fuel duty) providing a cheaper option than conventional fuels.

Pushing e-fuels into the market will negatively impact consumers, due to higher short term costs and heavy reliance on long-term subsidies. As shown in Figure 28, consumers overwhelmingly choose BEVs over any alternative powertrain, including ICEs running on e-fuels, with BEVs dominating demand for new vehicles from 2030 across all seven European markets considered. Rather than resisting consumer demand by heavily subsidising e-fuels, states should focus on the transition to electrified mobility, fulfilling infrastructure requirements for all consumers, and reducing lifecycle emissions across vehicle manufacturing and end-of-life.

E-fuels present a substantial risk to market equity and transport poverty as they most impact the poorest in society. The higher running costs of e-fuels would fall predominantly on poorer consumers who tend to buy used cars, and who will be reliant on ICEs whilst the second-hand BEV market matures.

⁵¹ Element Energy for BEUC (The European Consumer Organisation) (2021), *Electric Cars: Calculating the Total Cost of Ownership for Consumers*. [Link](#)

There is very limited support from car OEMs – as reported by Transport & Environment⁵², Volkswagen Group, which has the largest passenger car market share in Europe, describes how the "so-called potential of these alternatives for liquid fuels is[...] massively overestimated," as well as "complex, cost-intensive, not very climate-efficient and with low efficiency." Furthermore, e-fuels risk diverting investment away from fully decarbonized powertrains – supply chains should be supported in the transition to electrified mobility rather than investing in a technology with little future in a competitive market. It is essential that national and European regulatory focus is not distracted away from securing BEV uptake across Europe and building the necessary charging infrastructure, which is the clear path forward to reducing costs for consumers, while meeting net-zero ambitions.

3.3.3 Early charge point deployment

Access to public charging infrastructure is regularly cited as one of the main barriers to EV adoption, but as this research has shown vehicle purchase price is the primary deciding factor for consumers when considering which vehicle to purchase. Charging networks on their own do not generate demand for EVs, but a lack of charging infrastructure could hamper growth in BEV demand.

All six consumer segments identified during this study (detailed in section 2.2) showed a lower likelihood to purchase an EV if they did not have access to home charging – on average, a BEV would have to be €4,600 cheaper than the alternative for consumers without access to home charging to consider it. Fortunately, 59% of new car buyers in the markets studied have access to private off-street parking (Figure 29), meaning that the majority of new car buyers will not be reliant on public infrastructure for daily charging.

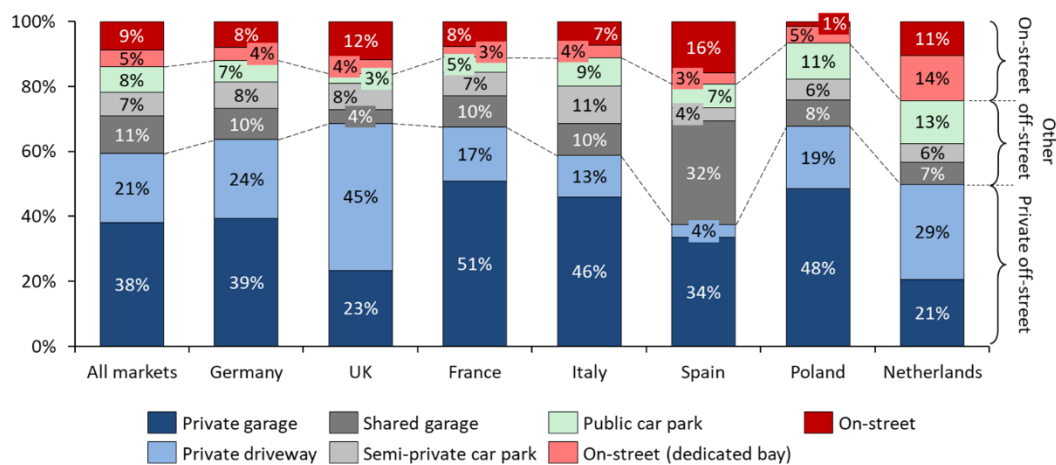


Figure 29: The location where survey respondents currently park their cars (14,052 respondents, 23,967 cars). Across all markets 85% of new car buyers have access to off-street parking, with 59% having access to private off-street parking.

Figure 30 outlines the increase in BEV demand if all consumers are assumed to have access to home and public charging by 2030 – in other words, if access to charging was no longer perceived as a barrier to EV adoption. Fundamentally, BEV demand at a European level does not increase substantially, with the increase being less than 10 percentage points in all years and the largest increase between 2030-35. Prior to 2030 demand for BEVs is limited by the purchase price premium over alternative powertrains, whereas conversely

⁵² Transport and Environment, *VW breaks with German auto industry over efuels*, [Link](#) (accessed 1 Dec 2021)

from the mid-2030s onwards the savings offered by BEVs outweigh any perceived disadvantage from not having access to either home or public charging.

However, as outlined in section 3.2.2 some countries are more constrained today by a lack of charging infrastructure. Spain for example has the lowest access to private off-street parking of all the countries studied (see Figure 29), and the public charging networks in Poland, Italy, and Spain are much smaller than those of the Netherlands, Germany, and France⁵³. In markets where access to private parking and access to public charging is limited, the deployment of additional charging infrastructure will likely unlock significant latent demand. Consumers who would otherwise purchase an EV in these markets will be dissuaded from buying an EV if they do not have *any* access to charging infrastructure, therefore improving charging networks in these markets should be a priority.

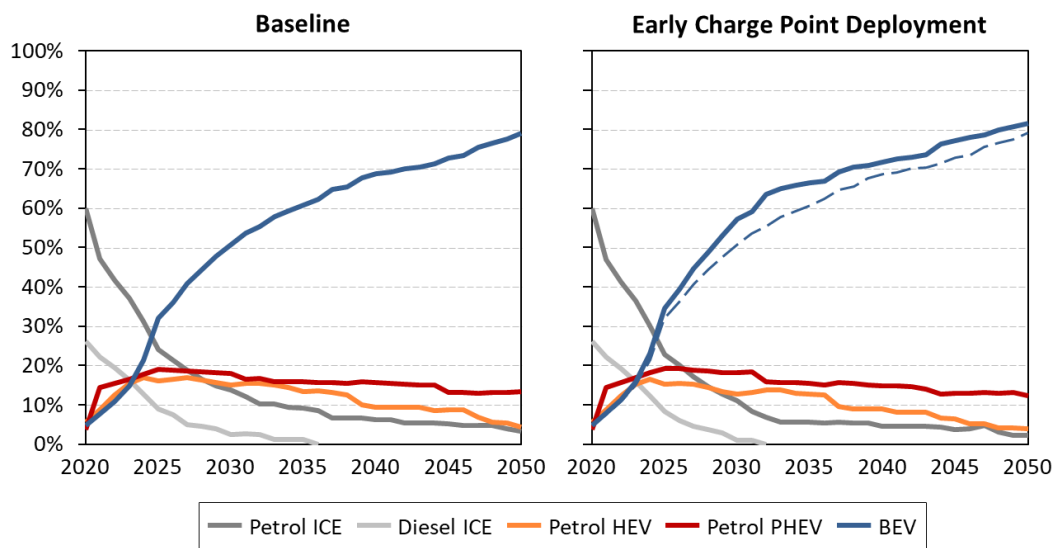


Figure 30: Demand for BEVs increases slightly if access to charge points is removed as a barrier from 2030. Baseline BEV uptake is shown in dashed blue (right).

3.3.4 Achieving near-term BEV purchase price parity

As discussed in Section 2.3, upfront purchase price is the most important attribute to all the private consumers segments identified in this study. Reductions to BEV upfront costs leads to the most significant change in BEV demand out of the vehicle attributes investigated.

The bottom-up cost modelling used in this study represents a realistic, but conservative projection of future vehicle prices. The projections consider expected changes in drivetrain component pricing, recouping of R&D costs by OEMs, expected changes to vehicle specifications (notably increased ranges of BEVs and PHEVs), and the introduction of new policy requirements, such as meeting Euro 7 regulations. Taken together, the resulting projections indicate that purchase price parity between BEVs and Petrol ICEs is achieved by 2030 for small cars, with medium and large cars retaining a purchase price premium of a between few hundred euros, up to a few thousand euros for the vehicles with the largest batteries. These costs represent a very realistic expectation of how purchase prices of new cars will evolve over the coming decades, however some studies project that purchase price parity will be achieved much sooner.

⁵³ Transport and Environment (2020), *Recharge EU: how many charge points will Europe and its Member States need in the 2020s*. [Link](#)

A 2021 study by Bloomberg NEF for Transport and Environment (T&E), which considered the additional cost savings due to the adoption of dedicated electric vehicle manufacturing platforms, forecast that BEVs will be cheaper than petrol cars in all size segments by 2027⁵⁴. Many BEVs on the market today are built on platforms modified from those for existing combustion engine models. However, several automakers have already developed dedicated platforms, such as VW’s MEB platform and Hyundai Motor Group’s Electric-Global Modular Platform, with similar examples in development by other OEMs, including Daimler, GM and Ford. It is expected that that by 2025 most BEVs available will be built on dedicated platforms⁵⁴.

According to the study by BNEF for T&E, the transition from modified ICE to dedicated BEV platforms can lead to ca. 10-30% reduction in the cost to manufacture and sell BEVs. A single BEV ‘skateboard’ platform can be used to make vehicles across a wide range of different body types, whereas an ICE platform typically only supports a few body types. This unlocks substantial savings as R&D costs are spread over higher volumes of vehicles, with more efficient inventory management providing additional savings. Dedicated platforms provide further opportunities to reduce costs through light-weighting, far simpler assembly, and specifically re-designed components, including axles and suspensions.

Figure 31 compares the baseline demand for different powertrains between 2020-50 to a sensitivity with decreased BEV purchase price due to dedicated platforms becoming the industry norm. Under this sensitivity BEV manufacturing costs are reduced by 25% against the baseline⁵⁵, with purchase price parity achieved for all car size segments by 2028. This has a substantial impact on the future demand profile of BEVs, with BEVs accounting for 80% of total demand by 2030 and close to 100% by 2050. Under this scenario Detrol ICE vehicles drop out of the seven European markets considered before 2030 due to poor sales, with demand for petrol vehicles (ICE and HEV) close to zero by 2035.

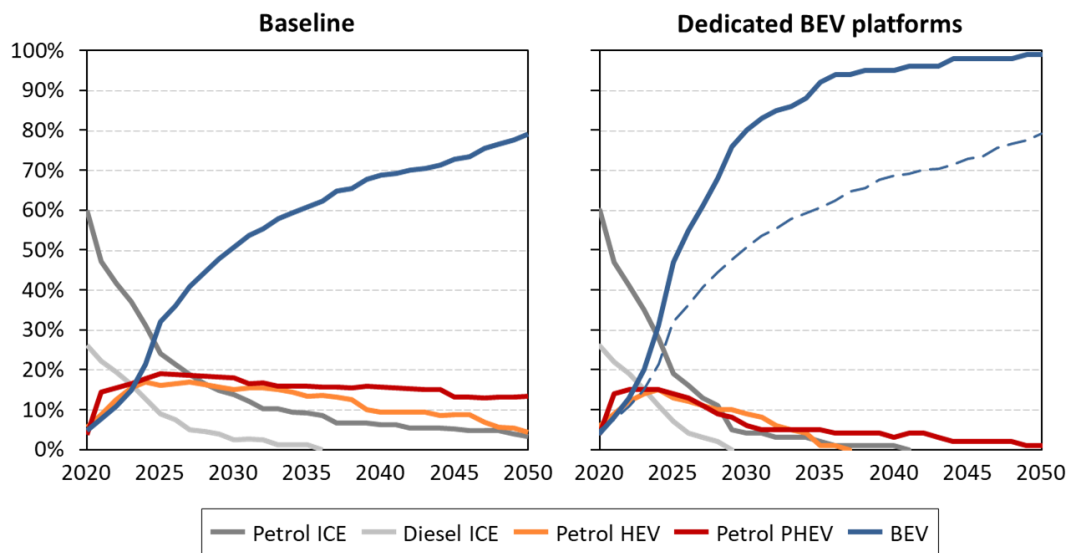


Figure 31: Demand for BEVs increases substantially with dedicated BEV platforms. Baseline BEV uptake is shown in dashed blue (right).

According to BNEF and T&E, the main drawback of developing a new platform is demand uncertainty, with upfront costs typically exceeding €5 billion and development often taking

⁵⁴ Bloomberg New Energy Finance for Transport and Environment (2021), *Hitting the EV Inflection Point*. [Link](#)

⁵⁵ Determined in conversation with Transport and Environment during the stakeholder engagement.

three to five years. Naturally with the transition to a new emerging technology such as BEVs there is a hesitancy to invest heavily before the technology has become mainstream. Many OEMs have produced BEVs on modified ICE platforms before investing in a dedicated BEV platform to hedge against this uncertainty, but as the projection in Figure 31 shows, widespread adoption of dedicated BEV platforms could unlock significant additional demand for BEVs.

However, adoption of dedicated BEV platforms is not the only method to achieve price parity with Petrol ICEs. Many BEVs on sale today are luxury vehicles competing in the high end of the market, so the introduction of lower specification budget BEVs could also trigger the rapid transition to BEVs shown in Figure 31. Governments can also reduce BEV purchase prices through subsidies and registration taxes, though it is vital these subsidies do not only support high-cost luxury vehicles and SUVs.

4 Conclusions

Consumers will drive the transition to electrified mobility

Consumer attitudes are not a barrier to widespread EV adoption – the results of this study indicate clearly that consumers are highly enthusiastic about EVs and, if the price is right, a significant majority of new car buyers will choose an EV as their next car by the mid-2020s.

Purchase price is the most important factor to private new car buyers when choosing a powertrain. Though driving range and running cost have a secondary impact, it is the cheapest powertrain which attracts the majority share of new-car demand. Demand for vehicles with internal combustion engines will be rapidly replaced by demand for battery electric vehicles by 2030 as BEVs become cost competitive with legacy powertrains. The falling costs of BEVs are a result of market economics – battery manufacturers are increasing production capacity to meet the growing demand for BEVs and energy storage within Europe and globally, driving down the manufacturing cost of the single biggest cost component of electric vehicles. Strong signals from European governments have encouraged vehicle OEMs to introduce battery electric models, and competition between manufacturers is delivering BEVs to market at increasingly competitive prices, with lower specification models targeting the mass-market.

Though access to private charging is desirable for all consumers, it is by no means a major barrier to uptake. Provided that consumers have the means to charge their car to meet their driving requirements, the perceived benefits of EVs today outweighs the inconvenience of not having a private charge point. In markets such as Spain where many consumers do not have access to private parking and public charging infrastructure is limited, increasing access to charging would almost certainly unlock latent EV demand. However, most European new-car buyers (ca. 59%) already have access to private off-street parking, and for these consumers, a majority will purchase the cheapest powertrain, regardless of the public charging infrastructure.

If the trends observed in the UK over the past decade continue, it is expected that the minority of consumers who demonstrate a hesitancy towards BEVs today will cease to do so within the coming years. As BEV market share continues to grow, driven by demand from enthusiastic consumers, awareness of the realities of owning an EV and the benefits they bring to consumers will spread via “word of mouth”, reassuring consumers who are hesitant today. Even if these consumers are assumed to remain hesitant towards BEVs indefinitely, once BEVs approach price parity with the competition most of these consumers are forecast to move with the market and switch towards BEVs.

Consumers have already embraced the transition to electrified mobility; so as long as governments continue to steer manufacturers towards a zero-emission future, BEVs will become the dominant new powertrain in Europe by the end of this decade.

Government enforcement will be required to end ICE sales

Though consumer demand for BEVs will significantly increase over the coming decade, it appears that the market alone will not achieve an end to ICE sales. This work has not enforced an ICE ban in any of the markets studied in order to investigate the underlying consumer demand out to 2050, however it has been assumed that poorly performing powertrains are gradually removed from the market by OEMs⁵⁶. Under the assumptions

⁵⁶ Details can be found on page 14

used in this report, Petrol ICEs, HEVs, and PHEVs all remain on sale in some markets until 2050, and as a result attract some market share⁵⁷.

As discussed throughout this report it is assumed that consumers continue to behave as they do today indefinitely. However, if consumers become more attracted to BEVs as their market share grows, as has been observed in the UK over the past decade, it may be that BEVs erode the remaining ICE demand even further. However, this uncertainty represents a substantial risk to a hands-off approach to achieving an ICE-phase out, and highlights the continued need for strong policy intervention.

⁵⁷ The choice model used in this work assumes a probabilistic distribution – if a powertrain is available in the market someone is always assumed to choose it

5 Appendices

5.1 Introduction to discrete choice analysis

The purpose of Discrete Choice Analysis is to simulate as far as possible the decision-making process followed by consumers in the real world. When choosing between various products or services consumers are assumed to make a trade-off between the attributes of each in order to come to a decision. For a car, these attributes could include purchase price, fuel consumption and range etc. Discrete Choice Analysis is used to quantify the different weighting consumers apply to each attribute, and thus the overall ‘utility’ that each alternative would provide. Mathematically, the utility, U , of a choice alternative, i , can be expressed as:

$$U_i = \sum_{j=1}^{j=T} \beta_j x_{ij} + \varepsilon_i$$

- x_{ij} is the value of the j^{th} observed attribute for choice alternative i (e.g., fuel consumption for a Petrol ICE).
- β_j is the choice coefficient (weighting) for the j^{th} observed attribute for choice alternative i (e.g., weighting of fuel consumption).
- ε_i is the utility value of the unobserved factors⁵⁸ for choice alternative i .
- T is the total number of observed attributes.

A consumer will choose the alternative that offers the greatest ‘utility’, and so the results can be used to predict the likely uptake of each member of a choice set. Critically, the technique simulates a choice between discrete alternatives which correctly represents the real-world process car-buyers go through when choosing between several distinct vehicles and choose only one. The results of Discrete Choice Analysis enable the value consumers place in various vehicle attributes to be quantified and investigated.

Discrete Choice Analysis has been in use since the 1970s and was developed by Daniel McFadden which earned him the Nobel Prize in Economics in 2000. It was first used to successfully predict demand for the San Francisco Bay Area Rapid Transit and has proved popular in the transport sector for predicting uptake of vehicle technologies. The US Department for Energy, for example, used discrete choice modelling to develop the Transitional Alternative Fuels and Vehicles Model which in its initial form was used to forecast fuel choice amongst vehicle buyers⁵⁹. This was subsequently extended to include hybrid and fuel cell technologies⁶⁰, and in its latest guise forms the uptake model used in the US Department of Energy’s Market Acceptance of Advanced Automotive Technologies (MA3T) Model. Models based on Discrete Choice Analysis have shown to be better predictors of vehicle uptake than those based on simpler methods, such as ‘diffusion curves’, as they account for changes in individual vehicle attributes, which do not necessarily change at similar or constant rates.

⁵⁸ Unobserved factors are the vehicle attributes not explicitly investigated through an observed attribute (x_i). This could be because they were not included in the choice experiment to quantify the utility of each attribute (e.g., vehicle colour) or because they are intangible or difficult to quantify (e.g., perceived risk associated with novel technology).

⁵⁹ Leiby and Rubin (1997), *Transitional Alternative Fuels and Vehicles Model*, Transportation Research Record, 1587(1), pp. 10-18. doi.org/10.3141/1587-02

⁶⁰ Greene (2001), *TAFV Alternative Fuels and Vehicles Choice Model Documentation*, ORNL/TM-2001/134, Oak Ridge National Laboratory

5.2 Comparison to similar studies

Table 2: Comparison of similar surveys including a choice experiment of alternative passenger car powertrains.

	Sample size	Geographic scope	Purchase price	Running cost	Range	Fuel / charging availability	Charging time	Emissions	Performance	Policy incentives
This study 2021	14,000	FR, DE, IT, NL, PL, ES, UK	X	X	X	X	X⁶¹			
Denny and Carroll for SEAI 2020	2,000	IE	X	X	X	X		X		
Noel et al. 2019	4,000	DK, FI, IS, NO, SE	X		X		X		X	
Vilchez et al. for JCR 2017	1,248	FR, DE, IT, PL, ES, UK	X	X	X		X	X		
Rudolph 2016	875	DE	X	X		X				X
Jacobs et al. 2016	167	DE	X		X		X		X	
Krause et al. 2016	961	US	X	X	X		X			
Jensen et al. 2016	290	DK	X	X	X	X	X	X		
Element Energy for DfT 2015	2,000	UK	X	X	X	X	X			
Axsen et al. 2015	1,754	CA	X	X	X		X			
Dumortier et al. 2015	2,759	US	X	X	X			X		
Helveston et al. 2015	832	CN, US	X	X	X		X		X	
Shin et al. 2015	675	KR	X	X		X				
Lieven 2015	8,147	Global				X				X
Glerum et al. 2014	666	CH	X	X						
Hoен & Koetse 2014	1,903	NL	X	X	X	X	X			X
Hackbarth & Madlener 2013	711	DE	X	X	X	X	X	X		X
Element Energy for H2M 2012	2,000	UK	X	X	X	X		X	X	
Element Energy for ETI 2011	2,000	UK	X	X	X	X	X	X	X	

⁶¹ Included in survey but shown to not be significant to purchase decision.