Quantitative analysis of carbon neutrality by 2030

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Executive summary

Since the declaration of a climate emergency by Jersey's States Assembly in May 2019, the Government of Jersey has been working on the development of a strategy to make Jersey carbon neutral by 2030.[1] Oxera has been assisting the Government with the economic analysis underpinning the strategy.

This report presents the first-round quantification analysis of the potential costs of delivering Jersey's 2030 net zero ambition, focusing on the six measures that are expected to make the biggest impact in terms of reducing carbon emissions,[2] namely:

- facilitating the retrofitting of electric heating to all domestic and commercial properties currently utilising oil and liquefied petroleum gas (LPG);[3]
- upgrading the insulation of the domestic housing stock to current energy efficiency standards;
- escalating existing fuel taxes to discourage the use of petrol and diesel vehicles;
- imposing a ban on the registration of fossil fuel vehicles;[4]
- providing financial incentive(s) for the purchase of electric vehicles (EVs), either in the form of a purchase grant, and/or in the form of a scrappage payment to owners of fossil fuel vehicles; and
- facilitating the use of second generation biodiesel, such as hydrotreated vegetable oil (HVO) for all diesel vehicles, subject to further technical due diligence of the feasibility of such a transition in Jersey.

It is likely that it will not be possible to eliminate all carbon emissions on Jersey, so to hit a net zero target some carbon offsetting will be required.[5] The costs of offsetting the remaining carbon emissions in heating and road transport sectors have also been quantified.

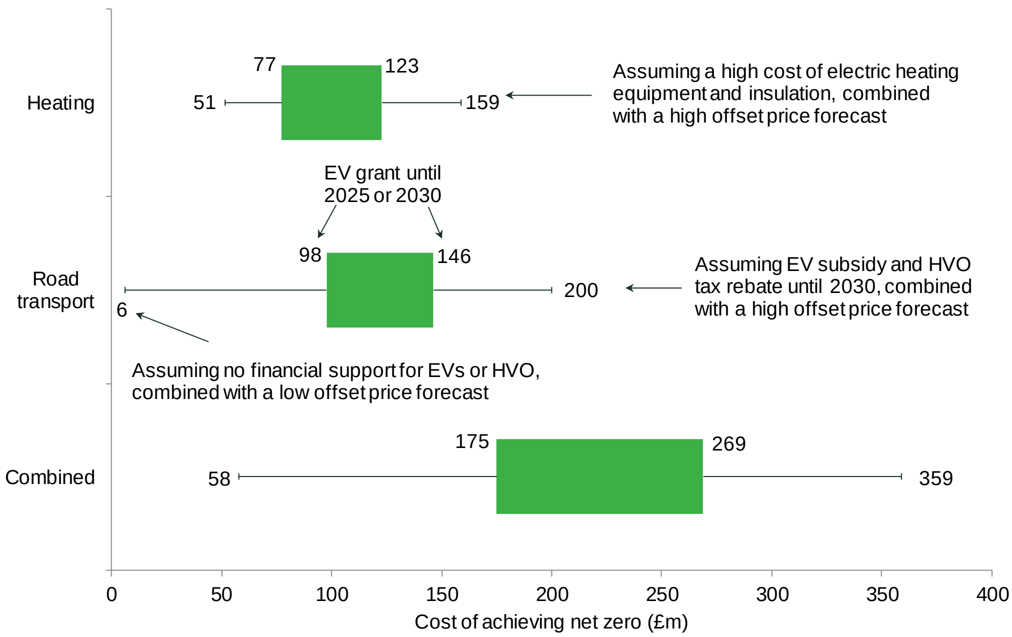
Throughout this report and analysis, we focus on the quantification of costs from the perspective of the Government of Jersey. With the assumptions and underlying data presented in this report, the analysis shows that from the perspective of the Government, **the cost of achieving net zero by 2030 in the heating and transport sectors is likely to be between approximately £60m and £360m** (see 'Combined' cost in the figure below).[6] The range is driven by policy choices and the evolution of industry-specific costs and offset prices.

[1] The Carbon Strategy as articulated by the States of Jersey defines its net zero target in the following terms. Net zero (or carbon-neutral) is defined as balancing the direct on-island carbon emissions, as well as the emissions arising from the generation of any imported energy, against any activity that captures, absorbs or reduces global emissions so that they are exactly offset. For more details, see section 1.
[2] For ease of presentation, in this report we use the terms 'greenhouse gas emissions' and 'carbon emissions' interchangeably.
[3] This report follows the notation used in Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October, where gas heating is referred to as LPG, according to the name of the underlying fuel source. However, strictly speaking, some of the gas heating equipment uses products derived from LPG.
[4] To the extent that diesel vehicles can immediately transition to the use of HVO (see the last bullet in the list) while maintaining a sufficiently low emission intensity, they can be exempt from the ban.
[5] An action or activity (such as the planting of trees or carbon storage) that compensates for the emission of carbon dioxide or other greenhouse gases to the atmosphere.
[6] Calculated in present value terms over the course of 2019–50.

Whether the costs of achieving net zero fall towards the top or bottom of this range is substantially affected by the Government's choices with respect to subsidisation of net zero measures in road transport. Specifically, current modelling shows that the cost of subsidies to encourage EV uptake could be between £98m–£146m, while simultaneous support for HVO could result in a cost as high as £200m. This includes the cost of offsets for any unabated emissions.

The figure below provides a summary breakdown of how the cost of achieving net zero by 2030 in the heating and road transport sectors varies across different modelling scenarios.

Cost of achieving net zero in heating and road transport



Note: The ranges above consider different scenarios for fossil fuel registration ban, financial support for EVs and HVO, cost of upgrading heating equipment and insulation, speed of heating electrification and future prices of offsets. All figures are shown in present value terms over the course of 2019–50. See section 2 and Appendix A1 for the description of input assumptions underlying the ranges presented in this chart.

Source: Oxera analysis, based on multiple sources.

These costs are subject to a significant degree of uncertainty, driven mostly by three factors:

- the degree of financial support required by consumers to engage with the vision of delivering the net zero agenda within an accelerated timescale;
- the outturn cost of the required heating and transport upgrades; and
- the outturn cost of carbon offsets.

While the costs of achieving net zero may be significant, the alternative to undertaking these policies to deliver the Carbon Neutral Strategy is not costless either. Carbon emissions impose a range of costs on society. Using prices recommended by HM Treasury, the present value of the social cost that the current level of carbon emissions would impose on Jersey citizens over

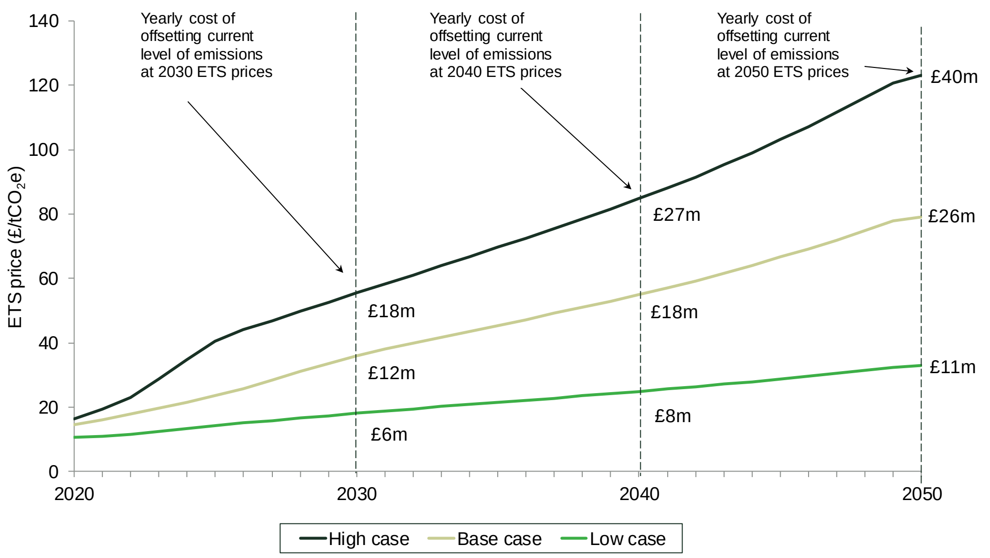
2019–50 amounts to around £600m.[7] In other words, to the extent that Jersey's net zero ambitions can be achieved and those emissions can be abated, £600m would represent a benefit to Jersey society.

Despite the uncertainty associated with exogenous factors (such as the prices of offsets), the Government and the citizens of Jersey have the ability to control the costs of implementing the Island's net zero strategy by changing the scope of policy measures through:

- the target timeline for full (or maximum feasible) reduction of emissions;
- the willingness of Jersey citizens to embrace an alternative, more environmentally friendly lifestyle; and
- policy decisions about the allocation of Government funding to particular measures.

To illustrate, Jersey's exposure to the prices of offsets can be controlled by the speed of abatement measures. As shown in the figure below, according to National Grid Future Energy Scenarios,[8] EU ETS prices are projected to increase over time, with the price of offsets possibly increasing by as much as six-fold by 2050. Consequently, investing in carbon reduction initiatives earlier will allow the Government to lower its expenditure on carbon offsets in the future.

ETS prices and annual nominal cost of offsetting



Note: The figure shows the estimated low, base and high case prices for ETS across the years and the associated cost of offsetting the current level of emissions in heating and road transport.

Source: Oxera analysis, based on data from National Grid.

[7] This is an illustrative cost to society if the current level of emissions were to flatline and no level of abatement from the present level of emissions were to be undertaken. In that case, the social cost of carbon produced by road transport and the heating sectors could be around £600m. This is estimated using the latest statistics on Jersey emissions, provided by Aether; in road transport and heating these amount to around 254 ktCO_2e. The present value of social costs of such emissions over the period of 2019–2050 amounts to £602.7m using the input of non-traded carbon prices and applying a discount rate of 3.5%, as featured in the HM Treasury Green Book and its Supplemental Guidance.
[8] National Grid (2019), 'Future energy scenarios data workbook', tab CP5.

Similarly, if the citizens of Jersey are willing and able to limit their reliance on petrol and diesel vehicles, either by changing their travel habits or by choosing to pay higher prices for new vehicles (to the extent that electric vehicles are more expensive), then the target of net zero in road transport can be achieved without material Government expenditure on EV subsidies.

Finally, the Government has significant flexibility in imposing limits on the level of its net zero expenditure. For instance, the provision of grants for EV purchase or insulation upgrade can be limited to (vulnerable) households with incomes below a certain level, as well as capped in its totality.

Achieving net zero requires striking the right balance between the lifestyle preferences of Jersey's citizens and the costs borne by the Government of Jersey. The findings in this report are intended to assist the States Assembly, the Government of Jersey and the Citizens' Assembly in determining a policy package that would be optimal for the Island of Jersey.

1 Introduction

In May 2019, the States Assembly of Jersey approved a proposition to declare a state of climate emergency, and recommended amending the 2014 Energy Plan to set a new net zero target by 2030.[9]

> Jersey should aim to be carbon neutral by 2030 and the Council of Ministers is accordingly requested to draw up a plan to achieve this, for presentation to the States by the end of 2019

In response to the request from the Council of Ministers, the Government of Jersey commissioned Oxera to:

- review the current sources of emissions in Jersey;
- review the current policies implemented in Jersey as part of the 2014 Energy Plan;
- review international precedents on decarbonisation policy; and
- on the basis of this analysis, identify the measures that should be prioritised within the new 2030 Carbon Neutral Strategy.[10]

A previous Oxera report 'Carbon neutrality by 2030' (the 'Oxera October 2019 report') traced the majority of emissions to two sources: road transport and the heating of buildings. This is illustrated in Figure 1.1.

[9] The Carbon Strategy as articulated by the States of Jersey defines its net zero target in the following terms. Net zero (or carbon-neutral) is defined as balancing the direct on-island carbon emissions, as well as the emissions arising from the generation of any imported energy, against any activity that captures, absorbs or reduces global emissions so that they are exactly offset. By including emissions from the generation of any imported energy, the Government of Jersey notes that it is exceeding its international legal obligations under the Kyoto Protocol. Note that emissions associated with the manufacture and transportation of the goods and services that are imported from abroad and then consumed in Jersey do not form part of the baseline for carbon neutrality. See 'Council of Ministers: Interim Response to the Declaration of a Climate Emergency', (2019) section 2.1 a.

[10] Oxera (2019), 'Carbon neutrality by 2030', 1 October.

Figure 1.1 Breakdown of Jersey carbon emissions, 2017

Source: Oxera analysis, based on data from Aether.

Based on the breakdown above, the Oxera October 2019 report recommended conducting a quantitative assessment of the main abatement measures in the heating and road transport sectors.

This report is structured as follows:

- section 2 outlines the scope of the assessment presented in this report;
- section 3 presents the assessment of the decarbonisation measures in the heating sector;
- section 4 presents the assessment of the decarbonisation measures in the road transport sector;
- section 5 concludes;
- the appendices provide additional detail on the analysis presented in sections 3 and 4.

2 Scope of this assessment

This report presents scenarios on the costs that the Government of Jersey might incur in delivering the transition to net zero, as a result of implementing selected policy measures in the road transport and heating sectors. The main set of scenarios consider:

- a range of timelines for the completion of maximum feasible abatement (with the end date varying from 2030 to 2050 in line with differing potential implementation timelines, for each policy measure under consideration);
- different levels of cost of heating equipment and insulation treatments;
- alternative levels of Government intervention in the road transport sector (ranging from no intervention to full support of electric vehicles (EVs) and biofuels); and
- various levels of future offset prices.

As set out in the introductory section, the quantification focuses on the cost of abating emissions in the two largest sources of emission for Jersey (i.e. heating and road transport). Together these account for around 70% of Jersey's emissions.[11] The remaining emissions are assumed to be offset from 2030 onwards, rather than being abated. To the extent that there is appetite for more ambitious abatement, e.g. in marine transport and agriculture, then further policy options can be developed and quantified for these less significant drivers of emissions in Jersey.

For all scenarios presented in this report, the main modelling assumptions are summarised in Box 1.1 below.

Box 1.1 Summary of the main modelling assumptions

- abatement measures considered are assumed to be initiated in 2020;
- from 2030 onwards, all unabated emissions from the heating and transport sectors need to be offset in line with delivery of a net zero target by 2030;
- offset prices are assumed to follow the EU Emissions Trading System (EU ETS) price projections in National Grid's 2019 Future Energy Scenarios;[12]
- the cost to the Government of Jersey is defined as the present value of the Government's expenditure on abatement measures and offsets incurred over 2019–50 (i.e. no terminal value considered), discounted at 3.5%, as per the HM Treasury Green Book guidance, unless explicitly stated otherwise;

[11] As per the Government's Carbon Neutral Strategy, the definition of net zero includes emissions generated from on-Island activities and emissions arising from generation of imported energy (i.e. electricity imported from France). For the avoidance of doubt, the emissions from the production and transportation of goods and services consumed in Jersey (i.e. scope 3 emissions) are not considered as part of this assessment. See Government of Jersey (2019), 'Carbon Neutral Strategy 2019', 31 December, available at https://www.gov.je/SiteCollectionDocuments/Environment%20and%20greener%20living/R%20Carbon%20Neutral%20Strategy%2020200109%20HL.pdf.
[12] National Grid (2019), 'Future energy scenarios data workbook', tab CP5.

- in the heating sector, the Government is assumed to bear 50% of equipment, installation and insulation upgrade costs;[13]
- in the road transport sector (for relevant scenarios only), the Government is assumed cover the cost of £3,500 EV grant and full fuel tax rebate for HVO;[14] and
- the social cost of carbon (i.e. the cost that society as a whole experiences per tonne of CO_2 emitted in the atmosphere) is assumed to be equal to the non-traded price of carbon from guidance in the HM Treasury Green Book.[15]

The analysis focuses on the direct costs of the abatement and offsets from the Government's perspective. The analysis does not quantify:

- the costs of potential upgrades to the electricity grid;
- the costs of potential rollout of hydrotreated vegetable oil (HVO) infrastructure;
- the costs of additional human resources that might need to be attracted in order to complete the abatement programme at an accelerated rate (relative to the status quo)[16];
- the administrative costs of introducing net zero measures, such as the costs of running a Government scheme for the provision of financial support for the retrofitting of electric heating systems, or for the acquisition of EVs;
- some uncertain prospective future costs, such as additional emissions that could be caused by an eventual increase in housing stock and the costs of offsetting or abating those emissions;[17] and
- the second-order benefits and costs, such as a change in employment, the fostering of new (green) industries, the health of citizens, and the reputational effects of delivering the net zero agenda.

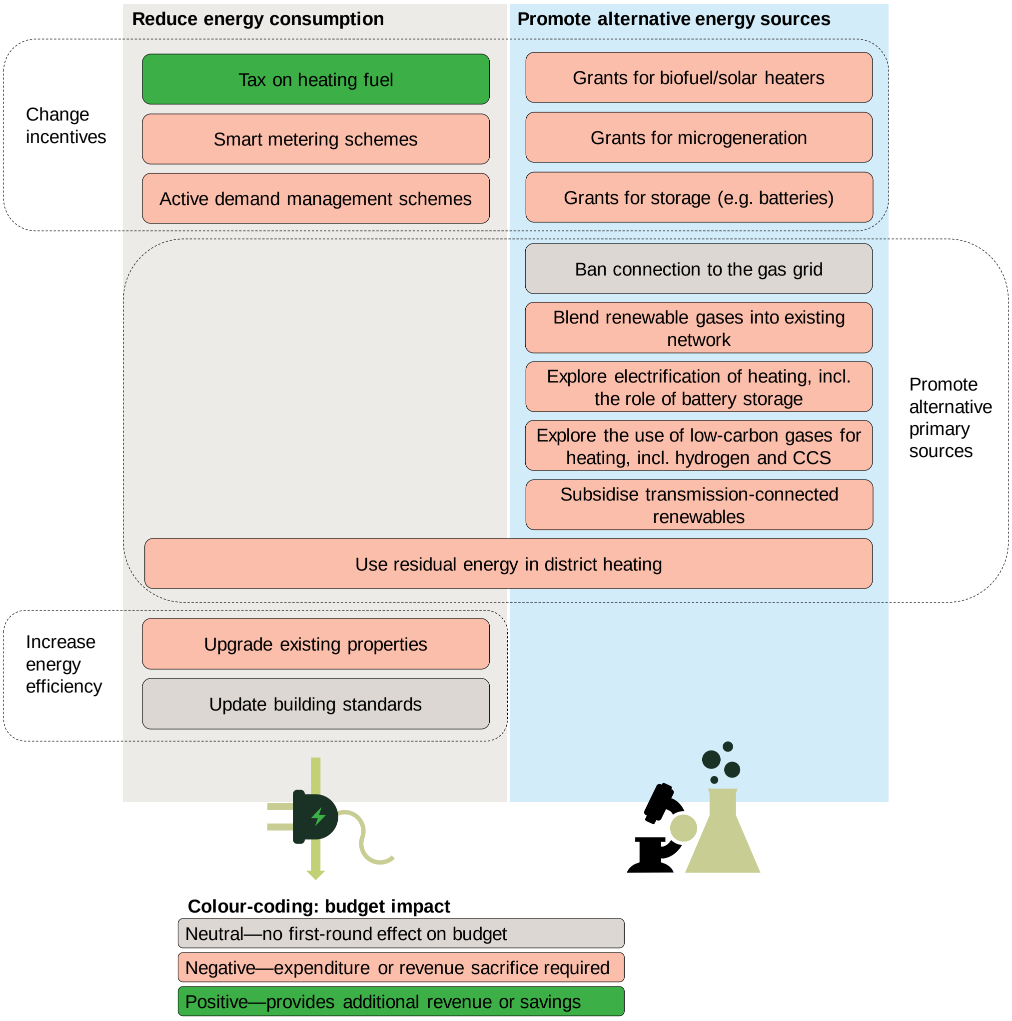
The next sub-sections elaborate on the scope of quantitative analysis for each of the two sectors considered in this report (i.e. heating and road transport).

[13] However, the effect of changing this assumption is explored in sensitivities presented in section 3.6.
[14] However, the effect of changing these assumptions is explored in sensitivities presented in section 4.4.
[15] UK regulators use these prices in the appraisal of energy policies. For instance, see Ofgem (2019), 'Targeted Charging Review: Decision and Impact Assessment', p. 135 and BEIS (2019), 'Smart Metering Implementation Programme—Cost-Benefit Analysis', p. 57. This cost of carbon, however, is an internationally focused benchmark, as it has been derived to take into account the costs that all nations (not just the UK) bear as a result of climate change. This, for example, includes the cost of increased flooding or drought. While Jersey will not bear all these costs directly, using the values as benchmarks for policy appraisal reflects the commitment of the States of Jersey to play its part in the global decarbonisation effort. See Department for Business, Energy & Industrial Strategy (2012), 'Green Book supplementary guidance, Data tables 1 to 19: supporting the toolkit and the guidance', Table 3.
[16] For example, upgrading the heating systems on Jersey may require a higher number of skilled electricians than the current workforce on the Island. To address the shortage, more skilled labour may have to be attracted to the Island, and/or higher salaries offered, in the event that a rapid abatement timetable is pursued.
[17] The evolution of the housing stock is dependent in part on the rate of population growth and net immigration to the Island—which will in turn be affected by policy—and may not be readily modelled with reference to historical data.

2.1 Heating sector

According to the latest (2017) official statistics, heating accounts for over 30% of overall emissions in Jersey.[18] This includes emissions from both domestic and commercial heating. Figure 2.1 summarises the policies employed in other jurisdictions to reduce emissions from heating. More details on this topic are available in the Oxera October 2019 report.[19]

Figure 2.1 Overview of heating decarbonisation policies



Source: Oxera (2019), 'Carbon neutrality by 2030', 1 October, p. 3.

For the Island of Jersey, electrification appears to have the most significant potential to deliver the Government's medium-to-long-term decarbonisation

[18] In 2017, total emissions in Jersey amounted to 366 $ktCO_2e$, while emissions from the 'business' and 'residential' sectors amounted to 80.3 and 56.0 $ktCO_2e$. While the domestic and commercial categories do not in themselves explain what drives the emissions in these segments, the underlying source data suggests that the vast majority of these emissions relates to heating. For instance, table 7 in the 2018 'Jersey Energy Trends' publication illustrates that the household energy consumption consists of petroleum products, manufactured gas and electricity. Since electricity in Jersey is largely carbon-natural, this implies that household carbon emissions originate from petroleum products and manufactured gas. The analysis suggests that the consumption of petroleum products does not include road transport. This in turn suggests that the emissions in the 'residential' category reported by Aether largely originate from heating. Similarly, based on our discussions with the Government of Jersey, we understand that most of the emissions within the 'business category' relate to heating. See Aether website, 'Jersey Greenhouse Gas Emissions 1990-2017', https://www.aether-uk.com/Resources/Jersey-Infographic and Government of Jersey (2018), 'Jersey Energy Trends'.

[19] Oxera (2019), 'Carbon neutrality by 2030', 1 October.

ambitions. This is underpinned by high levels of installed interconnection capacity with access to low-carbon imported electricity, relatively high penetration rates for electricity in the heating sector, and the potential synergies between the electrification of heating and the uptake of EVs in the transport sector. Electrification reduces carbon emissions in two ways:

- electric heating systems are more efficient than systems running on oil (which is the second most widely used energy source for domestic heating on the Island, after electricity).[20] This means that, all else being equal, a property heated through electricity consumes less energy than one heated through oil;[21]
- electricity has a lower carbon factor than any other heating energy source available on the Island. This means that for any given amount of energy consumed, an electric heating system emits the least carbon.[22]

Based on the review of approaches adopted in other jurisdictions, and taking into account policies already embedded in the 2014 Energy Plan,[23] we have subjected the following measures to a quantitative assessment.

- **Measure 1**: facilitating the retrofitting of electric heating to domestic and commercial properties currently utilising oil and LPG.
- **Measure 2**: upgrading the insulation of the domestic housing stock to current energy efficiency standards.[24]

Quantitative analysis for these measures is presented in section 3.

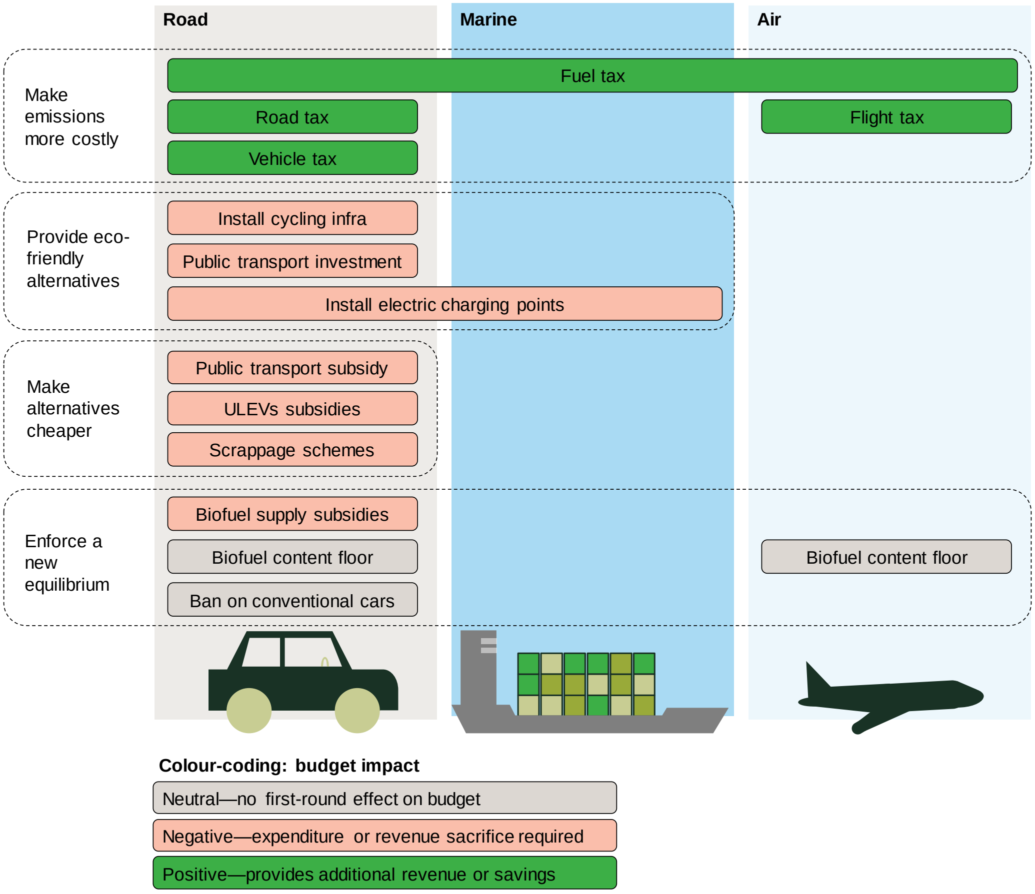
2.2 Road transport sector

According to the latest (2017) official statistics, road transport accounts for 32% of overall emissions in Jersey.[25]

Figure 2.2 provides an overview of policies employed in other jurisdictions to reduce emissions from transport. More details on this topic are available in the Oxera October 2019 report.[26]

[20] See Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October, p. 19.
[21] See Table 3.2.
[22] See Table 3.4.
[23] See Oxera (2019), 'Carbon neutrality by 2030', 1 October, section 1B.
[24] Properties more likely to need insulation measures are those that were constructed before the 1997 Building Bye-Laws. The 1997 Bye-Laws required a higher standard of construction and insulation. Since no precise figures were available on the property stock pre-1997, we used 2001 as the cut-off. To the extent that some houses added to the stock between 1997 and 2001 would have been built to higher standards, this would make the modelled estimate conservative as we would be modelling the conversion and insulation of properties that have already been upgraded. However, as a countervailing factor, we also note that industry feedback suggests some post-2001 properties also require an insulation upgrade. Quantification of the proportion of these properties within the Jersey housing stock was not possible due to the lack of data.
[25] In 2017, total emissions in Jersey amounted to 366 $ktCO_2e$, while emissions from road transport were equal to 118 $ktCO_2e$. See Aether website, 'Jersey Greenhouse Gas Emissions 1990-2017',https://www.aether-uk.com/Resources/Jersey-Infographic
[26] Oxera (2019), 'Carbon neutrality by 2030', 1 October.

Figure 2.2 Overview of decarbonisation policies in transport



Note: ULEVs—ultra low emission vehicles.

Source: Oxera (2019), 'Carbon neutrality by 2030', 1 October, p. 2.

We note that as an island economy Jersey has a relatively high level of dependence on marine and aviation transport as a means of access to goods and services. To the extent that low emission technologies for marine and air travel are not as evolved as those for road transport, and that Jersey has less control over these emissions (e.g. from international airlines), the emissions in these sectors would likely have to be offset rather than abated in the medium term. Moreover, road transport accounts for a much higher proportion of emissions than combined emissions from other sources of transport (see Figure 1.1). Therefore, the quantitative analysis in this report focuses on the road transport sector.

Based on the approaches adopted in other jurisdictions, and taking into account policies already embedded in the 2014 Energy Plan, we have considered the following measures as part of the quantitative assessment in the road transport sector.

- **Measure 1**: escalating existing fuel taxes to discourage the use of petrol and diesel vehicles.
- **Measure 2**: imposition of a ban on the registration of fossil fuel vehicles. To the extent that diesel vehicles can immediately transition to the use of HVO (see below) while maintaining a sufficiently low emission intensity, they can be made exempt from the ban.

- **Measure 3**: providing financial incentive(s) for the purchase of EVs, either in the form of a purchase grant, and/or in the form of a scrappage payment to owners of fossil fuel vehicles.
- **Measure 4**: facilitating the use of second generation biofuel, such as HVO for all diesel vehicles, subject to further technical due diligence of the feasibility of such a transition in Jersey. This would involve granting HVO an exemption from fuel taxation.[27]

Quantitative analysis for these measures is presented in section 4.

[27] According to feedback received from industry representatives, HVO is fully compatible with usage by the existing diesel fleet in Jersey. While HVO is costlier than diesel, industry feedback suggests that a fuel tax exemption would enable HVO to compete against diesel. Technical feasibility of the compatibility of HVO with the existing fleet and Jersey infrastructure is currently being conducted.

3 Analysis of the heating sector

This section presents quantitative analysis of potential carbon savings from the key decarbonisation measures in the Jersey heating sector, as well as the associated costs of these measures to the Government of Jersey.

This segment is structured as follows:

- section 3.1 presents an overview of the modelling approach, findings and scenario analysis;
- section 3.2 presents the analysis for domestic heating;
- section 3.3 presents the analysis for commercial heating;
- sections 3.4 to 3.6 aggregate the findings from the analysis of the domestic and commercial heating sector and present the total impact on emissions, the resulting costs and the sensitivities of this analysis;
- section 3.7 provides an overall conclusion to the quantitative analysis of the decarbonisation of Jersey's heating sector.

3.1 Overview of approach and findings in the decarbonisation of heat

The analysis of the decarbonisation of the heating sector of Jersey, presented in this section, quantifies the costs of, and resulting emission savings from, the following activities:

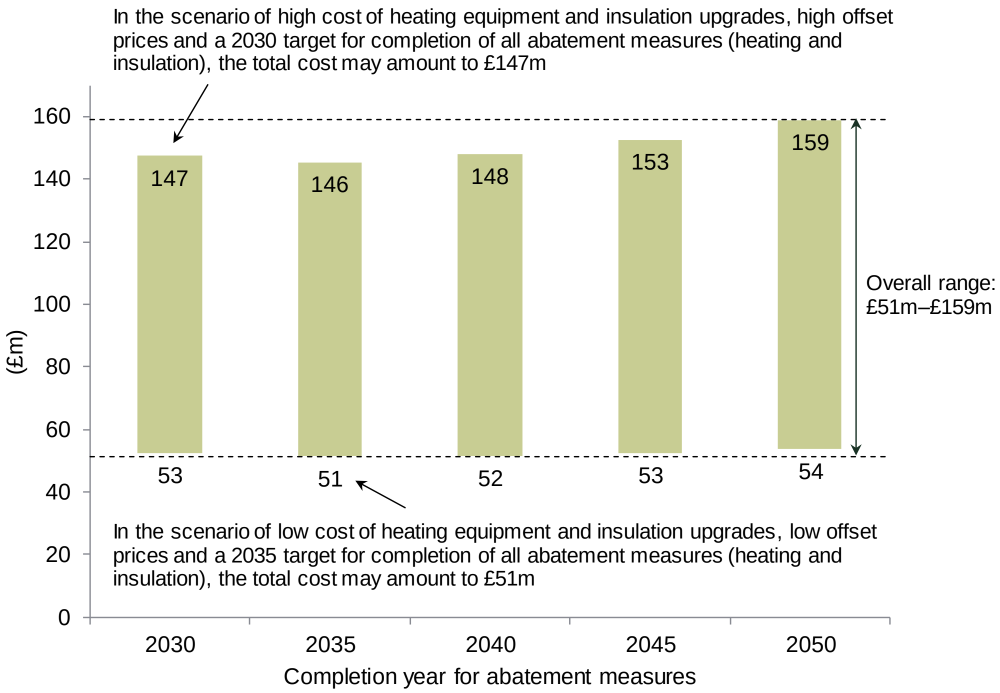
- retrofitting electric heating systems to existing domestic properties, currently heated by fossil fuels;
- upgrading the insulation of the domestic housing stock to current energy efficiency standards;
- retrofitting electric heating systems to existing commercial properties currently heated by fossil fuels;
- offsetting the emissions from the heating sector that have not been abated by 2030 (i.e. the envisaged start of the policy of net zero emissions in Jersey).[28]

Figure 3.1 illustrates the range of uncertainty around the cost of achieving the Government's net zero objective by 2030 is around £50m to £160m for the heating sector. The breadth of the range is driven by the assumed unit cost of heating equipment and insulation, offset prices and the timeline for the abatement programme.

In relation to the policy choice of the abatement timetable, note that at the upper end of the range, the present value of total cost increases from £147m to £159m, if Jersey chooses to complete its abatement measures by 2050 rather than by 2030. The increase is driven by a prolonged period of emission offsetting, as further explained in Figure 3.3.[29]

[28] The expenditure on offsets is estimated using the forecast for the prices of ETS from National Grid.
[29] We note that there might be practical constraints to achieving the accelerated abatement timetable, e.g. sufficient availability of skilled labour to undertake heating upgrades at such a scale and pace.

Figure 3.1 Range of uncertainty around the cost achieving of net zero in the heating sector



Note: The costs of net zero include both the present value of the costs of abatement, as well as the present value of the expenditure of offsetting the unabated emissions. Throughout all scenarios it is assumed that unabated emissions are being offset from 2030 onwards. All costs are presented in present value terms, discounted at 3.5%, as per the HM Treasury Green Book guidance. The assessment period covers the years 2019–50. The expenditure on offsets is estimated using the base case forecast for the prices of ETS from National Grid.

Source: Oxera analysis.

For the heating sector analysis in this section, we examine costs from the perspective of the Government in financially supporting abatement measures (i.e. the installation of electric heating equipment and insulation upgrades), as well as the costs of offsetting residual emissions from 2030 onwards.

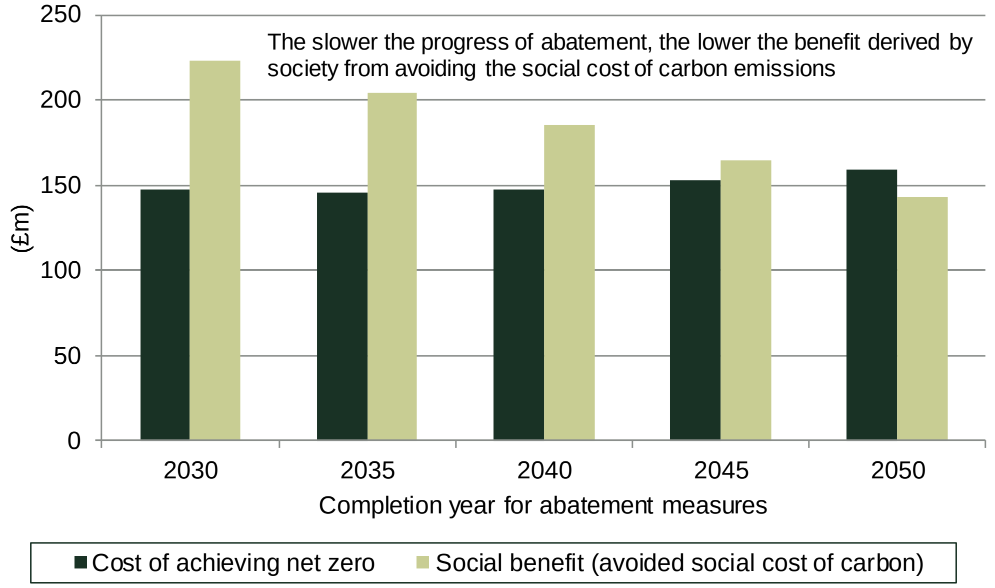
In discussion with the Government, we have modelled an assumed rate of subsidy of 50%, i.e. half of the costs of heating upgrades will be borne by the Government, rather than households and businesses in Jersey. This is for both the domestic and commercial heating sectors. The modelling assumes that the 50% subsidy will be sufficient to induce private individuals to switch from fossil-fuel to electric heating. This, likely conservative, assumption stems from insight from the recent Competition and Markets Authority (CMA) investigation into the British energy market, which has shown that average savings of 31% on the energy bill were not sufficient to induce consumer engagement and active switching across energy providers.[30] Therefore, allowing for a margin of error over and above the CMA's estimate of 31%, we assume that 50%

[30] In particular, the study found that consumers would neglect savings of around £330 against an average annual bill of £1,066. See CMA (2016), 'Modernising the Energy Market', 24 June.

subsidisation would be required to complete the abatement measures in domestic and commercial heating.[31]

At the same time, reducing the level of emissions decreases the economic and social costs caused by these emissions.[32] The analysis shows that the benefit from implementing abatement measures in the heating sector could be above £220m, based on guidance from the HM Treasury Green Book.[33] Figure 3.2 compares the 'avoided social costs of carbon' columns (i.e. benefits) and the 'costs of net zero' columns (i.e. high end of the Government cost range presented in Figure 3.1). As mentioned above, the figure assumes that a 50% subsidy will be sufficient to induce private individuals to switch from fossil-fuel to electric heating.

Figure 3.2 Cost of achieving net zero in the heating sector relative to social benefits



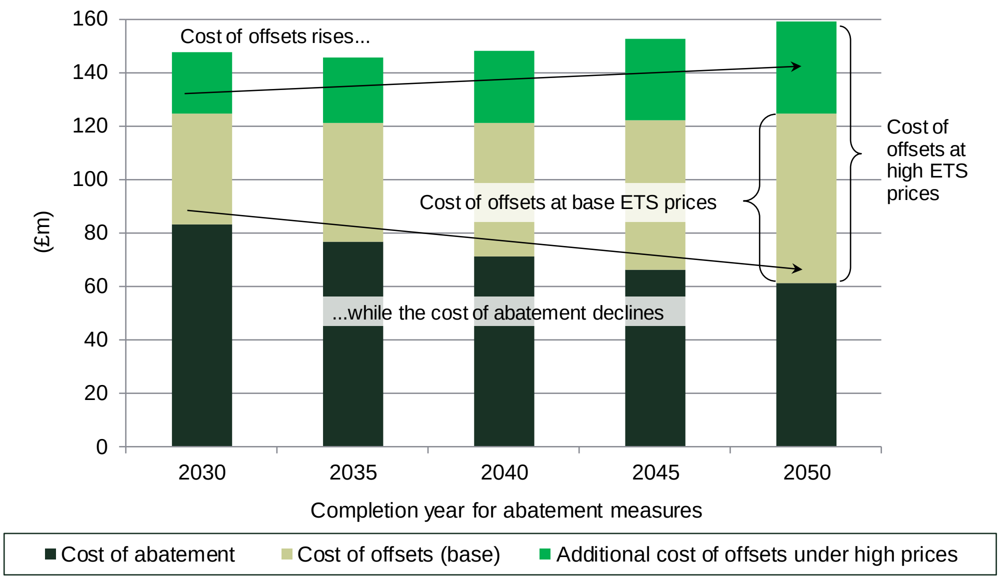
Note: This figure illustrates how the benefit derived from the abatement of carbon relates to the high end of the modelled cost range. The cost of delivering net zero includes the cost of abatement measures as well as the cost of offsetting the residual (unabated) emissions. All costs are presented in present value terms, discounted at 3.5%, as per the HM Treasury Green Book guidance. The period of assessment is 2019–50. The expenditure on offsets is estimated using the forecast for the prices of ETS from National Grid. The social cost has been priced according to guidance in the HM Treasury Green Book, using central estimates for the non-traded carbon prices.

Source: Oxera analysis, based on Department for Business, Energy & Industrial Strategy (2012), 'Green Book supplementary guidance, Data tables 1 to 19: supporting the toolkit and the guidance', Table 3: Department for Business, Energy & Industrial Strategy (2019), 'Valuation of Energy Use and Greenhouse Gas', p. 15, paras 3.44–6.

[31] Section 3.6 illustrates a sensitivity of how changing the assumed rate of subsidisation affects the cost of achieving net zero from the perspective of the Government of Jersey.
[32] As noted earlier in the report, this is not based on a Jersey-specific estimate of the Island's social costs of carbon. The HM Treasury estimate is not based on a UK- or Jersey-specific estimate of the social costs of carbon. Rather, this is based on a mid-point in a range of international social cost of carbon estimates by BEIS and is recommended by HM Treasury for carbon valuation in impact assessments. See UK government website, 'Carbon valuation', https://www.gov.uk/government/collections/carbon-valuation--2
[33] The HM Treasury estimate is not based on a UK- or Jersey-specific estimate of the social costs of carbon. Rather, this is based on a mid-point in a range of international social cost of carbon estimates by BEIS and is recommended by HM Treasury for carbon valuation in impact assessments. For more details, see: UK government website, 'Carbon valuation', https://www.gov.uk/government/collections/carbon-valuation--2

As can be seen from Figure 3.2, the faster the abatement measures are rolled out, the higher the benefit associated with avoiding the social cost of emissions.[34] Moreover, the speed of abatement also affects the economy's level of exposure to future movement in offset prices (which are expected to rise over time), as illustrated in Figure 3.3.

Figure 3.3 Relationship between the speed of abatement and the exposure to offset prices in the heating sector



Note: All costs are presented in present value terms, discounted at 3.5%, as per the HM Treasury Green Book guidance. The expenditure on offsets is estimated using the forecast for the prices of ETS from National Grid.

Source: Oxera analysis.

On the one hand, spreading the investment over a longer period of time decreases the total present value of costs (as costs incurred further away in the future are discounted more heavily). On the other hand, a more prolonged abatement process comes with an increased exposure to the future price of offsets. Current evidence suggests that the price of offsets is likely to substantially increase in the near future (see the Oxera October 2019 report),[35] which suggests that delaying the abatement programme for a sufficiently long period runs a high risk of increasing the overall cost of achieving net zero.

In summary, the cost for delivering decarbonisation of Jersey's heating sector can range between £53m–£146m, assuming that heating electrification and insulation upgrades are completed by 2030 and the Government bears half of that cost. The width of the range is driven by the uncertainty around the unit costs of the required heating equipment and insulation upgrades, as well as by the outturn level of offset prices. However, even at the upper end of this range, the cost of delivering net zero is lower than the social benefit of around £225m, achieved through avoiding the social cost of carbon.

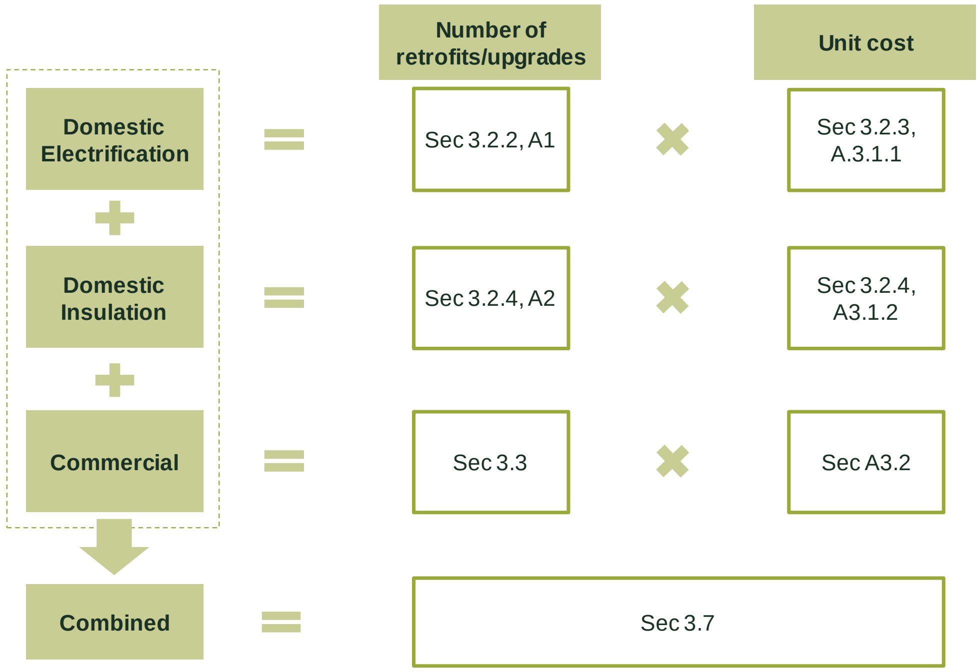
Delaying the completion of abatement measures to 2050, however, increases the cost range to £54m–£159m and decreases the benefit achieved from avoiding the social cost of carbon to around £145m. Therefore, a significant delay in implementation of abatement measures results in a higher combined

[34] Specifically, this is because the earlier level of carbon emissions is reduced, the earlier the society avoids the social cost associated with it and, therefore, the longer the periodic benefit from carbon abatement lasts.
[35] Oxera (2019), 'Carbon neutrality by 2030', 1 October.

cost of abatement and offsets to the Government, and a lower benefit derived by society from avoiding the social cost of carbon emissions.

We now turn to a more detailed description of the quantitative assessment of achieving net zero in the domestic and commercial heating sectors. Figure 3.4 provides an overview of different components of the quantitative analysis, which are discussed in sections 3.2, 3.3 and appendices A1 to A3.

Figure 3.4 Overview of the quantitative assessment for the heating sector in Jersey



Source: Oxera analysis.

3.2 Assessment of domestic heating

The data used for the assessment of Jersey's emissions from domestic heating is:

- the existing property stock, its heating energy sources and the related carbon footprint; and
- the costs and associated impact on the carbon footprint from upgrades to insulation and retrofitting of electric heating.

The next two sub-sections explain what data was available and what assumptions have been made to provide estimates for the sets of inputs above.

3.2.1 Assessing existing emissions from domestic heating: estimating domestic property mix and carbon footprint

Table 3.1 presents a snapshot of Jersey's existing property stock, split by property type and heating energy source, as used in the modelling for this assessment.

Table 3.1 Breakdown of Jersey domestic housing stock by type of property and heating energy source

Property type	Heating energy sources	Number of properties	% of total
Detached house	Fuel oil	4,475	10%
	LPG	1,147	3%
	Air source heat pumps	229	1%
	Other electric technologies	5,623	13%
Semi-detached house	Fuel oil	3,308	8%
	LPG	848	2%
	Air source heat pumps	170	0%
	Other electric technologies	4,157	9%
Terraced house	Fuel oil	1,875	4%
	LPG	481	1%
	Air source heat pumps	96	0%
	Other electric technologies	2,356	5%
Flat	Fuel oil	7,502	17%
	LPG	1,923	4%
	Air source heat pumps	385	1%
	Other electric technologies	9,425	21%
Total		**44,000**	**100%**

Note: The individual percentages in this table do not sum to 100% due to rounding.

Source: Oxera analysis based on Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October, Government of Jersey website, 'Households and dwellings statistics',https://www.gov.je/Government/JerseyInFigures/HousingLiving/pages/households.aspx , and information provided by the industry.

Since no up-to-date housing survey of Jersey properties was available at the time of this analysis, the figures in the table above had to be estimated from previously conducted studies. The estimation approach is described in Appendix A1.

With the snapshot of the current property stock established, the next step is to estimate the carbon footprint associated with each cluster of domestic properties.

Estimating the total emissions from Jersey's domestic property stock requires data on:

- average energy consumption for a given type of heating technology and property type; and
- emission intensity associated with each type of heating technology.

Average energy consumption varies strongly with the heating technology installed, as presented in Table 3.2.

Table 3.2 Energy consumption by heating technologies

Heating sources	Average kWh/year per property
Fuel oil	20,897
LPG	6,888
Air source heat pumps	3,776
Other electric technologies	11,327

Note: Average energy consumption for air source heat pumps was inferred from the average electricity consumption of other electric heating technologies and based on the Ricardo-AEA report, which states that air source heat pumps are three times more efficient than electrical resistance heating. We examine a sensitivity with respect to this assumption in section 3.6.

Source: Department of the Environment (2018), 'Internal Review of Home Energy Scheme for Policy Development' for average oil and LPG consumption and the consumption of other electric technologies, and Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October, p. 19 for the efficiency of heat pumps relative to other electric technologies.

The information presented in Table 3.2 represents an average across all types of properties and, therefore, does not provide the breakdown of energy consumption across different types of properties. It is, however, reasonable to assume that the energy consumption is positively related to the size of the property (e.g. on average, a detached house consumes a larger amount of energy than a flat). To correct for this gap in the data, we have assigned scaling factors to each property, as shown in Table 3.3 below.

Table 3.3 Scaling factor by property type to account for property size

Property type	Scaling relative to average (%)
Detached house	120%
Semi-detached house	107%
Terraced house	93%
Flat	80%

Note: The scaling factors were derived in such a way as to equate the total level of energy consumption across all properties to that derived based on the figures presented in Table 3.2. The numbers are rounded to the first percentage point.

Source: Oxera analysis.

The average carbon factors for various heating technologies were sourced from Ricardo-AEA (2015) and are listed in Table 3.4.

Table 3.4 Carbon emission factors by heating sources

Heating sources	Carbon factor ($kgCO_2e/kWh$)
Fuel oil	0.26
LPG	0.21
Electricity	0.092

Note: Electricity includes air sources heat pumps and other electric technologies, such as electric boilers, smart panels and storage heaters.

Source: Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October, p. 13.

Combining Table 3.2 and Table 3.3 produces an estimate of average energy consumption for the purposes of heating for each type of property. Further combining our estimates of average energy consumption with the carbon factors featured in Table 3.4 yields an indicative average carbon emission from heating, per each type of property. This calculation is presented in Table 3.5.

Table 3.5 Breakdown of average energy consumption for heating

Property type		Average energy consumption (unscaled) (kWh/annually)	Scaling factor	Carbon factor ($kgCO_2e/kWh$)	Average carbon emission(kg CO_2e)
		[A]	[B]	[C]	[A] x [B] x [C]
Detached house	Fuel oil	20,897	120%	0.26	6,542
	LPG	6,888	120%	0.21	1,742
	Air source heat pumps	3,776	120%	0.092	418
	Other electric technologies	11,327	120%	0.092	1,255
Semi-detached house	Fuel oil	20,897	107%	0.26	5,788
	LPG	6,888	107%	0.21	1,541
	Air source heat pumps	3,776	107%	0.092	370
	Other electric technologies	11,327	107%	0.092	1,110
Terraced house	Fuel oil	20,897	93%	0.26	5,056
	LPG	6,888	93%	0.21	1,346
	Air source heat pumps	3,776	93%	0.092	323
	Other electric technologies	11,327	93%	0.092	970
Flat	Fuel oil	20,897	80%	0.26	4,347
	LPG	6,888	80%	0.21	1,157
	Air source heat pumps	3,776	80%	0.092	278
	Other electric technologies	11,327	80%	0.092	834

Note: The figures are subject to rounding.

Source: Oxera analysis, based on Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October and Department of the Environment (2018), 'Internal Review of Home Energy Scheme for Policy Development', May.

3.2.2 Assessing cost of the electric heating equipment

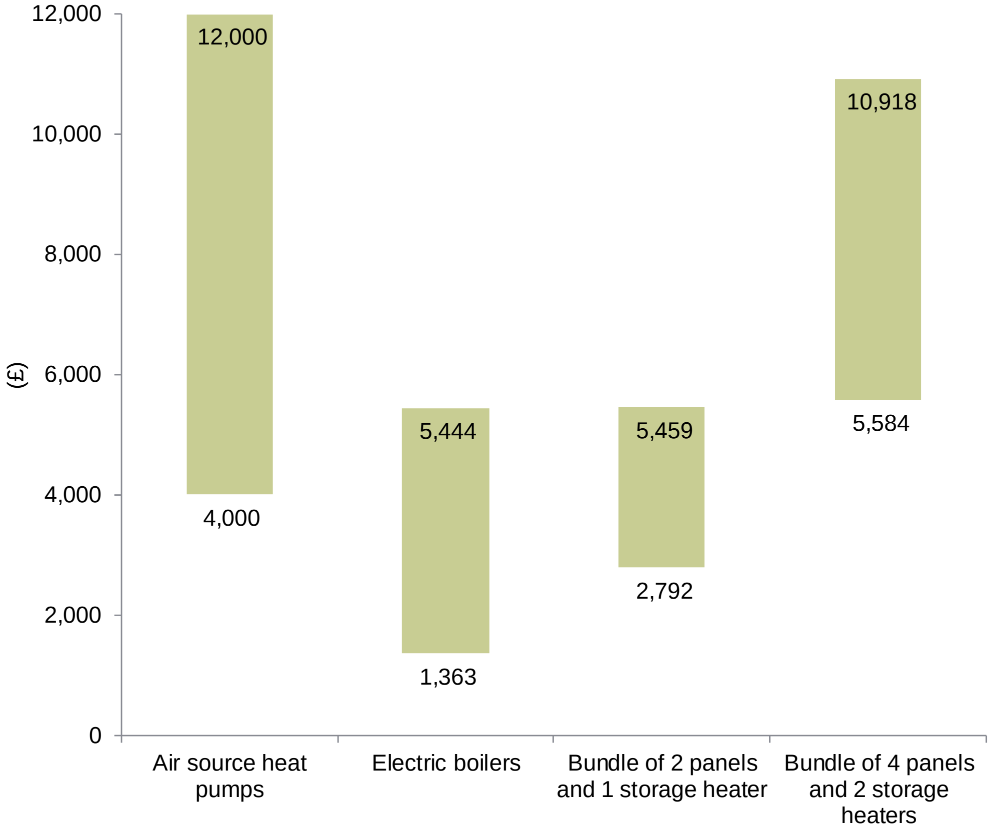
The assessment assumes that the domestic properties in Jersey currently heated by oil and LPG will be retrofitted with one of the following electric heating solutions:

- air source heat pumps;
- electric boilers; and
- a combination of smart panels and storage heaters.

We have assessed the cost of the above equipment, using prices available in the public domain. These are presented in Figure 3.5.

The price of heating equipment spans a wide range, with the cost of air source heat pumps varying from about £4,000 to £12,000, and electric boilers costing from about £1,400 to £5,400 (including installation). The main driver of the range is the capacity of equipment and the costs of installation. See Appendix A4 for a detailed list of underlying sources.

Figure 3.5 Cost of domestic electric heating equipment



Source: Oxera, based on data from Electric heating company (https://www.electric-heatingcompany.co.uk/), Rointe (https://rointe.com/uk/), Farho (http://www.farho.com/en/), Dimplex (https://www.dimplex.co.uk/).Boiler guide (https://www.boilerguide.co.uk/articles/best-electric-boilers) for electric boilers, direct heating supplies (https://www.directheatingsupplies.co.uk/) and data received from the Government of Jersey.

This variation in the level of domestic electric heating equipment costs is a significant driver of the difference in the lower and upper end of the total modelled cost to the Government, of achieving net zero by 2030 in Jersey's heating sector.

3.2.3 Assessing cost of upgrading the insulation of the domestic housing stock to current energy efficiency standards

As mentioned in section 2.1, certain properties may require insulation upgrades in addition to retrofitting of electric heating systems. Insulation upgrades serve two purposes:

- ensuring that the energy losses from heating are minimised; and
- ensuring that households are able to retain the required level of comfort when switching to electric heating.[36]

Given the information available, we estimate the cost of the necessary insulation measures to be between £4m and £10m in the low cost and high

[36] Anecdotal evidence suggests that for some properties, electric heating would not be able to generate sufficient amount of instantaneous power to achieve the desired temperature, unless the property is well insulated.

cost scenarios respectively (see Figure 3.8). The rest of this section explains how this range was obtained.

The assessment assumes that, depending on the type of property, one or more of the following insulation treatments is applied:

- loft insulation;
- cavity wall insulation;
- draught proofing;
- hot water cylinder insulation; and
- window upgrade.

Estimating the impact of insulation upgrades requires three sets of inputs:

- the number of upgrades of each type required for a given type of property (e.g. detached houses, heated by oil);
- the cost of each insulation upgrade; and
- the amount of energy saved, as a result of carrying out a given insulation upgrade.

Each of the three sets of inputs are presented below.

The modelling assumes that properties built before 2001 require an insulation upgrade. This assumption could be an overestimate of the number of properties that require such upgrades, because according to the 2014 Energy Plan, only properties constructed before the 1997 Building Bye-Laws require efficiency upgrades.[37] However, precise data on the number of properties built before 1997 was not available, as the most recent census data is available from 2001.[38] Therefore, we have assumed that all pre-2001 properties require an insulation upgrade, meaning that our cost estimate is conservative (i.e. potentially an overstatement).

Table 3.6 shows an estimated number of insulation upgrades required for the different property types. The breakdown across properties and types of insulation treatments is based on the methodology presented in KEMA (2007).[39] Appendix A3 presents the detailed derivations.

[37] States of Jersey (2014), 'Pathway 2050: An energy Plan for Jersey', March, p. 36
[38] Government of Jersey website, 'Households and dwellings statistics', https://www.gov.je/Government/JerseyInFigures/HousingLiving/pages/households.aspx
[39] KEMA limited (2007), 'Energy Efficiency Study', 03 April.

Table 3.6 Number of insulation upgrades per property type

Property type	Loft insulation	Cavity wall insulation	Draught proofing	Hot water cylinder insulation	Window upgrade
Detached house	10,107	2,630	5,466	2,785	897
Semi-detached house	6,622	1,723	3,581	1,824	588
Terraced house	3,834	998	2,073	1,056	340
Flat	-	3,627	7,539	3,841	1,238
Total	**20,562**	**8,978**	**18,659**	**9,506**	**3,063**

Note: The figures are subject to rounding.

Source: Oxera analysis, based on 2001 census data and KEMA limited (2007) 'Energy Efficiency Study'.

The unit cost of each insulation upgrade is presented in Table 3.7. Combining these estimates with the required number of upgrades shown in Table 3.6 yields the total cost of insultation upgrades. Note that the raw data on unit costs does not have the same level of granularity as the data presented in Table 3.7. Appendix A4.1.2 explains how the breakdown of unit costs by property type was derived.

Table 3.7 Average unit cost of an insulation upgrade (£)

Property type	Loft insulation		Cavity wall insulation		Draught proofing		Hot water cylinder insulation		Window upgrade	
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Detached house	120	602	602	1,806	60	144	18	120	1,204	1,686
Semi-detached house	107	533	533	1,598	53	128	16	107	1,065	1,491
Terraced house	93	465	465	1,396	47	112	14	93	931	1,303
Flat	80	400	400	1,200	40	96	12	80	800	1,120

Source: Data provided by the Government of Jersey.

Overall, the cost of insulation measures makes up a relatively small part of the overall costs of achieving net zero in the domestic heating sector (as later illustrated in Figure 3.8). Specifically, it can be seen that the unit costs of insulation measures are lower than the unit costs of heating equipment (comparing Figure 3.5 and Table 3.7). However, it is nevertheless important to account for these costs in the analysis, as at the level of an individual household, these additional costs could affect the decision of whether or not the heating system should be upgraded.

Finally, to account for the effect of insulation treatments on carbon emissions and the cost of carbon offsets in the domestic heating sector, we examine the energy savings, resulting from the insulation upgrades. These are presented in Table 3.8.

Table 3.8 Average reduction in energy consumption per type of insulation upgrade

	Loft insulation	Cavity wall insulation	Draught proofing	Hot water cylinder insulation	Window upgrade
Energy savings (kWh/year)	2,727	4,017	81	468	1,080

Note: The figures in this table refer to the average reduction in energy consumption for a general property and have subsequently been scaled to account for the different types of property.

Source: Department of the Environment (2018), 'Internal Review of Home Energy Scheme for Policy Development', May, p. 19 for loft insulation, cavity wall insulation, draught proofing and how water cylinder insulation, and Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October, p. 18 for window upgrade.

The energy savings in Table 3.8 represent an average across all types of properties and heating systems. To estimate the effect on a particular property type (e.g. detached house heated by oil) the figures have been scaled using the factors presented in Table 3.3 and Table 3.4.

It is worth noting that the ultimate effect of insulation upgrades on emissions strongly depends on the type of heating system used by a given household. All else equal, a house heated by oil will see a larger decrease in its emission following an insulation upgrade, relative to a house heated by electricity. For the next stage of the implementation of the action plan, it could therefore be useful to explore the current state of the Jersey property stock, including energy efficiency and heating systems employed. This will allow the effective prioritisation of insulation upgrades and retrofitting of heating systems, to deliver the largest emission savings upfront.

3.2.4 Conclusions on cost of abatement for domestic heating

Based on the quantitative analysis in this section, we show that the modelled cost to the Government of Jersey of implementing abatement measures in the domestic heating sector ranges between £22m–£47m. Depending on the timeline of the abatement and the price of offsets, offsets could cost a further £10m–£53m, yielding a combined range of £32m–£100m for the cost of achieving net zero in the domestic heating sector in Jersey.

3.3 Assessment of commercial heating

Due to the lack of detailed data and variation in commercial properties, a bottom-up assessment for each property cluster, as done for domestic heating, was not feasible. Instead, the scale of the required retrofits was estimated directly from the total amount of energy consumed by industry and the Government,[40] as reported by Jersey Energy Trends.[41] This is presented in Table 3.9.

[40] By applying the carbon factor to each energy type, the total amount of energy consumed was cross-checked against the latest values for carbon emissions estimated by Aether for the sector 'Business'.
[41] Government of Jersey (2019), 'Jersey Energy Trends'.

Table 3.9 Energy consumption in commercial sector by fuel type

	kWh consumed in 2018	Percentage of total
Electricity	298,483,950	60%
Oil	162,854,890	33%
LPG	39,611,780	8%
	500,950,620	**100%**

Note: Jersey Energy Trends data provides the total amount of energy consumed by industry and Government through oil (petroleum products), LPG (gas), and electricity. Underlying source data was converted from tonnes of oil equivalent (toe) to kWh using a standard conversion of 11,630 kWh = 1 toe. To the extent that not all of the energy is used for heating, the cost estimates of abating emissions from commercial heating presented in this section will be conservative. Carbon factors are assumed to be the same as for domestic properties. The figures in the right-hand column are rounded to the nearest percentage point.

Source: Government of Jersey (2019), 'Jersey Energy Trends'.

Given the amount of energy consumed through oil and LPG (as reported in Table 3.9), it is possible to derive the number of electric heating units required to generate the same amount of energy. Table 3.10 presents this derivation. Specifically:

- Assuming that an average heating unit is utilised for nine hours of each working day,[42] we have derived the implied capacity of the heating units by fuel consumption.
- Furthermore, a standardised heating unit, either a heat pump or boiler, is assumed to have a capacity of 23 kW.[43] This allows us to derive the total number of electric heating units required to produce energy to replace that which is currently generated by oil and LPG.

[42] With an eight-hour assumption for a standard working day and an additional hour to allow for a margin of error. Note that assuming a longer working day in this analysis would imply a higher historical utilisation of heating equipment, which would in turn result in a lower estimate for the number of electric heating units required for the retrofitting.

[43] Corresponds to the second-largest capacity of electric boilers, advertised for the Island of Jersey. The data can be found at the Electric Heating Company website, https://www.electric-heatingcompany.co.uk/electric-boilers/3-phase/. This allows for a capacity size larger than a typical domestic electric boiler, and more in line with what a commercial property might be expected to use. While we are aware that there are some commercial properties on the Island for which heating units of a significantly larger capacity would be appropriate, it appears unfeasible to determine accurately the relative proportions of commercial properties that would require small, medium or large heating units. Note that assuming a higher average unit capacity in this analysis would imply a lower estimate for the number of electric heating units required for the retrofitting. In this respect, our estimates could be viewed as conservative, i.e. we are tending to over-estimate the costs of the heating upgrades in the commercial sector with this assumption.

Table 3.10 Derivation of the number of electric heating units required for retrofitting commercial properties

	Total energy consumed (kWh)	Hours of energy consumption per year	Implied capacity (kW)	Capacity of one heating unit (kW)	Number of units required
	[Jersey Energy Trends]	[250 days/year x 9 hours/day]	[Energy consumed / Hours per year]	[Assumption]	[Implied Capacity / Capacity per heating unit]
Oil	162,854,890	2,250	72,380	23	3,147
LPG	39,611,780	2,250	17,605	23	765
Total					3,912

Note: To calculate the amount of energy consumed, we first calculated a standard amount of working hours in a year. Considering only working days (50 weeks, 5 days a week) and working hours (an assumed standard day of 9 hours), there are 2,250 hours per year for which the commercial sector will require heating. A standard unit was assumed to have a capacity of 23 kW; as this is larger than the high end of domestic capacity but is not as large as some commercial capacities, it represents a conservative assumption.

Source: Oxera analysis, based on Jersey Energy Trends and cost data from the public domain.

The estimation in the table above specifies how many electric heating units would be required. However, the cost of retrofitting would depend on which type of equipment would be installed for the heating upgrade. In the absence of further information, we have assumed a 50–50 split between heat pumps and electric boilers.[44] This, in turn, enables us to derive the cost to the Government of carrying out the electrification of commercial heating in Jersey, as illustrated in Table 3.11.

Table 3.11 Estimated costs of electrifying commercial heating

	Air source heat pumps	Electric boilers	Total
Number of installations	1,956	1,956	3,912
Assumed cost per unit	£12,000	£6,000	N/A
Total costs to the Government (undiscounted)	£11.7m	£5.8m	£17.6m
Estimated total cost to the Government (PV)	£9.6m	£4.8m	£14.4m

Note: Cost per unit includes installation cost. The present value of total costs is estimated assuming all retrofitting of electric equipment is completed by 2030. A 3.5% discount rate was used, as per the HM Treasury Green Book guidance.

Source: Oxera analysis, based on data from Electric heating company (https://www.electric-heatingcompany.co.uk/), Boiler guide (https://www.boilerguide.co.uk/articles/best-electric-boilers) for electric boilers (see Appendix A3).

Conclusions on cost of abatement for commercial heating sector

The present value of the total cost of achieving net zero by 2030 in the commercial heating sector, allowing for an abatement timetable of up to 2050,

[44] This is a conservative assumption for the estimation of equipment cost because air source heat pumps are more expensive than electric boilers, meaning the total cost of equipment under a 50-50 split is greater than under a 100% electric boilers assumption.

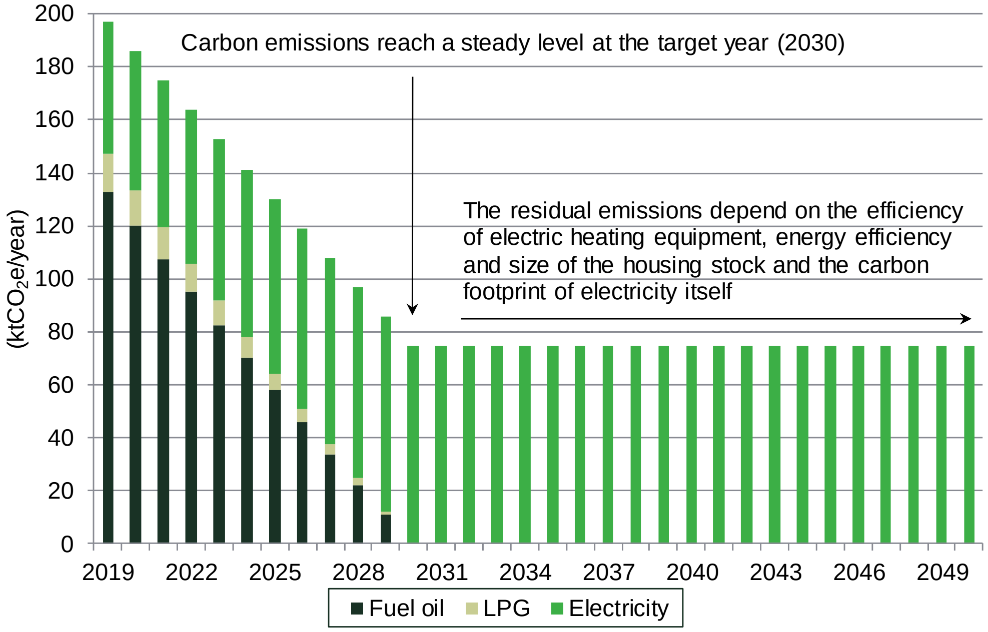
(from the perspective of the Government of Jersey) could fall within the range of £9m–£14m. Depending on the timeline of the abatement and the price of offsets, offsets could cost a further £11m–£45m, yielding a combined range of £20m–£59m for the cost of achieving net zero in the commercial heating sector in Jersey.

3.4 Impact of abatement measures on emissions from heating

Having detailed the modelling approach and input assumptions in sections 3.2 to 3.3 across the domestic and commercial heating sectors, we now illustrate how the emissions in the heating sector can change over time as a result of the abatement measures.

Figure 3.6 illustrates the evolution of carbon emissions assuming a full electrification of domestic and commercial heating by 2030. The emissions produced after 2030 (i.e. those persisting after the transition to higher energy efficiency and electric heating) originate from the carbon footprint of electricity used to power the heating systems.

Figure 3.6 Projected total emissions from commercial and domestic heating, by fuel source



Note: The figure considers emissions from the existing property stock only. As new properties are built in the future, all else equal, overall emissions will tend to increase. However, based on discussions with industry, it is unlikely that modern properties will be equipped with fossil fuel heating systems, and therefore are unlikely to require any further abatement. Moreover, to the extent that the energy management solutions become more efficient, the average consumption per property will tend to decrease over time across all properties, which may more than offset the upward pressure on emissions from the addition of new (relatively energy-efficient) properties.

Source: Oxera analysis.

The level of residual emissions (i.e. emissions remaining after the abatement programme is complete) is driven by two factors:

- the carbon footprint of electricity; and
- the efficiency of electric heating equipment.

Figure 3.6 assumes that the carbon footprint of electricity does not change over time. This assumption is likely to be conservative, as France's decarbonisation efforts may decrease the carbon footprint of electricity imported by Jersey.[45]

With regard to the efficiency of heating equipment (in particular, the amount of energy consumed by electric heating equipment) the modelling relies on published data from a 2018 report by Jersey's Department of the Environment.[46] However, because the new boilers (electric or otherwise) are likely to allow for connectivity between themselves and household networks, electrification of heating may also speed up implementation of smart heating which will reduce energy consumption. If this is the case then emissions will fall even quicker, making the glidepath presented in Figure 3.6 conservative.

3.5 Cost quantification of combined measures in domestic and commercial heating sectors

Having illustrated how the emission reduction pathway could develop over the years 2019–50, we now examine how the cost of achieving net zero in the heating sector could evolve over time—this is illustrated in Figure 3.7.

As previously explained, the modelled cost includes a 50% Government subsidy on retrofitting of electric heating and carrying out insulation upgrades, as well as expenditure on offsetting unabated emissions from heating, from 2030 onwards.

To the extent that the commercial sector would not require as much financial support (if any) in pursuing efficiency gains as the domestic sector might, the cost to the Government of Jersey will likely be lower. Therefore, the estimates presented in the Figure 3.7 can be deemed conservative if less than a 50% subsidisation rate is required.[47]

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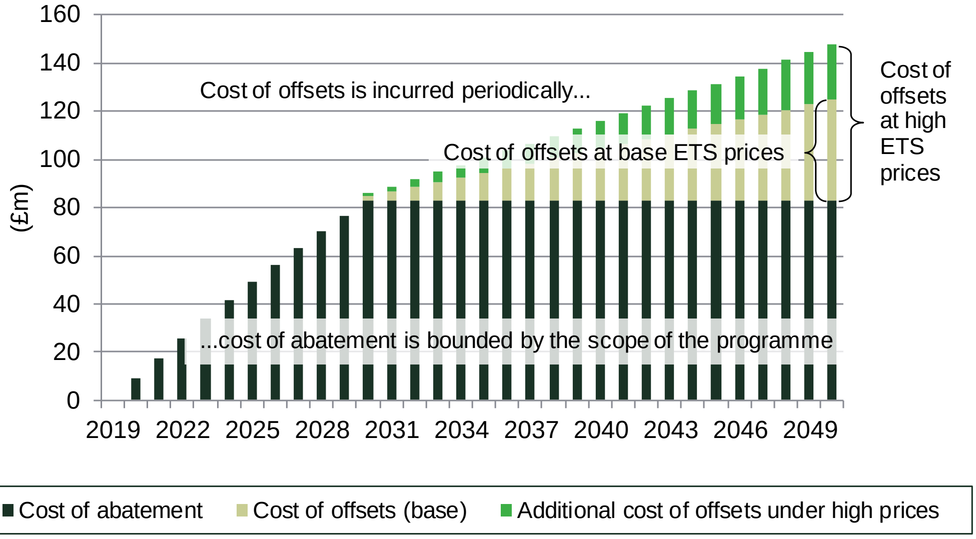
[45] In 2018, France adopted an Energy and Climate Strategy, committing the French government to reducing fossil fuel consumption by 40% by 2030, in favour of facilitating the development of clean renewable energies. This Bill also put achievement of net zero emissions for France by 2050 on a statutory footing. Therefore, the carbon factor for electricity generated in and imported from France may be lower by 2030. For more details, see the Government of France's website, 'France wants to be the first country in Europe to put the carbon neutrality goal on a statutory footing', https://www.gouvernement.fr/en/france-wants-to-be-the-first-country-in-europe-to-put-the-carbon-neutrality-goal-on-a-statutory, accessed on 4 December 2019.
[46] Department of the Environment (2018), 'Internal Review of Home Energy Scheme for Policy Development', p. 27.
[47] Section 3.6 illustrates a sensitivity of how changing the assumed rate of subsidisation affects the cost of achieving net zero from the perspective of the Government of Jersey.

Figure 3.7 Cumulative cost of achieving net zero emissions in the heating sector



Note: All costs are presented in present value terms, discounted at 3.5%, as per the HM Treasury Green Book guidance. The expenditure on offsets is estimated using the forecast for the prices of ETS from National Grid. The abatement costs assume 50% subsidisation of heating upgrades, in the form of electric heating sources and insulation measures, for households and industry.
Source: Oxera analysis.

As can be seen in Figure 3.7, in earlier years the cost of achieving net zero is largely composed of the costs of abatement. However, over time, the costs associated with offsets increase. The cost exposure to the offset market is driven by:

- the market price of offsets; and
- the volume of residual (i.e. unabated) emissions that need to be offset.

Figure 3.7 assumes that the emissions evolve according to the path illustrated in Figure 3.6. However, to the extent that the level of residual emissions may be different (see section 3.4), the level of offsetting expenditure may change as well (see section 3.6).

3.6 Sensitivities on the modelling of heating sector

This section illustrates how the cost of achieving net zero measures, and the level of emissions from the heating sector, change in response to changes in key modelling assumptions. The '2030 CO2e emissions' column represents the level of residual, i.e. unabated emissions, as at 2030. These emissions are assumed to be offset, in line with the net zero by 2030 target.

The findings of the sensitivity analysis in the heating sector are summarised in Table 3.12.

Table 3.12 Sensitivities to the modelling of decarbonisation measures in the heating sector

Sensitivity analysis of which variable?	Central range	Cost of achieving net zero (£m, PV over 2019–50)	2030 CO_2e emissions
Lower discount rate (at 3%)	£77m–£123m	£81m–£131m	75 ktCO_2e/year
Higher heat pump penetration in domestic heating (20%)	£77m–£123m	£80m–£125m	73 ktCO_2e/year
Higher heat pump penetration in commercial heating (75%)	£77m–£123m	£79m–£123m	72 ktCO_2e/year
Lower efficiency of heat pumps relative to other technologies (150% rather than 300% efficiency)	£77m–£123m	£78m–£126m	78 ktCO_2e/year
Higher consumption of electricity for domestic heating ([REDACTED] kWh/year)	£77m–£123m	£84m–£145m	100 ktCO2e/year
Lower capacity of a typical commercial heating unit (14 kW)	£77m–£123m	£87m–£132m	75 ktCO_2e/year
Higher Government subsidisation rate (100%)	£77m–£123m	£136m–£181m	75 ktCO_2e/year

Source: Oxera analysis.

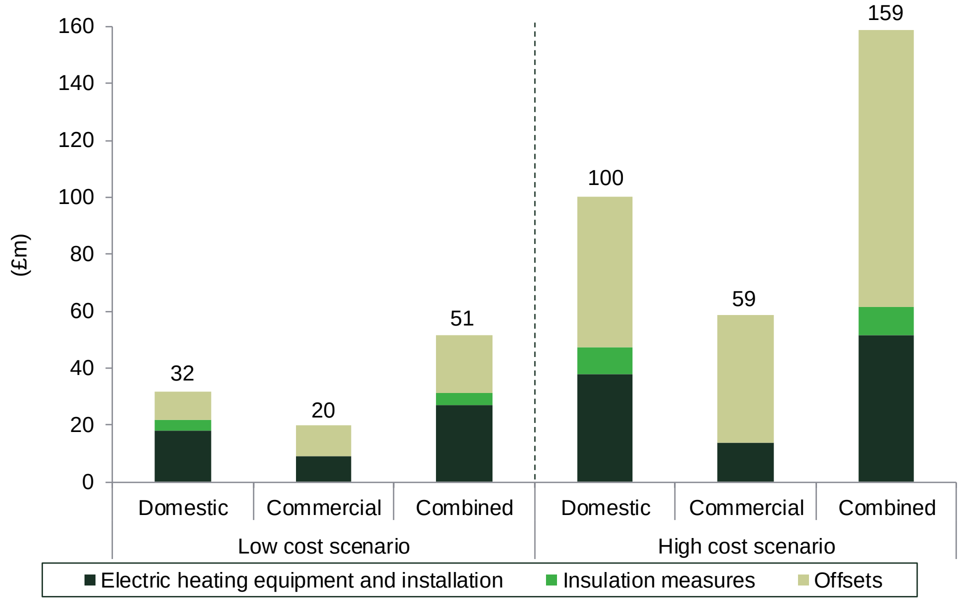
3.7 Overall conclusions on heating

As elaborated in this section, the costs of achieving net zero in the heating sector of Jersey are associated with a significant range of uncertainty, driven by:

- the unit cost of heating equipment and insulation;
- timeline for the abatement programme; and
- price level of offsets.

Figure 3.8 illustrates the breakdown of the cost of delivering net zero in the heating sector under the main scenarios.

Figure 3.8 Cost of delivering net zero in heating: Decomposition of the low and high ends of the uncertainty range



Note: Low (high) cost scenario assumes that the abatement programme is completed in 2035 (2050) and that the price of offsets follows a low (high) forecast. The sum of individual bars for the low cost scenario does not add to the total due to rounding.

Source: Oxera analysis, based on data from National Grid and the Government of Jersey.

4 Analysis of the transport sector

According to the most recent official statistics (2017), Jersey's transport sector accounted for just over half of the Island's total emissions. Road transport, which contributes the majority (63%) of transport emissions, is the sub-sector for which the current technology offers the greatest decarbonisation potential. This section of the report provides an overview of the road transport sub-sector, and an impact assessment of the measures for its decarbonisation.

The analysis presented in this report has quantified the costs of, and the resulting emission savings from, the following activities:

- escalating existing fuel taxes to discourage the use of petrol and diesel vehicles;
- providing financial incentive(s) for the purchase of electric vehicles (EVs), either in the form of a purchase grant, and/or in the form of a scrappage payment to owners of fossil fuel vehicles;[48]
- facilitating the use of second generation biodiesel, such as hydrotreated vegetable oil (HVO) for all diesel vehicles, subject to further technical due diligence of the feasibility of such a transition in Jersey; and
- imposing a ban on the registration of fossil fuel vehicles.

4.1 Overview of findings in relation to decarbonisation of road transport

The quantitative analysis shows that from the perspective of the Government of Jersey, the cost of delivering net zero emissions in the road transport sector by 2030 can be almost nil, or very high, depending on the policies chosen, with a modelled range of £6m–£200m.[49] This is in contrast to the heating sector, where the range is driven by factors that are largely outside the control of policymakers (i.e. the cost of equipment and the price of offsets).

This range of the modelled costs in road transport decarbonisation is strongly affected by the duration of policy measures in place—specifically, the duration of EV subsidisation offered by the Government to facilitate transition from fossil fuel vehicles to EVs and, potentially, HVO. A range of timeframes is examined for the duration of support for abatement measures in the road transport sector, with the most accelerated timetable assuming a full completion of abatement measures by 2025 and the most extended timetable by 2030. Note that the timeframe for abatement policy measures in the road transport sector is much shorter (up to 2030) than that considered for the heating sector (up to 2050). This is because achieving the decarbonisation of the vehicle fleet at a rapid pace may have fewer practical limitations in Jersey, than facilitating the rapid decarbonisation of heating. Not only the process of purchasing a new car is less likely to be disruptive than the process of changing heating equipment, it is also less likely to require a substantial local skilled labour force, to install electric heating equipment and upgrade the insulation of housing stock.

There is then a further consideration, about when a ban on the registration of fossil fuel vehicles is assumed to be instated. A measure, such as a ban on

[48] For ease of presentation, in this report we use the term 'EV grant' to denote either a purchase grant and/or scrappage grant, facilitating the substitution from a fossil fuel vehicle to EV.
[49] Note, the bottom end of the range was revised to £6m from £7m quoted in figure 7.4 of the Carbon Neutral Strategy. The top end of the range presented in the same figure corresponds to the scenario with EV support, but no HVO support. The cost under that scenario was revised from £147m quoted in the Carbon Neutral Strategy to £146m, presented in this report.

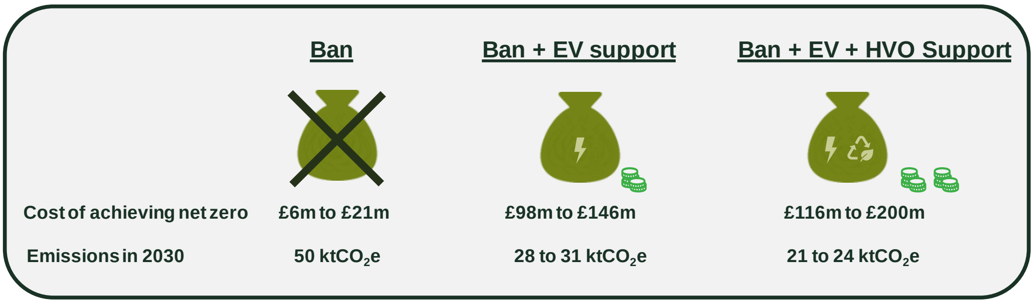
registrations, is a strong policy instrument because it directly restrains the choices of citizens, rather than creating financial incentives to achieve the desired outcome. To avoid imposing a financial burden on households, in scenarios where no financial incentives are being provided (i.e. the lower end of the modelled cost range), we assume that a ban on registration of fossil fuel vehicles only comes into effect after 2030, which is the latter end of the range of dates by which price parity between fossil fuel vehicles and EVs is forecast to occur (see Table 4.5).

Therefore, in summary:

- at the lower end of the modelled cost range where Government grants for EV uptake are assumed not to be provided, the ban comes into effect in 2030;
- at the mid-range of the modelled estimates, EV uptake grants are assumed to be in place until the date of the ban coming into effect (i.e. 2025, 2027 or 2030, depending on the modelled scenario); and
- finally, at the high end of the range, it is assumed that both EV and HVO receive Government support. An EV grant is assumed to be offered to the owners of petrol vehicles, who are willing to switch to EV. At the same time, HVO enjoys a tax rebate which allows it to compete with diesel. The support schemes are assumed to remain in place until the date of the ban coming into effect, from which point no petrol registration vehicles can be registered, while diesel vehicles have to rely exclusively on HVO.

The range of uncertainty around the cost estimates is illustrated in Figure 4.1.

Figure 4.1 Range of uncertainty around the cost of achieving net zero by 2030 for the road transport sector



Note: The cost of achieving net zero includes both the present value of the costs of abatement, as well as the present value of the expenditure of offsetting the unabated emissions. Throughout all scenarios it is assumed that unabated emissions are being offset from 2030 onwards. All costs are presented in present value terms, discounted at 3.5%, as per the HM Treasury Green Book guidance. The assessment period covers the years 2019–50. The expenditure on offsets is estimated using the forecast for the prices of ETS from National Grid.

Source: Oxera analysis.

The next section explains the details of the modelling methodology underpinning the cost estimates of achieving net zero in Jersey's road transport sector.

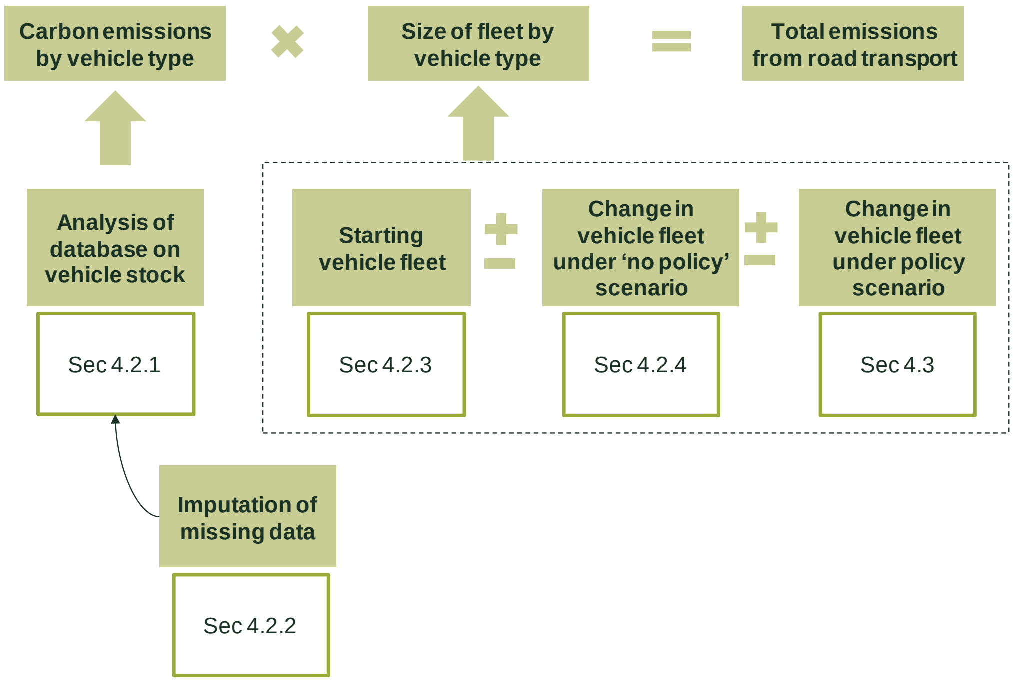
4.2 Methodology for quantitative assessment of road transport decarbonisation

Determining the cost of achieving net zero and the associated emission glidepaths requires three sets of inputs:

- the composition of the current vehicle fleet;
- the expected future changes to the current vehicle fleet; and
- the incremental effects of various measures on the current fleet and its future evolution.

As illustrated in Figure 4.2, each of the three sets of inputs are composed of several parameters.

Figure 4.2 Overview of the modelling of road transport decarbonisation



Source: Oxera analysis, based on DVS database.

The next sub-sections describe the analytical work undertaken in relation to each of these modelling inputs.

4.2.1 Estimating the composition of the current vehicle fleet

Table 4.1 presents our input assumptions on the breakdown of the current Jersey vehicle fleet, split by fuel type and average emissions intensity.

Table 4.1 Jersey's vehicle fleet as of 29 October 2019

Vehicle classes	Average emissions (gCO_2e/km)	Number of vehicles	Annual emissions ($ktCO_2e/year$)
	[A]	[B]	[C] = [A] x [B] x 9,656 /10^9
EV	**17**	**583**	0.10
D1	112	3,818	4.12
D2	140	6,995	9.46
D3	163	6,496	10.25
D4	190	6,162	11.30
D5	279	4,399	11.84
All diesel	**175**	**27,870**	**46.97**
P1	57	7,291	4.04
P2	92	4,485	3.99
P3	115	13,430	14.89
P4	135	18,291	23.93
P5	159	10,000	15.38
P6	185	2,939	5.26
P7	252	4,322	10.52
All petrol	**133**	**60,758**	**78.00**
Total	**145**	**89,211**	**125.07**

Note: According to the Government, vehicles on the Island of Jersey travel on average an annual distance of 9,656 km.

Source: Oxera analysis, based on the Driver and Vehicle Standards database.

The breakdown above is based on the Driver and Vehicle Standards database, which lists the following details for vehicles currently registered in Jersey:

- year of registration (ranging from 1921 to 2019);
- fuel type (such as petrol, heavy oil, gas, hybrid, electric);
- engine displacement (ranging from 0 to 18,000 CC);[50] and
- emission intensity (ranging from 0 to 2,400 g/km).[51]

The database has two limitations, however:

- information on emission intensity is not available for a large proportion of registered vehicles (61%);[52] and
- records on the vehicles that have been scrapped or have left the Island are limited.

The sub-sections below describe the approach taken to mitigate these limitations.

4.2.2 Estimating the missing data on emission intensity

For instances where the data on emission intensity of a vehicle is unavailable, we have used regression analysis to estimate the missing emission intensity

[50] Engine displacement is defined as 'the size of the area inside the engine (of a vehicle) where the air-fuel mixture is burned'. See Abdo, E. (2011), 'Power Equipment Engine Technology', p. 82.
[51] Note that in calculating the total emission from Jersey vehicle fleet we use carbon footprint of electricity (0.092 kg CO2e/kWh) for vehicles that are listed as having a zero emission intensity in the Driver and Vehicle Standards database.
[52] Information is generally more complete for vehicles that have been registered more recently.

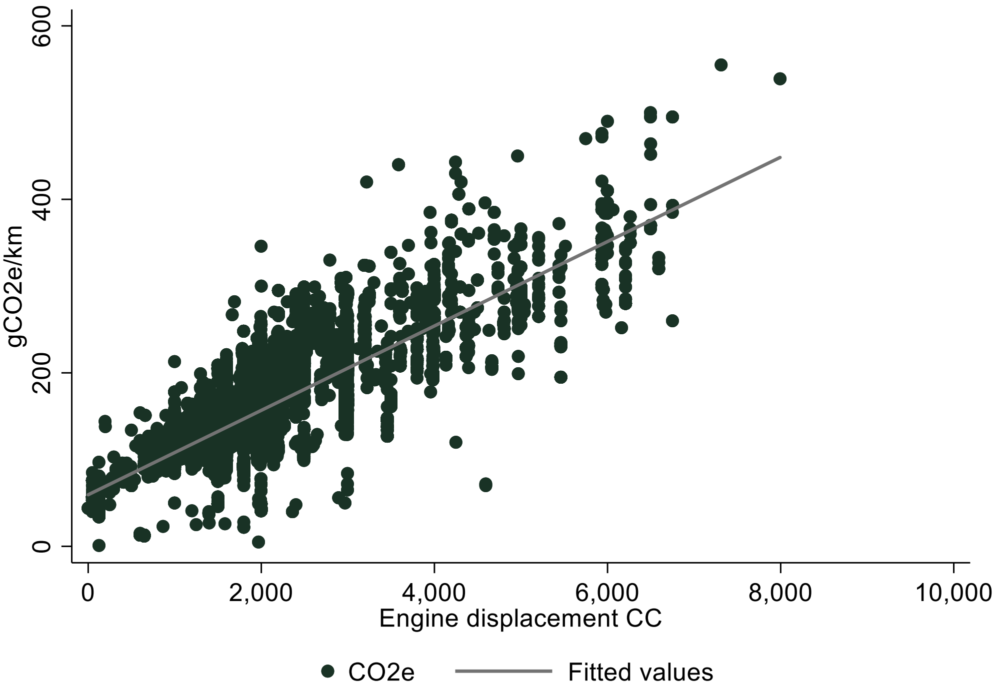
entries. The underlying econometric model assumes that emission intensity for a given vehicle depends on i) engine displacement, ii) the category of the vehicle (e.g. car, heavy vehicle or truck), and iii) the fuel type (e.g. petrol, diesel or hybrid).

EVs are not considered as part of this analysis, as the Driver and Vehicle Standards data attributes zero emissions to EVs. Note, however that in the assessment of offset costs, EVs are assumed to have a second-order average emission intensity of 17 gCO_2e/km.[53]

Plotting a scatter diagram of vehicles' CO_2e emission intensities to their engine displacements reveals an approximately linear relationship between the two variables, as shown in Figure 4.3. Therefore, we used a linear regression model to interpolate the relationship between CO_2e emission intensity and the variables that explain it.[54] Accordingly, emission intensity is regressed on engine displacement with dummy variables for each vehicle and fuel category.[55]

[53] A carbon factor of 0.092 $kgCO_2e$ is applied to every kWh of electricity consumed. According to an industry estimate, EVs on average consume 18.5 kWh/100km (see https://ev-database.org/cheatsheet/energy-consumption-electric-car). Assuming that EVs on average travel 9,656 km per annum (as suggested in the 2014 Energy Plan), EVs will have a second-order average emission intensity of 17 gCO_2e/km.
[54] The parameters of the model are estimated using the Ordinary Least Squares (OLS) method. The method seeks to minimise ('least') the sum of squares ('squares') of the error term, which is the discrepancy between actual and predicted values for CO_2e emission intensity.
[55] A dummy variable takes the value of 1 or 0, depending on whether a vehicle has (1) or has not (0) got a particular characteristic. For example, a vehicle can either be a car or not; or it can either run solely on petrol or not. The coefficient attached to the dummy variable estimates the impact of a vehicle being a car, relative to a baseline. Dummies are relative to a baseline characteristic, and when all dummies take the value 0, the vehicle will have this baseline characteristic. In this case, for example, the baseline is 'agricultural': dummies state the impact on CO_2e emission for a vehicle when it is *not* an agricultural vehicle.

Figure 4.3 Correlation between vehicle emission intensity and engine displacement



Source: Oxera analysis, based on the Driver and Vehicle Standards database.

The results of the regression are summarised in Table 4.2 below.

Table 4.2 Regression model for interpolating vehicle emission intensities

Explanatory variables	Coefficient value	Interpretation
Constant	146.87***	Scaling parameter
Engine CC	0.051***	A unit increase in engine displacement is predicted to increase CO_2e emissions by 0.05g CO_2e per km
Vehicle category dummies		
‘Agricultural’ category	NA	This is the reference category to which other categories are benchmarked
‘Caravan’ category	-37.46***	
‘Cars’ category	-67.49***	
‘Heavy’ category	-36.05***	
‘Light Com.’ category	-41.17***	
‘Light Util.’ category	-17.51	
‘Motorcycles’ category	-76.04***	
‘Trucks’ category	-116.57***	
Fuel category dummies		
‘Gas’ category	NA	This is the reference category to which other categories are benchmarked
‘Gas Bi Fuel’ category	106.33***	
‘Diesel’ category	-33.88***	
‘Hybrid Electric’ category	-88.30***	
‘Petrol’ category	-17.49***	
Regression characteristics		
R-squared	0.7341	Over 73% of variation in vehicle emissions can be explained by the regression
Adjusted R-squared	0.7340	
Number of observations	34,783	

Note: *** denotes statistical significance at the 1% level.

Source: Oxera analysis, based on the Driver and Vehicle Standards database.

As can be seen from the table above, over 73% of variations in emission intensity can be explained by the model (i.e. the R-squared ratio is 0.73 and adjusted R-squared is only very slightly lower). Moreover, all variables are statistically significant even at the 1% level, with the exception of the ‘Light Util.’ vehicle category.[56] This provides strong evidence that the regression model and explanatory variables used in this analysis are appropriate for explaining differences in CO_2e emission intensities across vehicles.

As an illustration of how the model is used to back-fill the missing data on emission intensity, consider the following example in Table 4.3. In the DVS database, vehicle Ford Fiesta Zetec Climate is recorded to have an engine with a displacement of 1,388 CC that runs on petrol. For these parameters, the econometric model presented in Table 4.2 predicts an emission intensity of

[56] Note, even though the ‘Light Util.’ category variable appears insignificant on its own, we have retained it in the model. This is because under multicollinearity—a situation when relevant explanatory variables have a high degree of correlation—relevant variables could appear insignificant. A joint test of all vehicle category dummies suggests that as a group, all the variables are significant at the 1% level.

132 gCO_2e/km. The actual observed value of emission intensity for this particular vehicle model amounts to 147 gCO_2e/km.

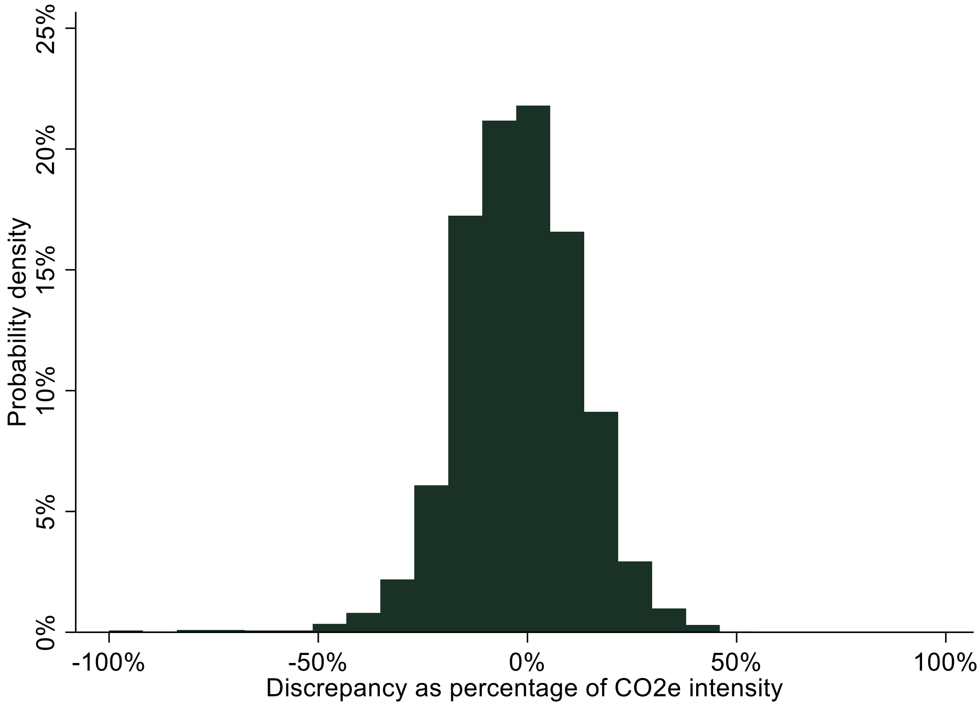
Table 4.3 Illustrative calculation of emission intensity prediction

Explanatory variable	Value of the explanatory variable	Coefficient value	Predicted effect on CO_2e emission intensity
	[A]	[B]	[C] = [A] x [B]
Constant	1	146.9	146.9
Engine CC	1,388	0.051	70.1
Category—car	1	-67.49	-67.5
Fuel—petrol	1	-17.49	-17.5
Prediction of emission intensity			132
Actual emission intensity			147
% discrepancy			10%

Source: Oxera analysis, based on the Driver and Vehicle Standards database.

Across the whole sample, the difference between predicted and actual emission intensity has a standard deviation of 23.1 gCO_2e/km, meaning that 90% of cars have their emissions correctly predicted to within 25% of their true value. The distribution of prediction errors is illustrated in Figure 4.4.

Figure 4.4 Probability density of errors



Note: Extreme outliers (0.3% of the sample) have been removed from the histogram.

Source: Oxera analysis, based on the Driver and Vehicle Standards database.

Using known emissions intensity wherever available, and estimated emission intensity otherwise, each vehicle is assigned to a class corresponding approximately to Jersey's Vehicle Emissions Duty bands. Separate classes are created for diesel and petrol fuel types, while EVs, which do not emit carbon directly, constitute a single unique class.

4.2.3 Estimating the number of active vehicles

As a next step, the second limitation of the DVS database is addressed. Since the data includes vehicles that are not in use ('inactive'), it is necessary to make assumptions about which of the vehicles listed in the DVS database are no longer used on the road. To estimate the size of the active vehicle fleet in Jersey, we assume that all vehicles registered before 2000 are no longer in use. Applying this cut-off year implies a current vehicle fleet size of around 89,000. This is likely, a priori, to lead to an over-estimation of the current fleet size, if the average age of the vehicle fleet is around 10 years, as per the modelling behind the Government's 2014 Energy Plan.[57]

However, we have then tallied this bottom-up estimate of the active vehicle fleet with a top-down approach by examining the total annual emissions from road transport. With a vehicle fleet assumption of 89,000 vehicles, the implied total emissions would be 125 ktCO_2e. This estimate of emissions is similar to the actual level of observed emissions, i.e. slightly above the latest (2017) official emission statistics, which amount to 118 ktCO_2e.[58] The similarity suggests the bottom-up estimate is approximately right.

The estimate of 89,000 vehicles is therefore assumed to be the size of the active vehicle fleet in this analysis.

4.2.4 Estimating expected changes in the vehicle fleet

Forecasting the future evolution of Jersey's vehicle stock across the different classes of vehicles is necessary to model the evolution of emissions over time. Two components determine the future evolution of the vehicle stock:

- retirement of existing vehicles; and
- registrations of new vehicles.

For the former, this analysis assumes that a 10% yearly retirement rate applies to all classes of vehicles. This assumption is based on Jersey's 2014 Energy Plan, where a 10-year average vehicle life was assumed.[59]

For the latter, an econometric model estimated on historical data is used to forecast vehicle registrations. The model assumes that the registrations in a given year are related to i) the expected population increase in that given year,[60] and ii) the previous year's number of registrations. Appendix A5 provides more detail on the projections of future registrations.

4.2.5 Summary of Jersey vehicle fleet

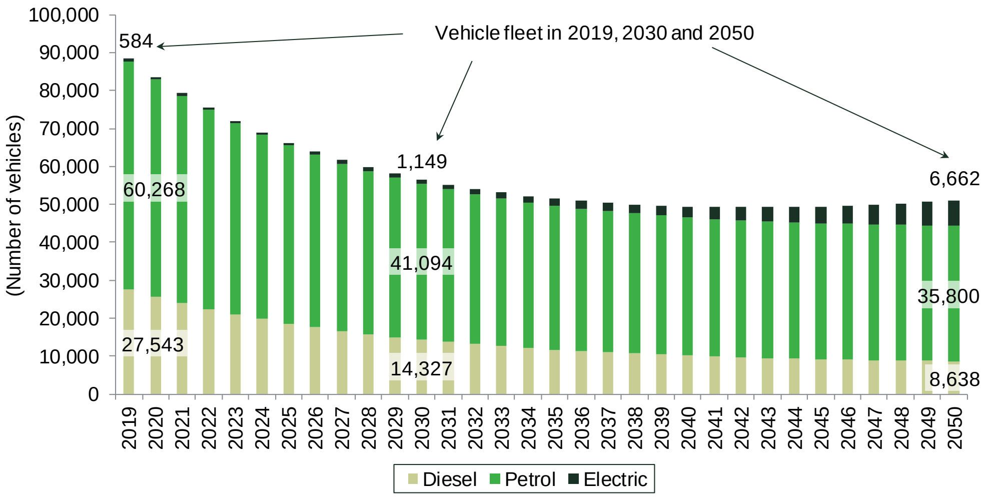
In summary, the three steps to estimate the current and the future level of Jersey's vehicle fleet under the business as usual (i.e. without carbon abatement measures analysed in this report being implemented) scenario are:

[57] As per the assumption used in the modelling conducted for the 2014 Energy Plan. See '2014 Supporting document B for Oxera 07.08.2019.xls', tab transport, cell B52.
[58] See Aether website, 'Jersey Greenhouse Gas Emissions 1990-2017', https://www.aether-uk.com/Resources/Jersey-Infographic.
[59] For more details, see '2014 Supporting document B for Oxera 07.08.2019.xls', tab transport, cell B52.
[60] For more details, see States of Jersey Statistics Unit (2016), 'Jersey population projections 2016 release', October, https://www.gov.je/SiteCollectionDocuments/Government%20and%20administration/R%20Population%20Projections%202016%2020161013%20SU.pdf, accessed on 3 December 2019.

- group the latest snapshot of Jersey vehicle fleet into classes by their fuel type and emission intensity;
- remove the vehicles which are expected to be inactive; and
- project future registrations and retirements using a combination of econometric analysis and assumptions underlying the 2014 Energy Plan modelling.

The resulting projections of the future vehicle stock under the business as usual scenario, are presented in Figure 4.5.

Figure 4.5 Projected evolution of Jersey's vehicle fleet under business as usual scenario



Source: Oxera analysis, based on the Driver and Vehicle Standards database and States of Jersey Statistics Unit (2016), 'Jersey population projections 2016 release', October, https://www.gov.je/SiteCollectionDocuments/Government%20and%20administration/R%20Population%20Projections%202016%2020161013%20SU.pdf, accessed on 3 December 2019.

Note that in addition to the vehicle fleet itself changing over time, the average distance travelled by each vehicle is assumed to change over time as well. 2014 Energy Plan assumed a 5% shift to sustainable modes of transport by 2020. [61] Accordingly, in our modelling of business as usual scenario we have assumed a 5% decrease in the average distance travelled by vehicles between 2020 and 2030. We examine the effect of this assumption in a sensitivity presented in section 4.4.

The next stage of the analysis is to examine how the emissions from road transport evolve under various policy measures. A comparison of the business as usual scenario with the projected evolution of emissions under differing policy interventions will then yield an estimate of the cost of delivering the net zero by 2030 agenda in the road transport sector.

4.3 Impacts of measures on costs and emissions

This section explains the economic mechanisms through which the four measures for decarbonisation of road transport presented in section 2.2 affect the economy. An overview of the modelled effects is provided in Table 4.4.

[61] Government of Jersey (2014), 'Pathway 2050: An Energy Plan for Jersey. Summary', March, available at https://www.gov.je/Government/Pages/StatesReports.aspx?ReportID=1039 p. 67.

Table 4.4 Effect of decarbonisation measures on road transport

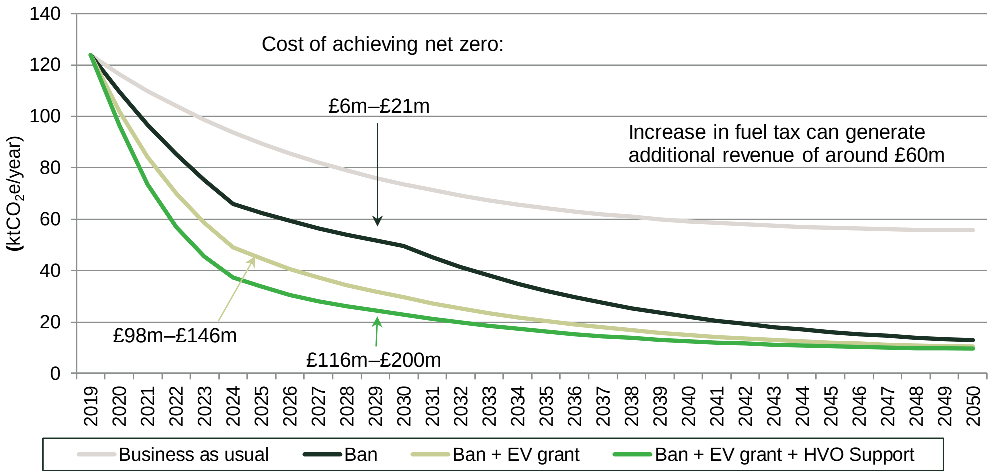
	Measure	Effect of measure on:		
		average distance travelled	existing vehicle stock	future registrations
1	Fuel tax	Decreases the average journey length	Increase in tax on diesel provides an additional incentive for existing diesel vehicles to switch to HVO.	No effect modelled
2	Registration ban	No effect modelled	No effect modelled	Future registrations migrate to EVs or to the use of HVO for diesel engines.
3	Financial support for EVs	No effect modelled	Rate of retirement increases to 17.5% for eligible vehicles during the years of financial support	EV registrations increase by the number of additional retirements, caused by EV financial support
4	HVO tax rebate	No effect modelled	Existing diesel vehicles switch to HVO. The degree of the switch is determined by the relative prices of diesel and HVO from the perspective of consumers.	No effect on the number of registrations, but there is an effect on what type of fuel the newly registered cars end up using.

Source: Oxera analysis.

The chart below shows the evolution of emissions in response to each policy intervention. Specifically:

- without the policy interventions, the level of emissions would decline from 125 ktCO_2e to around 74 (56) ktCO_2e by 2030 (2050);
- the increase in fuel tax does not create additional cost to the Government, hence is not shown in the figure below; current modelling suggests that it can generate up to around £60m of additional revenue (see section 4.3.1 for details);
- the introduction of a ban on registration of fossil fuel vehicles by the end of 2030, supports a decline in the level of emissions to approximately 50 (13) ktCO_2e by 2030 (2050), at a cost of £6m–£21m to the Government, to offset the residual road transport emission from 2030;
- further to the above, providing an EV grant to stimulate the uptake of EVs could further push the level of emissions down to approximately 30 (11) ktCO_2e by 2030 (2050), while increasing the cost to the Government to £98m–£146m; and
- finally, providing support for the uptake of both EVs and HVO could decrease the level of emissions down to around 23 (10) ktCO_2e by 2030 (2050), at the cost of £116m–£200m.

Figure 4.6 Evolution of emission and cost of achieving net zero under different measures



Source: Oxera analysis.

The rest of this section explains the main assumptions used in this analysis, and the expected impact on road transport emissions and Government expenditure for each of the measures above.

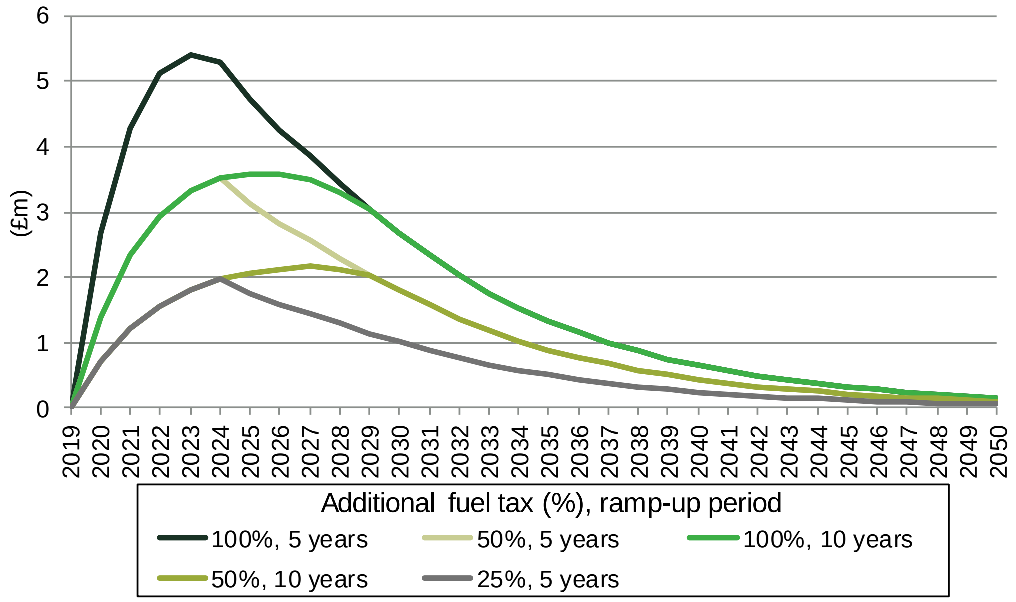
4.3.1 Measure 1: escalation of fuel tax

Implementing a higher tax on fossil fuels sold in Jersey is assumed to reduce the average distance travelled by vehicles. Based on empirical academic studies, a 1% increase in the price of fuel is expected to lead to a 0.1–0.67% decrease in the distance travelled by vehicles.[62] For the purpose of this assessment, we use the sensitivity from the top end of the range, i.e. 0.67%. This is because in a small jurisdiction such as Jersey, journeys tend to be shorter and substitutes, such as cycling or walking, are therefore likely to be more viable. We, however examine the effect of this assumption in a sensitivity presented in section 4.4.

An increase in fuel tax could therefore improve the fiscal position of the Government by generating additional tax revenue, as fuel consumption decreases less than proportionately to the increase in tax rate. This, however, also implies that, in the medium term, the use of private vehicles is likely to persist and, therefore, other measures will likely be needed to complement the escalation of fuel taxes. In the long term, as EVs become more common, the consumption of fuel and, therefore, additional fuel tax revenue decline. Figure 4.7 illustrates the potential increase in fuel tax revenue, as a result of fuel tax escalation.

[62] See, Dunkerley, F., Rohr, C. and Daly, A. (2014), 'Road traffic demand elasticities: A rapid evidence assessment', pp. 9–13, Table 2; and Frondel, M., Peters, J. and Vance, C. (2008), 'Identifying the Rebound: Evidence from a German Household Panel', p. 156, Table 3.

Figure 4.7 Potential change in fuel tax revenue



Note: Each line depicts the difference in the incremental present value of fuel tax revenue, when compared with a scenario where no additional fuel tax is imposed on consumers. Due to the price inelasticity of fuel, higher taxation rates lead to increased fuel tax revenue. However, in the long run, tax revenues from fuel are expected to decline as fuel consumption slowly decreases.

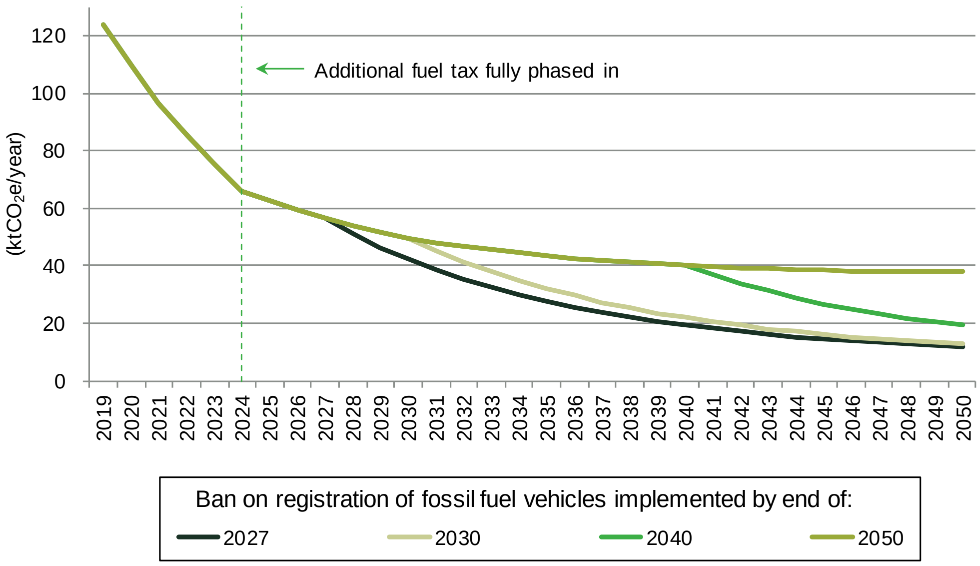
Source: Oxera analysis, based on the Driver and Vehicle Standards database and offset prices.

In total, the increase in fuel tax can generate £20m–£60m of additional revenue over 2020–50 (in present value terms), relative to a scenario where the fuel tax remains constant. While from an environmental perspective, a higher increase in taxes would be more aligned with achieving the net zero ambitions, it is important to consider the potential impact on (vulnerable) road users with income below a certain threshold. It would be important to establish that such users have adequate access to alternative modes of travel or, potentially, are offered fuel tax exemptions.

4.3.2 Measure 2: ban on registration of fossil fuel vehicles

Introducing a ban on the registration of fossil fuel vehicles will block the inflow of additional fossil fuel vehicles into the current vehicle fleet. Figure 4.8 compares future emission projections under different timings of the ban.

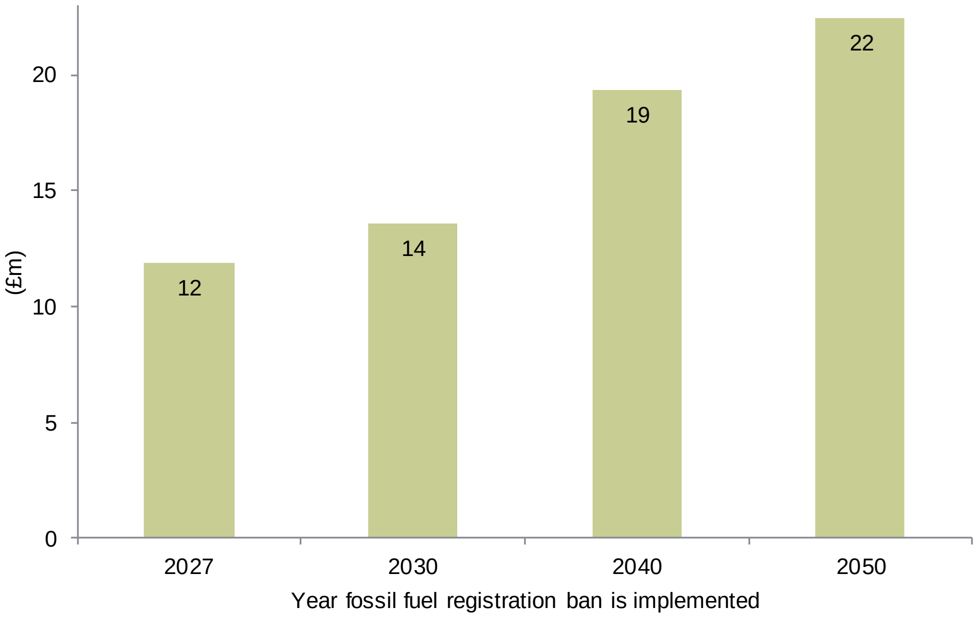
Figure 4.8 Projected emissions in the road transport sector under different ban timings



Source: Oxera analysis, based on the Driver and Vehicle Standards database and States of Jersey Statistics Unit (2016), 'Jersey population projections 2016 release', October, https://www.gov.je/SiteCollectionDocuments/Government%20and%20administration/R%20Population%20Projections%202016%2020161013%20SU.pdf, accessed on 3 December 2019.

As can be seen from Figure 4.8, future registrations are expected to account for a significant proportion of emissions over the next 20 years. Therefore, the timing of the ban significantly affects the abatement glidepath and, as a consequence, the projected offset expenditure. This is illustrated in Figure 4.9.

Figure 4.9 Projected offset expenditure for the road transport sector under different ban timings



Note: All scenarios presented in this figure assume a 100% increase in fuel tax over the years 2020–24.

Source: Oxera analysis, based on the Driver and Vehicle Standards database and States of Jersey Statistics Unit (2016), 'Jersey population projections 2016 release', October, https://www.gov.je/SiteCollectionDocuments/Government%20and%20administration/R%20Population%20Projections%202016%2020161013%20SU.pdf, accessed on 3 December 2019.

From the perspective of achieving net zero and minimising offset expenditure, an earlier implementation of the ban is desirable. However, the speed of abatement has to be balanced against the impact on the quality of life of Jersey citizens. As explained in section 4.3.3, the cost of EVs could match those of fossil fuel vehicles by as early as 2022, in which case a ban on new registrations from the late 2020s onwards is unlikely to impose a material financial burden on households (because EVs will not require a higher expenditure from consumers, relative to fossil fuel vehicles).

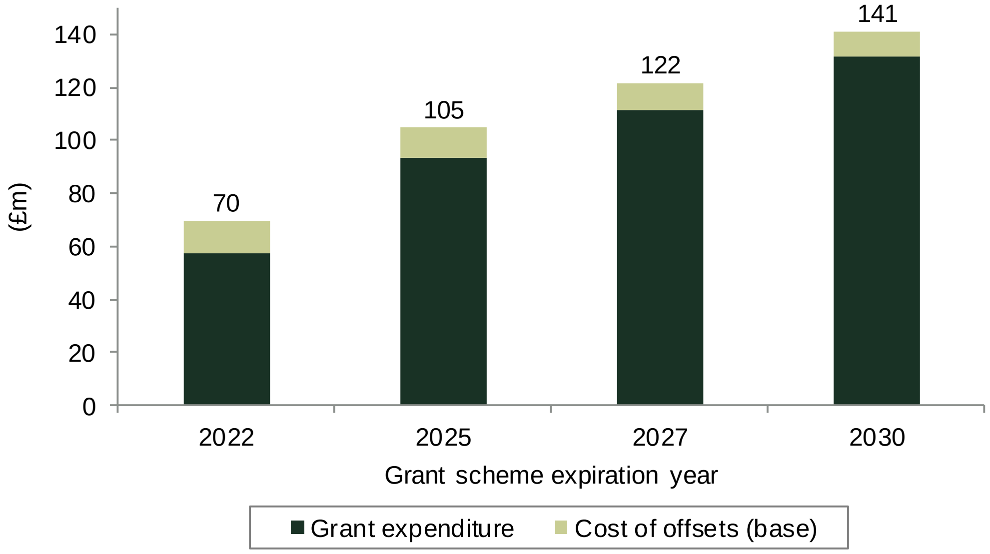
To the extent that the citizens of Jersey find themselves unable to commit to a relatively early ban of registration of fossil fuel vehicles (for instance, due to affordability concerns), financial support can be provided to stimulate the uptake of EVs and HVO, as described in sections 4.3.3 and 4.3.4.

4.3.3 Measure 3: financial support for EVs

The analysis assumes that a subsidy of £3,500 is offered to consumers as an EV purchase grant, and/or scrappage grant for a fossil fuel vehicle. The assumed level of the support is the same as that currently offered in the UK.[63] The cost implications for the Government are mainly driven by the duration of the scheme, which is illustrated in Figure 4.10 below.

[63] For more details, see the UK government website, 'Low-emission vehicles eligible for a plug-in grant', https://www.gov.uk/plug-in-car-van-grants, accessed on 3 December 2019.

Figure 4.10 Costs of achieving net zero emissions by 2030 under different scenarios for EV financial subsidies



Note: In this chart, the timing of the ban on fossil fuel vehicle registrations is assumed to be fixed at the end of 2030 regardless of the duration of EV subsidy. This is done in order to isolate the effect that the EV subsidy has on future emissions and, therefore, offset costs.

Source: Oxera analysis, based on DVS database and offset prices.

The duration of the grant support scheme is, in turn, closely linked to the speed of convergence between the prices of EVs and those of fossil fuel vehicles. Industry evidence (see Table 4.5) suggests that EVs are likely to reach price parity with fossil fuel vehicle models within the next ten years and, potentially, by as early as 2022. In cases where either no subsidy is required to stimulate the uptake of EVs beyond 2022, or the level of subsidy can be reduced in line with falling EV prices, the costs presented in Figure 4.10 would be conservative.

Table 4.5 Industry estimates on the timing of price parity between EVs and fossil fuel vehicles

Source	Jurisdiction	Predicted year of price parity between fossil fuel vehicles and EVs
McKinsey & Co.	USA	2025
Deloitte	UK	2024
Bloomberg	N/A	2024
Bloomberg	EU	2022–29

Source: See Bloomberg (2017), 'When will electric vehicles be cheaper than conventional vehicles?', 12 April, p. 5, Bloomberg (2019), 'When will electric vehicles be cheaper than conventional vehicles?', 12 April, p. 5, McKinsey (2019), 'Making electric vehicles profitable', March, para. 27, Deloitte (2019), 'Battery Electric Vehicles', February, p. 8.

In summary, providing an EV grant can accelerate the uptake of EVs, which could result in the level of emissions of around 30 (11) ktCO_2e in 2030 (2050). The total cost to the Government in this scenario would amount to £98m–£146m, including offsets. However, to the extent that the citizens of Jersey are prepared to switch away from fossil fuel vehicles without any financial support from the Government, the Government would only have to cover the cost of offsetting residual emissions; this would amount to £6m–£21m (see section 4.3.2). Willingness and ability of Jersey citizens to switch away from fossil fuel vehicles can be explored with the Citizens' Assembly.

4.3.4 Measure 4: support for HVO

According to the information received from Jersey industry representatives, HVO can be an efficient way of significantly reducing emissions from diesel vehicles, as it is expected to be fully compatible with the existing diesel vehicle fleet in Jersey, while causing significantly lower emissions than diesel. According to statements made in the public domain by industry participants, the use of HVO could reduce emissions from diesel vehicles by up to 90%.[64] Analysis is currently being conducted on the technical feasibility of the compatibility of HVO with the existing Jersey vehicle fleet and infrastructure.

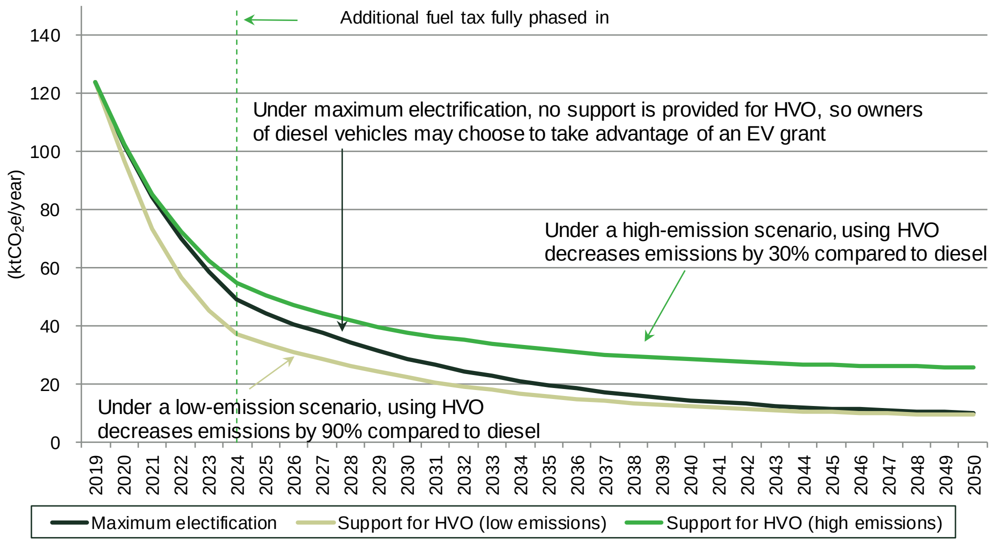
While HVO is costlier than diesel, industry representatives have suggested that a fuel tax exemption for HVO, would approximately establish price parity between HVO and diesel for the end-consumer. Therefore, in a scenario where HVO is granted a tax exemption, it seems possible to achieve a significant reduction in emissions from road transport, while continuing to make use of Jersey's existing diesel vehicle fleet. This is illustrated in Figure 4.11, which compares the projected emissions from road transport under the following scenarios:

- maximum electrification of road transport;
- HVO support, where HVO achieves a 90% emission reduction relative to diesel and maximum electrification of petrol vehicles; and
- HVO support, where HVO achieves a 30% emission reduction relative to diesel and maximum electrification of petrol vehicles.[65]

[64] See, for example, Volvo (2016), 'HVO fuel approval offers huge fossil CO_2 reductions to Volvo Penta engines', press release, https://www.volvogroup.com/en-en/news/2016/apr/news-151794.html#:~:targetText=HVO%20is%20a%20paraffinic%20fuel,feedstock%20used%20in%20its%20production, accessed on 19 November 2019; Scania's website, 'Alternative fuels and electrification', https://www.scania.com/global/en/home/products-and-services/articles/alternative-fuels.html, accessed on 19 November 2019; Biofuel Express' website, 'HVO100 renewable diesel performance meets sustainability', https://www.biofuel-express.com/en/hvo/, accessed on 19 November 2019; Neste's website, 'Benefits of Neste MY Renewable Diesel™', https://www.neste.com/companies/products/renewable-fuels/neste-my-renewable-diesel/key-benefits, accessed on 19 November 2019.

[65] According to the information in the public domain, 30% represents the lower bound of potential emission reduction from HVO relative to diesel. For more details, see Scandi Standard's website, 'HVO – a resource for reducing emissions', https://www.thescandiway.com/planet/hvo--a-resource-for-reducing-emissions/, accessed on 10 December 2019.

Figure 4.11 Projected evolution of emissions from road transport

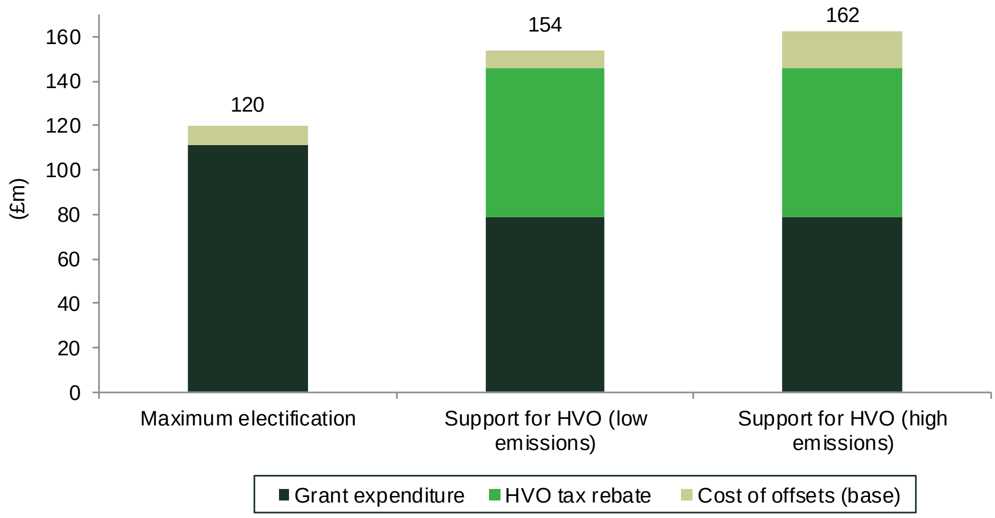


Note: The figures in this chart assume that the ban on the registration of petrol vehicles (and diesel vehicles unless the fuel is substituted by HVO) is instated at the end of 2027 as a mid scenario within the range of 2025–30.

Source: Oxera analysis, based on the Driver and Vehicle Standards database and States of Jersey Statistics Unit (2016), 'Jersey population projections 2016 release', October, https://www.gov.je/SiteCollectionDocuments/Government%20and%20administration/R%20Population%20Projections%202016%2020161013%20SU.pdf, accessed on 3 December 2019.

Figure 4.11 illustrates that under the scenario of low emission intensity of HVO, it is possible to achieve a faster pace of emission reduction in the short-term, and eventually converge, to a level of abatement that is similar to that under the scenario of maximum electrification. However, if HVO fails to deliver a sufficiently high level of emission abatement efficiency, the resulting level of emissions from road transport may turn out to be significant, which will, in turn, raise future costs due to offset requirements. This is illustrated in Figure 4.12.

Figure 4.12 Projected cost of achieving net zero in the road transport sector



Note: The figures in this chart assume that the ban on new registration of petrol vehicles (and diesel vehicles for maximum electrification scenario) is instated at the end of 2027. The year 2027 is chosen as the central estimate within the 2025–30 modelled range for the abatement timetable.

Source: Oxera analysis, based on the Driver and Vehicle Standards database and and States of Jersey Statistics Unit (2016), 'Jersey population projections 2016 release', October, https://www.gov.je/SiteCollectionDocuments/Government%20and%20administration/R%20Population%20Projections%202016%2020161013%20SU.pdf, accessed on 3 December 2019.

As Figure 4.12 shows, the support of HVO may allow for a reduction in the grant expenditure on the purchase of EVs. The relative advantage of HVO, therefore, is its potential compatibility with the existing diesel fleet, which may allow it to affect a large share of the vehicle fleet immediately. However, if unit emission savings of HVO prove to be towards the lower end of the range, the emission abatement effect will be limited, causing additional future offset expenditure.

In summary, providing support for both, EV and HVO uptake may enable Jersey to achieve a relatively fast reduction of emissions even with the current fleet, assuming that existing diesel fleet is technically equipped to efficiently run on HVO. In this scenario, the cost to the Government amounts to £116m–£200m, including offsets. However, similar to the scenario with EV grant only, to the extent that consumers are able to absorb an initial price difference between HVO and diesel, the Government may not necessarily have to provide this amount of financial support to unlock the benefits of HVO. These questions have to be explored by the Citizens' Assembly, with input from technical experts, who should inform on the current and prospective level of HVO cost relative to diesel, as well as compatibility of HVO with the existing diesel fleet.

4.4 Sensitivities on the modelling of road transport sector

This section illustrates how the cost of net zero measures, and the level of emissions from road transport, change in response to changes in key modelling assumptions. This is summarised in Table 4.6.

Table 4.6 Sensitivities to the modelling of decarbonisation measures in road transport sector

Sensitivity analysis of which variable?	Central range	Cost of achieving net zero (£m, PV over 2019–50)	2030 emissions ($ktCO_2e$/year)
Lower discount rate (at 3%)	£98m–£146m	£100m–£151m	28–31
50% HVO tax rebate	£98m–£146m	£71m–£112m	21–35
Lower size of the current vehicle fleet (at 67,584)	£98m–£146m	£78m–£121m	24–28
Higher number of registrations across all vehicle classes (3x increase)	£98m–£146m	£128m–£231m	50–68
Lower number of registrations across all vehicle classes (3x decrease)	£98m–£146m	£88m–£118m	19–21
Lower vehicle retirement rate (7.5%, i.e. average life of a vehicle of around 13 years)	£98m–£146m	£84m–£138m	39–42
No modal shift[1]	£98m–£146m	£98m–£147m	30–33
Higher uptake of EV grant (20% retirement rate, i.e. average life of fossil fuel vehicles of around 5 years)	£98m–£146m	£122m–£174m	26–27
Lower increase in fuel tax (a 25% increase over 10 years, as opposed to 100% over 5 years)	£98m–£146m	£99m–£149m	35–39
Lower decrease in distance travelled following an increase in fuel prices (0.1% decrease per 1% increase in prices, as opposed to 0.67% decrease)	£98m–£146m	£99m–£150m	36–41

Note: [1]2014 Energy Plan assumed a 5% shift to sustainable modes of transport by 2020. Accordingly, in our modelling of business as usual scenario we have assumed a 5% decrease in average distance travelled by vehicles between 2020 and 2030. In this sensitivity, we instead assume that average distance travelled by vehicle remains at 9,656 km/year in business as usual scenario.

Source: Oxera analysis.

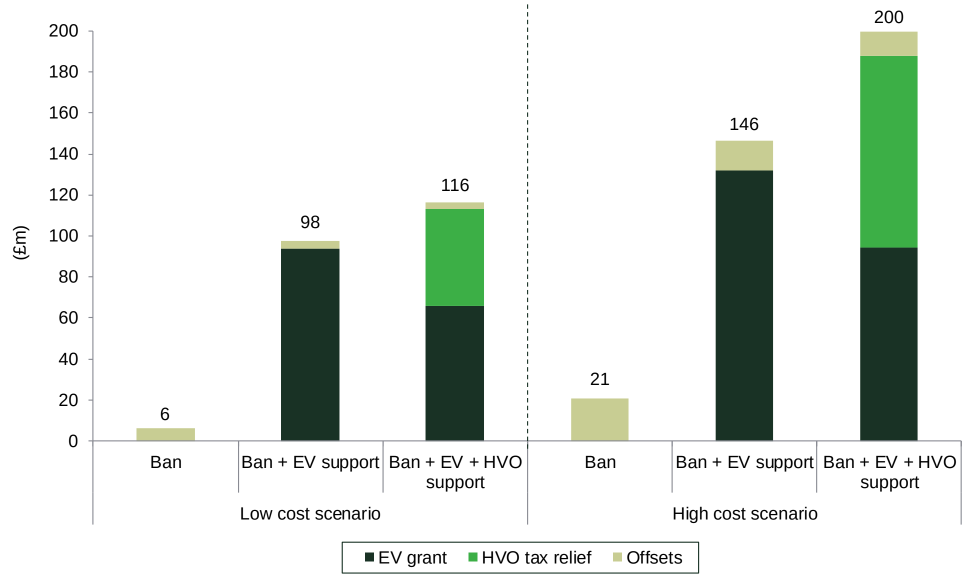
4.5 Overall conclusions on road transport

As elaborated in this section, the costs of achieving net zero in the road transport sector of Jersey are associated with a significant range of uncertainty, driven by:

- duration of financial support (if any) for purchase of EVs and/or scrappage of fossil fuel vehicles;
- duration of financial support (if any) for the uptake of HVO; and
- price level of offsets.

Figure 4.13 illustrates the breakdown of the cost of delivering net zero in the road transport under the main scenarios.

Figure 4.13 Cost of delivering net zero in road transport: Decomposition of the low and high ends of the uncertainty range



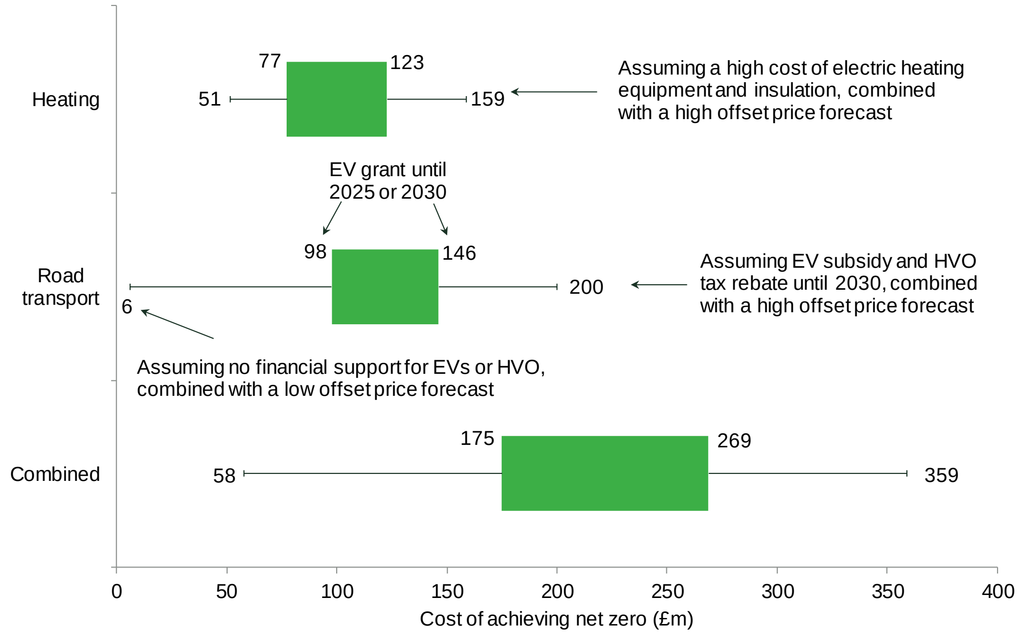
Note: Low (high) cost scenario assumes that support is provided until the end of 2025 (2030) and that the price of offsets follow a low (high) forecast. All scenarios assume a 100% increase in fuel tax over the course of five years.

Source: Oxera analysis, based on data from National Grid, the Driver and Vehicle Standards database and States of Jersey Statistics Unit (2016), 'Jersey population projections 2016 release', October, https://www.gov.je/SiteCollectionDocuments/Government%20and%20administration/R%20Population%20Projections%202016%2020161013%20SU.pdf, accessed on 3 December 2019.

5 Conclusion and next steps

The analysis has shown, under modelling assumptions described in this report, the combined cost of achieving net zero by 2030 in the heating and road transport sectors in Jersey is likely to be between £60m and £360m, as illustrated in Figure 5.1.

Figure 5.1 Cost of achieving net zero in heating and road transport



Note: The ranges above consider different scenarios for fossil fuel registration ban, financial support for EVs and HVO, cost of upgrading heating equipment and insulation, speed of heating electrification and future prices of offsets. All figures are shown in present value terms over the course of 2019–50. See section 2 and Appendix A1 for the description of input assumptions underlying the ranges presented in this chart.

Source: Oxera analysis, based on multiple sources.

Whether the costs of achieving net zero are at the top or bottom of this range is substantially affected by the Government's choices with respect to subsidisation of net zero measures in road transport. Specifically, current modelling shows that the cost of subsidies to encourage EV uptake could be between £98m–£146m, while simultaneous support for HVO could result in a cost as high as £200m. This includes the cost of offsets for any unabated emissions.

Achieving net zero would necessarily involve striking the right balance between the speed of transition towards carbon neutrality and the impact on the lifestyles of Jersey citizens and the Government budget (i.e. the cost to taxpayers).

5.1 Heating

In the heating sector, the main question to consider is the degree of Government support required to achieve the electrification of heating within acceptable timescales. There are several policy choices Jersey has to make with respect to Government support for heating:

First, what should be the allocation of Government support between the domestic and commercial sectors? Different arguments can be made in that regard. On the one hand, the commercial sector may be able to deliver large emission savings in a short timeframe, for instance, due to economies of scale. Accordingly, this suggests prioritising the delivery of abatement measures in the commercial sector. On the other hand, to the extent that the commercial sector may not require as much support to adopt new heating technologies, providing financial support to the domestic sector may be a more preferable option.

Second, focusing on the domestic sector, it needs to be assessed what level of support offered by the Government is necessary to incentivise households to engage in the transition. The level of support offered will have to balance the incentives for rapid electrification on the one hand and the opportunity cost of government expenditure on the other. In particular, applying government funding for the achievement of net zero has to be weighed against the allocations of these funds to other areas, such as social housing, schools, hospitals and roads. One policy option in this context would be to offer financial support to households with an income below a certain threshold. The level of that threshold would need to be informed by the specific circumstances of Jersey's economy—something that a Citizens' Assembly might be well placed to assess.

5.2 Road Transport

In the road transport sector, the key policy question for Jersey is to what extent the citizens of Jersey are prepared to switch away from fossil fuel vehicles without any financial support from the Government.

If the citizens of Jersey are willing and able to limit their reliance on petrol and diesel vehicles, either by changing their travel habits or by accepting higher prices for new vehicles, then net zero emissions in road transport can be achieved without material Government expenditure. In this scenario, the Government spending would be limited to offsetting residual (unabated) emissions and would amount to a total of £6m to £21m over 2030–50. The transition itself would be implemented through the introduction of a ban on the registration of new fossil fuel vehicles from 2030 onwards (i.e. the latter end of the range of dates by which price parity between fossil fuel vehicles and EVs is expected to be achieved).[66]

Alternatively, if Government support is required to promote switching to EVs, the cost of subsidies could fall within the range of £98m to £146m (including offsets), assuming support until 2025 to 2030 and the level of the subsidy being set at the UK level (i.e. £3,500 per vehicle).

In both cases, the Government could support the transition while generating revenues by an increase in the road fuel tax (subject to affordability by households), which would marginally discourage the use of the existing fossil fuel fleet. Assuming a relatively limited response to higher fuel prices resulting from the tax increase, the additional revenue over 2020–50 could be as high as £60m. While from an environmental perspective, a higher increase in taxes would be more aligned with achieving the net zero ambitions, it is important to consider the potential impact on (vulnerable) road users with an income below a certain threshold. It would be important to establish that such users have adequate access to alternative modes of travel or, potentially, are offered fuel tax exemptions.

[66] See Table 4.5.

5.3 General conclusions

Concerning all sectors, a key question that the Government, the States Assembly and the Citizens' Assembly are encouraged to consider is the timeline and the level of commitment that is desirable to offset the residual emissions. Under a full upfront commitment to achieve net zero by 2030 and abate any residual emissions from that point onwards, the Government of Jersey will be exposed to potential increases in the price of offsets over time. According to the present forecasts, the level and range of uncertainty around the offset prices is expected to increase significantly. While offsetting the current level of Jersey emissions in 2030 would cost between £5m and £17m (for 2030 alone), offsetting the same amount of emissions in 2050 could be as high as £38m (for 2050 alone).

The degree and timing of the commitment has to be considered in the context of the expected speed of abatement programmes, as this will determine Jersey's level of exposure to offset prices. More broadly, there may be practical constraints which restrain the ability of policymakers and the citizens of Jersey in embarking on a rapid abatement timetable. For example, there may be shortage of local skilled labour, necessary to perform retrofitting of electric systems and insulation upgrades.

For the next stage, as the climate action plan evolves towards implementation, the following factual and Island-specific questions could be usefully further explored:

- the current state of the Jersey property stock, including energy efficiency and heating systems employed;
- the extent to which HVO is compatible with the existing diesel fleet, level of financial support required (if any) to set up a distribution chain of HVO in Jersey;
- the scope of engineering upgrades (if any) required for the Jersey electricity supply and networks to adapt to an increased level of electrification of the economy; and
- the potential cost of under-utilisation of existing infrastructure, in which the Island has already invested, due to any changes in policy towards electrification and biofuel uptake.[67]

We understand that certain representatives of the commercial and public sectors have already initiated research into the above issues. The answers to these questions will determine the optimal timescale for the abatement measures, the scope of Government intervention and, ultimately, the economics of achieving net zero in Jersey.

[67] The extent and timing of any existing infrastructure being under-utilised will depend on the speed of abatement. This is therefore affected by the policy choices, that are to be deliberated by the States Assembly and Citizens' Assembly, as well as wider stakeholders like the Energy Forum.

A1 Assumptions underlying the cost ranges of achieving net zero

This appendix summarises the assumptions underlying the cost ranges of achieving net zero, as depicted in the executive summary and section 5.

Table A1.1 Assumptions driving the cost ranges of achieving net zero in heating and road transport sectors in Jersey

	Left whisker	Bottom range	Top range	Right whisker
Heating				
Abatement completion year	2035	2030	2030	2050
Cost level of equipment	Min	Average	Average	Max
Road transport				
Grant end year	No grant	2025	2030	2030
Fossil fuel ban enacted by year end	2030	2025	2030	2030
Full HVO tax rebate	No HVO support	No HVO support	No HVO support	Yes
Offset prices	Low	Low	High	High

A2 Assessment of existing housing stock

The estimates of the existing domestic housing stock are based on three sources of evidence:

- an estimate of the total number of occupied households, sourced from the industry;
- the latest (2011) census, which provides a breakdown of domestic occupied properties by different property types (e.g. detached houses, flats); [68] and
- the Ricardo-AEA 2015 report, which provides the split of households by different heating systems.[69]

Table A2.1 summarises our estimate of Jersey's property stock, split by types of property.

Table A2.1 Estimate of Jersey domestic housing stock, split by property type

Property type	Proportion of properties of a given type (%)[1]	Number of properties
	[A]	[B] = 44,000 x [A]%
Detached house	26	11,475
Semi-detached house	19	8,483
Terraced house	11	4,807
Flat	44	19,235
Total	**100**	**44,000**[2]

Note: [1] The split of properties across different property types is based on the latest (2011) Jersey census. [2] The 2019 total number of properties is based on information provided by the industry (44,000 units). We have also reviewed the address database, provided by the Government of Jersey. The database suggests a lower number of domestic properties, namely 36,739 observations labelled as 'residential' instead of the 44,000 shown in the industry data. Therefore, our current assumption is conservative, as it potentially overestimates the number of properties that require upgrades, and therefore the projected expenditure.
Source: Government of Jersey website, 'Households and dwellings statistics', https://www.gov.je/Government/JerseyInFigures/HousingLiving/pages/households.aspx, and information provided by the industry.

The breakdown above, however, does not provide information on the heating sources used across different types of properties. For example, it is not possible to determine what proportion of detached houses use fuel oil, as opposed to LPG or electricity. To bridge this gap, we have considered the information on domestic heating sources, presented in the Ricardo-AEA (2015) report.[70] This is illustrated in Table A2.2.

[68] Government of Jersey website, 'Households and dwellings statistics', https://www.gov.je/Government/JerseyInFigures/HousingLiving/pages/households.aspx
[69] Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October, p. 19.
[70] Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October.

Table A2.2 Breakdown of energy sources used for domestic heating

Type of fuel	Proportion used in domestic heating (%)
Fuel Oil	39
LPG	10
Air source heat pumps	2
Other electric technologies	49

Source: Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October, p. 19.

Under the assumption that heating sources are equally distributed across the housing stock of different property types, the information in Table A2.1 and Table A2.2 can be combined to derive a more detailed breakdown of property stock by type of property and heating source.

To illustrate, assuming that 39% (see top row of Table A2.2) of all detached houses (see top row of Table A2.1) are heated by fuel oil implies that there are 4,475 detached houses that are heated by fuel oil. Applying this logic to all types of properties yields the estimates shown in Table 3.1.

A3 Deriving the number of properties that require insulation upgrading

An assessment has been made to estimate the number of properties requiring the insulation treatments considered in this study, namely loft insulation, cavity wall insulation, draught proofing, hot water cylinder insulation, and window upgrade. The overall results on the estimated number of upgrades required are summarised in Table A3.1.

Table A3.1 Number of insulation upgrades

	Loft insulation	Cavity wall insulation	Draught proofing	Hot water cylinder jacket	Window upgrade
Estimated number of upgrades	20,562	8,978	18,659	9,506	3,063

Note: Figures are subject to rounding.

Source: Oxera analysis.

This appendix presents the process of estimating the number of insulation upgrades required for different types of domestic properties, as reported in Table 3.6.

The first step is to determine the number of properties that potentially need some form of upgrade to current efficiency standards.

As described in section 3.2.3, the stock of properties requiring insulation treatments is assumed to be housing stock built before 2001. The overall number of domestic properties constructed before 2001 was sourced from KEMA (2007),[71] while the breakdown across different property types was obtained from the 2001 census data.[72] The resulting estimates are provided in Table A3.2.

[71] KEMA limited (2007), ‘Energy Efficiency Study’, 3 April, p. 11.
[72] Government of Jersey website, ‘Households and dwellings statistics’, https://www.gov.je/Government/JerseyInFigures/HousingLiving/pages/households.aspx

Table A3.2 Breakdown of the 2001 stock of properties

Property type	%	Number
	[A]	[B] = 35,562 x [A]
Detached house	29	10,313
Semi-detached house	19	6,757
Terraced house	11	3,912
Flat	40	14, 225
Total number of properties considered in the analysis	**99**	**35,206**
Temporary structures (excluded from the analysis)	1	356
Total	**100**	**35,562**

Note: Figures are subject to rounding.

Source: Oxera analysis, based on 2001 census data and KEMA limited (2007), 'Energy Efficiency Study', 3 April.

The next step is to determine what percentage of properties in Table A3.2 require a particular form of insulation. The assessment followed the methodology presented in KEMA (2007) and Ricardo-AEA (2015).[73] We discuss each type of insulation below.

Loft insulation. It is assumed that all properties with pitched roofs will require a loft insulation. According to KEMA, 98% of houses (note, flats are not included) in Jersey have pitched roofs,[74] which implies that 20,562 properties will need a loft insulation (see Table A3.3).

Table A3.3 Properties requiring loft insulation

Property type	Housing stock built before 2001	% of properties requiring the treatment	Number of properties requiring the treatment
	[A]	[B]	[A] x [B]
Detached house	10,313	98%	10,107
Semi-detached house	6,757	98%	6,622
Terraced house	3,912	98%	3,834
Flat	14,225	-	-
Total			**20,562**

Note: Figures are subject to rounding.

Source: Oxera analysis, based on 2001 census data and KEMA limited (2007), 'Energy Efficiency Study', 3 April.

Cavity wall insulation. KEMA (2007)[75] estimates that a 85% share of the 2001 domestic housing stock had cavity walls as of 2001. KEMA then use the UK data to benchmark the proportion of houses that have had wall insulation measures since 2001. Accordingly, Household Energy Efficiency National Statistics (2018)[76] reports that in the UK, 70% of houses with cavity walls have

[73] Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October.
[74] KEMA limited (2007), 'Energy Efficiency Study', 3 April, p. 17.
[75] KEMA limited (2007), 'Energy Efficiency Study', 3 April, p. 17.
[76] Department for Business, Energy & Industrial Policy (2018), 'Household Energy Efficiency National Statistics, Detailed Report 2018', 18 April, p. 15, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/795929/Detailed_Release_-_HEE_stats_18_Apr_2019.pdf

already received the insulation treatment. We therefore estimate that a 25.5% share of all pre-2001 Jersey properties could potentially benefit from cavity wall insulation. Applying this percentage to Jersey's housing stock built before 2001 results in a total number of 8,978 (see Table A3.4).

Table A3.4 Properties requiring cavity walls insulation

Property type	Housing stock built before 2001	% of properties requiring the treatment	Number of properties requiring the treatment
	[A]	[B]	[A] x [B]
Detached house	10,313	25.5%	2,630
Semi-detached house	6,757	25.5%	1,723
Terraced house	3,912	25.5%	998
Flat	14,225	25.5%	3,627
Total			**8,978**

Note: Figures are subject to rounding.

Source: Oxera analysis, based on 2001 census data and KEMA limited (2007), 'Energy Efficiency Study', 3 April.

Draught proofing. According to KEMA (2007),[77] the share of properties that require draught proofing equals 53%. Applying this percentage share to Jersey's housing stock built before 2001 results in a total number of 18,659 properties requiring this insulation measure (see Table A3.5).

Table A3.5 Properties requiring draught proofing

Property type	Housing stock built before 2001	% of properties requiring the treatment	Number of properties requiring the treatment
	[A]	[B]	[A] x [B]
Detached house	10,313	53%	5,466
Semi-detached house	6,757	53%	3,581
Terraced house	3,912	53%	2,073
Flat	14, 225	53%	7,539
Total			**18,659**

Note: Figures are subject to rounding.

Source: Oxera analysis, based on 2001 census data and KEMA limited (2007), 'Energy Efficiency Study', 3 April.

Hot water cylinder jacket. According to KEMA (2007),[78] a 73% share of all houses in Jersey already have hot water cylinders insulated; this leaves an estimated 27% of the total number of properties requiring the measure, which is equal to 9,506 (see Table A3.6).

[77] KEMA limited (2007), 'Energy Efficiency Study', 3 April, p. 18.
[78] KEMA limited (2007), 'Energy Efficiency Study', 3 April, p. 16.

Table A3.6 Properties requiring hot water insulation

Property type	Housing stock built before 2001	% of properties requiring the treatment	Number of properties requiring the treatment
	[A]	[B]	[A] x [B]
Detached house	10,313	27%	2,785
Semi-detached house	6,757	27%	1,824
Terraced house	3,912	27%	1,056
Flat	14, 225	27%	3,841
Total			**9,506**

Note: Figures are subject to rounding.

Source: Oxera analysis, based on 2001 census data and KEMA limited (2007), 'Energy Efficiency Study', 3 April.

Window upgrade. According to Ricardo-AEA (2015),[79] only a 9% share of the housing stock needs this kind of upgrade; this equals 3,063 (see Table A3.7).

Table A3.7 Properties requiring window upgrades

Property type	Housing stock built before 2001	% of properties requiring the treatment	Number of properties requiring the treatment
	[A]	[B]	[A] x [B]
Detached house	10,313	9%	897
Semi-detached house	6,757	9%	588
Terraced house	3,912	9%	340
Flat	14, 225	9%	1,238
Total			**3,063**

Note: Figures are subject to rounding.

Source: Oxera analysis, based on 2001 census data and Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October.

[79] Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October, p. 17.

A4 Assessment of the unit cost of electric heating equipment and insulation upgrades

A4.1 Domestic properties

A4.1.1 Electric heating equipment

This study has considered the implementation of the following types of heating equipment for domestic properties:

- air source heat pumps;
- electric boilers; and
- a combination of smart panels and storage heaters.

The estimation of the range of costs associated with retrofitting domestic properties has followed a three-step process:

- identifying a range of prices for the unit cost of heating equipment, based on different publicly available sources[80] and on data received from the Government of Jersey;[81]
- identifying a range of installation costs based on information available in the public domain[82] and discussions with industry representatives; and
- summing the two components above.

Table A4.1 shows the breakdown of the price range between equipment and installation costs.

Table A4.1 Breakdown of installation and heating equipment costs for domestic properties (£)

	Air source heat pumps		Electric boilers		Bundle (2 smart panels; 1 storage heater)		Bundle (4 smart panels;2 storage heaters)	
	Low	High	Low	High	Low	High	Low	High
Unit equipment cost	3,000	10,000	681	2,722	1,125	2,729	2,250	5,459
Installation cost	1,000	2,000	681	2,722	1,667	2,729	3,333	5,459
Total	**4,000**	**12,000**	**1,363**	**5,444**	**2,792**	**5,459**	**5,584**	**10,918**

Note: Figures are subject to rounding.

Source: Oxera, based on Electric heating company (https://www.electric-heatingcompany.co.uk/), Rointe (https://rointe.com/uk/), Farho (http://www.farho.com/en/), Dimplex (https://www.dimplex.co.uk/) and data received from the Government of Jersey.

A4.1.2 Insulation upgrades

[80] Prices of electric boilers, storage heaters and smart panel heaters have been retrieved from the following websites: Electric heating company (https://www.electric-heatingcompany.co.uk/), Rointe (https://rointe.com/uk/), Farho (http://www.farho.com/en/), and Dimplex (https://www.dimplex.co.uk/).
[81] Prices on air source heat pumps have been retrieved from the Government of Jersey spreadsheet titled 'EPO-ID-jersey indicative costs for tool from Quidos', provided to Oxera by the Government of Jersey on 28 October 2019.
[82] The ratio between cost of unit equipment and cost of installation has been calculated according to information available at the Boiler Guide website (https://www.boilerguide.co.uk/articles/best-electric-boilers).

This study has considered the following types of insulation measures for domestic properties in Jersey:[83]

- loft insulation;
- cavity wall insulation;
- draught proofing;
- hot water cylinder insulation; and
- window upgrade.

Data received from the Government of Jersey[84] has been used in order to estimate the unit cost of the respective upgrades. The information provided contained a range of prices for each type of treatment (see Table 3.7). Subsequently, we scaled these approximate costs to account for the size of the different types of properties. This was done with the same scaling factors as reported in Table 3.3.

Table A4.2 below lists the range of prices for insulation measures, as reported in the underlying data source, provided by the Government of Jersey.

Table A4.2 Range of prices for insulation upgrades

	Loft insulation	Cavity wall insulation	Draught proofing	Hot water cylinder insulation	Window upgrade
High	500	1,500	120	100	1,400
Low	100	500	50	15	100

Source: Oxera, based on data received from the Government of Jersey.

It is assumed that the figures in this table are assumed to apply to a property of an average size (i.e. a 'general property'), since the dataset does not specify the types of properties underlying these estimates. Therefore, to account for potential variation in the cost of insulation upgrades across different properties, we have applied the same scaling factors, as those used for deriving energy consumption for each domestic property type (see Table 3.3).

A4.2 Commercial properties

This study considered the retrofitting of commercial properties through the following types of electric heating equipment:

- air source heat pumps; and
- electric boilers.

Since no data was available on the prices of heating equipment for commercial properties, an adjustment has been made on the ranges considered for domestic properties. Assuming that the commercial properties are bigger in

[83] The types of upgrade considered (loft insulation, cavity wall insulation, draught proofing, hot water cylinder insulation and window upgrade) are common insulation measures and are considered in many previous studies such as KEMA limited (2007), 'Energy Efficiency Study', 3 April; Department of the Environment (2018), 'Internal Review of Home Energy Scheme for Policy Development', May; and Ricardo-AEA (2015), 'Developing an approach to Domestic Energy Efficiency Retrofit in Jersey', 29 October.
[84] Government of Jersey spreadsheet titled 'Jersey measure costs', provided to Oxera by Government of Jersey on 15 October 2019, and Government of Jersey spreadsheet titled 'EPO-ID-jersey indicative costs for tool from Quidos', provided to Oxera by Government of Jersey on 28 October 2019.

dimension and therefore have higher heating needs with more expensive equipment requirements, the following approach was undertaken:

- the lower bound of the price range for commercial property heating upgrades to be equal to the average price for domestic property heating upgrades; and
- the mid-point value of the prices considered for commercial property heating upgrades to be equal to the upper bound price for domestic properties.

The upper bound for commercial property heating upgrades can be deduced by linear interpolation from the above values, i.e. the derived lower and mid-point price estimates for commercial property heating upgrades.

In estimating the unit costs of electric boilers for commercial properties we rounded the unit costs for domestic properties to the nearest thousand, allowing for a margin of error.

Figure A4.1 visualises the estimation of the unit cost of equipment for commercial properties.

Figure A4.1 Estimation of the unit cost of equipment for commercial properties

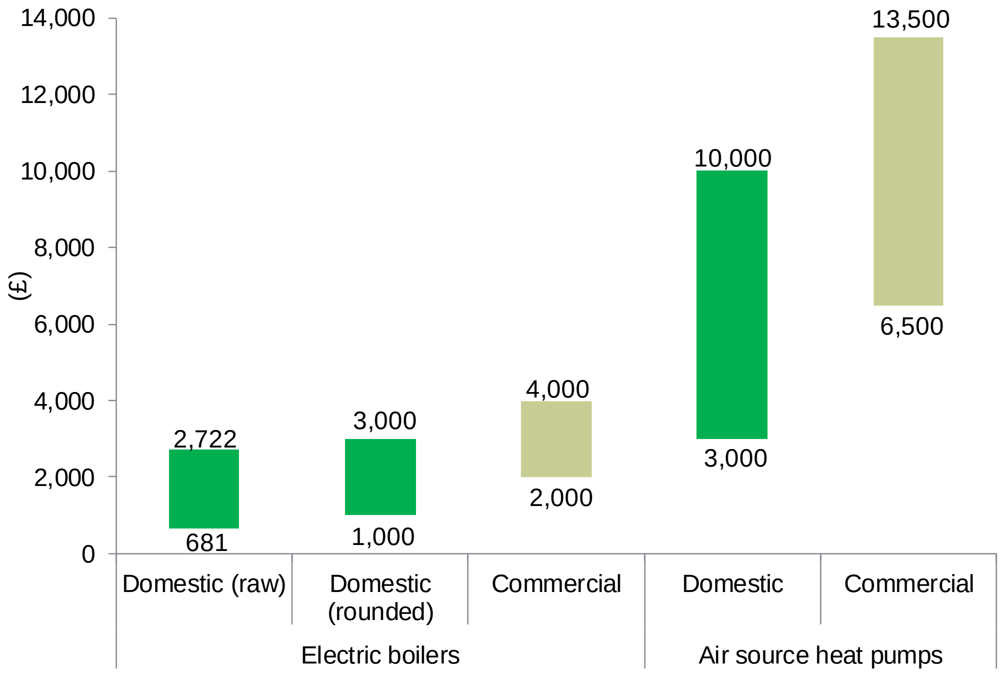


Table A4.3 shows the breakdown of the price range between equipment and installation costs.

Table A4.3 Breakdown of installation and heating equipment costs for commercial properties

	Air source heat pumps		Electric boilers	
	Low	High	Low	High
Unit equipment cost	6,500	13,500	2,000	4,000
Installation cost	2,000	2,000	2,000	4,000
Total	**8,500**	**15,500**	**4,000**	**8,000**

Source: Oxera, based on Electric heating company (https://www.electric-heatingcompany.co.uk/) and data received from the Government of Jersey.

Note that the central range depicted in Figure 5.1 uses the average of the range presented in the table above.

A5 Projecting future vehicle registrations under business as usual scenario

This appendix provides a detailed analysis of how we obtained vehicle registration forecasts for the period 2020 to 2050 using data from historical vehicle registrations in Jersey.[85] The underlying dataset used is the Driver and Vehicle Standards database provided by the Government of Jersey.

The statistical specification used in the model for forecasting vehicle registrations is an autoregressive model of order 1, or AR(1), with an additional explanatory variable of projected population for Jersey, taken from the Government of Jersey's population forecasts.[86]

As mentioned in section 4.2.4, future registrations are estimated using regression analysis, where registrations in a given year are related to:

- the expected population in that given year; and
- the previous year's number of registrations.

Separate regressions were estimated for the three types of vehicles—'EV', 'Diesel' and 'Petrol'. Hybrid vehicles, which comprise approximately 1% of vehicles in Jersey, have been accounted for as part of the 'Petrol' class.

As the projections have been estimated separately for each fuel type, higher projected registrations for EVs do not mechanically imply lower projected registrations for fossil fuel vehicles. Although this modelling approach is simplified in not modelling a direct feedback loop between EVs and fossil fuel vehicle registrations, we consider it appropriate for this study where the quality and availability of historical data on registrations is limited. As explained below, we have set the modelling parameters to avoid a potential underestimation of the costs of achieving net zero in road transport.

A key modelling decision in projection future registration is the choice of estimation window, i.e. how far back to extend the estimation sample, on which projections will be based. This decision requires judgment, as there is a trade-off between having a larger sample size, which tends to increase statistical robustness, and having a more recent sample that is potentially more representative of current conditions. A more recent sample would tend to avoid the inclusion of historical observations that may no longer be applicable, or cause bias. On balance, we have considered a range of samples starting from 2006 and ending between 2018 and 2019.[87]

In particular, we use five different time periods for each of the three vehicle types to forecast future registrations, with start years from 2006 to 2009, and end years of 2018 and 2019.[88] The resulting forecasts of vehicle registrations in Jersey obtained from this analysis are shown in Figure A5.1 to Figure A5.3.

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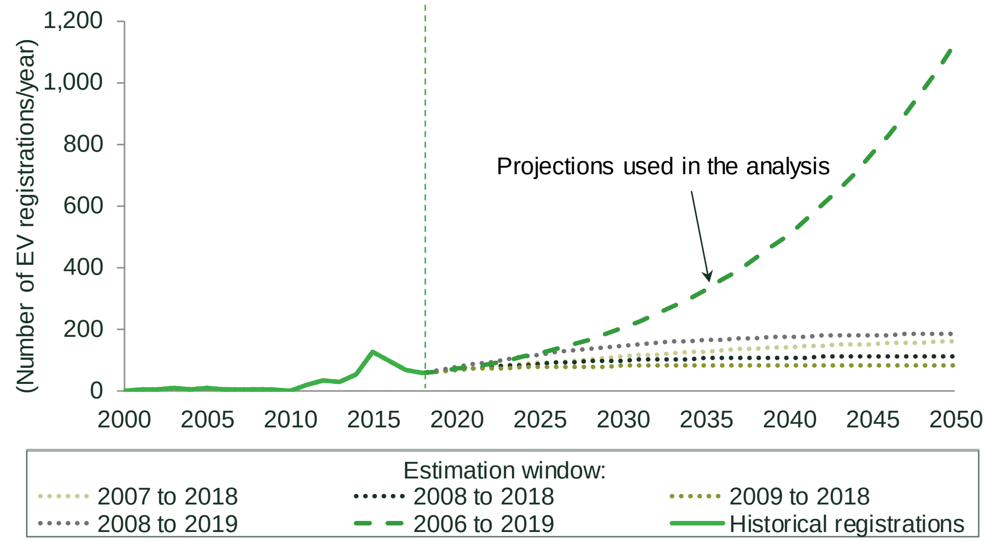
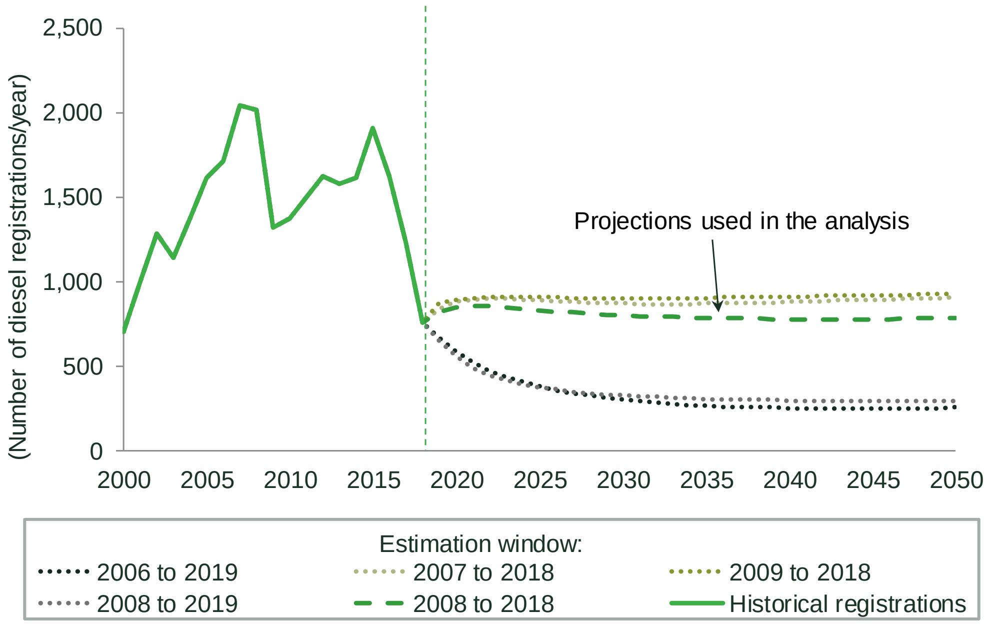
[85] See 'Oxera DVS data request as at 29Oct2019.xls', tab Sheet 1.
[86] For more details, see the Government of Jersey website https://www.gov.je/SiteCollectionDocuments/Government%20and%20administration/R%20Population%20Projections%202016%2020161013%20SU.pdf, accessed on 3 December 2019.
[87] 2019 data is available only up to the month of October, not for the full year. We uprated the registrations for 2019 by a factor of 1.2 to cover a full year. 1.2 is calculated by dividing the total months in a year (12) by the number of months where data is available (10).
[88] The five time periods considered are 2007 to 2018, 2008 to 2018, 2009 to 2018, 2006 to 2019, 2008 to 2019.

Figure A5.1 Forecasts of EV registrations with different estimation windows



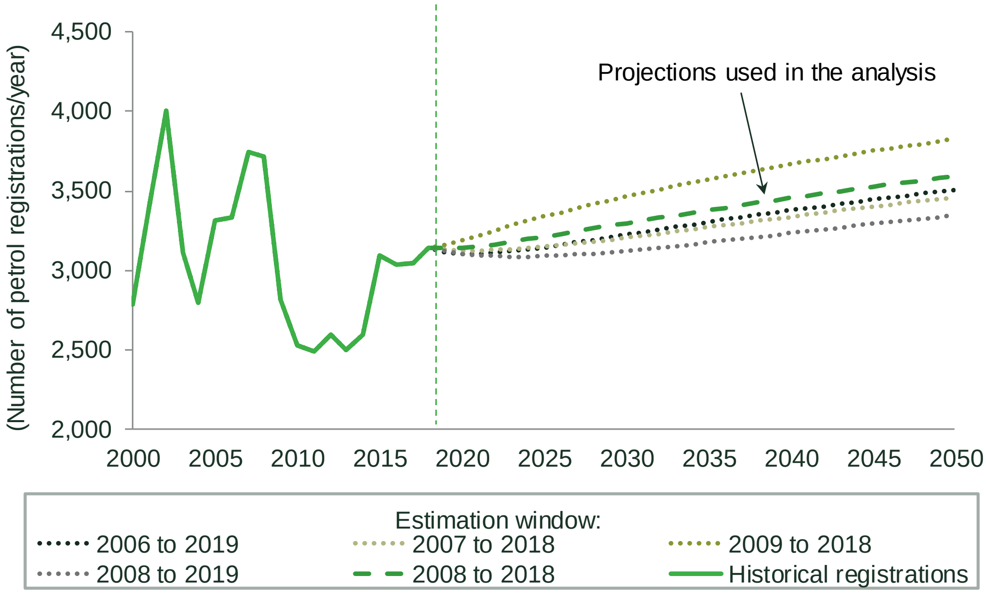
Source: Oxera analysis, based on Driver and Vehicle Standards database.

Figure A5.2 Forecasts of diesel registrations with different estimation windows



Source: Oxera analysis, based on Driver and Vehicle Standards database.

Figure A5.3 Forecasts of petrol registrations with different estimation windows



Source: Oxera analysis, based on Driver and Vehicle Standards database.

The results of our regressions are summarised in Table A5.1 below.

Table A5.1 Vehicle registration forecasts in 2050 under business as usual

	Minimum	Maximum	Forecast used in the modelling
EV	84	1,124	1,124
Diesel	258	932	786
Petrol	3,349	3,828	3,593

Source: Oxera analysis, based on Driver and Vehicle Standards database.

For all classes of vehicles, the analysis conducted for the 2008 to 2018 period produces statistical forecasts that appear plausible. Therefore we consider this the most suitable regression period to use for fossil fuel vehicles for this forecasting analysis.

For the EV class we have relied on the data from 2006 to 2019 as it yields the highest projection of future EV registrations. We consider this assumption appropriate since, as the industry continues to develop, lower EV prices will drive higher levels of EV uptake in the future. Moreover, since registrations are forecasted independently for each vehicle class, assuming a higher rate of EV registrations does not automatically decrease the projected level of registrations for petrol and diesel vehicles. Therefore, such a choice of an estimation window does not make the forecast unduly optimistic.

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