OZEV - PORTFOLIO-LEVEL RETROSPECTIVE EVALUATION

An evaluation of the Plug-in Vehicle Grant, Electric Vehicle Homecharge Scheme, and Workplace Charging Scheme

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1 EXECUTIVE SUMMARY

The Office for Zero Emission Vehicles (OZEV) is a team working across the Department for Transport (DfT) and the Department for Business, Energy & Industrial Strategy (BEIS) to support the transition to zero emission vehicles (ZEVs). OZEV has overall responsibility for the 2030 Mission to end the sale of new petrol and diesel cars and vans in 2030 and ensure that all new cars and vans in the UK are zero emission at the tailpipe by 2035.[1] Given the implications for the wider energy system and the automotive sector, BEIS Automotive and Energy teams are also responsible for significant elements of the Mission. Achieving this goal is an important part of the UK's overall Transport Decarbonisation Plan, a key priority for DfT as a whole.[2] OZEV's primary objective is to build the market for electric vehicles (EVs) in the UK by supporting the take-up of plug-in vehicles and chargepoint infrastructure across the UK in order to create a self-sustaining market for ZEVs.

DfT commissioned Frontier Economics to evaluate three schemes within the overall grant portfolio of OZEV: the Plug-in Vehicle Grant (PIG) for cars and vans; the Electric Vehicle Homecharge Scheme (EVHS); and the Workplace Charging Scheme (WCS). While OZEV and DfT had collected some data on the schemes, undertaken regular analysis on the importance of the Plug-in Car Grant (PICG) to consumers and modelled the potential impact of making changes to grant schemes to inform policy recommendations to ministers, a systematic programme of collecting consistent data for the purpose of evaluation was not in place. The long history of the schemes and access to limited data in some cases have influenced the design of this evaluation and its conclusions and recommendations.

This evaluation is part of a broader effort to embed evaluation into the policy development cycle at DfT and was informed by the 2021 National Audit Office report on reducing carbon emissions from cars.[3]

This report provides a cross-cutting assessment of the schemes, including our findings relating to the impact of this "portfolio" of grants as a whole and a set of recommendations for future evaluations. This was a rapid evaluation, including developing the framework, which took place over a three-month period between January and March 2022. The approach was tailored to address three evaluation questions developed with OZEV based on the objectives of the grant schemes being considered, in order to evaluate the following:

- The impact of the three grant schemes on demand for new EVs and chargepoint infrastructure;
- The impact on the manufacturing and supply of EVs and related infrastructure and technologies; and
- The potential wider environmental benefits from the grants.

Overall, this evaluation found that the grants have had material impacts on demand for new EVs and chargepoint installations, particularly for cars and home chargepoints, and that the market for electric cars is now maturing. However, the electric van market remains at an early stage of development due to ongoing constraints to uptake.

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[1] See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005301/transitioning-to-zero-emission-cars-vans-2035-delivery-plan.pdf

[2] See DfT, Decarbonising Transport – A Better, Green Britain. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009448/decarbonising-transport-a-better-greener-britain.pdf.

[3] https://www.nao.org.uk/wp-content/uploads/2021/02/Reducing-Carbon-Emissions-from-cars.pdf

- **New EV registrations as a percentage of new car registrations have exceeded OZEV's original projections and the market for EVs appears to be maturing in line with OZEV's stated objectives.** EV registrations as a percentage of all new car registrations surpassed the projection of 5% by 2020 set out at the start of the PICG,[4] with the share continuing to grow and reaching almost 20% (four times the initial target) by Q3 2021.
- **Key stakeholders in the sale and manufacturing of EVs indicated that, while there are a number of drivers of new EV registrations, the OZEV grants have had an important impact in building demand for electric cars in the market.** This is corroborated by surveys conducted by DfT and supported by evidence showing a notable shift between demand for different types of EVs in response to changes in grant eligibility.
- **Stakeholders across the EV market also indicated that price has become a relatively less important driver of demand for electric cars over time, with charging becoming an increasingly prominent concern.** Overall, the importance of the PICG has reduced as the market has matured and price has become less of a barrier to vehicle uptake. The value of the PICG has also reduced over time, further reducing its importance. However, price remains a more significant barrier to electric van uptake. Other price- and cost-related incentives besides the plug-in grants may also continue to contribute to EV uptake.
- **Changes to plug-in grant eligibility for electric cars correlate with a noticeable shift in demand.** In particular, following grant eligibility being restricted to battery electric vehicles (BEVs) in October 2018, demand in the market shifted noticeably away from Plug-in Hybrid Electric Vehicles (PHEVs) and towards BEVs in 2019.
- **Based on the observed number of registrations, grant value as a proportion of price and available evidence about the price elasticity of demand for EVs, the additional electric car demand attributable solely to the reduction in purchase price provided by the PICG is estimated to have been about 90,000 between 2011 and November 2021**. This estimate does not include any of the wider market-building impacts of the OZEV grants, network or signalling effects of the grants, or impacts of the EVHS or WCS grants (all of which may be significant). As a result, it is only an estimate of a subset of the overall potential demand-side impact of the OZEV grants being evaluated.
- **New EV registrations as a percentage of new van registrations have not met OZEV's original projections, with fleet experts suggesting that low electric van uptake has been driven by product limitations.** Fleet experts reported that the Plug-in Van Grant (PIVG) is becoming increasingly important as electric vans become viable.
- **Increasing the availability of charging infrastructure is an important part of developing the market for EVs, with home charging particularly important.** The number of EVHS-funded chargepoint installations has also continued to increase over time even as the maximum value of the grant has reduced**,** illustrating strong uptake of the grant in the market.
- **According to experts in the chargepoint industry, the EVHS and WCS helped the growth of the chargepoint industry at its infancy,** contributing to the development of a diversified market.
- **While the number of WCS-funded chargepoint installations has also increased over time, overall uptake of WCS has been limited.** Stakeholders suggested this may be due to a combination of low awareness and the grants, by design, not being suited for large fleet charging.
- **The OZEV portfolio may have caused some distortion of prices in the market and favoured more affluent early adopters.** There is some evidence that prices decreased for a subset of car models in

[4] While part of this appears to have been driven by a decline in general vehicle demand due to COVID-19, the increasing trend in EV registrations was well established independently of this and it appears this 5% projection would have been met regardless of the drop in overall demand.

order to retain grant eligibility when the maximum eligible price was lowered. As EV prices were relatively high in the early stages of the market (and remain high relative to internal combustion engine vehicles), the grants may also have favoured higher-income households, which were more likely to be early adopters.

Evidence of the impact of the PIG, EVHS and WCS on manufacturing and investment is more limited. However, the grants may have played a role in securing supply of imported vehicles for the UK and in providing additional quality standards for chargepoints.

- **It is difficult to attribute growth in UK EV manufacturing directly to the grants under evaluation, and the overall impact on investment in manufacturing is limited.** EV and battery manufacturing experts indicated that other factors such as business rates and overall long-term government strategy are far more significant drivers of investment than the market mechanisms in the OZEV portfolio.
- **Input from vehicle sales experts suggests that the OZEV portfolio may have contributed to securing product allocation in the UK.** Some stakeholders indicated that the relative level of grant support across markets is a driver of product allocation and that, in the absence of the grants, it might have been more difficult to secure product in the UK, particularly in the context of demand for EVs often exceeding supply in the last few years.
- **The EVHS and WCS grants have effectively provided additional quality standards for the chargepoint market.** Chargepoint experts interviewed indicated that technical requirements specified by the EVHS and WCS grants have acted as additional product standards and have served the purpose of guaranteeing the safety and quality of chargepoints installed.

Emissions and pollutant reductions are only one part of the potential benefits provided by increased uptake of EVs, with impacts also potentially including energy security and social benefits. However, the emissions benefits of building a self-sustaining market for EVs are potentially significant, with about 6 tonnes of CO_2e abated over the lifespan of a car when choosing a BEV over an average internal combustion vehicle.[5]

- **If we assume that the grants resulted in additional demand equal to 10% of all PICG-eligible car purchases between 2011 and 2021, this would imply that about 193,400 tonnes CO_2e of greenhouse gases and 7 tonnes of other important air pollutants were abated as a result of the grants**. This is roughly consistent with lower-range estimates of additional EV demand attributable to the price reduction provided by the PICG, based on academic evidence on price elasticities. In monetary terms this is worth £38 million.[6]
- **If we assume that the grants resulted in additional demand equal to 30% of all PICG-eligible car purchases between 2011 and 2021, this would imply that about 580,300 tonnes CO_2e of greenhouse gases and 22 tonnes of other important air pollutants were abated as a result of the grants**. This is roughly consistent with higher-range estimates of additional EV demand attributable to the price reduction provided by the PICG, based on academic evidence on price elasticities. In monetary terms this is worth £114 million.

[5] This is based on Frontier Economics modelling, drawing on BEIS emission conversion factors, and includes the full lifecycle emissions of the fuel and electricity used by the vehicles (and not just tailpipe emissions). There are a range of factors which influence this estimate (including future levels of grid decarbonisation), but this estimate is consistent with existing emissions factors estimated by BEIS. This is described in more detail in Section 5.3 and Annex C2.

[6] Based on BEIS carbon pricing for policy evaluations in the years in which the emission reductions are realised, discounted to 2021 values.

- Neither figure includes possible wider impacts on EV demand (and therefore emissions) resulting from the wider market-building or network effects of the grant schemes considered.

The methodology of this evaluation was shaped in response to two key challenges:

- Quantitative evaluation was limited by a lack of consistent monitoring data, baseline information and clearly and consistently defined objectives for the grant schemes over time; and
- The relatively limited time available to conduct the evaluation meant it was not possible to gather large-scale primary data (e.g. through surveys of market participants).

As a result, this evaluation adopted a theory-based approach drawing on mixed methods.[7] This involved qualitative analysis of interviews with market experts and stakeholders which focused on exploring the impacts attributable to the grant schemes, as well as other drivers of market outcomes. This qualitative analysis was complemented by quantitative analysis of the relationship between observable market trends and the OZEV grants, with modelling and estimation of attributable impacts where feasible.

The EV market is highly complex, with outcomes driven by a large range of often interdependent factors. The OZEV portfolio is only one of the drivers of market outcomes, and this complexity and the limited data available for this evaluation limit the ability to attribute direct impacts to the grants being evaluated. The EV market is also affected by broader government policy such as company car tax benefits for low emission vehicles, CO_2 regulation and BEIS support for innovative automotive and battery technology.[8] Policy support for development of the demand and supply of ZEVs internationally also plays a significant role in the development of the market for EVs, as do factors such as fuel prices and general consumer attitudes.

As a result of this complexity and the limited baseline data available for this evaluation, where quantitative estimates of impact are presented in this report, they should not be taken to represent the entirety of the benefit attributable to the OZEV grants. Instead, they represent a subset of the potential benefits which are quantifiable. Furthermore, the overall objective of the OZEV portfolio is to be market building, with the OZEV interventions intended to support market creation in the context of emerging technologies. Policy decisions were made in the context of a very dynamic environment, with these potential market-building impacts of the OZEV grants particularly difficult to quantify due to the range of inputs which go into developing a self-sustaining market. **The qualitative evidence is particularly important when assessing this market-building impact.**

In delivering this evaluation, we also identified specific recommendations for future evaluation of OZEV policies. These are intended to provide steps for OZEV to take in the near term which will help overcome some of the data limitations that restricted the analysis set out in this report and so support more robust future evaluation. Recommendations to assist with future monitoring and evaluation work are explored in more detail in a forward-looking monitoring and evaluation framework developed by Frontier in collaboration with OZEV and the DfT Evaluation Centre of Excellence, which was prepared alongside this report. These recommendations are:

1 **Develop and preserve baseline evidence.** Scheme leads should record the current status of the market, the expected impact of the grants (including assumptions informing this expected impact),

[7] A monitoring and evaluation framework was developed in parallel to this report to ensure that robust monitoring data is available for future evaluation work at OZEV.

[8] See https://www.gov.uk/government/news/over-30-million-government-investment-to-boost-batteries-and-hydrogen-vehicles

and key stakeholder and market views of the current impact of the grants at regular periods over time and when making significant changes to the grant scheme.

2 **Record quantitative data consistently where possible.** Given the difficulty of robust counterfactual analysis, future evaluation work may need to draw heavily on changes in key market metrics over time as a means of making assessments. In order to make valid comparisons over time, it will be important to gather consistent quantitative data on an ongoing basis.

3 **Adapt evidence collection where appropriate to capture changes in policy and the market over time.** In view of changing market conditions, OZEV should adapt the data collection plan developed as part of the forward-looking monitoring and evaluation framework in order to capture relevant information that contributes to the evidence base for later evaluation work.

4 **Ensure control and retention of future appraisal and forecasting models to assist with impact validation.** As well as comparisons to baseline, future evaluation of OZEV schemes could be strengthened by being better able to compare market outcomes with projections or forecasts made by OZEV in policy appraisal or development and by assessing why projections were (or were not) achieved to help isolate the role of the OZEV policy. Data or evidence relating to those projections and appraisals, including assumptions made or details of modelling work done to support those assessments, should therefore be stored.

5 **Work with other parts of government and third parties to ensure availability of relevant data to support future evaluation**. Our retrospective evaluation relied heavily on qualitative stakeholder views supplemented with limited quantitative analysis of available secondary data to draw conclusions. OZEV should work with stakeholders including the Office for National Statistics (ONS), DfT, the Driver and Vehicle Licensing Agency (DVLA), the Society of Motor Manufacturers and Traders (SMMT) and holders of proprietary industry data to scope wider data that may be available, including by adding questions to existing surveys, to provide more comprehensive and granular quantitative data.

2 INTRODUCTION

2.1 EVALUATION REQUIREMENTS

The Department for Transport (DfT) commissioned Frontier Economics to evaluate three schemes within the overall grant portfolio of the Office for Zero Emissions Vehicles (OZEV): the Plug-in Vehicle Grant (PIG) for cars and vans; the Electric Vehicle Homecharge Scheme (EVHS); and the Workplace Charging Scheme (WCS). This report provides a cross-cutting assessment of the schemes, including our findings relating to the impact of this "portfolio" of grants as a whole, and a set of evidence-based recommendations.

The evaluation draws on a framework developed collaboratively with OZEV which informed the evaluation questions and design. At the portfolio level, our focus was on the impact of the grant schemes on the demand and supply sides of the UK electric vehicle (EV) market (including the role of the grants in shaping the market) and wider social impacts. The evaluation, including developing the framework, took place over a three-month period, between January and March 2022.

This evaluation is part of a broader effort to embed evaluation into the policy development cycle at DfT, in line with DfT's commitment to evidence-based policies and achieving desired impacts and value for money for taxpayers. As part of this commitment, DfT is gathering evidence on the impact of key interventions to date targeted at decarbonising road transport. The 2021 National Audit Office (NAO) report on reducing carbon emissions from cars, particularly the emphasis on the importance of demonstrating the additional impact of OZEV spending, was also a contributing factor in undertaking this evaluation.[9].

This evaluation is retrospective, looking at the impact of grant schemes to date. The evaluation faced the following key challenges:

- Quantitative evaluation was limited by a lack of consistent monitoring data, baseline information and clearly-defined objectives for the grant schemes over time, which limited our ability to make quantitative assessments of additionality. As noted by the NAO, while OZEV and DfT have undertaken regular analysis on the importance of the Plug-in Car Grant (PICG) to consumers and have modelled the potential impact of making changes to grant schemes, "*When it introduced the plug-in car grant in 2011, OZEV was not clear what yearly increase it was expecting on sales, above and beyond what might have happened anyway, due to uncertainties in the market*".
- The relatively limited time available to conduct the evaluation meant it was not possible to gather large-scale primary data (e.g. through surveys of market participants). The evaluation therefore relied on data already held by OZEV, publicly available data on vehicle registrations and chargepoints, modelling work drawing on wider literature and interviews with key experts in the market.

Separately, we also worked with the DfT Evaluation Centre of Excellence and OZEV to develop a forward-looking monitoring and evaluation framework for future evaluations which includes clear guidelines on data gathering and evaluation options. This framework will allow DfT and OZEV to revisit the evaluation of their portfolio and individual schemes once more robust monitoring data is available and to draw on a wider range of data and evidence gathered specifically for evaluation.

[9] https://www.nao.org.uk/wp-content/uploads/2021/02/Reducing-Carbon-Emissions-from-cars.pdf

2.2 INTERVENTIONS IN SCOPE FOR THIS EVALUATION

OZEV is a team working across DfT and the Department for Business, Energy & Industrial Strategy (BEIS) to support the transition to zero emission vehicles (ZEVs). OZEV has overall responsibility for delivery of the 2030 Mission to end the sale of new petrol and diesel cars and vans in 2030 and ensure that all new cars and vans in the UK are zero emission at the tailpipe by 2035.[10] Given the implications for the wider energy system and the automotive sector, BEIS Automotive and Energy teams are also responsible for significant elements of the Mission. Achieving this goal is an important part of the UK's overall Transport Decarbonisation Plan, which is a key priority for DfT as a whole.[11] OZEV's primary objective is to build the market for ZEVs in the UK by supporting the take-up of plug-in vehicles and chargepoint infrastructure across the UK in order to create a self-sustaining market for ZEVs. Supporting the development of this market will lead to benefits in terms of reducing greenhouse gas (GhG) emissions and air pollution on our roads, as well as facilitating vibrant and growing market opportunities in EVs and associated supply chains.

OZEV currently provides funding to support take-up of a range of plug-in vehicles and home, workplace and on-street residential charging infrastructure. This retrospective evaluation does not cover the full range of OZEV's activities; rather, it focuses on the following three schemes, which we refer to as the "OZEV portfolio" for purposes of this evaluation:

- **The Plug-in Vehicle Grant (PIG),** in particular, grants provided under the Plug-in Car Grant (PICG) and Plug-in Van Grant (PIVG).[12] These grants aim to reduce the purchase price differential between new low/ zero emission vehicles and internal combustion engine (ICE) vehicles, and thereby increase demand for the former vehicles and ultimately stimulate the development of a self-sustaining low and zero emissions vehicles market. The evaluation covers grants awarded during the period from January 2011 to November 2021 for the PICG and February 2012 to November 2021 for the PIVG.
- **The Electric Vehicle Homecharge Scheme (EVHS).** The aim of this grant scheme is to reduce the upfront cost of purchasing and installing EV chargepoints in homes with dedicated off-street parking in order to reduce charging-related barriers to EV uptake and increase demand for EVs. The evaluation covers grants awarded during the period September 2014 to December 2021.
- **The Workplace Charging Scheme (WCS)**. This grant scheme aims to reduce the upfront cost of purchasing and installing EV chargepoints at businesses, charities and public sector organisations. This is intended to help provide a means for employees to charge their cars (further reducing charging-related barriers to EV uptake) and support the electrification of commercial vehicle fleets by increasing the availability of overnight charging for businesses. The evaluation covers grants awarded during the period from November 2016 to December 2021.

The scope of the evaluation focused on these schemes because of the relatively large size of the PIG when compared to spending on the other OZEV grants (see Figure 1) and to understand the impact of changes made to the magnitude of the EVHS and WCS over time (see Figure 2).

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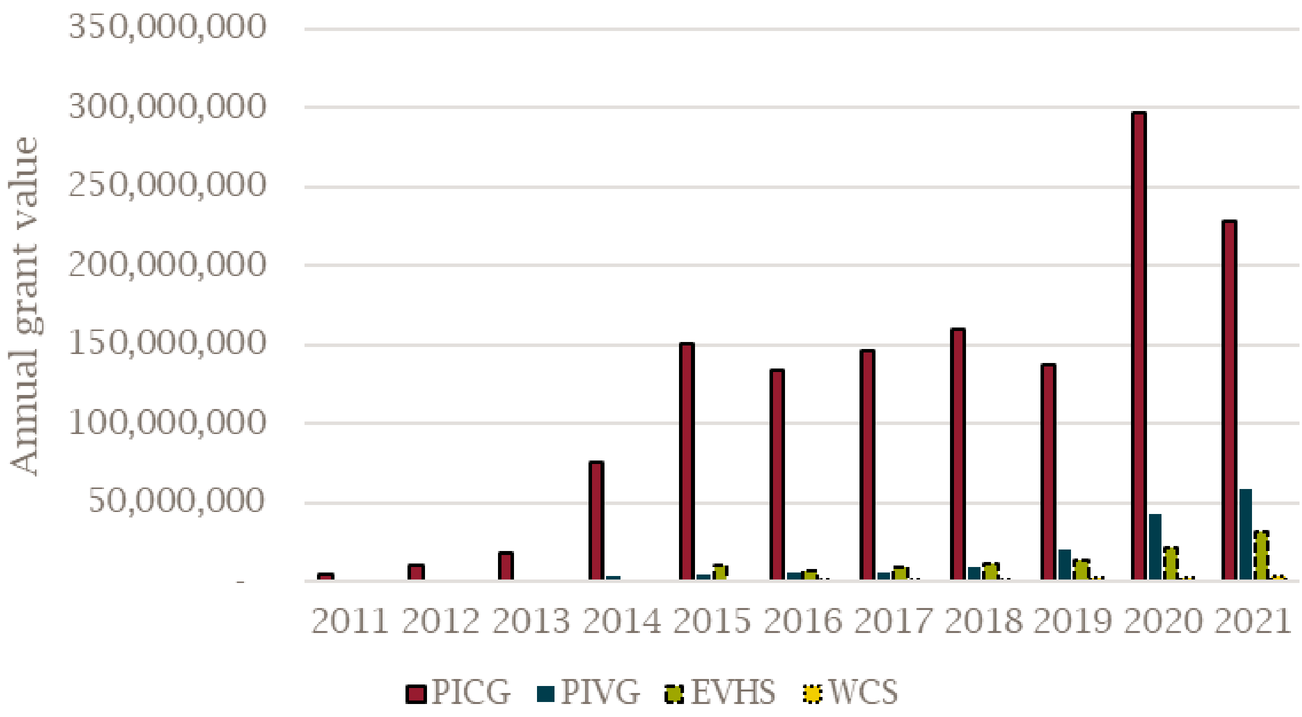
[10] See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005301/transitioning-to-zero-emission-cars-vans-2035-delivery-plan.pdf

[11] See DfT, Decarbonising Transport – A Better, Green Britain. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009448/decarbonising-transport-a-better-greener-britain.pdf.

[12] The Plug-in Van Grant now covers small vans, large vans, small trucks and large trucks, all of which are in scope for this evaluation. Throughout this document we will continue to refer to it as the Plug-in Vans Grant (PIVG).

Total spending on the PICG was around £1,360 million and spending on the PIVG was around £150 million for orders created between January 2011 and end of November 2021.[13] Total spending on the EVHS from its start in September 2014 was around £100 million as at end of December 2021, while total spending on the WCS from its start in November 2016 was around £9 million as at the end of December 2021. These figures represent the direct costs of the grants but do not include additional costs in terms of time and resources involved in administering them. Given the different scale of the grants, we focused particular attention in this evaluation on the PIG scheme.

FIGURE 1 GRANT SPENDING OVER TIME, 2011-2021

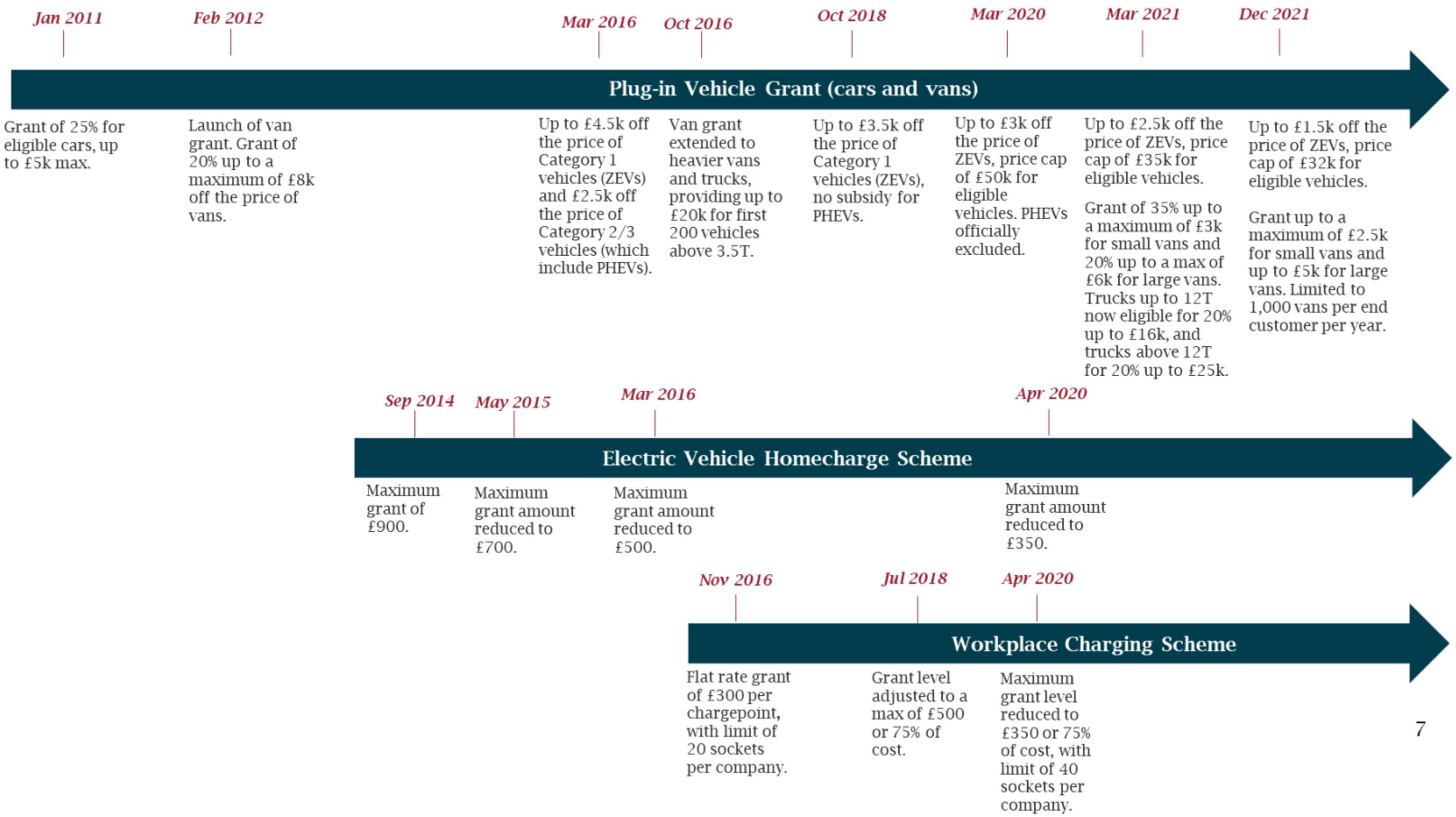


Source: OZEV grant spending data

Note: PICG and PIVG grant values are based on order creation date in the grant database, with data for 2021 covering the period to end November 2021. EVHS and WCS data is based on chargepoint installation month and covers the period to end December 2021.

[13] While the first few PICG grants were awarded in December 2010, January 2011 was the first full month of operation.

FIGURE 2 TIMELINE OF KEY CHANGES TO PIG, EVHS, AND WCS, 2011 TO 2021



Source: Frontier Economics

3 LOGIC MODEL

In collaboration with OZEV and DfT Evaluation Centre of Excellence, we developed a **portfolio-level logic model** which sets out the intended impacts of the grant schemes and theoretical logical pathways linking the grants to these impacts in terms of outputs and outcomes. This model informed the evaluation questions and indicators.

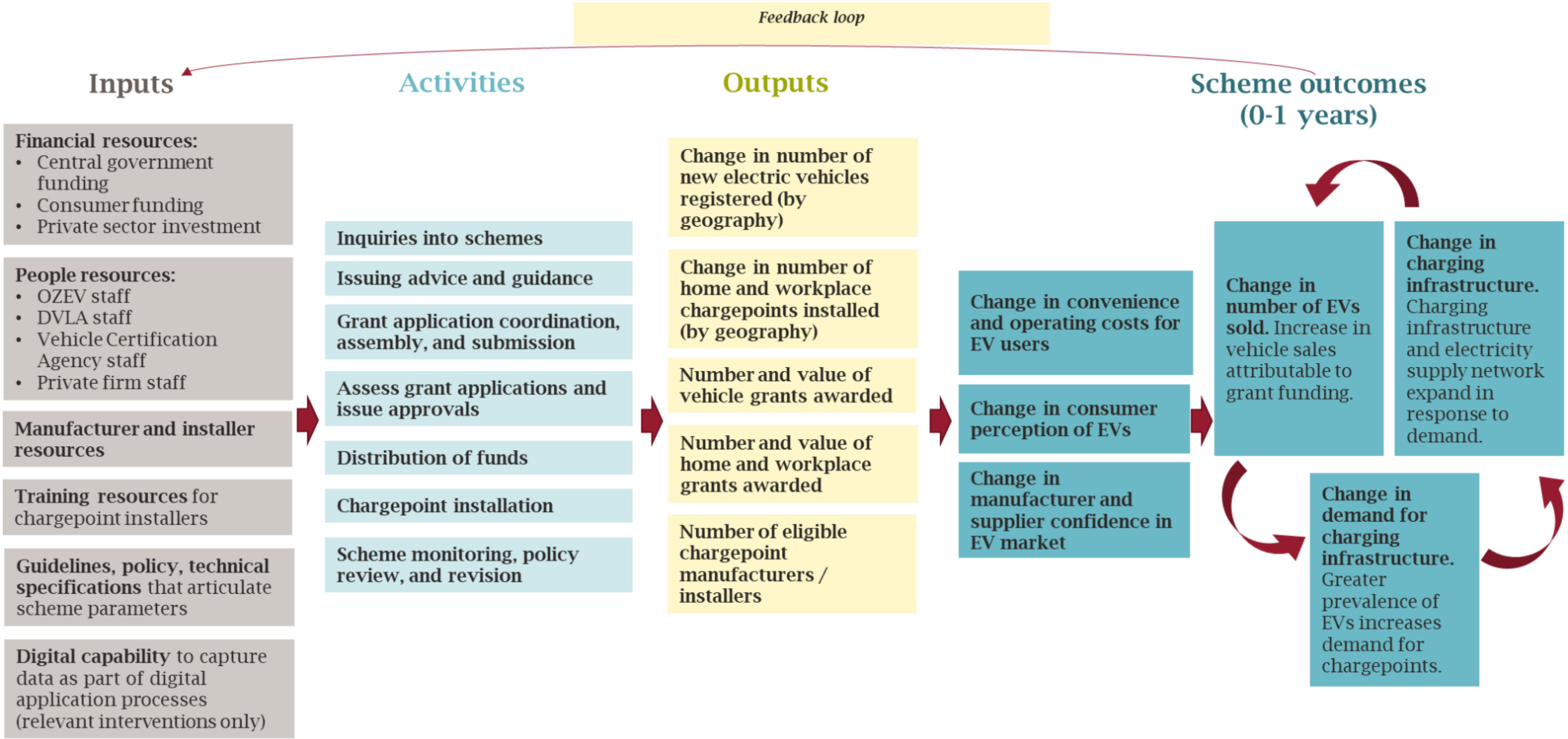
The logic model is split into two parts, reflecting the timescales over which benefits are expected to occur. Figure 3 illustrates the scheme-level inputs, activities, outputs and outcomes of the grant schemes in scope for this evaluation. Each of the grant schemes in the OZEV portfolio relies on a set of key inputs for its delivery – this includes resources, such as the staff designing and administering the scheme, as well as the government funding which enables the grants to be provided. These resources then enter into a number of key activities, such as assessment of grant applications and distribution of grant funding for vehicles and chargepoints. Examples of the outputs from these activities include new or accelerated vehicle registrations and new or accelerated installation of chargepoints. This then leads to a number of direct short-term outcomes, such as changes in overall demand for eligible vehicles and chargepoints and the resulting changes in the perception of EVs and the convenience and cost of EV operation. Overall, the schemes in the OZEV portfolio each contribute to a feedback loop where a change in the demand for EVs affects demand for charging infrastructure and the availability of charging infrastructure, which in turn affects demand for new EVs.

Figure 4 illustrates the longer-term outcomes and impacts connected to these changes. Increased demand for EVs and chargepoints may lead to increased market share for new electric cars and vans, changes in investment and product allocation of EV models in the UK, and displacement of petrol and diesel vehicle travel. In turn, these support further outcomes: changes in the EV share of the used car market, a broader shift of consumer values towards EVs and changes in the EV supply chain. All of these potential outcomes contribute to OZEV's strategic objective of creating a self-sustaining EV and chargepoint market. In the longer term, this supports wider dynamic impacts, including development of EV-related technologies, reduced purchase prices due to economies of scale, foreign direct investment into the UK EV supply chain and a range of broader environmental, social and energy security benefits.

These outcomes and impacts are interdependent. In particular, EVs can only be used if there are chargepoints available, and the benefits of chargepoint investment can only be realised if EVs are purchased and used. It is therefore useful to consider the interventions at the portfolio level because the interventions are, to some extent, mutually reinforcing. However, this also makes attribution of benefits to any specific intervention challenging due to the inherent interconnectedness of the drivers of changes in the EV market.

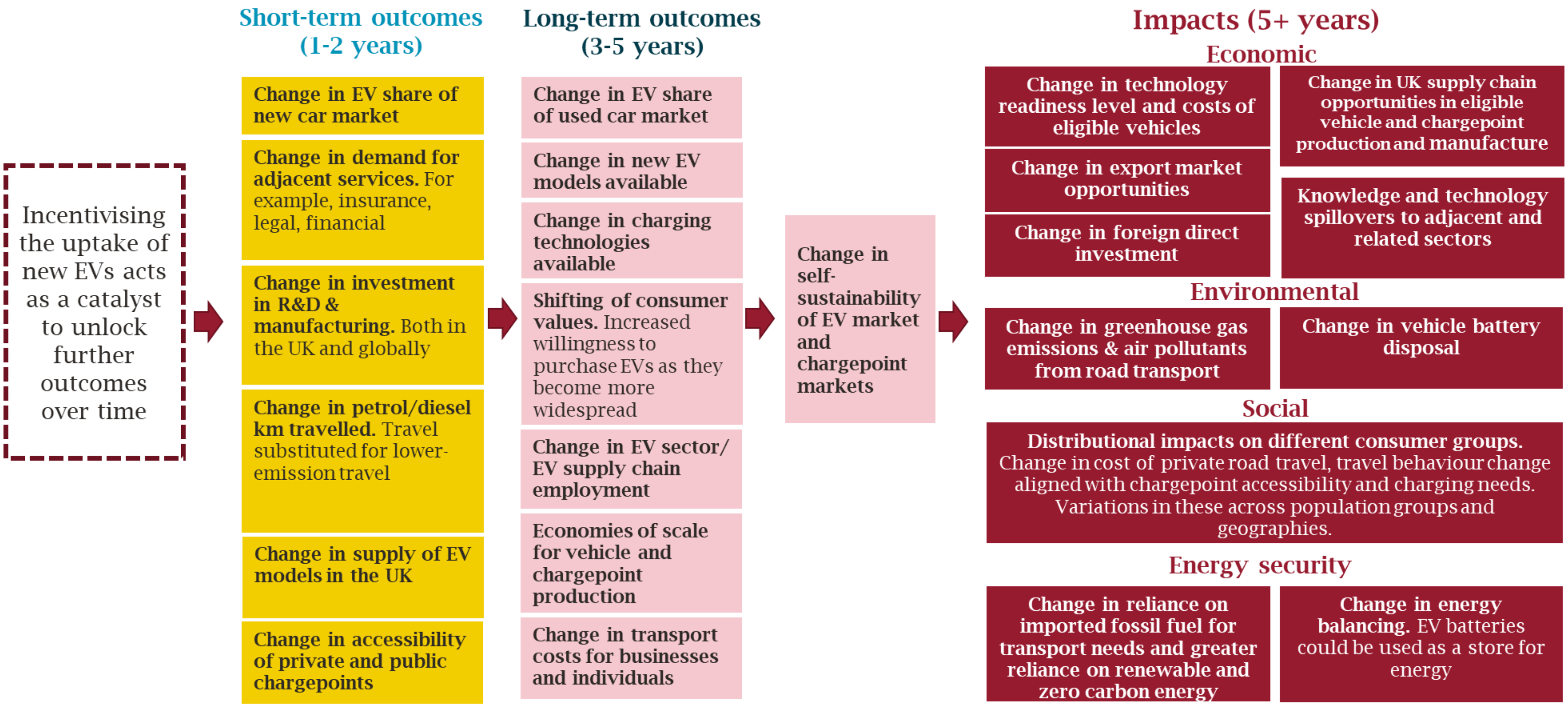
The EV market is highly complex, interconnected and international. Attribution of impacts is therefore complicated further by the major barriers and enablers to EV market development that are outside of OZEV's control. These include energy and fuel prices, tax incentives (e.g. the benefit-in-kind company car tax reduction for EVs), public perception of EVs, UK and international regulation (e.g. CO_2 regulation), shocks to the supply chain (e.g. around input costs) and the wider business environment. These broader barriers and enablers need to be considered when considering the outcomes and impacts of OZEV's activities.

FIGURE 3 PORTFOLIO-LEVEL LOGIC MODEL (PART 1)



Source: Frontier Economics

FIGURE 4 PORTFOLIO-LEVEL LOGIC MODEL (PART 2)



Source: Frontier Economics

4 EVALUATION QUESTIONS AND METHODOLOGY

4.1 PORTFOLIO-LEVEL EVALUATION QUESTIONS

Building on the logic model, we developed an evaluation methodology that was as robust as possible given constraints around data availability and time available to undertake the evaluation.

The approach was tailored to address the following three evaluation questions developed with OZEV and DfT's Evaluation Centre of Excellence, based on the objectives of the grant schemes being considered:

- To what extent have the grants impacted **demand for new EVs**[14] **and chargepoint infrastructure** installation, relative to what would have happened in the absence of the grants?
- To what extent have the grants impacted the manufacturing and **supply of EVs, EV infrastructure and related components and technologies in the UK**, relative to what would have happened in the absence of the grants?
- To what extent have the grants enabled wider benefits, in particular **environmental benefits**, relative to what would have happened in the absence of the grants?

Each of these evaluation questions was assessed against a set of indicators. More detail on these indicators is set out in Annex B.

While not an evaluation question in its own right, when considering the impact of the grant portfolio on the demand and supply side of the EV market, we also considered evidence around how the portfolio has contributed to the goal of creating and shaping the market in the UK. One of OZEV's stated aims for the portfolio was to create the conditions to secure the long-term future of the UK automotive industry and its supply chain. OZEV aimed to achieve this goal through strengthening domestic demand for EVs and improving the availability of local EV technology, supply chains and skills through the grants.

4.2 EVALUATION METHODOLOGY

The methodology was developed in line with *Magenta Book* guidance.[15] Because of the range of objectives for the OZEV schemes being evaluated, the complex landscape in which the policy operated and the lack of clear objective "control groups" that could provide counterfactual evidence, we adopted a **theory-based** approach to the evaluation. This involved attempting to test the theoretical links between OZEV activities and intended impacts identified in the logic model by gathering, assembling and triangulating across a range of data sources, as follows:

- **Qualitative analysis of interviews with market experts and stakeholders.** These interviews focused on exploring the impacts attributable to the grant schemes as well as other drivers of market outcomes, and were key to exploring the additionality of the OZEV portfolio. In-depth interviews were held with 11 key stakeholder organisations in the EV market. These interviews each lasted approximately an hour and included one to four participants per organisation.[16] Organisations interviewed included stakeholders in the manufacturing, sale and leasing of EVs, as well as think tanks and industry bodies representing chargepoint suppliers and vehicle manufacturers. We did not attempt

[14] This report focuses on the impact on demand for EVs (BEVs and PHEVs). A very small number of hydrogen cars also received plug-in grant funding prior to the introduction of vehicle price caps, although most of these were also eligible for other funding such as via the UK's hydrogen for transport programme.

[15] See the HMT *Magenta Book*, available at https://www.gov.uk/government/publications/the-magenta-book.

[16] In total, 22 people across 11 organisations participated in qualitative interviews in support of this evaluation, and we thank them for their input.

to "sample" a random set of interviewees from all those we could conceivably have engaged; rather, we worked with OZEV and drew on our own market intelligence to identify a broad range of experts and stakeholders who could provide important, informed qualitative views across the range of evaluation questions we sought to answer (see below).

- **Quantitative analysis of the relationship between observable market trends and the OZEV grants**, with modelling and estimation of attributable impacts where feasible. This analysis assessed trends in new EV registrations and chargepoints installed under the EVHS and WCS schemes and their correlation with changes to the grant schemes, and how observed outcomes compared with initial targets. We also estimated new electric car demand directly attributable to the reduction in purchase price provided by the grant (drawing on a review of the literature on price elasticities for EVs) and modelled the environmental impacts attributable to this switch.

The sample size of possible in-depth interview participants was restricted by the time available for this evaluation. In order to give a wider perspective, we focused primarily on interviewing representatives of industry bodies or those that we felt could provide relatively holistic assessments across multiple evaluation questions. We identified gaps in the quantitative data where qualitative input was important for a more robust assessment of the evaluation questions. This led us to broad categories of interviewees (e.g. manufacturers, EV dealers, chargepoint installers, battery manufacturers). We then agreed a list of specific stakeholders to interview in collaboration with OZEV. To ensure comparability of evidence across participants, interview questions were designed using a semi-structured approach that was informed by the logic model. The interview guide also included questions on the potential role of other drivers of demand and supply outside of the OZEV portfolio, such as other policies affecting the price and cost of EVs and emissions regulation.

Interviews were conducted using Microsoft Teams and were facilitated by two or three members of the Frontier team. With permission, we recorded and transcribed the interviews for later analysis. We reviewed the transcripts and coded views against the evaluation questions using a **framework analysis** methodology.[17] This allowed us to identify common themes under each question where views were largely consistent across those we interviewed, and where stakeholder views appeared to diverge in ways that related to the type of stakeholder we consulted. Important quotes that illustrated wider views were identified and are used in this report.

Given the relatively limited number of people we consulted and that qualitative analysis is not intended by itself to provide evidence from which wider inference can be made, we **triangulated** qualitative insights with wider evidence to form our views as part of the theory-based assessment. This meant that the **qualitative input was cross-checked with quantitative data where available.** Where supporting quantitative data was available (for example, on changes in EV uptake or consumer preferences), we sense-checked stakeholder views against the changes and outcomes observed in the quantitative data.

The qualitative findings reported in Section 5 and key takeaways from the stakeholder interviews in Section 6 are based on this overall assessment of the body of quantitative and qualitative evidence received. The findings are not based on only one data point received from a single stakeholder, nor on a view reported by a stakeholder that was refuted by another. Instead, they are based on qualitative data that was reported consistently across different interview participants. In analysing this data, we attempted to take account of the particular biases which could be introduced as a result of stakeholders' views of or position in the market by considering the input received alongside the available quantitative data, economic theory underpinning demand and supply-side behaviour, and the logic model.

[17] See, for example, Goldsmith, L. J. (2021). Using Framework Analysis in Applied Qualitative Research. *The Qualitative Report*, 26(6), 2061-2076.

More detail on the data and inputs which entered into this analysis is provided in Annex B.

5 PORTFOLIO-LEVEL FINDINGS

This section sets out the findings from the evaluation, drawing on both the qualitative and quantitative data. It focuses on the scheme impacts which are most relevant for determining the impact of the portfolio as a whole. It is divided into four sub-sections:

1. The impact of the grants on demand for new EVs and charging infrastructure;
2. The impact of the grants on manufacturing and domestic supply of new EVs;
3. The wider environmental benefits delivered by the grants; and
4. A brief overview of the limitations of the analysis.

5.1 IMPACT OF THE GRANTS ON DEMAND FOR NEW EVS AND CHARGING INFRASTRUCTURE

5.1.1 IMPACT OF THE GRANTS ON NEW ELECTRIC CAR REGISTRATIONS

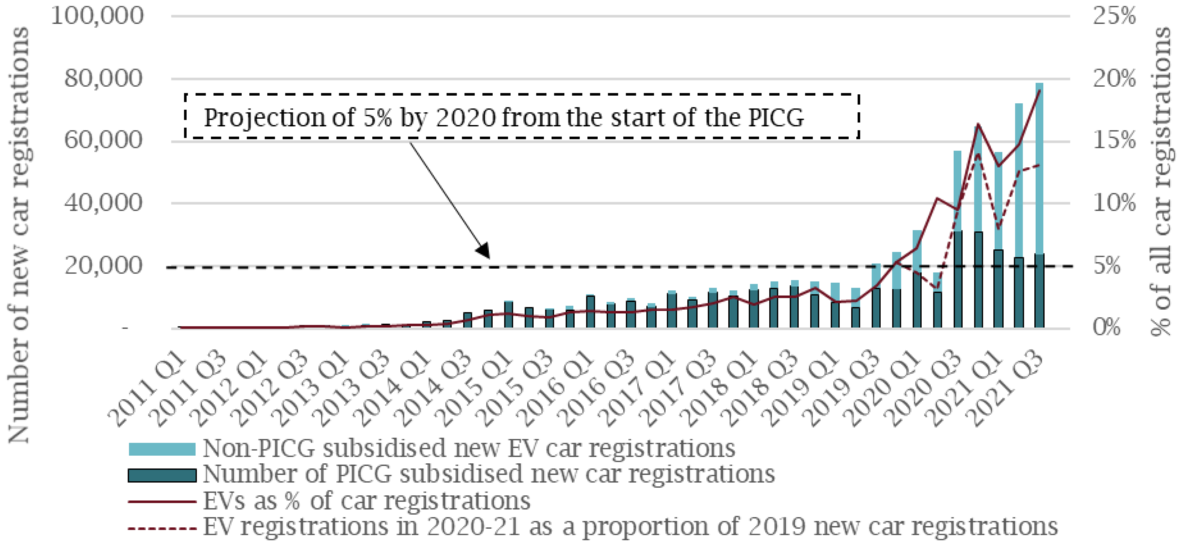
New EV registrations as a percentage of new car registrations have exceeded OZEV's original projections. The market for EVs appears to be maturing in line with OZEV's stated objectives.

New EV registrations exceeded the projection set out at the inception of the PICG in 2011 to be 5% of all new car registrations by 2020, with the share continuing to grow and reaching almost 20% (four times the initial target) by Q3 2021.[18] This is illustrated in Figure 5 below.

- At the inception of the PICG in 2011, new EV registrations represented less than 0.1% of all new car registrations. New EV registrations exceeded 5% of all car registrations for the first time in Q4 2019, reaching a level of 5.3%. As of Q3 2021, this had risen further, with around 19% of all new car registrations in Q3 2021 made up of EVs.
- Part of this increase in the 2020 and 2021 percentage of EV registrations appears to have been driven by a decrease in total car registrations due to COVID-19. However, even if we assume that total car demand in 2020-2021 was unchanged compared with 2019, the projection would still have been reached comfortably (illustrated by the dotted line in Figure 5).

[18] These figures are based on BEVs and PHEVs as a proportion of all car registrations, and the percentage of EV registrations reported here does not include the non-plug in ultra-low emission cars and plug-in quadricycles registered between 2011 and 2021. However, including these other types of vehicle would have a minimal impact on the figures.

FIGURE 5 NEW EV REGISTRATIONS AS A PERCENTAGE OF ALL NEW CAR REGISTRATIONS



Source: OZEV Grant portal data and DVLA data on vehicle registrations published by DfT (available here)

Note: Estimates of the proportion of new car registrations eligible for the PICG are unavailable for 2021 in the publicly published DVLA data. As a result, the number of PICG-subsidised new car registrations in this figure is derived from the OZEV grant data. This yields a slightly different estimate than the DVLA data published by DfT, which is an estimate of PICG-eligible vehicles based on model characteristics. EV car registrations are reported as the sum of BEV and PHEV registrations. Values for the EVs as % of car registrations before 2014 Q3 are the values for Great Britain due to data availability; all data from 2014 Q3 onwards is for the UK as a whole.

Key stakeholders indicated that, while there are a number of drivers of new EV registrations, the OZEV grants have had an important impact in building demand for electric cars in the market. This is supported by surveys conducted by DfT.

As outlined in Section 3, there are a wide range of external factors influencing EV demand. This makes it difficult to directly attribute changes observed in the market to OZEV's grant portfolio. Stakeholders we interviewed consistently identified the PICG as a key factor in developing and establishing a viable plug-in car market. In particular, they highlighted that price was a material barrier to electric car uptake at the inception of the PICG in 2011 and that the PIG was a key part of the overall policy portfolio incentivising uptake of EVs.

"[The PICG] was initially incredibly vital to start the transitions for cars, for multiple reasons." (Vehicle leasing expert)

"[The PICG] was absolutely essential to kickstart the EV Market." (Vehicle sales expert)

"The fact that there is a [PICG] has motivated a lot of people to consider an electric vehicle." (Expert industry body)

"We see things like the plug-in car grant as fundamental [in driving uptake of EVs]." (Manufacturing expert)

Several stakeholders also indicated that, beyond the value of the grant, the signalling value it provides to consumers has been significant.[19] In particular, even though the grant represents only a portion of the overall purchase price, it provides a clear signal of confidence in EVs from government. Stakeholders also suggested that there may be a behavioural "nudge" for demand in the funding being provided by government.

[19] We use the term significant here, and throughout, in a qualitative sense to mean that the scheme/portfolio appears to be an important driver of change. This does not imply statistical significance as we were not able to provide a quantitative assessment of the contribution. Rather, it is a judgement based on the weight of evidence we were able to gather, in line with our overall theory-based approach.

"[The PICG has been] critical in sending a clear message that government is serious about this market." (Expert industry body)

Available survey evidence validates the view that vehicle purchase price has been a barrier to vehicle uptake in the market. Between 2014 and 2016, DfT conducted surveys of public attitudes towards EVs in the UK.[20] In 2014, 29% of respondents indicated that the cost to buy would deter them from buying an electric car or van, with this proportion remaining fairly consistent at 25% and 26% in 2015 and 2016 respectively.[21] These statistics relate to adults aged 16 and over who are full driving licence holders and live in private households in Great Britain.

The 2016 survey explicitly asked about the impact of the PIG and EVHS.[22] Thirty-five percent of respondents stated that they either would not consider buying an electric car or van without the grant or were more likely to consider buying an electric car or van due to the grant. A further 10% felt the grant was important but not large enough to make them consider purchasing. Only 10% of respondents indicated they would buy, or consider buying, an EV if the grant were not present, 29% said they would not consider purchasing an electric car or van at all, and 16% provided other answers or indicated that the grant was neither important nor unimportant.

As surveys were not conducted in earlier years, this made comparisons over time difficult. However, the results do suggest that in the relatively early years of the EV market purchase price was considered a barrier and (at least among those who would consider an EV at all) the grants affected the stated intention to purchase for a majority of the potential market.

The role of the price incentive provided by the PICG in influencing demand appears to have lessened over time.

Discussions with market experts in vehicle manufacturing, sale and leasing highlighted that the impact of the price reduction provided by the PICG has lessened as the market has continued to develop. Overall, as the market has matured, price has become less of a barrier to vehicle uptake, with charging concerns becoming comparatively more important. This has been compounded by the reduction in the value of the PICG and the introduction of additional eligibility thresholds, which have limited the proportion of vehicles eligible for grant funding. As a result, the market has increasingly been driven by other factors:

- Stakeholders in vehicle manufacturing, leasing and sale also indicated that the differential between the benefit-in-kind company car tax allowance for EVs relative to ICE vehicles is significant, and the incentive this provides is materially larger than the value of the plug-in grants for consumers. As a result, the incentives provided by the reduction in company car tax may now be a more significant driver of market demand overall when compared to the PICG.
- Experts suggested that consumer concerns have increasingly shifted towards range and charging concerns and that these concerns have become more important relative to price as the market has developed.
- According to experts in vehicle sales and leasing across multiple organisations, the grants have also become less visible as the market has moved towards leasing and personal contract purchases, potentially limiting their effectiveness.

[20] See Table ATT0506 and ATT0507, available at https://www.gov.uk/government/collections/statistics-on-public-attitudes-to-transport.

[21] This was calculated as the proportion of individuals surveyed who responded that, if they were to buy a car or van in the next 12 months, cost would put them off buying an electric car or van, multiplied by the proportion of those who answered cost and who then went on to reply purchase cost specifically would put them off purchasing an electric car or van.

[22] See Table ATT0510, available at https://www.gov.uk/government/collections/statistics-on-public-attitudes-to-transport.

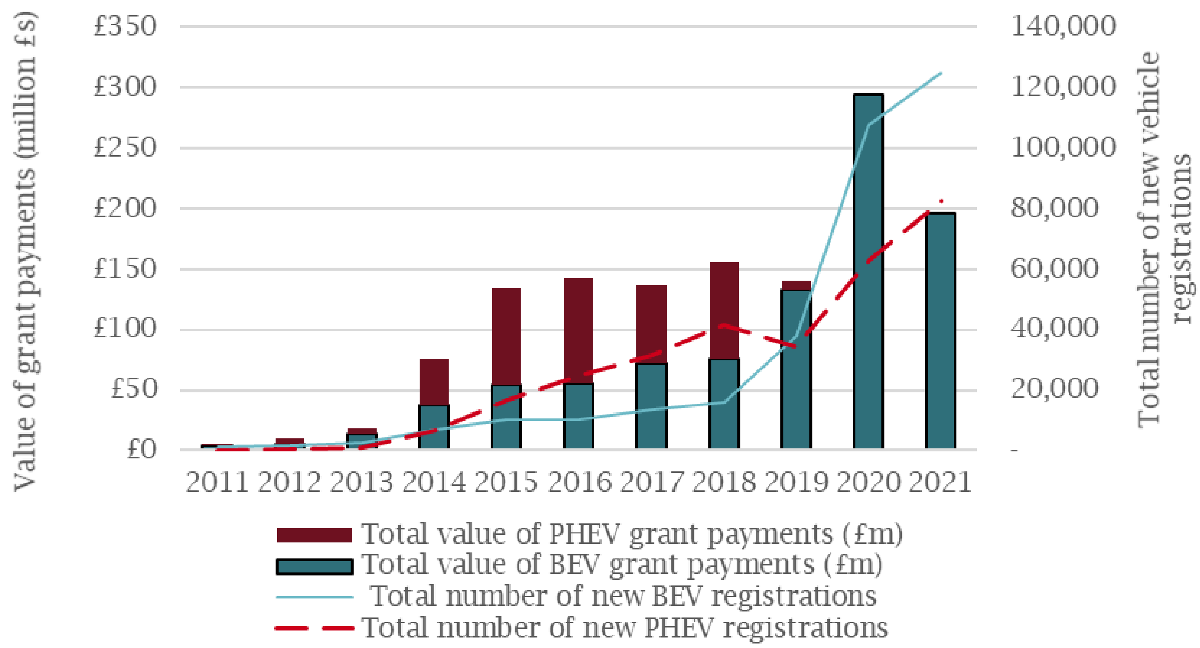
- Post 2019, regulatory changes, particularly Clean Air for Europe (CAFE), have become an increasingly important driver of EV sales.[23] Vehicle manufacturers need to meet strict average emissions targets while still remaining profitable. According to experts interviewed, this creates an incentive to sell large (and more profitable) ICE vehicles, and then to combat the upwards pressure on emissions this creates by also selling large volumes of ultra-low emissions vehicles in order to meet average CO_2 emissions targets.

Changes to plug-in grant eligibility for electric cars correlate with a noticeable shift in demand.

Correlations between changes in PICG eligibility and EV purchasing also indicate that the grants may have been a significant driver of consumer demand and purchase decisions. In particular, following grant eligibility being restricted to battery electric vehicles (BEVs) in October 2018, demand in the market shifted noticeably away from Plug-in Hybrid Electric Vehicles (PHEVs) and towards BEVs in 2019. While demand for both PHEVs and BEVs then continues an upwards trend post 2019 (consistent with there being important drivers of demand for vehicles other than the OZEV grants), this change in grant eligibility correlates with a strong shift in the market which leads to demand for BEVs overtaking PHEVs. This is illustrated in Figure 6 below.

- In 2017, total PICG funding value was roughly evenly split between PHEVs (£65 million) and BEVs (£72 million), with nearly twice as many new PHEVs (31,294) as BEVs (13,807) registered in the market.
- In 2019, the first full year after eligibility was restricted to BEVs, the number of new PHEVs and BEVs registered was roughly equal, with 34,591 PHEVs and 37,932 BEVs registered for the first time.
- In 2020, BEVs became the dominant form of new electric cars registered, with 63,109 PHEVs registered compared to 107,878 BEVs.

FIGURE 6 VALUE OF PICG GRANTS AND BEV AND PHEV REGISTRATIONS, 2011 TO Q3 2021



Source: DVLA registrations data (available here) and OZEV grant portal data

[23] The UK has had to establish its own independent average CO_2 emissions regime after leaving the EU, meaning that manufacturers have targets in Great Britain as well as the EU. As of the time of this evaluation, the UK has designed this new regime to be very similar to the existing regulation under EU Regulation 2019/631, with only minor amendments. However, this regime could in theory diverge further in the future. For more information see https://www.lexology.com/library/detail.aspx?g=71a8e354-df7d-4fb2-a050-c88e5335b88d.

Note: Grant payment dates are based on the registration year of the vehicle in the OZEV grant portal. As a result, although PHEVs were no longer eligible for plug-in car grants as of end 2018, a small value of grant payments for PHEVs is present in this figure for 2019 due to the subsidised vehicles being registered the following year.

It is estimated that approximately 90,000 additional electric car sales may be directly attributable to the price reduction provided by the PICG. This only represents a portion of the total additional demand attributable to the OZEV portfolio and wider indirect impacts.

We conducted a modelling exercise designed to estimate the potential additional demand attributable to the PICG, which represents a subset of the overall demand impact of the OZEV portfolio. In particular, using data on observed new car registrations funded by the grants between 2011 and end of November 2021, the actual value of the PICG as a proportion of price over time and estimates of own-price elasticity of demand from the literature, we estimated the additional demand which is attributable solely to the reduction in purchase price provided by the PICG. Assuming an own-price elasticity of demand of -2.76 for BEVs and -2.65 for PHEVs yields an estimate of around 90,000 electric car sales directly attributable to the price reduction provided by the grant.

These elasticities are based on Xing et al. (2021).[24] They estimate the elasticities of demand for EVs using US data for the period from 2010 to 2014 based on rich household survey data. We conducted a broader review of elasticities (see Annex C1) which suggests that these estimates are consistent with the range of potential elasticities implied by the literature; indeed multiple studies find that demand for new consumer vehicles may be even more elastic (for both electric and ICE vehicles).

This analysis is only an estimate of the direct demand effects attributable to the grants' impact on vehicle prices. The results do not include an estimate of the wider effects of the grants to develop and grow the market, such as the network effects of providing greater visibility and awareness of EVs due to a greater number of EVs being present on roads. It also ignores the complementary impact of the infrastructure grants and wider signalling or behavioural impacts of the grants. These wider, unquantified impacts may be significant – for example, Li et al. (2017) found that indirect network effects accounted for 40% of the increase in EV sales attributable to the federal income tax credit for EV buyers in the USA from 2011 to 2013.[25]

This estimate assumes full passthrough of grant value to consumers. Incomplete passthrough of the grant funding may lead to this being an overestimate of the direct price impact of the PICG on demand. However, as noted above, overall, the estimate above is likely to only cover a portion of the overall demand impact as it does not include wider indirect or market-building effects. More detail on the approach taken for this estimate and on the literature on elasticities of demand can be found in Annex C1.

5.1.2 IMPACT OF THE GRANTS ON NEW ELECTRIC VAN REGISTRATIONS

New EV registrations as a percentage of new van registrations has not met OZEV's original projections.

For vans, new EV registrations as a percentage of all light goods vehicle (LGV) registrations did not meet the initial projection of 5% by 2020,[26] and the proportion of electric vans receiving the PIVG remains high

[24] Jianwei Xing, Benjamin Leard, and Shanjun Li (2021). What Does an Electric Vehicle Replace? *Journal of Environmental Economics and Management*, 107.

[25] Shanjun Li, Lang Tong, Jianwei Xing, and Yiyi Zhou. 2017. The Market for Electric Vehicles: Indirect Network Effects and Policy Design. *Journal of the Association of Environmental and Resource Economists.* 4(1), 89-133.

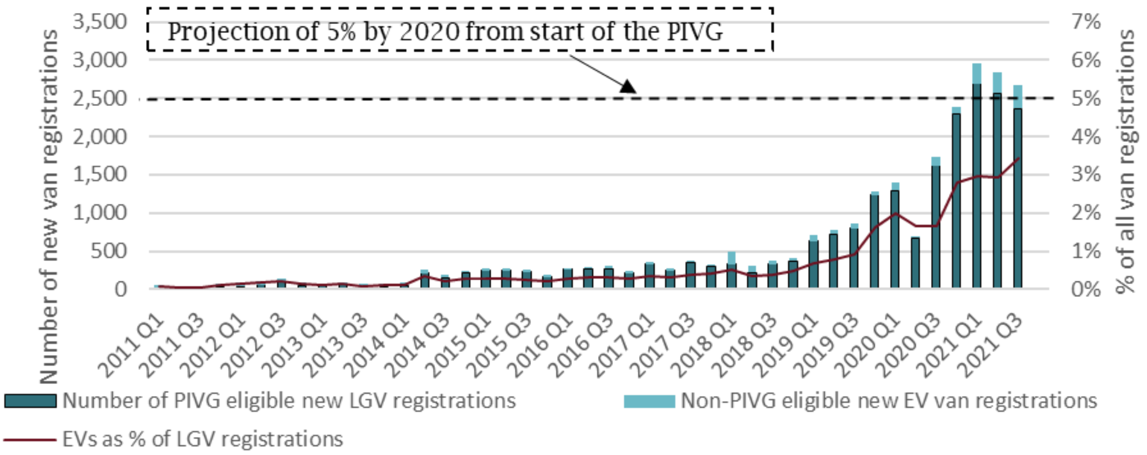
[26] When making this initial projection, OZEV noted that there was a larger degree of uncertainty in this projection when compared to the projection for cars.

(and much higher than the share of electric cars receiving the PICG). This suggests that **the market for electric vans remains in relatively early stages of development**.

As shown in Figure 7 below:

- New electric vans as a share of all new vans registered did not exceed 1% until after Q3 2019. The share rose to 3.5% in Q3 2021 but is still below the 5% projection for 2020 set out in 2011.
- In 2020 and 2021, 90% of electric vans received PIVG funding.

FIGURE 7 NEW EV REGISTRATIONS AS A PERCENTAGE OF ALL NEW LGV REGISTRATIONS



Source: DVLA data on vehicle registrations published by DfT. Available here

Note: Values for the EVs as % of LGV registrations before 2014 Q3 are the values for Great Britain due to data availability; all data from 2014 Q3 onwards is for the UK as a whole.

Experts in the market suggested that low electric van uptake has been driven by product limitations and the PIVG is becoming increasingly important as electric vans become viable.

Discussions with experts in commercial vehicle purchasing and leasing and fleet electrification emphasised that, while price is an important factor, vehicle characteristics and functionality have been major barriers to electric van uptake by commercial users. Product range has been a limiting factor, with few choices of electric vans and commercial users being constrained by payload, range and charging requirements. Overall, the stakeholders interviewed suggested that the limited variety of electric vans available has been a major barrier to uptake, with these product limitations representing a barrier outside of OZEV's control. This barrier is closely tied to the objective of the PIVG to grow the early market. The view of all the stakeholders we interviewed on electric vans was that falling short of the 5% projection is not therefore strong evidence of a lack of impact of the PIVG; rather, that the grant was introduced at an incredibly early stage of market development when product range was extremely limited.

Commercial fleet and vehicle experts interviewed also indicated that commercial users purchasing vans and trucks are even more price sensitive than private consumers, with decisions being made based on total cost of ownership alongside product functionality. As a result, despite the current limits on vehicle uptake imposed by product range, the PIVG remains important in driving demand for vans and will likely continue to be important as new electric van models are brought to market. An expert in large commercial fleet electrification suggested that changes to PIVG eligibility in December 2021, which reduced the grant amount and imposed a limit of 1,000 vehicles per year, have had a significant impact on the cost of transition for them and could limit the speed at which they are able to electrify their fleet.

"The [PIVG] being reduced had a massive impact on the planning around [the transition] and it means that we have to revisit how many electric vehicles we actually purchase next year." (Fleet transition expert)

Overall, the stakeholders interviewed consistently stated that the PIVG was and continues to be a major driver of demand for electric vans and expressed concern about the cost for and ability of commercial users to transition if the grant were to be restricted further or removed, particularly as viable electric van models become more readily available but the price premium remains.[27] This is consistent with DfT survey evidence for the 2019-2020 period which found that purchase price remained the most important reason for not considering an ultra-low emission van, with 38% of respondents indicating it was the most important barrier to uptake. This was followed by concerns about size, range and capacity, which were highlighted as the most important barrier to uptake by 30% of respondents.[28]

"The [PIVG] makes a huge difference in decisions for those consumers." (Manufacturing expert)

5.1.3 IMPACT OF THE GRANTS ON INFRASTRUCTURE DEPLOYMENT

Increasing the availability of charging infrastructure is an important part of developing the market for EVs, with home charging particularly important.

Experts interviewed indicated that the charging grants (particularly the EVHS) are important factors in overcoming EV purchase barriers.

"Approximately 80% of charging is done at home, so getting as many chargepoints in as many houses as possible and removing that barrier to EV uptake for those that can charge at home while figuring out the more difficult on-street / rapid charging issues was good." (Expert industry body)

Increasing the availability of charging infrastructure is also a key part of building the EV market and overcoming barriers to adoption. Industry experts recognised that the infrastructure grants, and the EVHS in particular, have been important in reducing purchase barriers and are an important piece of the "jigsaw" of policy overall. These views are supported by the wider literature and evidence on consumer attitudes which show the importance of home charging to EV adoption:

- Research commissioned by the Energy Technologies Institute[29] showed that mainstream consumers prefer charging at home, based on consumer charging trials.
- Drawing on evidence from trials and the DfT's public opinion trackers, the Behavioural Insights Team and the Transport Research Laboratory (TRL) suggested that availability and access to charging infrastructure is a critical barrier to adoption of EVs. Their research highlighted that access to charging at home was the most important form of access to charging overall, followed by access to charging at work and access to public charging.[30]

The number of EVHS-funded chargepoint installations has increased over time even as the maximum value of the grant has reduced.

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[27] These interviews were conducted prior to the government's announcement on 15 March 2022 of the PIVG being extended for two years until at least 2024/25.

[28] Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/978087/van-statistics-2019-to-2020.pdf.

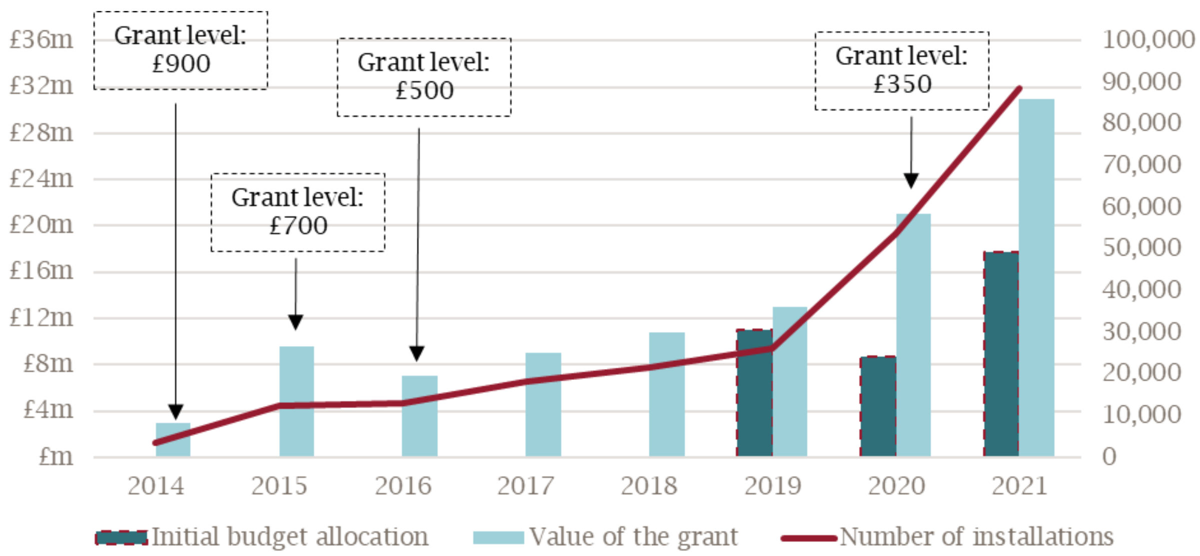
[29] Energy Technologies Institute (2019). Consumers, Vehicles and Energy Integration Project – Final Project Summary Report, available at https://trl.co.uk/uploads/trl/documents/CVEI-190927-D04-D8.1-Final-Project-Summary-Report-(2).pdf

[30] The Behavioural Insights Team and TRL (2020). Driving and Accelerating the Adoption of Electric Vehicles in the UK, available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/914111/driving-and-accelerating-the-adoption-of-electric-vehicles-in-the-uk.pdf

There has been a steady increase in uptake of EVHS-funded chargepoint installations since the inception of the grant scheme in 2014. This increase has continued even as the grant levels have been reduced, with no clear changes in the trend in installations that align with changes in grant level. This increased uptake has exceeded OZEV expectations for the 2019-2021 period. This is illustrated in Figure 8 below.

- The number of annual installations funded under EVHS tripled between 2017 and 2020, rising from 18,052 to 53,761. This rose again to 88,624 in 2021.
- The total value of grant funding rose at a slower rate over this period, increasing 2.3 times between 2017 and 2020 (from £9 million to £21 million).
- For each year in 2019 to 2021, the value of the EVHS funding exceeded OZEV budget allocations (budget allocations are not available for earlier years). In 2020, the total value of the grant was around 2.4 times the initial budget allocation amount. In 2021, the value of the grant was around 1.7 times the budget allocation. This likely reflects the rapid growth in EV sales in recent years (which generates the need for additional home chargepoints), suggesting that this growth has also been underestimated.

FIGURE 8 CHARGEPOINT INSTALLATIONS FUNDED BY EVHS COMPARED WITH LEVEL AND VALUE OF GRANT FUNDING, 2014 TO 2021



Source: OZEV Electric vehicle charging device scheme statistics: January 2022. Available here. Budget allocations from OZEV internal documents

Note: EVHS: Budget allocation projections for 2019 were produced in 2018, budget allocations for 2020 and 2021 were produced in 2019. Figures are based on the minimum budget allocation. Earlier budget allocations not available.

The EVHS and WCS helped the growth of the chargepoint industry at its infancy, contributing to the development of a diversified market and specific routes to market.

Stakeholders interviewed recognised that the market for chargepoints has greatly developed compared to its state at the beginning of the schemes, with more choice available to consumers in terms of chargepoint range.

"If you look at the diversification of products and specifications in the marketplace, there is a more mainstream approach than at the beginning of EVHS." (Trade body expert)

Supporting the development of the industry, chargepoint industry experts indicated that grants have also contributed to the development of routes to market that did not previously exist. For instance, consumers can now get a chargepoint bundled in with special EV energy tariffs, which was not a possibility just a few years ago. Only one stakeholder indicated that the downside is that, at the same time, grants may have limited the development of some points of sale (e.g. specific online retailers, department stores), encouraging consumers to get chargepoints from car dealerships and official installers, as these were the only organisations that could process the grant.

Despite the steady growth in grant-funded chargepoint installations observed in the last few years, stakeholders and survey data suggest that charging is still a barrier to consumer uptake of EVs, while cost is less of an issue.

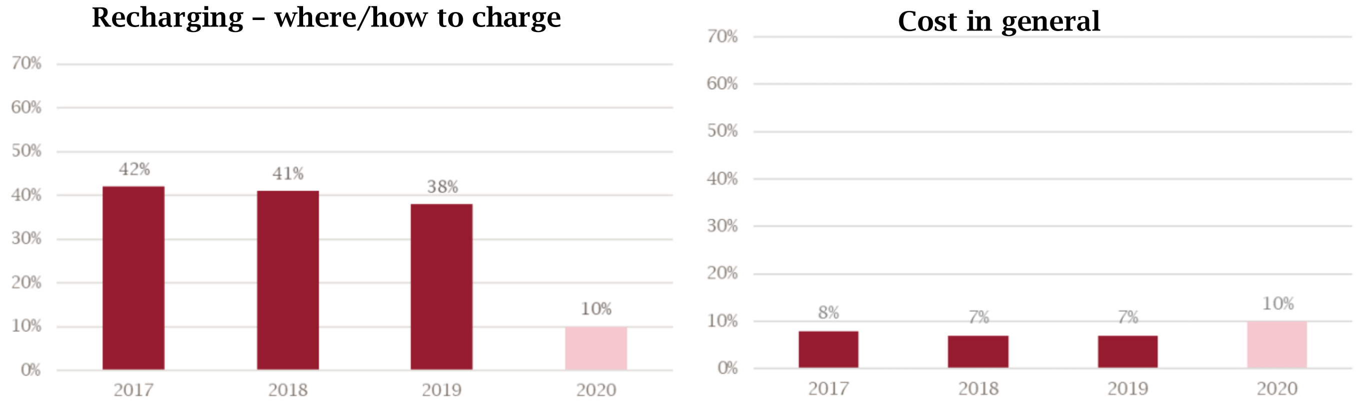
According to industry experts interviewed, as EV capability has increased, the availability of chargepoints has become a more significant barrier to adoption, surpassing purchase price in importance for consumers. Stakeholders argued that the charging grants remain an important part of driving demand for EVs in the market and that there are still barriers to uptake for multiple customer segments (including consumers both with and without access to off-street residential parking).

"Charging is a massive barrier, and is becoming more and more significant over time. Would argue that we should be going in the other direction and provide a free homecharger for all new vehicle purchases." (Industry expert)

Existing DfT survey evidence also illustrates the importance of charging. Excluding 2020 survey evidence (which was conducted in August 2020 and appears to have been affected by the pandemic), the ability to charge EVs has consistently been more important than cost in general over the 2017-2019 period. This is illustrated in Figure 9 below. In particular:

- When prompted to think about disadvantages of EVs, between 38% and 42% of respondents mentioned knowing where to charge (at home, elsewhere) in the years 2017-2019.
- At the same time, a much lower percentage of respondents (between 7% and 8%) identified general cost as one of the disadvantages of EVs over petrol and diesel cars.
- Earlier and later waves of this survey are available but a direct comparison is not feasible due to the use of different survey methodologies over the years.

FIGURE 9 SURVEY QUESTION: WHAT DO YOU THINK ARE THE DISADVANTAGES, IF ANY, OF ELECTRIC VEHICLES OVER PETROL OR DIESEL CARS?



Source: DfT's public attitudes tracker. Available here. Survey base: all adults 16+ in England

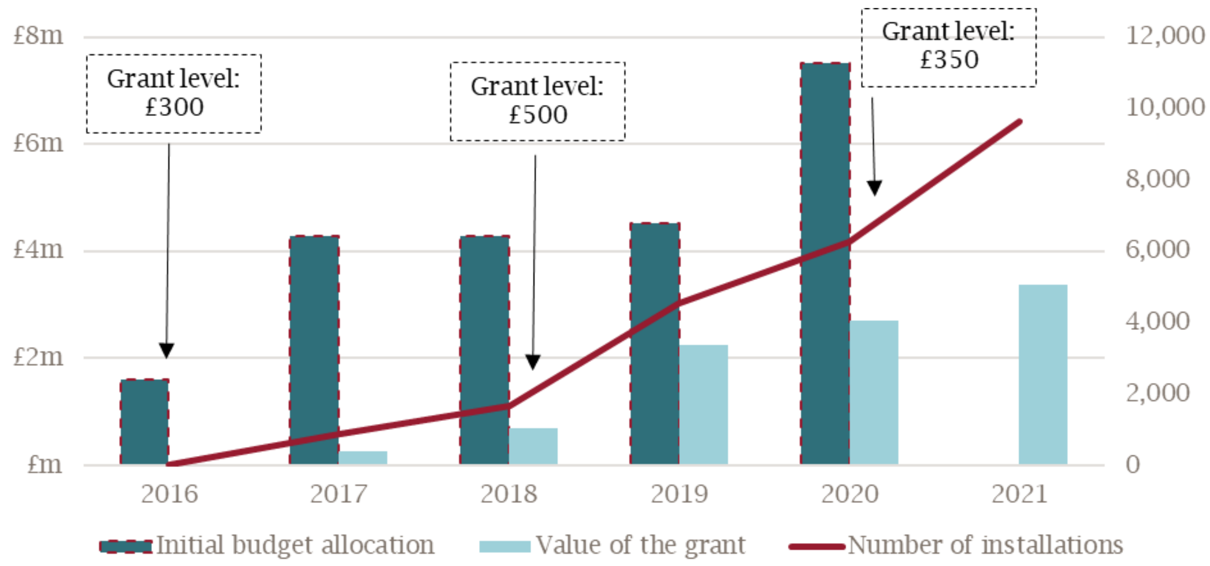
Note: Due to COVID-19 restrictions, the 2020 wave of the survey is significantly different in sample composition and measurement mode. Comparisons with other waves are therefore unadvisable. The 2021 wave also underwent a substantial methodological change and as a result has not been included here as it is not comparable.

The number of WCS-funded chargepoint installations has also increased over time; however, overall uptake of WCS has been limited.

While the number of WCS installations has increased over time, uptake has been limited and appears to have fallen below OZEV budget allocations. This is illustrated in Figure 10.

- The number of WCS installations increased from around 900 in 2017 to over 6,000 in 2020, while the value of the grant increased from £0.3 million to £2.7 million over the same period.
- This was below OZEV budget allocations, which stood at £4.3 million in financial year 2017/18 and £7.5 million in financial year 2020/21.

FIGURE 10 CHARGEPOINT INSTALLATIONS FUNDED BY WCS COMPARED WITH LEVEL AND VALUE OF GRANT FUNDING, 2016 TO 2021



Source: OZEV Electric vehicle charging device scheme statistics: January 2022. Available here. Budget allocations from OZEV internal documents
Note: The budget allocation refers to the financial year and not the calendar year. Budget allocations for FY 2021/2022 not available..

According to stakeholders, the relatively low WCS uptake may be a result of low awareness and other barriers to fleet electrification that are not within the scope of the scheme.

Stakeholders suggested that the low uptake of WCS may be due to a combination of low awareness and the scheme not being designed to target large fleets.

> *"The workplace one didn't seem to be promoted that well."* (Expert industry body)

The WCS was not designed with a specific focus on electrifying fleets. Instead, its original aim (as set out by OZEV) was primarily to provide a slow charging solution so that commuters could charge their vehicles during the day, while potentially providing some additional benefits in terms of support for fleet charging and network effects from making EVs in workplace carparks more visible.

Stakeholders with expertise in commercial vehicle and fleet purchasing highlighted that there remain significant charging-related barriers to fleet electrification. These barriers impose an ongoing constraint on uptake of EVs by fleet users, and the OZEV portfolio has not been intended to overcome all of these barriers.

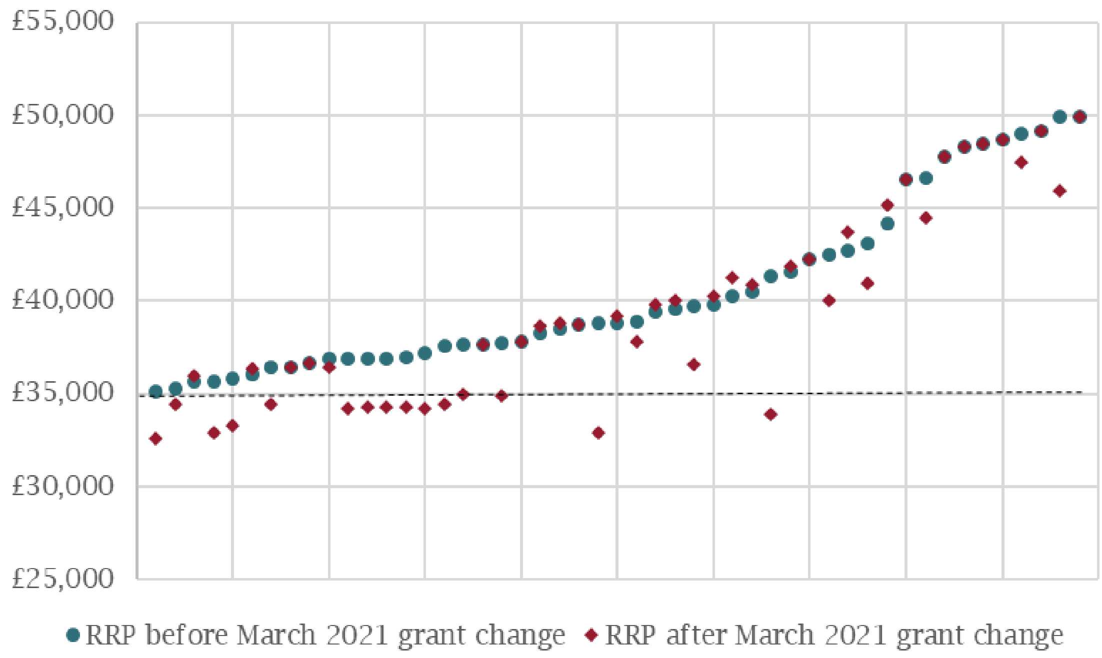
5.1.4 UNINTENDED CONSEQUENCES OF THE OZEV GRANTS

The PICG may have distorted vehicle prices by keeping them artificially high in the recent period when the market was more mature.

Market analysis of public data on vehicle pricing shows that a number of electric car models reduced their price in response to the £35,000 maximum price threshold imposed in order to retain eligibility. This is illustrated in Figure 11 below.

- Analysis of the impact of price on 119 EV model-trim combinations that were eligible for the PICG prior to the eligibility change in March 2021 shows that 15 of these model-trims reduced their recommended retail price (RRP), the price before the grant is applied, in order to remain eligible for the plug-in grant. Figure 11 shows the change in RRP before and after the March 2021 PICG change for vehicles whose prices were between £35k and £50k prior to the change in grant eligibility.
- However, 27 of the models that had prices below the £50k limit prior to March 2021 (including those with prices that were already below £35k) increased their prices in response to the £500 point reduction in maximum grant amount (from £3k to £2.5k), with the price increasing for these models by £437 on average. This suggests that for at least a portion of the market there was a reasonable degree of passthrough, with the grant resulting in reduced prices for consumers as opposed to being retained by manufacturers or dealers.
- There is less evidence of the grants potentially leading to artificially high vehicle prices prior to this. Following the introduction of a £50k grant limit and a reduction in the maximum grant amount by £500 to £3k, in March 2020, an analysis of 34 plug-in car models eligible for the grant showed that 23 increased prices in line with the grant reduction, six absorbed the reduction in grant value and only one model reduced prices in order to retain the grant. Overall, this suggests a high degree of passthrough to consumers at the time of this grant change and that manufacturers were not absorbing the grant without reducing vehicle prices.
- Taken together, this suggests that as the market has become increasingly mature some manufacturers may have failed to pass on the full value of the grant to end consumers, leading to artificially high vehicle prices in some cases.

FIGURE 11 ELIGIBLE VEHICLE PRICES BEFORE AND AFTER MARCH 2021 PICG CHANGE, FOR THOSE MODEL-TRIMS WITH INITIAL PRICES BETWEEN £35K AND £50K



Source: Frontier Economics, based on market analysis of public data from vehicle brochures and price lists on vehicle model-trim combinations pricing

Note: For a given point on the x-axis, the plotted dots indicate the RRP for a given vehicle model-trim before and after the grant change, for those vehicles whose price was between £35-50k before the change in grant eligibility.

Some experts in vehicle manufacturing interviewed argued that this is not in and of itself evidence of lack of passthrough or price distortions. These manufacturing experts suggested that the decline in retail price may be a combination of two primary factors:

- Manufacturers may have adjusted the framing of their vehicle offer by removing some vehicle features from the default specification and making them add-ons and by adjusting financing arrangements in order to comply with the new £35k price limit.
- Manufacturers may have accepted a further reduction in margin due to price elasticity constraining their ability to raise price without leading to a significant loss in volume.

However, the above input does not rule out that the grant was distortionary for some vehicle prices, and some of this input does suggest that manufacturers might have priced differently in the absence of the grants. Overall, this suggests that changes in the vehicle grant may have had some distortionary effect on price (or other manufacturer decisions) as the market for cars matured.

The grants may have benefited relatively high-income households due to favouring early adopters.

Some experts interviewed for this evaluation also suggested that the OZEV grants may have favoured more affluent consumers, as early adopters of EVs are likely to have been relatively high income given the large upfront purchase costs, even with grants available. Similarly, the EVHS may have benefited higher-income households due to it being targeted at individuals with access to off-street parking (who tend to be homeowners)[31] prior to 2022.

"Early adopters by and large belonged to a more affluent demographic. This means that we've given money to a group of people that may as well have been able to do this anyway. Although that's speculation, the offshoot of that is that it just widened the gap between people that can charge at home and people that can't." (Trade body expert)

This is backed up by external analysis. For example, in a report for the Environmental Defense Fund, Frontier Economics (2019) estimated that the richest 10% of households in 2015/16 to 2016/17 owned more than 30% of the EV stock in the UK, while the poorest 10% of households owned only around 2% of EVs.[32] This is a much more pronounced skew than for ICE vehicles.

This impact may have been unavoidable given OZEV's portfolio's objective of growing the early market (which by definition will mean favouring early adopters). Some recent changes to grant eligibility may also have helped to reduce these distributional impacts. OZEV introduced price caps on vehicles eligible for the PICG in 2020, with this price cap reduced in 2021, effectively excluding premium cars from grant eligibility and focusing the grants on more mainstream vehicles. As of April 2022, the EVHS will also no longer be available to homeowners in single-unit properties and, instead, will be targeted at homeowners who live in flats and those in rental accommodation. Although the carbon savings associated with adoption of EVs provide benefits for the wider public, and not just for adopters of EVs, the distributional effects of the grants are an important consideration going forward and as these markets develop.

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[31] PwC ran a survey targeted at vehicle drivers across the UK and found that 78% of homeowners had access to off-street parking. PwC (2018). Charging Ahead! The Need to Upscale UK Electric Vehicle Charging Infrastructure, available at https://www.pwc.co.uk/power-utilities/assets/electric-vehicle-charging-infrastructure.pdf

[32] Frontier Economics and EDF (2019), Electrifying the UK: Ensuring the Transportation Revolution Benefits Everyone, available at https://www.edf.org/sites/default/files/documents/EDFE%20EV%20electrification%20report%20Oct%202019%20FINAL.pdf

5.2 IMPACT OF THE GRANTS ON MANUFACTURING AND DOMESTIC SUPPLY OF NEW EVS

This section sets out the evidence gathered on the impact of the PIG, EVHS and WCS grants on the production and sale of new EVs, both in terms of product allocation of EVs to the UK and manufacturing of new EVs, EV components and EV infrastructure in the UK.

While turnover and employment did increase in the EV sector (which includes both vehicles and infrastructure) between 2014 and 2019, it is difficult to attribute any of this growth directly to the grants under evaluation.

Over the past decade, several companies have started to produce (or have announced an intent to produce) EVs in the UK or expand existing production. For example:

- In 2013, Nissan began the production of the electric Nissan Leaf in Sunderland;[33]
- In 2019, BMW Group announced the production of MINI Electric in Oxford;[34]
- In 2021, Ford announced new investments to build EV components in the UK[35]; and
- In 2022, Bentley announced the plan to build its first electric car at the company's plant in Crewe.[36]

There have also been announcements relating to battery production, a key component of EVs:

- Nissan is expected to open a Gigafactory by 2024 in Sunderland;[37] and
- Britishvolt intends to build a battery Gigaplant in Northumberland.[38]

Available Office for National Statistics (ONS) data[39] on turnover and employment in the low emission vehicles and infrastructure sector also shows an upwards trend in the size of the market.[40] The data shows turnover beginning to accelerate after 2016, almost doubling from £3.4 billion in 2016 to £6 billion in 2019. The pattern for employment is more volatile, but again has grown since 2016 from around 10,200 full-time equivalent (FTE) workers to 15,900 in 2019 (see Figure 12**)**.

[33] Nissan launches production of new and improved 100% electric Nissan Leaf in Sunderland, UK (28/03/2013).

[34] Mini Electric unveiled at Oxford as brand turns 60 (09/07/2019).

[35] Ford to invest £230 million to transform Halewood operations in UK to build its first electric vehicle components in Europe (18/10/2021).

[36] Bentley secures UK production of first electric car – commits to £2.5 billion sustainability investment in a decade (26/01/2022).

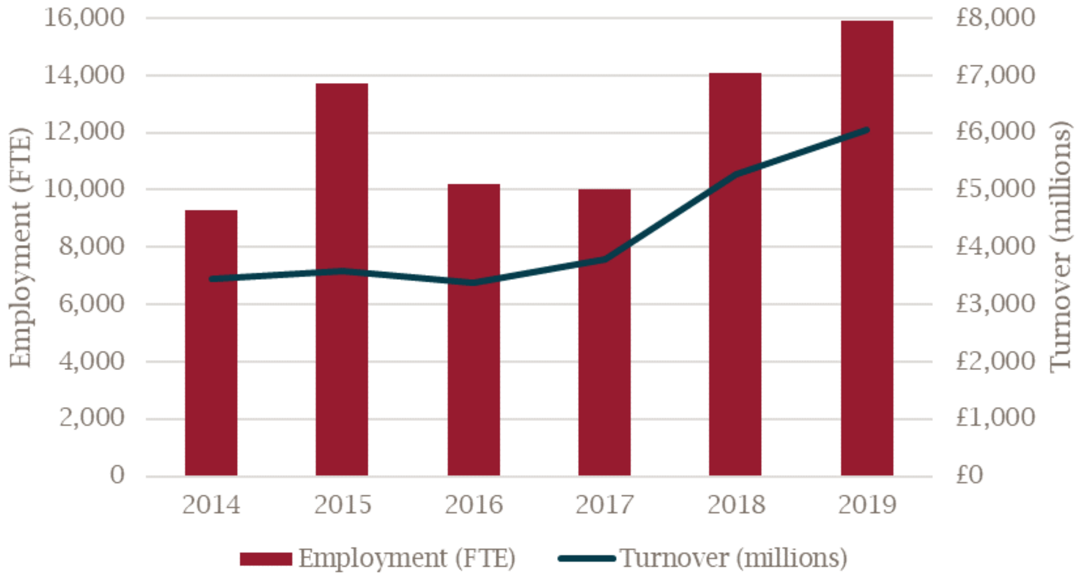
[37] Nissan expected to announce plans to build battery "gigafactory" in Sunderland (28/06/2021).

[38] Britishvolt powers ahead with plans to build transformational UK battery Gigaplant to meet EV demand (21/01/2021).

[39] See The UK's Low Emission Vehicle Sector, published on 8 November 2021 by the ONS.

[40] This is based on ONS estimates of sector size. The low emission vehicles and infrastructure sector includes subsets of multiple SIC codes and sectors, with the significant majority coming from the manufacturing sector (and small amounts from professional, scientific and technical activities, wholesale and retail trade for the repair of motor vehicles and motor cycles, and construction).

FIGURE 12 TURNOVER AND EMPLOYMENT IN UK EV INDUSTRY, 2014-2019



Source: ONS data on low emission vehicles and infrastructure sector

Note: There is a higher degree of uncertainty in the first three years of estimates, in particular in 2015. Full-time equivalent (FTE) is a unit for measuring employed persons that makes them comparable although they may work or study a different number of hours per week. (source)

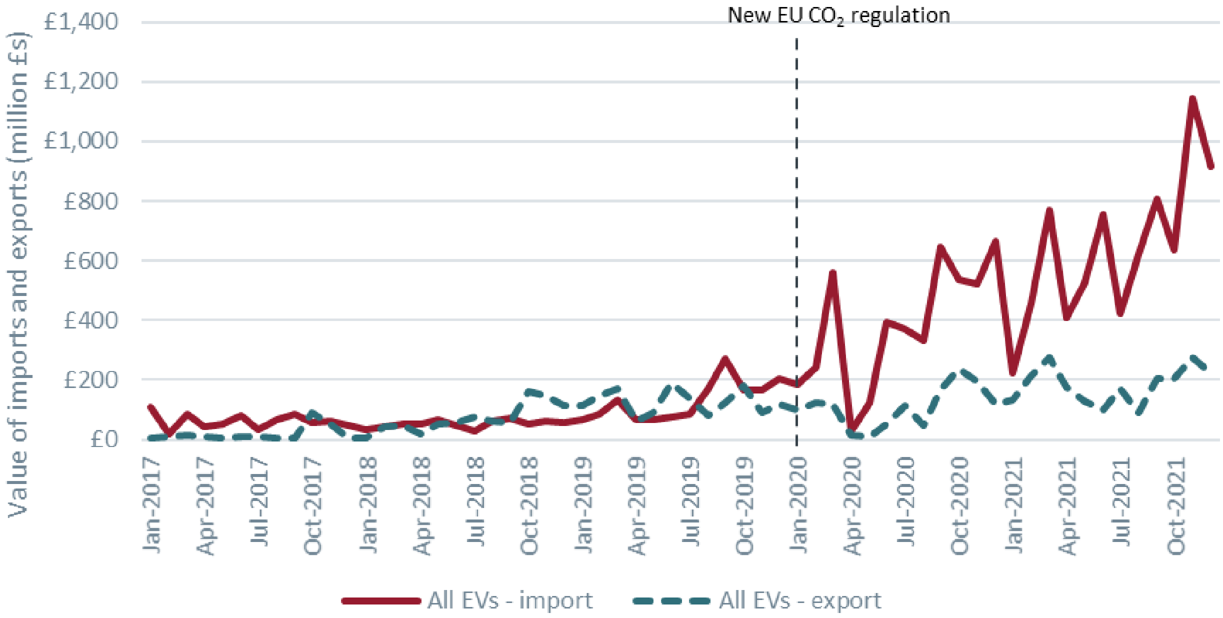
While manufacturing of EVs and EV components is continuing to expand in the UK, key stakeholders we consulted for this evaluation suggested that the **impacts of the grants alone on investment and manufacturing are likely marginal.** Interview participants consistently responded that there are other much more important drivers of investment decisions than the OZEV grants – in particular, business rates, energy costs, labour costs, trading costs and overall long-term government strategy. Experts in battery manufacturing noted that decisions to manufacture batteries in the UK are driven by the whole business ecosystem, including availability of high-skilled domestic labour and expertise as well as the overall policy environment. While having a viable local market may provide a limited incentive for investment, ultimately the EV market is highly international and manufacturers are producing vehicles for a global market. As a result, while the OZEV portfolio may have an impact as a component of overall government policy, the direct impact attributable to the OZEV portfolio specifically is likely limited.

Input from market experts suggests that the OZEV portfolio may have contributed to securing product allocation in the UK.

The majority of EVs in the UK are imported, with stakeholders suggesting that approximately 80% of UK demand for EVs is met through imports.[41] As a result, attracting imports of the available supply of EVs (particularly as demand is currently outpacing supply of EVs globally, according to industry experts) is an important part of building a sustainable EV market in the UK. Figure 13 below illustrates that imports of EVs to the UK over time have increased substantially, even as exports of EVs have remained relatively steady. Imports of EVs have accelerated notably post January 2020, which coincides with the introduction of CAFE targets.

[41] This is consistent with evidence on the proportion of UK registrations accounted for by imported cars (including both ICE and EVs) which was consistently in the region of 80-90% between 2010 and 2020. See SMMT (2021). UK Automotive Trade Report 2021, available at https://www.smmt.co.uk/wp-content/uploads/sites/2/SMMT-Trade-report-2021.pdf

FIGURE 13 IMPORTS AND EXPORTS OF PLUG-IN ELECTRIC VEHICLES TO THE UK, 2017-2021



Source: UK Trade Info data from HM Treasury. Based on analysis of relevant HS codes (870380, 870240, 870360, 870370, 870220 and 870230)

Vehicle manufacturing and sales experts we consulted indicated that the OZEV portfolio may have been important in ensuring allocation of EVs to the UK. Some stakeholders commented that EV models are often a loss leader, and so allocation of EVs to local markets is driven by comparisons of the local market environments. Clearly, this assessment is driven by a range of factors, including trade barriers and exchange rate movements, but several stakeholders noted that the relative level of government grants and funding for EVs across countries appears to be a factor. As a result, while grant support for EVs in the UK is lower than in other key markets such as Norway and Germany, if the OZEV grants had not been present at all (or present at an even lower rate) it might have been more difficult to secure EV supply in the UK.

The technical requirements specified by the grants have effectively provided additional quality standards for the EV market, particularly for chargepoints.

Chargepoint experts interviewed indicated that minimum technical requirements for the EVHS and WCS grants have effectively acted as additional product standards and have served the purpose of guaranteeing safety and quality of chargepoints installed. Stakeholders stressed the importance of these technical requirements in encouraging UK manufacturing in the charging space and incentivising installers to enter the market. They also expressed concern about the impact on safety and consumer confidence in the long run if the grants were to be removed without explicit minimum requirements being regulated in the market.

"Those [EVHS] requirements were the de facto standards for EV domestic chargepoint manufacturers and installers." (Trade body expert)

The PIG requirements may also have been relevant to some degree in setting common standards for vehicles (for instance, for battery durability and warranties). However, as the UK is part of the global market for EVs and decisions on product capability are made for this international market, experts indicated that considerations about local technical requirements are likely to have played a much less important role for EVs when compared to chargepoints.

5.3 WIDER ENVIRONMENTAL BENEFITS DELIVERED BY THE GRANTS

There are a number of potential benefits which may be delivered by the OZEV grants. As set out in Section 3, these may include benefits from environmental impacts in the form of changes in emissions and impacts on battery disposal, social impacts resulting from distributional impacts across different groups and areas of the country, benefits for consumers due to fuel cost savings from switching to EVs and energy security impacts due to changes in demand for imported fossil fuels and impacts on grid balancing. It was not possible to gather evidence on and evaluate most of these impacts within the time and data availability constraints of this evaluation. As a result, we focused on the potential emissions reductions stemming from switching to EVs which are quantifiable.

The UK has ambitious decarbonisation goals, with a commitment to meet net zero by 2050. A key part of achieving this goal is decarbonising transport, which contributed 27% of UK domestic GhG emissions in 2019.[42] Inducing switching to EVs has a significant impact on the ability of the UK to achieve decarbonisation of transport and meet its net-zero targets.

This section sets out some of the potential environmental benefits of the OZEV portfolio. These benefits arise from the abatement of GhGs[43] and pollutants[44] that would have been emitted if individuals had purchased a diesel or petrol car instead of an EV. It is possible to quantify the reduction in pollution from electric cars delivered by the grants and its monetary value[45] based on an assumption of the portion of EV demand that can be attributable to the grants. However, it is important to note that this should not be taken as the sole benefit delivered by the grant. Rather, the figures below provide an estimate of a subset of the overall potential benefits of the grants. These figures do not include wider benefits (for example, in terms of impacts on energy security or the value to consumers of a shift towards EVs with lower fuel costs), and do not include further environmental or social benefits linked to the wider market-building impacts of the grants. Rather, these estimates focus on those emissions benefits attributable to the impact of the direct price reduction provided by the grants. The estimates below also do not include potential benefits from the decarbonisation of vans.

The GhG and air pollution benefits from switching a petrol or diesel vehicle to an electric car are significant.

We estimated the reduction in GhGs and air pollution derived by switching an ICE car to a BEV or PHEV car based on its year of purchase. Switching to a BEV leads to a higher reduction in GhG emissions across the whole period in which the grants were available, where between 5 and 6 tonnes of CO_2e are abated over the useful product life[46] of a BEV as opposed to around 3 tonnes of CO_2e abated over the lifespan of a PHEV. As

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[42] See DfT, Decarbonising Transport – A Better, Green Britain. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009448/decarbonising-transport-a-better-greener-britain.pdf.

[43] The GhGs taken into consideration are those included in BEIS's CO_2e emissions conversion factors: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). CO_2e or "carbon dioxide equivalent" is a term which describes different GhGs in a common unit. For any quantity and type of GhG, CO_2e signifies the amount of CO_2 which would have the equivalent global warming impact. Source: https://ecometrica.com/assets/GHGs-CO2-CO2e-and-Carbon-What-Do-These-Mean-v2.1.pdf

[44] As additional air pollutants, we took into consideration sulphur dioxide (SO_2), particulate matter that is 10 micrometres and smaller (PM_{10}).

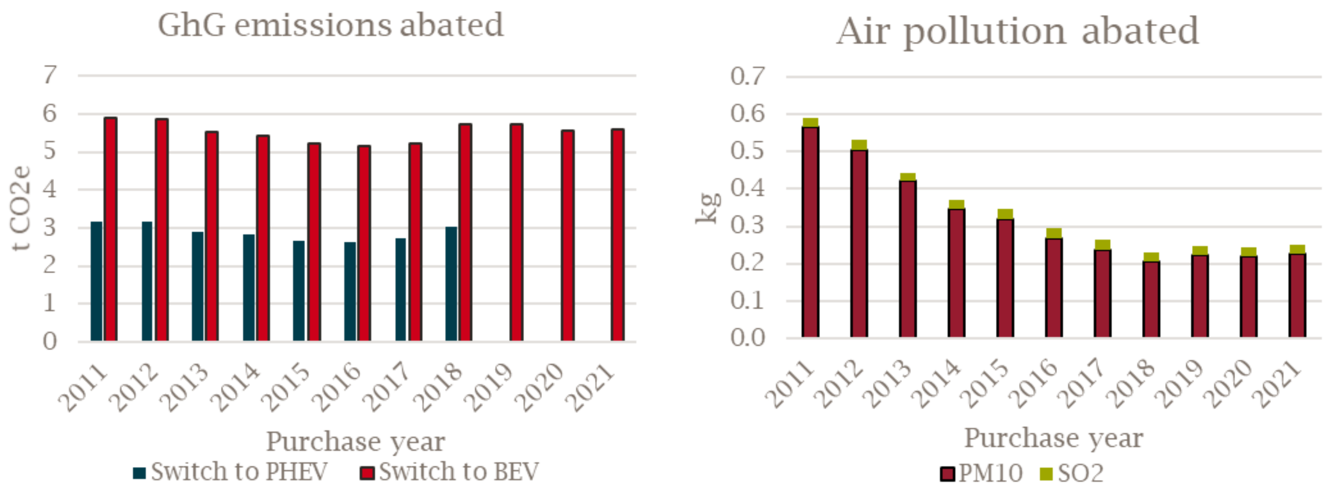
[45] Monetary values are based on BEIS's carbon values, which represent a monetary value that society places on one tonne of CO_2e, and the Department for Environment, Food and Rural Affairs' (DEFRA) pollutants damage costs, which include the impact that pollutants have on public health, the natural environment, and the economy.

[46] Based on conversations with industry experts and the usual warranty duration for an EV battery, we assumed a lifespan of eight years.

set out in Annex C2, this estimate includes the full lifecycle emissions from fuel and electricity used for travel by ICE and EVs.

Switching to an EV also leads to reductions in SO_2 and PM_{10} emissions. As Figure 14 below shows, the amount of pollutants abated have declined over the years as engine efficiencies of vehicles have improved over time: in 2011, purchasing an EV instead of a diesel or petrol vehicle led to a reduction of around 0.6 kg of these pollutants, while in most recent years around 0.3 kg of pollutants are abated for each EV purchased in place of an ICE vehicle. This is illustrated in Figure 14.

FIGURE 14 ABATED GHG AND POLLUTANTS OVER AN ELECTRIC CAR'S USEFUL LIFE, BY PURCHASE YEAR



Source: Frontier Economics calculations using BEIS and DfT data
Note: Analysis for PHEVs is only presented to 2018, when PHEVs were removed from plug-in grant eligibility.

Depending on assumptions about EV demand being attributable to the OZEV grants, the overall environmental impact of inducing additional uptake to EVs is significant.

Within the limitations of this evaluation, we did not estimate the full additional impact of the OZEV portfolio on the demand for EVs. As a result, we drew on the available academic literature summarised in Annex C1 to determine a plausible overall range of electric car demand attributable to the OZEV portfolio. This range is used to illustrate potential emissions benefits under different assumptions on demand.

If we assume that the grants resulted in additional demand equal to 10% of all PICG-eligible EVs purchased between 2011 and 2021, this would imply that ~193,400 tonnes of greenhouse gases and 7 tonnes of air pollutants were abated over the full lifespan of the vehicles, equal to a total value of £38 million in monetary terms.[47] A 10% figure is approximately consistent with the additional demand attributable solely to the price reduction provided by the PICG under the lower bound of elasticity of demand assumptions provided by the academic literature summarised in Annex C1. This does not include any impact on EV demand stemming from the wider market-building or network effects of the OZEV portfolio.

If we instead assume that 30% of EV cars purchased were driven by the availability of the grants, the environmental benefits increase to 580,300 tonnes of GhG emission savings and 22 tonnes of air pollution reduction, equal to £114 million in monetary terms. A 30% figure is approximately consistent with the additional demand attributable solely to the price reduction provided by the PICG under the upper bound of elasticity of demand assumptions provided by the academic literature summarised in Annex C1. This

[47] Based on BEIS carbon pricing values for the relevant years in which emissions reductions are occurring.

does not include any impact on EV demand stemming from the wider market-building or network effects of the OZEV portfolio. It is conservative when compared with evidence in the USA from Li et al. (2017),[48] which found that the federal subsidy programme contributed to 40% of total EV sales over the period studied (with this impact including indirect network effects).

Overall, while only a subset of the overall wider impact and value for money of the OZEV portfolio, the potential benefits in terms of emissions and pollutant reductions appear significant. However, these figures should not be taken to be the whole return on investment from the OZEV portfolio.

5.4 LIMITATIONS OF ANALYSIS

As noted in Section 2, the analysis in this section was limited both by the time available to undertake this evaluation and a lack of consistent monitoring data and information on targets for the market over time. As a result, caution should be taken when using these results to quantify the additional impact of the OZEV portfolio on the EV market.

The analysis does not attempt to estimate the entirety of the impact of the OZEV portfolio.

Determining the impact that the schemes have had on the market is extremely difficult as the counterfactual – what would have occurred absent the grants – is hard to evidence given the lack of available data and the highly complex and interconnected nature of the market and wider drivers. The inferences that can be drawn on additionality from both quantitative and qualitative analysis are therefore limited. We have attempted to present relevant data and analysis showing market trends and, where possible, we modelled some of the direct impacts of price reduction on demand. This analysis draws on a wider literature of consumer price responsiveness, supplemented with stakeholder insights to test inferences drawn.

There is limited data available for conducting assessments of the impact of the OZEV grants.

As noted previously, the lack of consistent data (in terms of baseline, monitoring evidence and secondary data) means it was hard to track the interventions over time. We note that secondary sources also suffer from inconsistencies – for example, there is a discontinuity in the questions asked in DfT's public surveys of EV sentiment before and after 2017 and a lack of any such survey data in earlier years when the market was particularly nascent. Given that the period of evaluation of the OZEV portfolio extends back to 2011 when the PICG was first introduced, this limits the ability to assess impacts over time. We therefore relied on expert views, particularly around the introductory period.

The evaluation took place in a limited time frame, which restricted the analytical techniques and additional data gathering which was feasible.

This evaluation was carried out between January and March 2022. The limited timeframe imposed challenges in terms of gathering primary data, including precluding the ability to conduct a widespread survey of market participants, for example. As a result, we relied heavily on stakeholder and expert interviews as the main source of additional evidence gathered. These interview results are, by definition, more qualitative in nature and, while we focused as much as possible on organisations with a whole-market view, the qualitative results may also be affected by the limited sample size of participants.

[48] Shanjun Li, Lang Tong, Jianwei Xing, and Yiyi Zhou (2017). The Market for Electric Vehicles: Indirect Network Effects and Policy Design. *Journal of the Association of Environmental and Resource Economists*. 4:1, 89-133.

6 KEY TAKEAWAYS FROM STAKEHOLDER INTERVIEWS

In the course of our stakeholder interviews, we identified a set of “key takeaways” which were consistently emphasised. These represent important qualitative data and insights which highlight areas for possible future exploration by policy stakeholders**.**

The key takeaways in this section are not evaluator recommendations but, rather, represent qualitative data that was consistently raised as areas for future exploration or action by stakeholders. As noted in Section 4, these key takeaways are not based on only one data point received from a single stakeholder, nor on a view reported by a stakeholder which was refuted by another. Instead, they are based on qualitative data that was reported consistently across different interview participants, and they were considered alongside the theory underpinning the logic model and the available quantitative data.

Providing increased signalling of circumstances under which grant schemes might change could improve confidence and certainty in the market.

Stakeholders repeatedly highlighted the uncertainty introduced into the market by the sudden changes to the grant schemes and emphasised the importance of engaging with the market when making changes. They uniformly reported that the sudden changes to the PICG and PIVG were highly disruptive to the market and have introduced a large degree of uncertainty. This disruption is both in terms of the administrative burden that it imposes on car dealers and manufacturers to comply with new grant eligibility criteria (particularly for vehicle transactions that are in process but have yet to be concluded) and the uncertainty it creates about future pricing and the level of government support.

There are significant practical reasons why OZEV announces the grant changes without prior notice. Namely, stakeholders and OZEV scheme leads noted that prior notice of grant changes has led to sudden surges in demand for the schemes, which in turn leads to budgetary pressures on the available funding. However, stakeholders suggested that it may be possible to reduce some of this uncertainty without providing full advanced notice of changes to the grants. In particular, OZEV could provide additional visibility by signalling during which broad periods of the year, or under what set of conditions (for example, when certain market or budgetary milestones are hit), the grants may undergo changes.

Stakeholders highlighted that there remain significant barriers to uptake for key segments of the overall market, particularly used vehicles and van fleets.

As noted in Section 5, input from stakeholders and the available DfT survey evidence suggest that charging concerns are now the main barrier to uptake, with price-related barriers still a concern for parts of the market. Stakeholders consistently emphasised that price-related barriers to chargepoint installation, and EV uptake more generally, are more significant for subsets of the market such as used vehicles and large van fleets. Several stakeholders highlighted that there are significant costs associated with installing chargers for fleets (such as for reinforcing the substations, software purchase), which make it particularly difficult for fleet operators to initiate a transition. Experts in fleet electrification also emphasised that price remains a significant barrier to uptake of commercial EVs, particularly electric vans by large fleets. This is consistent with the low uptake of electric LGVs observed to date in the DVLA registrations data. These stakeholders expressed significant concern that the grant levels were being reduced at a time when viable van products were becoming available, but at a continued price premium.

Multiple stakeholders in vehicle sales and manufacturing also suggested that further support may be needed to drive uptake in the used vehicles market due to factors such as chargepoints representing a relatively large proportion of used vehicle price, and therefore presenting a more significant barrier to uptake when compared to new vehicles.

Overall, stakeholders indicated that further support may be needed for these market segments as they continue to mature. This aligns with our wider finding that the PICG was an important contributing factor to the development of the electric car market, which is now more mature, and the theoretical rationale for financial support being stronger in the early stages of market maturity.

Stakeholders emphasised the importance of the consistency of policy signals from across different parts of government in supporting the demand and supply side of the EV market.

Stakeholders consistently emphasised the importance of consistency across the overall government policy portfolio. Since its inception, OZEV has collaborated with other government departments to ensure that the design and functioning of its schemes would achieve the intended objectives. To the extent possible, “joining up” OZEV decisions around grant schemes with changes in wider policy is important to support that consistency. For example, stakeholders highlighted that the company car tax benefit-in-kind reduction provides a strong incentive for uptake for car fleets, meaning that less support for car fleets may be needed from OZEV when compared to the private vehicle market.

Manufacturers and industry experts also indicated that OZEV should consider wider supply-side factors when making changes to the grants.

In particular, stakeholders consistently suggested that the OZEV portfolio may continue to be important for ensuring product availability in the UK due to supply constraints, which should be considered when making changes to the grants. For example, experts emphasised the importance of the current supply shortages of semiconductors in limiting supply and putting upwards pressure on vehicle prices, and the importance of the OZEV grants and other forms of government support relative to support in other international markets for securing allocation of available vehicles in the UK. This means that, even with strong domestic demand, it may be difficult to secure imports of EVs in the UK without government support if support and margins are higher in other markets.

Several stakeholders also suggested that the grants have been important in providing a high level of product quality in the chargepoint market and that the minimum technical specifications required by the EVHS have effectively acted as a set of product standards in the market. They reported that, were the OZEV charging grants to be removed, appropriate regulation would be needed to ensure that a high quality of charging product continues to be provided for the chargepoint market. Ensuring that a high standard of product quality remains in place for chargepoints could help avoid an erosion of product quality and safety, which could undermine consumer confidence and limit uptake of EVs.

Where possible, limiting the bureaucratic complexity of the grant schemes for applicants could reduce the burden on suppliers and assist with bringing new products to market in the UK.

Stakeholders suggested that the administration of some of the schemes could benefit from simplification and improved digitalisation. For example, some stakeholders highlighted that the approval process for vehicles under the PIG can be difficult, lengthy and frustrating for manufacturers. This could lead to delays in product launches and significant transaction costs (as their vehicles need to be transported from abroad, and so on). At the same time, the EVHS process for funds distribution has been mainly paper based and the distribution of funds has often been delayed. This inefficiency has had an impact on the number of installers deciding to participate in the scheme. Easing these process inefficiencies could lead to higher take-up of the grants and improved achievement of the intended objectives in the view of the stakeholders interviewed for this report and could be explored further by OZEV.

7 RECOMMENDATIONS TO ASSIST WITH FUTURE EVALUATIONS

In delivering this evaluation, we also identified specific recommendations for future evaluation of OZEV policies. These are intended to provide steps for OZEV to take in the near term which will help overcome some of the data limitations which have restricted the analysis set out in this report, and so support more robust future evaluation. Monitoring and evaluation planning improvements must be implemented now to ensure that better quality evaluations are possible in the future.

Recommendations to assist with future monitoring and evaluation work were explored in more detail with OZEV and DfT's Evaluation Centre of Excellence in a separate forward-looking monitoring and evaluation framework developed alongside this report. The recommendations below summarise the key points learned during the retrospective evaluation which informed the forward-looking monitoring and evaluation framework.

Develop and preserve baseline evidence.

A key element in the data collection plans developed as part of the forward-looking monitoring and evaluation framework is that baseline data is collected for new schemes. Scheme leads should record the current status of the market, the expected impact of the grant (including assumptions informing this expected impact), and key stakeholder and market views of the current impact of the grants at regular periods over time and when making significant changes to the grant scheme.

Specific recommendations for data collection are included in the forward-looking monitoring and evaluation framework.

Record quantitative data consistently where possible.

Given the difficulty of robust counterfactual analysis, future evaluation may need to draw heavily on changes in key market metrics over time as a means of making assessments.

In order to make valid comparisons over time, it will be important to gather consistent quantitative data on an ongoing basis. For primary data collection conducted by OZEV and DfT, this will require maintaining consistent administrative data and commissioning new waves of surveys that are comparable to historical waves. For secondary data collection from other sources, this will require liaising with data owners to ensure that administrative and survey data collection is consistent over time where possible.

Adapt evidence collection where appropriate to capture changes in policy and the market over time.

The OZEV portfolio- and scheme-level objective to create self-sustaining markets for EVs and EV infrastructure is complex and multi-dimensional. Therefore, OZEV should adapt the data collection plan developed as part of the forward-looking monitoring and evaluation framework, in view of changing market conditions, in order to capture relevant information that contributes to the evidence base for later evaluation work.

This could include regular qualitative engagement with market participants to understand the impact of OZEV interventions on markets and where changes to data collection are needed.

Ensure control and retention of future appraisal and forecasting models to assist with impact validation.

As well as comparisons to baseline, future evaluation of OZEV schemes could be strengthened by being better able to compare market outcomes with projections or forecasts made by OZEV in policy appraisal or development and by assessing why projections were (or were not) achieved, to help isolate the role of the OZEV policy.

A key tool for forecasting the impact of changes to the grant on market outcomes has been the Element Energy Electric Car Consumers (ECCo) model. However, this model is not controlled by OZEV, and OZEV was unable to provide full access to the inputs used in historical versions of the model for this evaluation. This interferes with the ability to validate outcomes against targets and forecasts and attribute causal impacts to the grant schemes. A number of key market factors can impact whether or not market uptake meets appraisal forecasts, including changes in gross domestic product (GDP) growth, inflation, consumer preferences and international trade constraints. Data or evidence relating to projections and appraisals, including assumptions made or details of modelling work done to support those assessments, should therefore be stored.

In allocating resources to appraisal modelling, OZEV and DfT should take account of the value of having full control and access to the modelling for purposes of future evaluation. Preserving modelling in an accessible, documented and updatable form for future use is recommended as a concluding step in policy appraisal.

Work with other parts of government and third parties to ensure availability of relevant data to support future evaluation.

Our retrospective evaluation relied heavily on qualitative stakeholder views supplemented with limited quantitative analysis of available secondary data to draw conclusions. OZEV should collaborate with stakeholders including the ONS, DfT, DVLA, SMMT and holders of proprietary industry data to scope wider data that may be available, including by adding questions to existing surveys, to provide more comprehensive and granular quantitative data. This is explored in more detail in the data collection plan included as part of the forward-looking monitoring and evaluation framework developed alongside this report, which includes guidance on which third parties should be engaged and recommendations as to when monitoring data should be collected and reviewed.

8 CONCLUSION

The overall objective of the OZEV portfolio is to be market building, with the interventions intended to support market creation in the context of emerging technologies. However, the EV market is highly complex, with outcomes driven by a large number of often interdependent factors. This makes quantifying the potential impacts of the OZEV portfolio particularly difficult due to the range of inputs which go into developing a self-sustaining market.

Within these limitations, this evaluation found that the grants have had material impacts on building the early market and demand for new EVs and chargepoint installations, particularly for cars and home chargepoints, and that the market for electric cars is now maturing. However, the electric van market remains at an early stage of development due to ongoing constraints to uptake, and continued support is likely necessary to overcome barriers to fleet electrification. Consumer concerns have also shifted increasingly towards their ability to charge EVs and away from concerns around the upfront purchase price of vehicles.

Evidence of the impact of the OZEV portfolio on manufacturing and investment is more limited. However, the grants may have played a role in securing allocation of EVs in the UK, and the EVHS and WCS may also have acted to provide additional quality and safety standards for the chargepoint market.

The environmental benefits of building a self-sustaining market for EVs are potentially significant. While it has only been possible to quantify a subset of the potential environmental and wider impacts of the OZEV portfolio within this evaluation, the potential range of environmental benefits indicates that substantial emissions reductions may have been achieved.

Going forward, there are a number of key takeaways from the stakeholder interviews which OZEV could explore further. In particular, stakeholders highlighted that increased signalling of circumstances under which grant schemes might change could improve confidence and certainty in the market. They also highlighted the importance of consistency of policy signals from across different parts of government. Stakeholders also emphasised that there remain significant barriers to uptake for key segments of the overall EV market, that OZEV should consider wider supply-side factors when making changes to the grants, and that there is scope for limiting the bureaucratic complexity of the grant schemes for applicants.

We also identified specific recommendations for future evaluation of OZEV policies. To assist with future evaluation work, OZEV should develop and preserve baselines and evidence over time, adapt this evidence collection where appropriate in response to changes in policy and the market, ensure control and retention of future appraisal and forecasting models to assist with impact validation, and work with other parts of government and third parties to ensure availability of relevant data to support future evaluation.

ANNEX A - GLOSSARY OF TERMS

TABLE 1 GLOSSARY OF TERMS

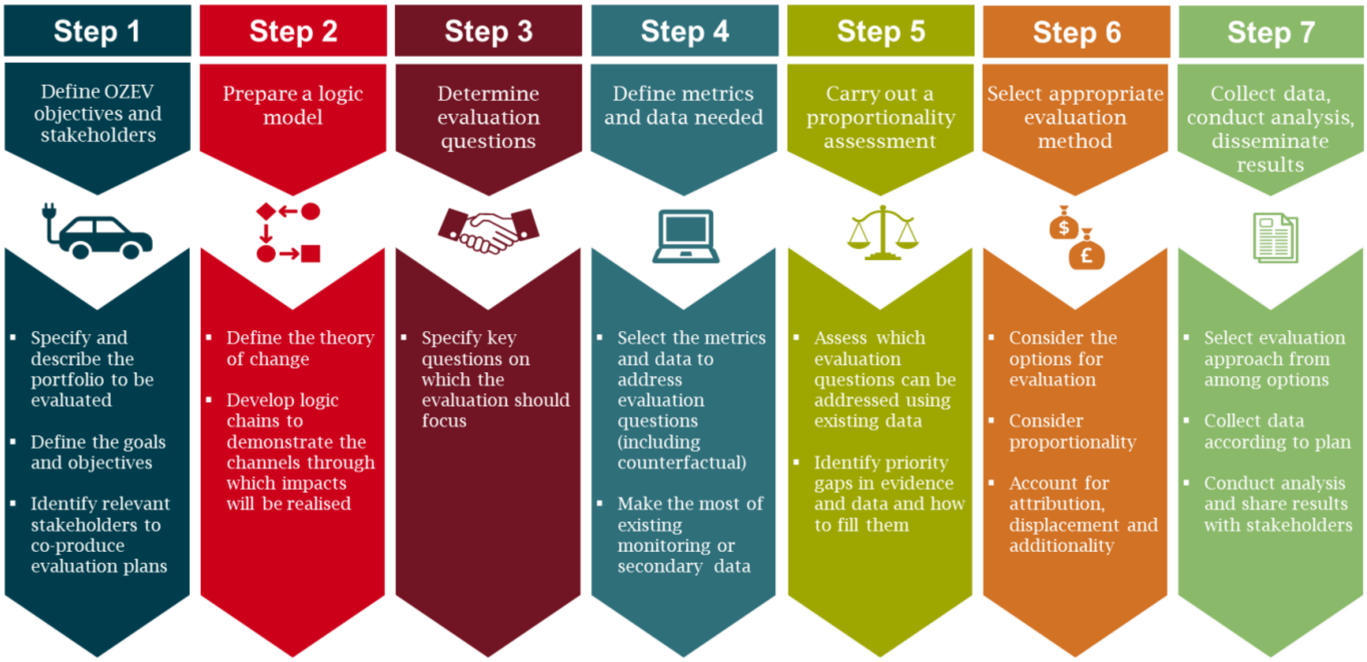
ABBREVIATION	DEFINITION
BEIS	Department for Business, Energy & Industrial Strategy
BEV	Battery electric vehicle
CAFE	Clean Air for Europe programme
DEFRA	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DVLA	Driver and Vehicle Licensing Agency
EV	Electric vehicle
EVHS	Electric Vehicle Homecharge Scheme
GDP	Gross domestic product
GhGs	Greenhouse gases
ICE	Internal combustion engine
LGV	Light goods vehicle
NAEI	National Atmospheric Emissions Inventory
NAO	National Audit Office
ONS	Office for National Statistics
OZEV	Office for Zero Emission Vehicles
OZEV portfolio	For the purposes of this evaluation, this includes a subset of overall OZEV programmes. In particular, it is limited to the PICG, the PIVG, the EVHS and the WCS.
PHEV	Plug-in hybrid electric vehicle
PIG	Plug-in Vehicle Grant
PICG	Plug-in Car Grant, a subset of the Plug-in Vehicle Grant
PIVG	Plug-in Van Grant, a subset of the Plug-in Vehicle Grant
RRP	Recommended retail price
SMMT	Society of Motor Manufacturers and Traders
WCS	Workplace Charging Scheme
ZEV	Zero emission vehicle

ANNEX B - EVALUATION DESIGN

Our overall evaluation followed a step-by-step evaluation framework that is aligned with the *Magenta Book*. This is described below and in Figure 15.

1 We began by defining the OZEV portfolio's objectives through close collaboration with OZEV and a review of key business documents. Particular emphasis was placed on defining the original objectives of the in-scope grant schemes to ensure that the relevant impacts were being measured.
2 We then prepared a retrospective logic model for the OZEV portfolio and defined the theory of change.
3 From this logic model, we determined key evaluation questions on which to focus the evaluation.
4 We then defined the metrics and data needed to address these evaluation questions and identify the counterfactual.
5 Taking account of the data and time constraints on the evaluation, we assessed the proportionality of which evaluation questions could be addressed using existing data and where gaps in the data could be filled through in-depth interviews. This proportionality assessment also informed the evaluation questions and metrics on which this evaluation focused.
6 We then selected the most appropriate evaluation method, choosing a theory-based approach.
7 Finally, we carried out the evaluation.

FIGURE 15 THE STEP-BY-STEP EVALUATION FRAMEWORK



Source: Frontier Economics

As explored in Section 4, the sample size of possible in-depth interview participants was restricted by the time available for this evaluation. We focused primarily on interviewing representatives of industry bodies or those that we felt could provide relatively holistic assessments across multiple evaluation questions in order to give a wider perspective and address the identified gaps in the quantitative data. This led us to broad categories of interviewees (e.g. manufacturers, EV dealers, chargepoint installers, battery manufacturers), with a list of specific stakeholders to interview agreed in collaboration with OZEV and DfT's Evaluation Centre for Excellence. We reviewed the transcripts of these interviews and coded views against the evaluation questions using a **framework analysis** methodology

Given the relatively limited number of people we consulted and that qualitative analysis is not intended by itself to provide evidence from which wider inference can be made, we **triangulated** qualitative insights with wider evidence to form our views as part of the theory-based assessment. This meant that **qualitative input was cross-checked with quantitative data where available.** Where supporting quantitative data was available (for example, on changes in EV uptake or consumer preferences) we sense-checked stakeholder views against the changes and outcomes observed in the quantitative data.

The three key portfolio-level evaluation questions alongside the associated metrics and key data points used to answer these questions are summarised in Tables 2 to 4 below. In addition to these three questions, we explored potential process improvements and overall key takeaways with the market experts engaged for the in-depth interviews. These informed the key takeaways in Section 6.

TABLE 2 TO WHAT EXTENT HAVE THE GRANTS IMPACTED DEMAND FOR NEW EVS AND CHARGEPOINT INFRASTRUCTURE INSTALLATION, RELATIVE TO WHAT WOULD HAVE HAPPENED IN THE ABSENCE OF THE GRANTS?

INDICATOR	DATA USED TO ASSESS	RELEVANT SECTION IN REPORT
Change in sales of new EVs and the resulting change in market share of EVs in the new car and van markets	• DVLA vehicle registrations data, published by DfT • OZEV grant portal data on the level of grants, vehicle prices and number of grants provided over time • Academic literature on consumer willingness to pay and own-price elasticity of demand • Qualitative interview evidence from in-depth stakeholder interviews	See Sections 5.1.1 and 5.1.2
Extent to which price, charging and other factors are barriers to EV uptake	• Existing DfT survey evidence on consumer attitudes to EVs • Academic evidence of drivers of EV uptake • Qualitative interview evidence from in-depth stakeholder interviews	See Sections 5.1.1, 5.1.2 and 5.1.3
Change in installation of private chargepoints	• Published statistics on EVHS and WCS on the number of installations and grant value awarded • Qualitative interview evidence from in-depth stakeholder interviews on the importance of the grants on chargepoint adoption and other drivers of these decisions	See Section 5.1.3
Change in vehicle price of eligible vehicle categories for consumers	• Public vehicle pricing data and market analysis of changes in vehicle prices in response to grant changes	See Section 5.1.4

INDICATOR	DATA USED TO ASSESS	RELEVANT SECTION IN REPORT
Extent to which unintended consequences have been observed	• Qualitative interview evidence from in-depth stakeholder interviews	See Section 5.1.4

TABLE 3 TO WHAT EXTENT HAVE THE GRANTS IMPACTED THE MANUFACTURING AND SUPPLY OF EVS, EV INFRASTRUCTURE AND RELATED COMPONENTS AND TECHNOLOGIES IN THE UK, RELATIVE TO WHAT WOULD HAVE HAPPENED IN THE ABSENCE OF THE GRANTS?

INDICATOR	DATA USED TO ASSESS	RELEVANT SECTION IN REPORT
Change in EV manufacturing output and capacity in the UK	• ONS data on EV investment and manufacturing statistics in the UK • Public announcements of investment decisions • Qualitative interview evidence from in-depth stakeholder interviews with manufacturing experts	See Section 5.2
Change in the supply and stock of EVs to the domestic market	• Import and export data from HM Treasury's UK Trade Info Database • Qualitative interview evidence from in-depth stakeholder interviews with manufacturing and vehicle sales experts	See Section 5.2
Change in job and skills creation in EV and EV infrastructure manufacturing	• ONS data on EV investment and manufacturing statistics in the UK • Qualitative interview evidence from in-depth stakeholder interviews with EV and battery manufacturing experts	See Section 5.2

TABLE 4 TO WHAT EXTENT HAVE THE GRANTS ENABLED WIDER BENEFITS, IN PARTICULAR ENVIRONMENTAL BENEFITS, RELATIVE TO WHAT WOULD HAVE HAPPENED IN THE ABSENCE OF THE GRANTS?

INDICATOR	DATA USED TO ASSESS	RELEVANT SECTION IN REPORT
Change in emissions from switch to electric cars	• National Travel Survey data on average km travelled by vehicle type in the UK • Carbon emissions conversion factors for transport, available from BEIS	See Section 5.3

INDICATOR	DATA USED TO ASSESS	RELEVANT SECTION IN REPORT
	• Carbon valuation data, available from BEIS	
Change in air pollution from switch to EVs	• National Travel Survey data on average km travelled by vehicle type in the UK • Pollutant emissions conversion factors for transport, available from BEIS • Pollutant damage costs, available from BEIS	See Section 5.3

ANNEX C - METHODOLOGY

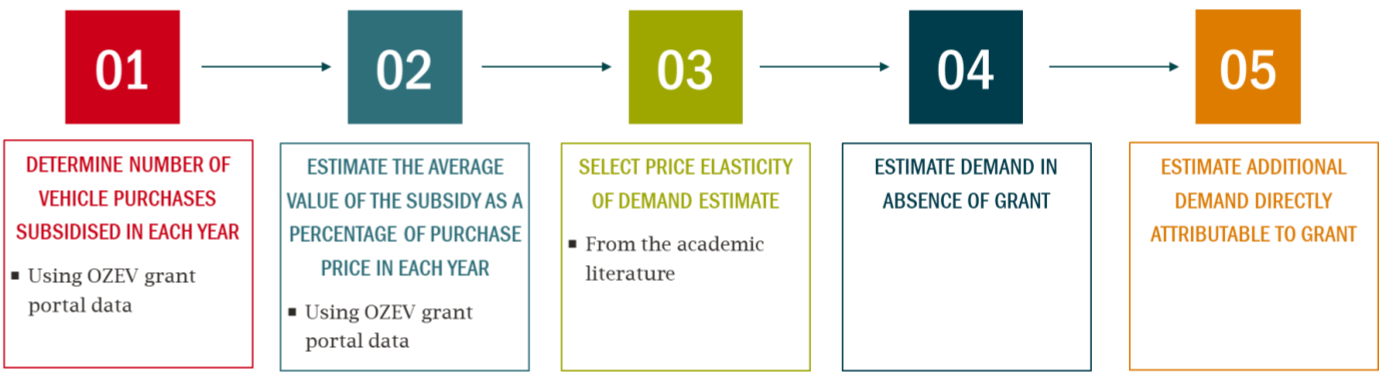
C.1 - ESTIMATING ADDITIONAL ELECTRIC CAR DEMAND ATTRIBUTABLE TO THE PRICE REDUCTION PROVIDED BY THE GRANT

Using the value of the grant as a percentage of vehicle purchase price and estimates of own-price elasticity of demand, we estimated additional EV purchases attributable to the direct reduction in purchase price provided by the PICG over time. As noted in Section 5.1.1, this is likely to only represent a subset of the overall impact of the OZEV portfolio on demand for new electric cars as it does not include any effects from the OZEV portfolio's potential wider market-building impact, any indirect network effects, or any impacts from the EVHS or WCS grant. This impact is estimated using the formulas below, with the calculation steps described in Figure 16.

$$[\textit{Electric car demand in absence of grant}] = \frac{[\textit{Number of vehicle purchases subsidised by the PICG grant}]}{1+[\textit{own-price elasticity of demand for electric cars}]\times[\textit{value of grant as percentage of vehicle price}]}$$

$$[\textit{Additional demand attributable to the grant}] = [\textit{Number of vehicle purchases subsidised by the PICG grant}] - [\textit{Electric car demand in absence of grant}]$$

FIGURE 16 CALCULATION STEPS FOR ESTIMATING IMPACT ON DEMAND FROM THE PRICE REDUCTION PROVIDED BY THE PICG



Source: Frontier Economics

The own-price elasticity of demand estimate used had a significant impact on the result of this calculation. In our modelling, we assumed an own-price elasticity of demand of -2.76 for BEVs and -2.65 for PHEVs, in line with Xing et al. (2021). That paper developed a random coefficient discrete choice vehicle demand model incorporating both aggregate sales data and secondary survey choice data from the USA to estimate own-price elasticities of demand for EVs. We used this paper as our baseline for three key reasons:

- It draws on a robust dataset, primarily relying on household-level survey data of households that purchased or leased new vehicles, covering vehicle model years 2010-2014. This data was complemented by datasets on vehicle characteristics and aggregate vehicle sales data.
- The vehicle demand model is built upon a clearly articulated theoretical framework which takes account of different interactions and issues of additionality.
- The estimates of demand from this paper sit within the range of plausible elasticity of demand coefficients implied by the rest of the literature review, and do not appear to be outliers.

A summary of the academic literature on elasticity of demand surveyed for this evaluation is provided in Table 5 below.

TABLE 5 SUMMARY OF KEY LITERATURE EVIDENCE ON ELASTICITY OF DEMAND

PAPER	OWN-PRICE ELASTICITY OF DEMAND ESTIMATE	SUMMARY OF APPROACH
Jianwei Xing, Benjamin Leard and Shanjun Li (2021). What Does an Electric Vehicle Replace? *Journal of Environmental Economics and Management*, 107.	-2.76 for BEVs, -2.65 for PHEVs	Uses a random coefficient discrete choice vehicle demand model incorporating both aggregate sales data and secondary survey choice data from 2010-2014 in the USA to estimate own-price elasticities of demand for EVs.
Erich Muehlegger and David S. Rapson (2021). Subsidising Low- and Middle-income Adoption of Electric Vehicles: Quasi-experimental Evidence from California. *NBER Working Paper*.	-3.3 for EVs. Also finds nearly 100% passthrough of EV subsidies.	Uses transaction-level data in California and evidence from the Enhanced Fleet Modernisation pilot programme (launched in 2015) to specify a difference-in-difference model to estimate elasticities of demand.

PAPER	OWN-PRICE ELASTICITY OF DEMAND ESTIMATE	SUMMARY OF APPROACH
eftec (2008). Demand for Cars and their Attributes.	-3.7 for new cars in general.	Uses a discrete choice behavioural model to estimate demand for new cars, using DVLA registrations data combined with datasets on vehicle physical attributes and vehicle pricing. Elasticities are estimated on a vehicle market segment basis but are not split by fuel type.
Anders Fjendbo Jensen, Mikkel Thorhauge, Stefan Eriksen Mabit and Jeppe Rich (2021). Demand for Plug-in Electric Vehicles across Segments in the Future Vehicle Market. *Transportation Research Part D: Transport and Environment,* Volume 98.	For vehicle customers living in houses: -1.117 for BEVs and -1.215 for PHEVs. For vehicle customers living in apartments: -1.165 for BEVs and -1.187 for PHEVs.	Using data from a 2020 stated choice survey in Denmark, estimates a mixed logit model and elasticities of demand.
Shanjun Li, Lang Tong, Jianwei Xing and Yiyi Zhou (2017). The Market for Electric Vehicles: Indirect Network Effects and Policy Design. *Journal of the Association of Environmental and Resource Economists.* 4:1, 89-133.	Approximately -1.3 for EVs.	Draws on panel data of quarterly EV sales in the USA from 2011-2013 to estimate a stylised model of network effects and simulate results using ordinary least squares regressions.
Lasse Fridstrøm and Vegard Østli (2021). Direct and Cross Price Elasticities of Demand for Gasoline, Diesel, Hybrid and Battery Electric Cars: The Case of Norway. *European Transport Research Review.* 13:3.	-0.99 for BEVs and -1.72 for PHEVs.	Uses a discrete choice model and a dataset consistently of the significant majority of all 1.8 million new passenger car transactions in Norway from 2002-2016, derives direct and cross price elasticities of demand for plug-in hybrid and battery electric cars.

C.2 - WIDER ENVIRONMENTAL BENEFITS DELIVERED BY THE GRANTS

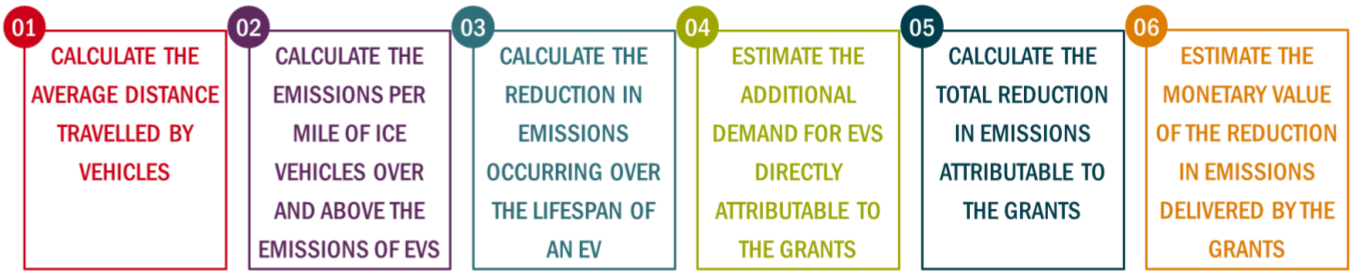
In this annex, we present the data used and the steps implemented to calculate the potential reduction in emissions delivered by the grants. We focused, in particular, on the impact on GhGs[49] and pollutants.[50]

CALCULATION STEPS

The wider environmental and social benefits presented in Section 5.3 were calculated over the period when the plug-in vehicle grants were available (2011–2021) and each of the calculation steps presented below was implemented for each year of this period, as this allowed us to take account of the changes of the data over time. Moreover, to reflect the different emission intensities of petrol vehicles, diesel vehicles, PHEVs and BEVs, and the resulting differences in level of emission abatement, we estimated separately the GhG abatement from switching from a diesel car to a PHEV and a BEV and the abatement delivered by switching from a petrol car to a PHEV and a BEV. With regard to pollution abatement (SO_2 and PM_{10}), given that BEVs do not emit tailpipe emissions and no data is available on the relative emission factors of PHEVs, we assumed that all air pollutant emissions of BEVs and PHEVs were zero.[51]

The calculation steps illustrated below follow HM Treasury's *Green Book*[52] and DEFRA's guidance, and the estimates rely on publicly available data provided by BEIS, DfT and National Atmospheric Emissions Inventory (NAEI).

FIGURE 17 STEPS FOLLOWED TO ESTIMATE THE WIDER ENVIRONMENTAL AND SOCIAL BENEFITS DELIVERED BY THE GRANTS



Source: Frontier Economics

1 **Calculate the average distance travelled by vehicles** using the data available on the average number of trips and the average distance travelled by a car/van driver;

2 **Calculate the GhG and pollutants per mile emitted by the petrol and diesel vehicles over and above the emissions produced by EVs.** This was calculated as the difference between the petrol and diesel conversion factors and the BEV and PHEV conversion factors. The result of this step was "net" conversion factors;

3 **Calculate the reduction of GhG and pollutants occurring over the lifespan of an EV.** This was done by combining the relevant "net" conversion factors calculated at step 2 with the average distances travelled each year by the vehicles calculated at step 1. We assumed a lifespan of eight

[49] GhGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). See BEIS's conversion factors for further information.

[50] The air pollutants taken into consideration are sulphur dioxide (SO_2), particulate matter that is 10 micrometres and smaller (PM_{10}).

[51] The risk of not having air pollution conversion factors for PHEVs and consequently potentially overestimating the benefits arising from the abatement of air pollution is mitigated by its relatively small magnitude with respect to the overall environmental benefits.

[52] See *The Green Book: Appraisal and Evaluation in Central Government*, updated on 3 December 2020 by HM Treasury.

years for EVs based on conversations with experts in the sectors and the duration of an electric car battery's warranty;

4 **Estimate the additional demand for EVs directly attributable to the grants.** This was done by using DfT's data on the number of PICG-eligible EV purchases and assuming that every year 10% to 30% of these can be directly attributable to the grants, based on the plausible range suggested by the academic literature.[53] We also used DfT's data on annual vehicle registration by fuel type to estimate the proportion of petrol and diesel vehicles that would have been purchased in the counterfactual;

5 **Calculate the total reduction in emissions attributable to the grants**: combine the reduction in GhG and pollutants per vehicle calculated at step 3 with the estimated additional demand of EVs directly attributable to the grants; and

6 **Estimate the monetary value of the reduction in emissions delivered by the grants:**

   a Apply the carbon values and pollution damage costs to the reduction in emissions estimated at step 5. This step was done so that the reduction in emissions occurring in a specific year was valued using the carbon value of the same year. This meant that the emissions expected to be abated in a given year would be valued in the same way, regardless of the year in which the EVs were purchased.

   b Discount the monetary benefits using a 3.5% discount rate.[54]

DATA SOURCES AND ASSUMPTIONS

Travel data

The data used to estimate the average distance travelled by cars or vans over a year was the average number of trips and the average distance travelled by car/van drivers. This was gathered by the DfT[55] in the 2020 National Travel Survey, which provides data on personal travel patterns within Great Britain by residents of England.

As our estimates cover a period that goes beyond 2020 and that data is not yet available, we assumed that the data for the years after 2021 was equal to the average of the data recorded in the previous five years.

EV purchases directly attributable to the grants

To estimate the demand for EVs attributable to the grants, we used the data collected by DfT on the number of ultra-low emission vehicles registered for the first time in the UK between 2011 and end of November 2021.[56] In particular, the dataset records separately the annual number of BEVs and PHEVs eligible for plug-in grants, which are identified respectively under Category 1 and Category 2/3.

Moreover, to separately estimate the impacts of purchasing an EV instead of a petrol and diesel car, we also used DfT's data on cars registered for the first time by propulsion/fuel type[57] to calculate which proportions of petrol and diesel cars are purchased every year. We then applied these figures to the

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[53] We assumed that every year the same proportion of demand was affected by the grants. In reality, it is more likely that a higher proportion of demand was affected in the earlier years when the value of the grants was proportionally higher. As benefits in later years are discounted more heavily than benefits realised in earlier years, this approach is generally conservative.

[54] See *The Green Book: Appraisal and Evaluation in Central Government*, updated on 3 December 2020 by HM Treasury. Page 119.

[55] See National Travel Survey: 2020, published on 22 September 2021 by DfT. The data used is available in the NTS0303 data table.

[56] See All Vehicles Statistical Data Set, published on 13 January 2022 by DfT. The data used is available in the VEH0170 data table. The dataset was complemented with internal OZEV grant portal data on the number of EVs purchased in 2021 under the PICG.

[57] See Cars Statistical Data Set, published on 13 January 2022 by DfT. The data used is available in the VEH0253 data table.

number of PHEVs and BEVs to estimate the amount of petrol and diesel cars that would have been purchased in the counterfactual.

Greenhouse gas conversion factors

GhG conversion factors represent the amount of GhG emissions (converted to kg of CO_2e) produced for each mile driven by a vehicle.[58] Annual conversion factors are provided by BEIS[59] and enable consideration of both the emissions produced by driving the vehicles (Scope 1) and emissions that occur outside of the direct control of the vehicle drivers (Scopes 2 and 3). For the purpose of this analysis, we considered the conversion factors estimated for average-sized cars. In particular, we used:

- **Vehicle conversion factors (Scope 1):** these are used to report the emissions produced by travelling with the vehicles. These conversion factors are relevant for all types of vehicles;
- **UK electricity for EV conversion factors (Scope 2):** these enable consideration of the emissions resulting from the production of the electricity used by the EVs. These conversion factors are relevant only for PHEVs and BEVs;
- **UK electricity transmission and distribution (T&D) for EV conversion factors (Scope 3):** these enable consideration of the emissions associated with grid losses. These conversion factors are relevant only for PHEVs and BEVs; and
- **Well-to-tank (WTT) conversion factors (Scope 3)**: these report the emissions associated with extraction, refining and transportation of the raw fuels before they are used to power the transport mode. These conversion factors are relevant for all types of vehicles.

The total conversion factors of PHEV, BEV, diesel and petrol are calculated by summing all the relevant conversion factors, as summarised in Table 6 below.

TABLE 6 CONVERSION FACTORS

FACTOR	SCOPE	PETROL/DIESEL VEHICLE	PHEV/BEV
Vehicles conversion factors	Scope 1	X	X
UK electricity for EVs	Scope 2		X
UK electricity T&D for EVs	Scope 3		X
WTT	Scope 3	X	X

Source: BEIS guidance

We noted two main gaps in the data:

- 2011 conversion factors are not available; and
- Due to the limited number of electric vehicles circulating between 2012 and 2016, conversion factors for EVs are not available for those years.

[58] The conversion factors are based on information from the DfT which regularly analyses the mix of cars on the road in the UK through DVLA records and automatic number plate recognition data. The conversion factors are updated each year to reflect changes in the spectrum of cars of different types and ages being driven.

[59] Government Conversion Factors for Company Reporting of Greenhouse Gas Emissions, published every year by BEIS. The conversion factors used are available in the full set of conversion factors data table.

We filled these data gaps by using the conversion factors available in the next immediate years. This means that we used the 2017 EV conversion factors for the period between 2011 and 2016. Similarly, we used the 2012 petrol and diesel conversion factors in the calculations related to 2011.

Greenhouse gas emissions values

GhG emissions values ("carbon values") were used for valuing the impacts of GhG emissions. Carbon values are updated by BEIS[60] each year and represent a monetary value that society places on one tonne of CO_2e.

The data available covers annual updated carbon values over the 2011–2020 period, with an exception for 2019. However, as each BEIS update provides the most recent carbon value and forecasts of the short-term traded carbon values for a period up to 2030 or 2050, it was possible to fill the data gaps using the available data published. In particular, the 2019 forecast published in the 2018 update was used for the 2019 carbon values and all carbon values relative to the years following 2020 were the forecasts available in the 2020 update.

All carbon values were converted to 2021 prices using the GDP deflator.[61]

Pollution conversion factors

The pollution conversion factors used were provided by the NAEI.[62] This dataset contains emission factors for hot exhaust, cold start exhaust, and tyre and brake wear by vehicle type. For the purpose of the analysis, we focused on SO_2 and PM_{10} emissions produced by hot and cold start exhausts, as these are the emissions that are not produced by EVs.

The available NAEI datasets covered the period between 2011 and 2019. For this reason, we used the 2019 factors for 2020 and 2021.

Pollutants damage costs

The pollutants damage costs used were provided by DEFRA,[63] which estimated the societal costs[64] associated with small changes in pollutant emissions. In particular, we used DEFRA's PM_{10} road transport-specific damage costs[65], while for SO_2 we used the central estimates of the national averages of damage costs as road transport-specific costs were not available.

The data that DEFRA made available were the damage costs for 2017. However, we were able to estimate the annual damage costs for each year following the air quality appraisal guidance which suggests applying an annual uplift of 2% to the damage costs to reflect the assumption that willingness to pay for health outcomes will rise in line with real per capita GDP growth. All damage costs were converted to 2021 prices using the GDP deflator.

[60] See Carbon Valuation, last updated on 2 September 2021 by BEIS.

[61] Following the *Green Book* guidance, for each year, the conversion of the carbon value of year t is calculated as £2021 $Carbon\ value_t = Carbon\ value_t \times GDP\ deflator_{2021} / GDP\ deflator_t$). GDP deflators are available here.

[62] See Emission Factors for Transport tables.

[63] See Air Quality Appraisal: Damage Cost Guidance, last updated on 26 March 2021 by DEFRA, Table 10.

[64] These costs include the impact that pollutants have on public health, the natural environment, and the economy.

[65] PM_{10} damage costs are calculated using DEFRA's $PM_{2.5}$ damage costs and $PM_{2.5}/PM_{10}$ conversion factors.

ANNEX D - ANALYTICAL ASSURANCE STATEMENT

This evaluation underwent analytical assurance in line with DfT guidance.[66.] All analysis was subject to Frontier's quality assurance process, with analysis checked by an experienced consultant. Draft and final versions of the report were reviewed by the Frontier Project Manager, Director and Quality Assurance Director. Draft findings were also discussed and reviewed with experienced analytical leads at DfT and OZEV. Further detail on each of the key assurance dimensions is provided below.

- *Reasonableness of the Analysis – Medium.* The time and data availability constraints which informed this analysis are set out in Section 4. Within these constraints, the analysis relied on appropriate sources of evidence, and all assumptions were developed in line with the logic model and input from OZEV and the DfT's Evaluation Centre of Excellence.
- *Risk of Error – Low.* This analysis went through Frontier's quality assurance procedure, and the methodological approach for the more complicated modelling and estimation exercises were sense-checked with analytical leads at DfT. Overall, the staff involved in this evaluation have extensive experience in monitoring and evaluation.

As noted in Section 4, the complex landscape in which the OZEV grants have operated and the lack of clear objective "control groups" that could provide counterfactual evidence constrained the analysis. This introduced a material degree of uncertainty into the quantifiable impacts of the OZEV schemes on the development of the market, and any interpretation of the quantitative estimates of impact included in this report should take this into account. While we focused primarily on interviewing representatives of industry bodies or those that we felt could provide relatively holistic assessments across multiple evaluation questions in order to give a wider perspective, the limited sample of interviews which it was feasible to undertake for this report may mean that qualitative views reported here are not wholly reflective of the broader sector.

[66] See https://www.gov.uk/government/publications/dft-analytical-assurance-framework-strength-in-numbers/xyz#annex-d-guidance-on-analytical-assurance-statements.

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