Chapter 5. Environmental and economic implications of policy scenarios aimed at decarbonising urban transport

This chapter presents an evaluation of reference and counterfactual scenarios. The findings indicate that policy inaction can prevent urban transport from becoming carbon neutral any time soon. Under the reference scenario, in which no substantial policy change occurs, total emissions from road transport will continue increasing, while 60% of the per capita emissions in 2018 will be produced in 2050. Stringent policies that promote public transport and electric vehicles, as well as interventions that give rise to a more compact urban form may reduce the latter figure to 30%. The analysis highlights the policies that curb greenhouse gas emissions and increase welfare, while also identifying the order at which these policies should be implemented.

This chapter presents an evaluation of reference and counterfactual scenarios, as detailed in Chapter 2. The associated policy simulations are carried out with the use of MOLES (Tikoudis and Oueslati, 2017[1]). The model has been adapted for the specific needs of this case study as described in Chapter 3. It has been calibrated as described in Chapter 4. This chapter is structured across three sections. The first presents the headline results regarding emissions and vehicle use. The second offers a detailed analysis of the changes projected in the reference scenario. The third summarises the components of the policy scenario, describing the environmental, housing, fiscal and welfare implications of the different policy scenarios. Chapter 6 tests the importance of exogenous variables in driving the overall results and examines how the effectiveness of policies varies under different scenarios of demographic, socio-economic and technological change.

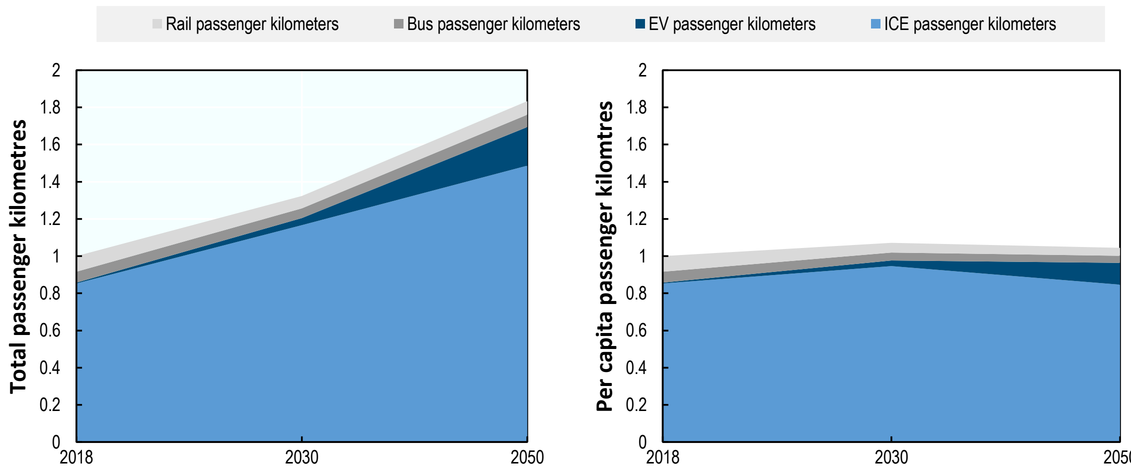
5.1. Headline results for greenhouse gas emissions and vehicle use

Total annual CO_2e emissions from road transport in Auckland are projected to increase by 7% in 2050, relative to emissions in year 2018. That increase is largely driven by the rise in total passenger kilometres, which are set to increase mainly due to the growing population. Thus, the effect of population growth outweighs the effect of the emission reductions stemming from various factors. These include the increasing vehicle energy efficiency, the declining costs of electric vehicle use, a less carbon-intensive electricity generation sector and the electrification of public transport.

In *per capita* terms, passenger kilometres do not change significantly between 2018 and 2050. As the carbon intensity of each transport mode falls and the share of ICE vehicles in the fleet declines, *per capita* emissions from urban transport fall across all scenarios. Transport modes become less emissions-intensive, since they consume less fuel and electricity. For EVs, emission intensity decreases also due to the further decarbonisation of the electricity grid. Additionally, the share of EVs in the fleet increases. The same holds true for the share of vehicle kilometres travelled by EVs. These increases occur because technological progress gradually increases the degree of parity between ICE vehicles and EVs. The evolution of passenger kilometres, both in total and *per capita* terms, is presented in Figure 5.1.

Figure 5.1. Evolution of total and *per capita* passenger kilometres by mode in the reference scenario

Percentage values are relative to total passenger kilometres in 2018, the base year of the study.



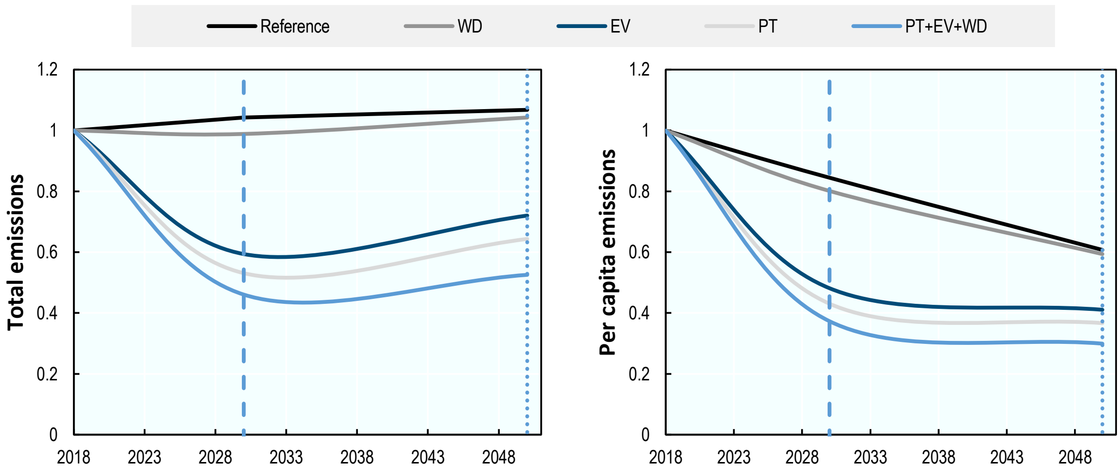
Note: Percentage values are relative to total passenger kilometres in 2018, the base year of the study.
Source: Generated by the authors, using results of simulations from MOLES.

Various policy packages are simulated in the study. These are: the "promote public transport" policy package, which incentivises a switch to bus and rail transport though road pricing mechanisms and fare subsidies; the "promote electric vehicles" policy package, which exempts electric vehicles from heightened operational costs imposed on conventional vehicles; and various densification packages that relax maximum density regulations.

Results indicate that these policy packages provide effective pathways to reduce emissions from urban road transport in Auckland. The public transport package is found to reduce aggregate emissions by 40% in 2050, relative to the reference case, while the electric vehicle package reduces aggregate emissions by 30% in 2050. Reforming land-use regulations can enhance the emission reductions achieved by transport policies. For instance, a general relaxation of density regulations in Auckland can reduce emissions by an additional 10% when implemented in combination with policies that promote public transport and electric vehicles. These results are presented at an aggregate and *per capita* level in Figure 5.2.

Figure 5.2. Emissions from urban transport in the different policy scenarios

Percentage values are relative to emissions in 2018, the base year of the study.

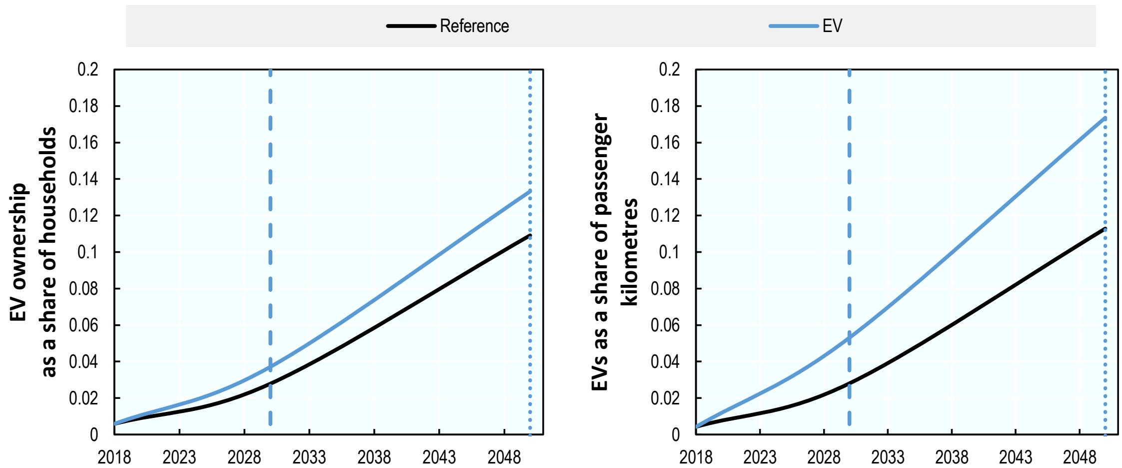


Note: Left panel: total emissions; right panel: per capita emissions. WD refers to a scenario of widespread relaxation of density regulations; EV refers to a scenario where the "promote electric vehicles" policy package is active; PT refers to a scenario where the "promote public transport" policy package is active; PT+EV+WD refers to a scenario where all three policy packages are active. See Chapter 2 for details on the components of the policy packages.
Source: Generated by the authors, using results of simulations from MOLES.

The measures to support the adoption of EVs are composed of instruments that increase the price of owning and operating a conventional vehicle. They also include subsidies, which reduce the private cost of owning and operating an electric vehicle. These policy components have a moderate effect in the ownership rate of EVs. In 2050 in the reference scenario, 78.4% of modelled households own a conventional vehicle, 10.6% do not own a vehicle and 10.9% own an electric vehicle. In particular, the policy package that supports electric vehicles over conventional vehicles increases the EV ownership share to 13.3% from 10.9% it would otherwise be (reference scenario) in 2050. The reason for this moderate response is that the non-modelled advantages of conventional vehicles over EVs are not affected by the policy package. This is explored in more detail in section 5.2 and 5.3.

While the rate of EV ownership responds moderately to the policy package, the share of total passenger kilometres generated by EVs increases substantially. This occurs because the policies described above render EV use much cheaper relative to ICE vehicles. The changes to modal split and passenger kilometres by mode are presented in Figure 5.3.

Figure 5.3. Electric vehicles as a share of ownership and passenger kilometres



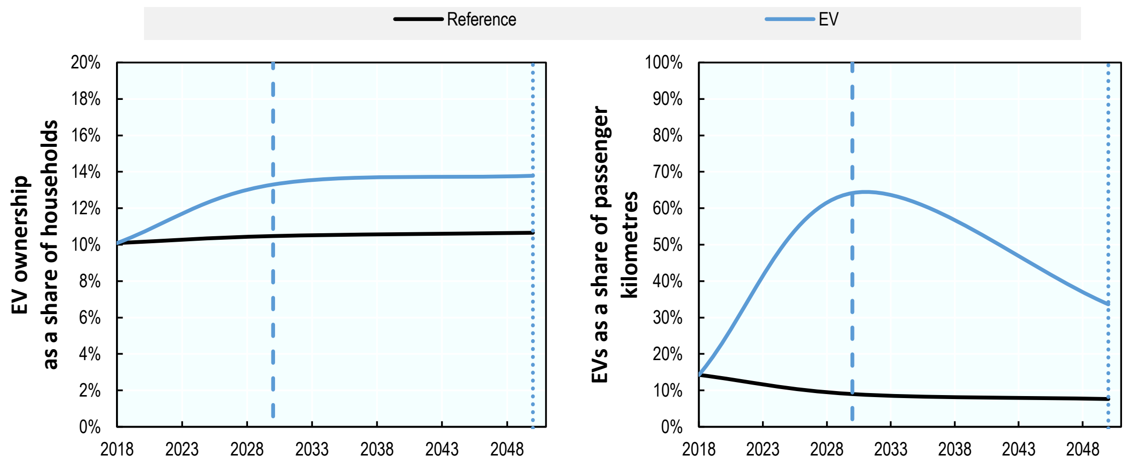
Note: Left panel: electric vehicles as a share of vehicle ownership; right panel: electric vehicles as a share of passenger kilometres.
Source: Generated by the authors, using results of simulations from MOLES.

Similarly, the channels through which the "promote public transport" package reduces emissions relative to the reference case can be evaluated. The package induces a 3.1% increase in the number of households that will choose not to own a vehicle in 2050. The rigidity of the ownership rate of private vehicles can be attributed to a series of non-pecuniary disadvantages of public transport. The low frequency of service and poor connectivity of public transport in low-density areas are two examples of such disadvantages.

The "promote public transport" policy package induces a significant change in the composition of passenger kilometres. In 2050, the share of passenger kilometres undertaken by public transport modes increases to 33.6%, from 7.6% in the reference case. This implies that the majority of households choose to retain the option of owning a private vehicle, possibly in order to use it for certain trips, but alter their commuting behaviour in favour of public transport.

The increase in passenger kilometres caused by the "promote public transport" package is even more pronounced in 2030. This can be explained by the fact that both conventional and electric vehicles become more attractive as fuel economy and energy efficiency increases. In contrast, the attributes of public transport remain fixed throughout the period. This means that public transport is relatively more attractive in 2030 than in 2050 where technological developments has improved the characteristics of conventional and electric vehicles. The share of households which do not own a vehicle and the share of passenger kilometres undertaken by public transport is presented in Figure 5.4.

Figure 5.4. Share of households that do not own a private vehicle and public transport as a share of total passenger kilometres



Note: Left panel: no vehicle ownership as a share of households; right panel: public transport as a share of passenger kilometres.
Source: Generated by the authors, using results of simulations from MOLES.

This section has briefly highlighted the main changes in vehicle use and emissions prompted by changes in technology, demographics and policy. Sections 5.2 and 5.3 explain the mechanisms driving these changes in detail and present the environmental, fiscal and distributional implications of the different scenarios.

5.2. Analysis of the reference scenario

5.2.1. Evolution of policies under the reference scenario

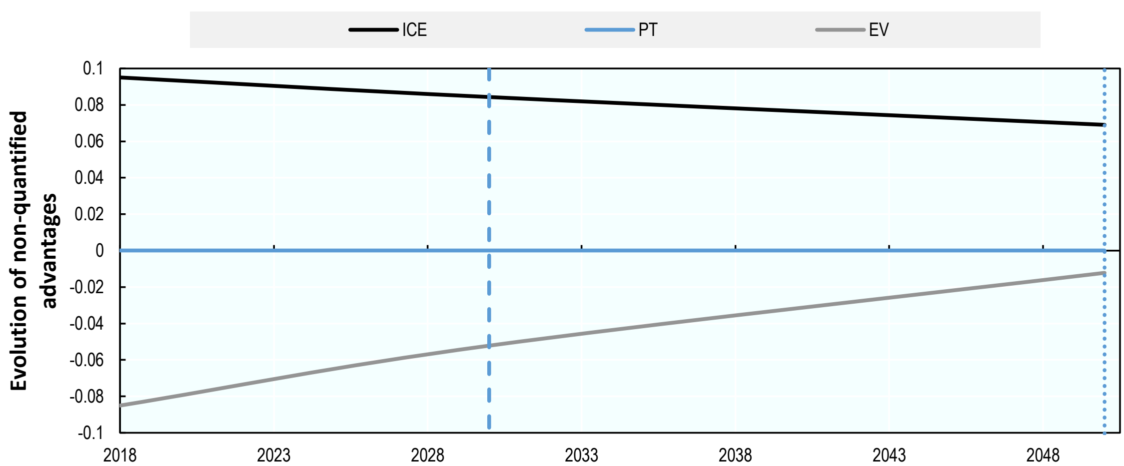
The reference scenario models a "business-as-usual" evolution of the key policies that affect emissions from urban transport. These policies include a set of rather moderate taxes on vehicle ownership, as well as on vehicle and fuel use. They also include limited support for EV uptake and the persistence of relatively high public transport fares. Therefore, the switch to less carbon-intensive modes of urban transport is not highly incentivised in the reference scenario.

At the same time, the reference scenario assumes a particularly slow fade-out of the unmeasured advantages of ICE vehicles *vis-à-vis* EVs. The scenario assumes that the technological progress will bridge part of the gap between ICE vehicles and EVs. Among others, that translates into an evolution of the factors that are not directly quantified in the modelling exercise: a growing variety of affordable EVs, a shorter average charging time and cheaper spare parts. However, the reference case assumes that, due to a rather weak policy support for innovation in the EV industry, the pace of that evolution will be moderate. Consequently, the difference in consumer utility derived from the non-quantified features that differ between ICE and EVs will fall by approximately 2% per year over the period 2018-2050. This means that roughly 45% of the non-modelled advantage that ICE vehicles possess *vis-à-vis* EVs is preserved in 2050.

Finally, the reference scenario assumes that the large comparative advantage of ICE vehicles vis-à-vis public transport modes will fall only slightly. This advantage stems from negative non-pecuniary attributes that characterise public transport. They include waiting times, connections, walking distances, as well as the frequency and reliability of service. The reference scenario assumes that these attributes improve at a very slow pace. As a result of the public transport system's gradual improvement, the gap in consumer utility derived from the non-quantified features that differ between public transport and all other modes slowly narrows with time. That is, it reduces at a pace that lies between 2% and 3% per year in the period 2018-2050. The evolution of the utility from the non-quantified attributes of ICE vehicles, EVs and public transport is displayed in Figure 5.5. This assumption is highly significant for the overall results. The effect of adopting a more optimistic view regarding the non-quantified advantage of ICE vehicles vis-à-vis EVs and public transport over time is tested in the sensitivity analysis presented in Chapter 6.

Figure 5.5. Evolution of utility from non-quantified differences between different modes of transport.

The non-quantified utility of an ICE vehicle and an EV evolve over time.



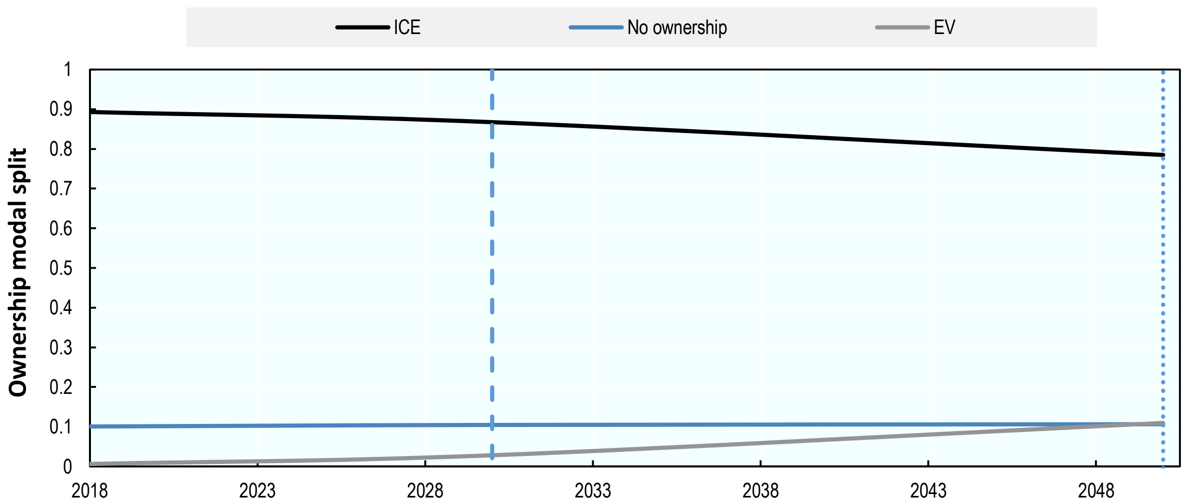
Note: As the modelling exercise is based exclusively on *utility differences*, the unobserved utility of public transport is set to zero and used as reference.
Source: Generated by the authors, using results of simulations from MOLES.

5.2.2. Vehicle use and emissions

The assumptions about EVs in the reference scenario give rise to a path in which private ICE vehicles remain the dominant mode of urban transport. The evolution of the modal split in the reference scenario is shown in Figure 5.6. The share of EVs in the fleet increases from 0.5% in the benchmark year (2018) to 2.8% in 2030 and to 10.9% in 2050. That growth is coupled with a gradual decrease of the share of ICE vehicles in the modal split, which decreases from 89.3% in 2018 to 86.7% in 2030 and to 78.4% in 2050. The share of households that do not own a vehicle remains relatively stable, i.e. it is 10.6% in 2050. The corresponding share of passenger kilometres by ICE vehicles, EVs and public transport is shown in Figure 5.7.

Figure 5.6. Ownership modal split

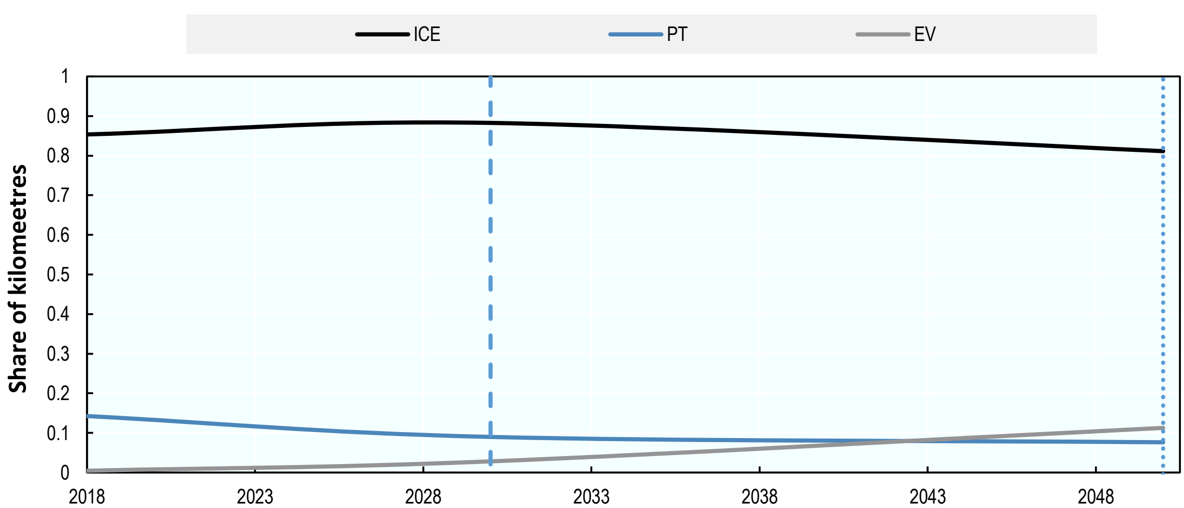
The share of EVs increases gradually to 11% and the share of ICE vehicles declines to 78%.



Source: Generated by the authors, using results of simulations from MOLES.

Figure 5.7. Composition of passenger kilometres

The evolution of the share of passenger kilometres made by ICE vehicles, EVs and public transport.

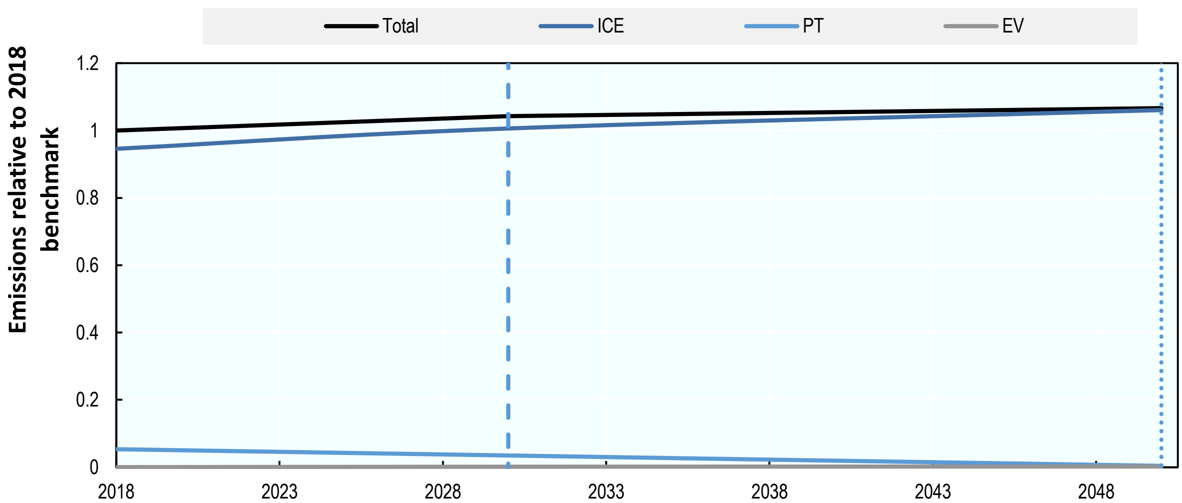


Source: Generated by the authors, using results of simulations from MOLES.

The reference scenario predicts that the total greenhouse gas emissions from urban transport will continue growing. Relative to the 2018 levels, these emissions will have increased by 4% in 2030 and by 7% in 2050. The projected trend of the total emissions from urban transport, relative to their respective value in 2018, is shown by the solid grey curve in Figure 5.8. In the same figure, the rest of the curves represent the greenhouse gas emissions attributed to ICE vehicles, EVs and public transport. These are also expressed relative to the total amount of greenhouse gas emissions in 2018. In 2050, the projection shows that almost all (99.4%) of the emissions from urban transport in Auckland will be generated by the use of ICE vehicles. This is indicated by the convergence of the curves representing ICE and total emissions respectively.

Figure 5.8. Greenhouse gas emissions from urban transport

Evolution of total emissions and their components.

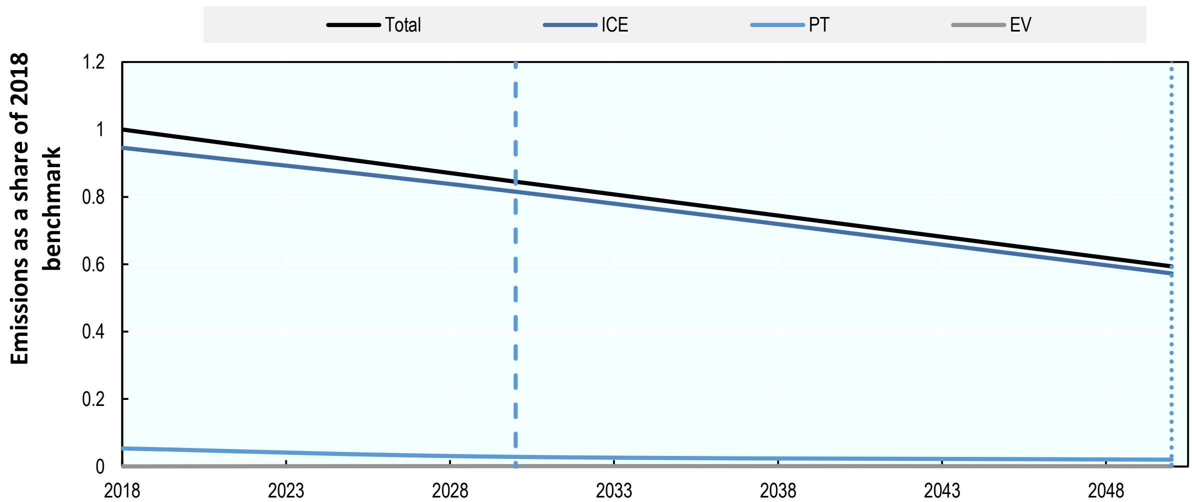


Note: All emissions are reported relative to the total emissions from urban transport in year 2018. The grey curve expresses the total emissions from urban transport as a fraction of the respective emissions in 2018. The three black curves (solid, short dashed and long dashed) decompose the total emissions into those originating from internal combustion engine (ICE), electric (EV) and public transport vehicles.
Source: Generated by the authors, using results of simulations from MOLES.

Three critical assumptions underlie this finding. First, the carbon intensity of the electricity generation in New Zealand will continue decreasing, from 0.12 kg of CO_2e per kWh in 2018 to 0.02 kg of CO_2e per kWh in 2050. Second, the electricity consumption of a representative EV is assumed to fall considerably. From a starting value of 0.17 kWh in 2018 it falls to 0.09 kWh per km in 2050. Thus, the amount of CO_2e generated per kilometre by an EV in 2050 is less than 10% of the respective amount in 2018. Finally, all urban public transport modes in 2050 are assumed to be electrified in line with the planned policies to reduce emissions from public transport (Auckland Transport, 2018[2]). Therefore, policies that target greenhouse gas emissions should focus on reducing the kilometres of any existing ICE fleet and on accelerating its replacement by EVs.

The growth in greenhouse gas emissions displayed in Figure 5.8 is partially driven by a substantial increase in population. That increase is approximately 75% in the period 2018-2050. To understand how total greenhouse gas emissions from urban transport could evolve in a city characterised by no population growth, Figure 5.9 displays the *per capita* CO_2e emissions in Auckland. These emissions, which are expressed relative to their value in 2018, are projected to fall by roughly 40% in 2050. The largest part of this decline is due to improvements in the fuel efficiency of ICE vehicles, which is projected to increase by 55% between 2018 and 2050. The analysis presented in Figure 5.8 and Figure 5.9 indicates that the technological evolution in the industries of ICE vehicles and EVs will most likely fall short of delivering carbon neutrality in transport sector by 2050.

Figure 5.9. *Per capita* greenhouse gas emissions from urban transport



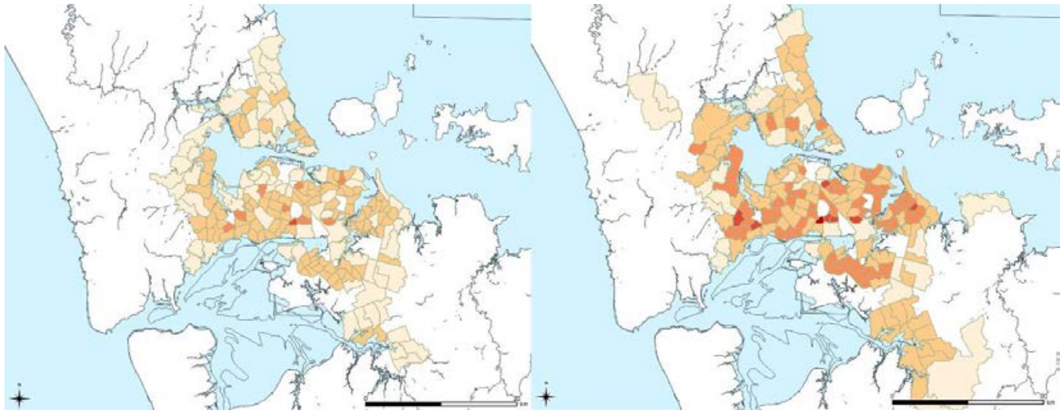
Note: *Per capita* emissions are reported relative to the *per capita* emissions from urban transport in year 2018. The grey curve expresses *per capita* emissions from urban transport as a fraction of the respective emissions in 2018. The three black curves (solid, short dashed and long dashed) decompose these relative total emissions into those originating from internal combustion engine (ICE), electric (EV) and public transport vehicles.
Source: Generated by the authors, using results of simulations from MOLES.

5.2.3. The evolution of urban form, housing prices and affordability

The evolution of transport-related greenhouse gas emissions is closely linked to two factors: the evolution of urban form and the level of housing supply. In the reference scenario, urban form evolves through the gradual increase in population density in existing areas. It also changes through the conversion of designated future urban areas to residential areas. The development pattern in newly developed areas is similar to that of existing residential areas. The development pattern in existing residential areas remains intact.

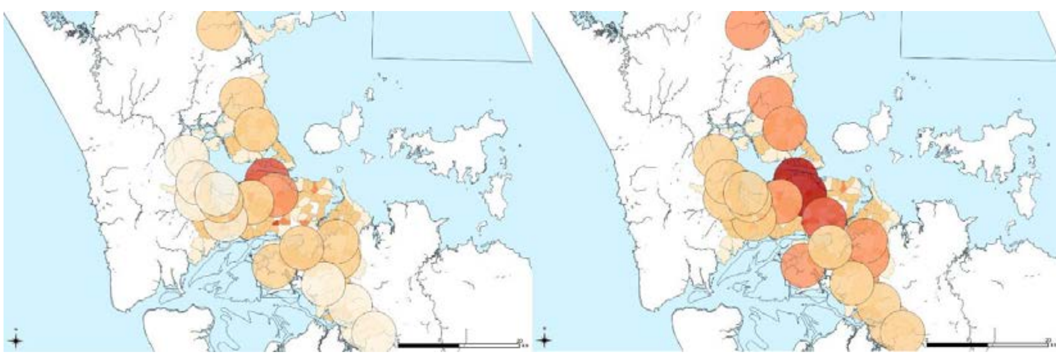
The gradual increase in population density is presented in Figure 5.10. Population density in 2050 is higher than in 2018. This is illustrated by the increased prevalence of darker colours, which indicate areas of higher population density. The right panel of Figure 5.10 includes several new residential areas. Employment evolves in a similar manner. Figure 5.11 displays the evolution of job density by employment zone. In 2050, the employment areas remain the same as in 2018 but employ more people.

Figure 5.10. Evolution of population density by residential zone



Note: Left panel: population density in 2018; right panel: population density in 2050. Darker colours represent area units with higher population density.
Source: Generated by the authors, using results of simulations from MOLES.

Figure 5.11. Evolution of job density by employment zone



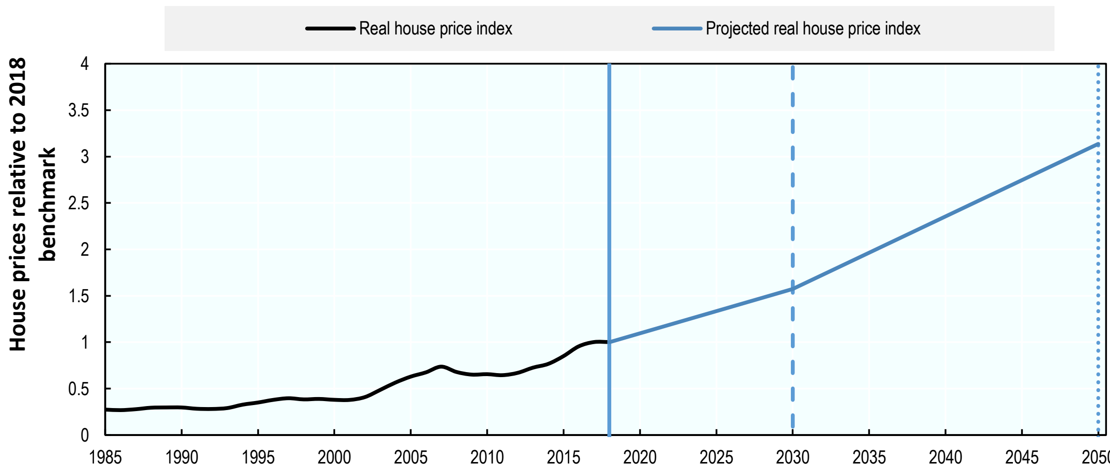
Note: Left panel: employment density in 2018; right panel: employment density in 2050. Darker colours represent areas of higher employment density.
Source: Generated by the authors, using results of simulations from MOLES.

Housing supply evolves according to the patterns established in the existing urban form and is a key determinant of housing prices and housing affordability. The impact of policies targeting housing supply may be twofold, as they are likely to affect housing prices and the environmental performance of a city.

The reference scenario predicts that the average housing prices in Auckland will steadily increase between 2018 and 2050. Compared to 2018, real housing prices will have increased by at least 50% by 2030 and by more than 200% by 2050. This steep increase is displayed in Figure 5.12. The projection implies an average growth rate of real prices that is approximately 3.6% per year. The findings from the simulation of the reference scenario are in line with the observations from the 32-year period that preceded the benchmark year, i.e. the period 1985-2017 (The Economist, 2019[3]). During that period, real average housing prices in Auckland increased between 200% and 300%. Furthermore, in the 25-year period between 1989 and 2014, the city's population increased by 55%. The annual average growth rate of the population during that period was 1.76%, which is the growth rate assumed in the reference scenario. Finally, the various indicators of urban footprint extent increased between 25% and 32% over the 1989-2014 period, a change that is comparable to the one assumed in the reference scenario.

Figure 5.12. Average real housing prices in Auckland in the reference scenario

Observed and projected evolution of housing prices.



Note: The evolution of the housing price index is computed using the OECD's real house price index. The values displayed in the dotted curve (1985-2017) are expressed relative to New Zealand's housing price index reported in 2017. The projected mean values displayed in the solid curve are expressed relative to the mean housing price in the model's benchmark year (2018). The vertical lines mark the years at which housing prices are computed with MOLES.
Source: Real house price index between 1985 and 2017 uses past time series (The Economist, 2019[3]); the projected real house price index is generated by the authors, using results of simulations from MOLES.

To a large extent, the house price growth in the reference scenario stems from the projected growth in population and in real income. Increases in both variables are known to raise demand for housing and to exert a positive pressure on housing prices. Population and income are projected to be 75% and 54% higher, respectively, in 2050, as shown in Chapter 2.

Most importantly, the reference scenario assumes that urban development continues to take place in a business-as-usual manner. This means that low residential density remains the predominant development pattern in the existing urban fabric, within which housing supply remains constant. Furthermore, in the reference scenario low residential density constitutes the recipe for future development. To keep the simulation results tractable, the reference scenario rules out infill development.

If the steep increase in projected house prices materializes, it will have a significant impact on private budgets. It is also likely to reduce the overall welfare gains expected in the examined period. An alternative interpretation of the simulation results is that the projected increase in housing prices will materialise only partially. This is likely because any substantial house price increase may hamper the expected population growth, which is also a driver of rising house prices. Even in this case, however, part of the expected welfare gains will be foregone, as these gains are linked to the attraction of a highly skilled labour force from other parts of New Zealand and the world. Therefore, growing housing prices and limited housing supply are two interrelated challenges that must be addressed simultaneously.

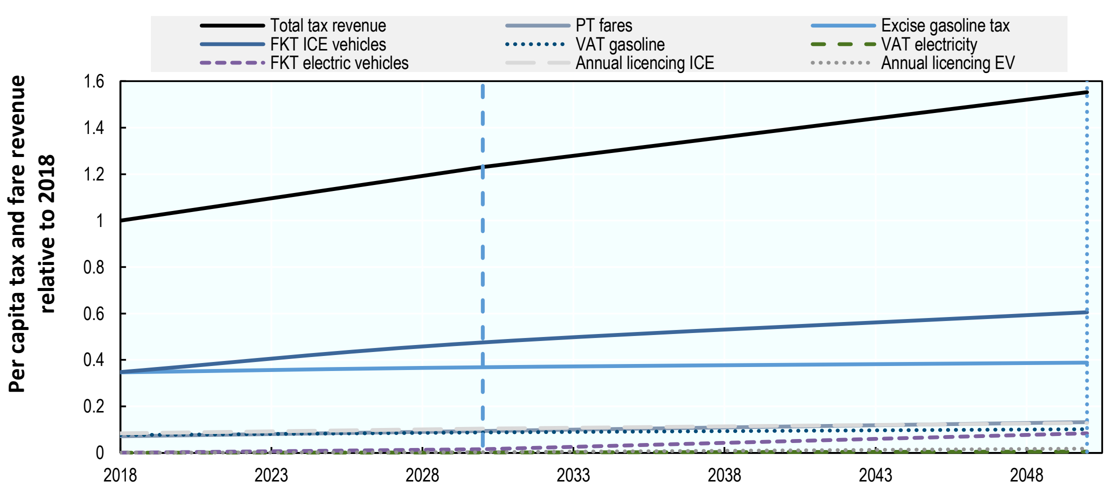
Given the strong projected growth in housing costs, the simulation of the reference scenario predicts a steep increase in the share of income spent on housing costs. Such a substantial increase will be accompanied by significant distributional impacts, which are likely to be detrimental for some parts of the population. That holds true especially for those with limited borrowing capacity. On the other hand, current landlords with negative net housing expenditure will benefit from the limited growth in housing supply and the associated increase in housing prices.

5.2.4. Fiscal implications

The reference scenario yields important insights on the performance of the set of fiscal instruments considered in the study. The revenues from public transport fares, vehicle licencing fees, kilometre taxes, the excise and *ad-valorem* taxes on gasoline and electricity evolve over time. Some of these revenue changes are more distinct, since the bases of the corresponding taxes undergo more profound changes as the ownership and the kilometre share of each transport mode evolves. Figure 5.13 displays the evolution of the *total* tax revenue and its components, expressing them relative to the total tax revenue in 2018.

Figure 5.13. Total tax and fare revenue

The evolution of revenue from national and local tax instruments and public transport fares.



Source: Generated by the authors, using results of simulations from MOLES.

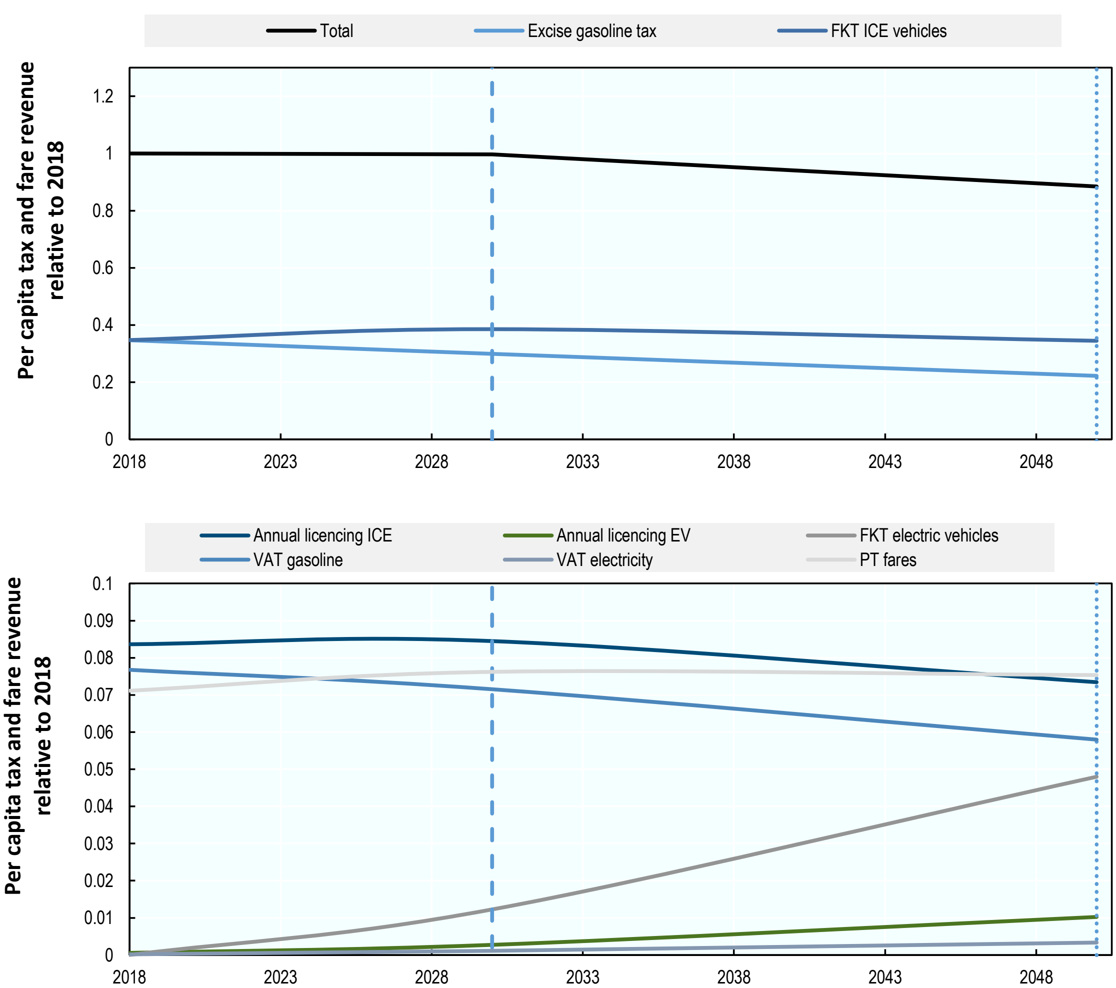
The total revenue from the considered instruments, displayed in the solid black curve of Figure 5.13, increases by approximately 55%. The most important contributor to that is population growth, which is 75% and implies a considerable increase in some tax bases. The corresponding changes of *per capita* revenues are shown in Figure 5.14. Total tax revenue *per capita*, indicated by the thick solid curve in the upper panel of the figure, decreases by 12% in the considered period (2018-2050). One of the most notable findings is that the revenue from the excise tax on gasoline falls. This occurs primarily because the fuel consumption of the remaining ICE vehicles drops substantially, i.e. by 36% in 2050, due to improvements in the fuel efficiency of ICE vehicles. The changes in the revenue from the kilometre tax in ICE vehicles are negligible. A moderate shrinkage of the ICE vehicle fleet (88% of all vehicles in 2050) and a slight increase in travel demand, which offsets the former effect, underlie this finding.

The rest of the tax instruments are shown in the lower panel of Figure 5.14. These make up a substantial part of the total revenue. However, the separate contribution of each of these instruments is small compared to that of the excise gasoline tax and of the ICE vehicle kilometre tax.

The revenues from the annual licencing and circulation fees of ICE vehicles, as well as from the VAT on gasoline, decline. The downward trend of the former can be attributed to the shrinkage of the ICE vehicle fleet. The latter revenue declines as the fuel economy improves, inducing a decrease in fuel consumption.

The revenue from the kilometre tax imposed on EVs increases, as the share of these vehicles in the fleet grows. In 2050, 5-6% of the total tax revenue from the instruments examined in the report will be generated by the kilometre tax on EVs. The revenues from the licencing fees on EVs and from the VAT imposed on their consumed electricity will together account for less than 2% of total tax revenue. This is mainly due to the low levels of annual EV licencing fees. It could also be due to the increasing energy efficiency of EVs. The latter increase offsets part of the increase in electricity consumption that stems from the growth of the EV fleet. Finally, the moderate growth of the share of public transport in the modal split results in a slight increase in the revenue from public transport fares (5.6%).

Figure 5.14. Tax and fare revenue *per capita*



Source: Generated by the authors, using results of simulations from MOLES.

5.3. Analysis of counterfactual scenarios

This section examines the environmental and economic impact of the policy packages described in detail in Chapter 2. Subsection 5.3.1 provides a brief summary of these packages. Subsection 5.3.2 provides an analysis of the environmental and economic impact of counterfactual scenarios based on the implementation of different policy packages.

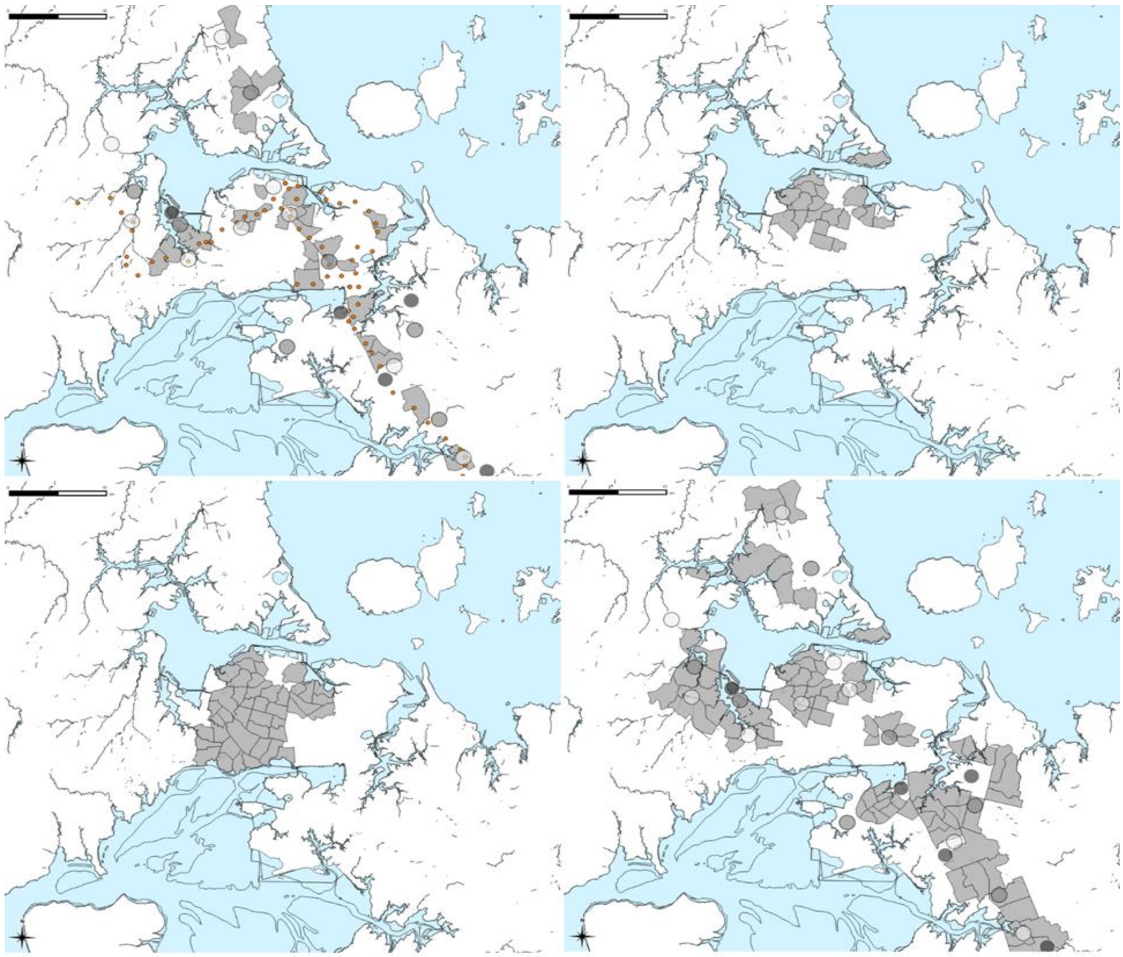
5.3.1. A brief summary of policy packages

The packages examined in the study are:

- a "***promote public transport*"** package. This package contains measures that drastically increase the fixed private costs of both ICE vehicles and EVs. This is done by increasing the annual circulation fees and the operational costs of these vehicles. This is done through a steep increase in the existing kilometre tax and the current level of the excise tax on gasoline. Furthermore, an urban road pricing scheme is introduced in Auckland. The scheme takes the form of a double cordon, with the inner cordon surrounding the central business district and the outer cordon surrounding the inner part of the urban area. The scheme is therefore similar in design to the one introduced in Stockholm. The additional revenue from the aforementioned adjustments suffices not only to provide a drastic subsidy of public transport fares, but also to finance other initiatives. These initiatives are not modelled explicitly, but the analysis derives an approximate measure of the social value of this revenue.
- a "***promote electric vehicles***" package. This package contains a generous subsidy for EVs. That subsidy is a monetary representation of a direct purchase subsidy, e.g. a VAT and annual circulation fee exemption, and of other indirect benefits that EVs may enjoy. These may include the right to use bus lanes, free parking and other benefits, whose effect is not modelled explicitly with MOLES. Moreover, the package introduces a steep increase in the kilometre tax paid by ICE vehicles, but exempts EVs from it. Therefore, it generates a substantial difference in the ownership and operational costs of the two types of vehicles.
- a "***widespread densification***" package. This contains measures that relax the existing density regulations in the city. The package allows buildings to be taller and to occupy a larger share of their land plots. Changes in density are proportional to the existing building height and the land plot coverage (50%) and are uniform across space. Therefore, the supply of residential floor space increases everywhere in the city. However, that increase is more profound in the inner core of the urban area, where structural density is currently higher.
- various "***targeted densification***" packages. These packages substantially relax density regulations in selected areas of the city, while they preserve existing regulations in the rest of the urban fabric. The various packages select the areas to be densified according to different criteria. For example, such criteria may include the proximity to the central business district or the distance from major public transport nodes and employment hubs. The areas selected by each targeted densification package are shown in Figure 5.15.

Figure 5.15. Targeted densification

Four versions of selected densification in Auckland



Note: Upper left panel: further densification of already-dense areas lying close to major employment hubs and public transit nodes (TD1); Upper right panel: densification of low-density zones surrounding the central business district (TD2); Lower left panel: densification of low-density areas in Auckland's isthmus (TD3); Lower right panel: densification of areas in close proximity to employment hubs (TD4).
Source: Generated by the authors.

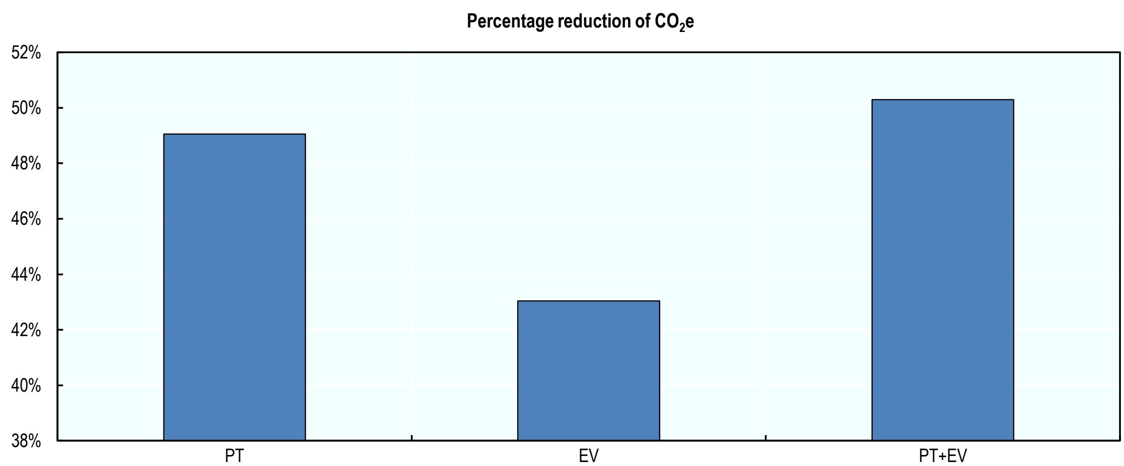
5.3.2. The mid-term (2018-2030) environmental impact of packages

The results presented in this subsection compare the environmental performance of a number of policy packages and their combinations. Each package is evaluated based on its potential to reduce the greenhouse gas emissions from urban transport (CO_2e).

The percentage reductions in CO_2e emissions from the implementation of three policy counterfactual scenarios are displayed in Figure 5.16. These are the "promote public transport" package, the "promote electric vehicles" package and their combination. The reported reductions are expressed relative to the aggregate CO_2e emissions predicted by MOLES for 2030 in the reference scenario. In turn, the reference emissions in 2030 are approximately 4% higher than their value in the benchmark year (2018).

Figure 5.16. Effect of promoting public transport and EVs on emissions in 2030

Estimated percentage of emissions eliminated by promoting public transport, EVs, or both. Percentage values are relative to emissions in the reference case in 2030.



Note: PT refers to the "promote public transport" policy package; EV refers to the "promote electric vehicle" policy package; combinations of the packages are denoted with '+'.
Source: Generated by the authors, using results of simulations from MOLES.

The simulations with MOLES show that both packages, as they are elaborated in Chapter 2, will induce considerable CO_2e reductions. Emissions in 2030 will be 49% lower than their reference level in 2030 with the implementation of the "promote public transport" package. That includes a considerably larger kilometre charge, a steep increase in the ownership and excise gasoline taxes, the introduction of urban road pricing and a generous subsidy of public transport fares. The combination of these drastic interventions induces a 2.5% decrease in the number of households that will choose to own a vehicle in 2030. That rigid response can be attributed to the large relative disadvantages of existing public transport services in low-density areas. Among others, these disadvantages include the low frequency of service and poor connectivity. These are not taken into explicit account in the simulations, but they may explain a large part of the modal split in ownership. Without policies to substantially reduce these disadvantages, the ownership modal split will remain relatively unresponsive to policies that promote public transport only *via* reductions in pecuniary costs, i.e. without improving the quality of the service. In spite of that, the policy components included in the "promote public transport" package can induce a significant change in the composition of passenger kilometres. In 2030, the share of passenger kilometres undertaken by public transport modes can be increased from the reference level of 9.3% to 64.1%. The third column of Table 5.1 displays these changes.

Furthermore, Figure 5.16 suggests that 43% of the reference greenhouse gas emissions in 2030 can be eliminated with the implementation of the "promote electric vehicles" package. That package incorporates the same measures as the "promote public transpor*t*" package, but contains three policy components that substantially alter the relative costs between EVs, ICE vehicles and public transport. First, EVs are exempt from all road charges and urban tolls. Second, they are provided a considerable annual subsidy, which is a monetary representation of several non-pecuniary benefits these vehicles may receive (e.g. preferential parking or use of bus lanes). Finally, public transport subsidies are not considered in this package.

Table 5.1. Key modal split changes induced by emission-reducing policies

	Reference	PT	EV	PT + EV
% not owning a private vehicle	10.8%	13.3%	10.7%	13.0%
% km generated with public transport	9.3%	64.1%	46.8%	59.9%
% owning an EV	2.8%	2.6%	3.7%	4.5%
% km generated with an EV	2.8%	1.3%	5.3%	6.6%

Note: PT refers to the "promote public transport" policy package; EV refers to the "promote electric vehicle" policy package.
Source: Generated by the authors.

The policy measures described above increase the attractiveness of EVs, but have a modest effect on their ownership rate, as Table 5.1 suggests. That is, the rate of EV ownership increases from 2.8% it is in 2030 in the reference scenario to 3.7%. The reason for this moderate response is that the non-modelled disadvantages of EVs (e.g. limited range and availability of charging stations) that are part of the vehicle choice decision remain considerable in 2030 (Figure 5.5). In spite of this, the "promote electric vehicles" policy package is capable of inducing substantial changes in the share of kilometres generated by EVs. This occurs because once an EV has been purchased, the package renders its use much cheaper than it would otherwise be. Furthermore, the package contains all the components that discourage the use of ICE vehicles. As such, the "promote electric vehicles" package drastically increases the share of passenger kilometres generated by public transport. That increase, i.e. from 9.3% to 46.8%, is comparable but somewhat smaller than the one induced by the "promote public transport" policy package (64.1%).

The last column of Table 5.1 displays the effects from the simultaneous implementation of the two aforementioned packages. In that case, generous subsidies are provided both to public transport and to EV use. The findings suggest that some of the measures contained in these two packages may have an antagonistic effect with respect to the outcomes of interest. For example, efforts to promote EVs can reduce the passenger kilometres travelled *via* public transport modes, if they render EVs more attractive than public transport. For this reason, any potential synergies between these two policy packages are likely to be limited in size.

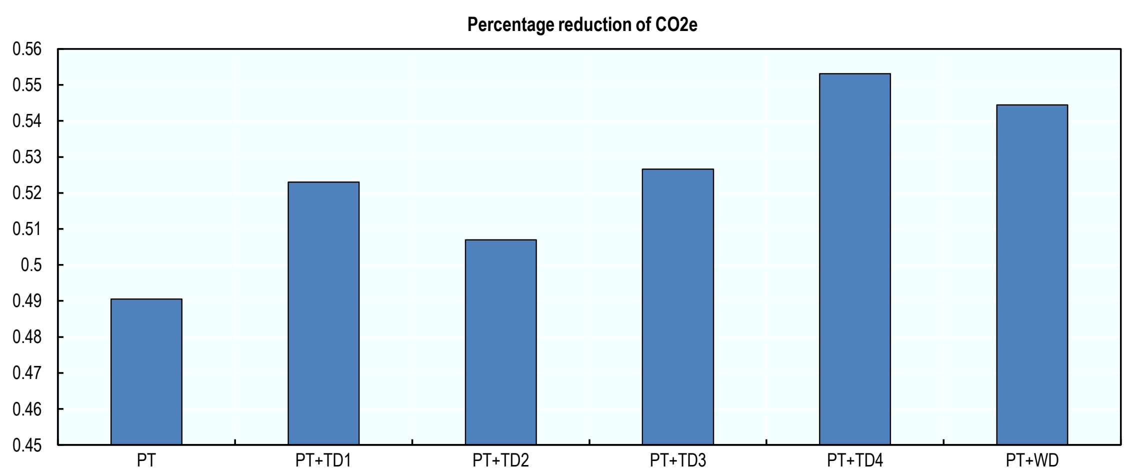
Combining the "promote public transport" package, as elaborated above, with a densification package may yield larger cuts in greenhouse gas emissions from urban transport. Figure 5.17 highlights the additional impact of targeted and widespread densification. The largest additional emission reductions (6.3%) are generated by a targeted densification program that increases residential density around the largest employment hubs. That package has significant emissions reduction potential as a stand-alone measure (-14%), but this potential is even greater when it is combined with policies that actively encourage the greater use of public transport.

A similarly considerable effect is generated by widespread densification, which relaxes density regulations everywhere within the urban area. However, as explained in detail in Chapter 2, the uniform relaxation of density coefficients generates more additional floor space in areas where density is relatively higher. These constitute mainly central areas that lie relatively closer to key points of activity, such as jobs and large shopping hubs.

For reasons that are expanded upon in the next section, only the targeted densification programs TD2 and TD3 are welfare improving. These densify the areas surrounding the central business district and the low-density parts of Auckland's inner core, respectively. Additional emission reductions in 2030 relative to the reference scenario will be 1.7% and 3.7%, respectively.

Figure 5.17. The mid-term (2018-2030) environmental impact of the "promote public transport" policy package and the various densification programmes

The CO_2e reductions from promoting public transport as a stand-alone policy or in combination with a densification program. Percentage values are relative to emissions in the reference case in 2030.



Note: PT refers to the "*promote public transport*" policy package; EV refers to the "*promote electric vehicle*" policy package; WD refers to a *widespread densification* program; TD refers to a *targeted densification* program; combinations of the packages are denoted with '+'.
Source: Generated by the authors, using results of simulations from MOLES.

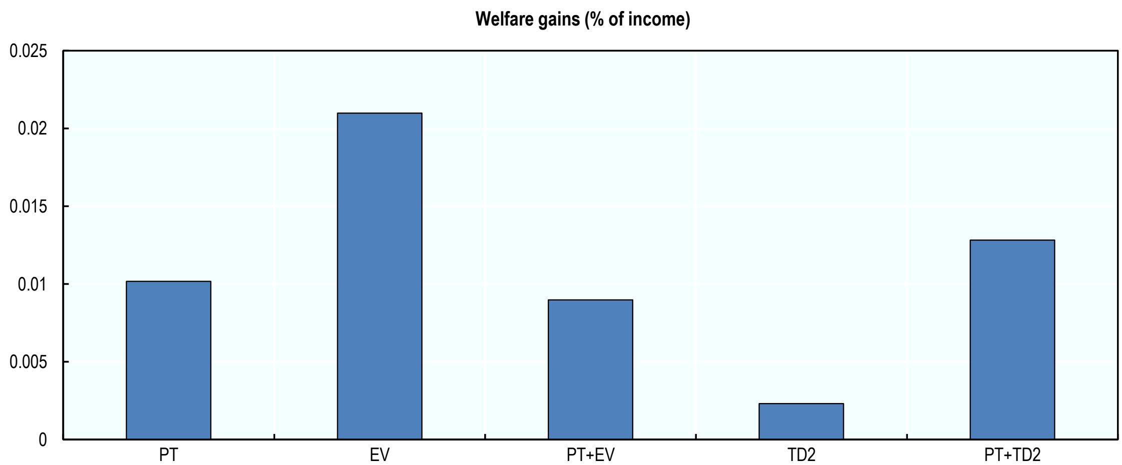
5.3.3. The mid-term (2018-2030) welfare impact of packages

The analysis in the previous subsection focused on the environmental impacts of the policy packages examined in the study. This subsection highlights the potential trade-offs between environmental and economic performance and identifies the policies that achieve both objectives.

The values displayed in Figure 5.18 are monetised welfare gains associated with a selection of policy packages and their combinations. The welfare calculations, described in full detail in Chapter 3, are based on three measures. The first is the compensating variation of each policy. That measure is the amount of money households need to be compensated with, *ex-post* to the implementation of the policy, in order to be equally well-off as in the reference case. The second component of welfare is the social cost (respectively, benefit) from the fiscal deficit (respectively, surplus) that the package generates *vis-à-vis* the reference case. The final component is the social cost (respectively, benefit) from the carbon emission increases (respectively, reductions) the package generates *vis-à-vis* the reference case. The sum of these measures yields the welfare gain (or loss) of a policy, which is expressed relative to the projected average income in the considered year.

Figure 5.18. The mid-term (2018-2030) economic impact of recommended policies

The annual welfare gains *per capita* (net of environmental benefits) from promoting public transport, EVs and selected densification of low-density areas around the central business district.



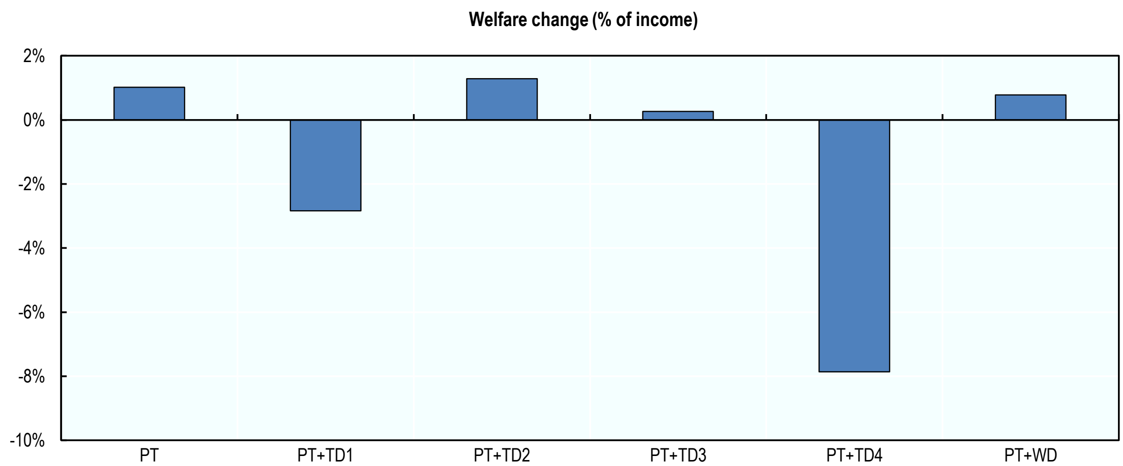
Note: PT refers to the "promote public transport" policy package; EV refers to the "promote electric vehicle" policy package; WD refers to a widespread densification program; TD refers to a targeted densification program; different combinations of the packages are denoted with '+'.
Source: Generated by the authors, using results of simulations from MOLES.

In 2030, both "promote electric vehicles" and the "promote public transport" packages are effective, not only in reducing emissions but also in generating a substantial welfare benefit. Promoting EVs increases social welfare by 2.1% of income. A large part of the welfare gain originates from the reduction of traffic and congestion. The package generates these gains because the ownership and use of private ICE vehicles are heavily taxed. A similar effect is generated by the "promote public transport" package. However, that package offers a significant subsidy to public transport modes without generating substantial additional benefits in terms of congestion relief. Furthermore, these large subsidies give rise to a much lower net revenue.[1]

Densification of low-density areas around the city's central business district is welfare increasing as a stand-alone package. The package constitutes a mild densification program that increases housing supply in the areas surround the Central Business District as shown in the upper right panel of Figure 5.15. These areas lie close to jobs, shopping malls and other key trip destinations. The program leaves the development pattern in the rest of the suburban areas intact. In this way, it accommodates the high demand for private open space, which is generated by the part of the population with a strong preference for low-density development. Combining this mild densification program (TD2) with the measures that promote public transport yields an annual gain equivalent to 1.3% of income.

Figure 5.19. The mid-term (2018-2030) economic impact of promoting public transport and densification

The annual welfare gains or losses *per capita* (net of environmental benefits) from promoting public transport as a stand-alone policy or in combination with a densification program.



Note: PT refers to the *"promote public transport"* policy package; EV refers to the *"promote electric vehicle"* policy package; WD refers to a widespread densification program; TD refers to a targeted densification program; TD1 refers to further densification of already-dense areas lying close to major employment hubs and public transit nodes; TD2 refers to densification of low-density zones surrounding the central business district; TD3 refers to densification of low-density areas in Auckland's isthmus; TD4 refers to densification of areas in close proximity to employment hubs; different combinations of the packages are denoted with '+'.
Source: Generated by the authors, using results of simulations from MOLES.

5.3.4. Policy recommendations for the mid-term (2018-2030)

The following general recommendations, which refer to the period from 2018 to 2030, can be extracted from the findings:

- **Implement immediate measures to reduce the use of private vehicles and congestion.** The findings of the study show that minor increases of the kilometre charge and the environmental component (ETS) of the gasoline tax are not sufficient to reduce greenhouse gas emissions from urban transport considerably. The model simulations suggest that sizeable increases in the kilometre charge (e.g. NZD 0.50) and the excise gasoline tax (e.g. NZD 1.00) are needed to induce a significant shift to public transport.
- **Finance electric vehicle benefits through an increase of the annual costs of ICE vehicle ownership.** Annual circulation fees are relatively low in New Zealand. Their gradual increase could finance investments in support infrastructure for EVs, such as recharging stations.
- **Improve the quality of public transport system services.** To facilitate the transition from private vehicle use to public transport ridership, the local public transport system has to be upgraded. It should become less fragmented and more reliable, in order to provide a viable alternative to private vehicle use. Increasing

the frequency of service in areas where population density is relatively high would be particularly effective. Comfort is another important non-pecuniary attribute that should also be taken into consideration by policy makers.

- **Introduce a mild densification program that intensifies gradually.** Reforms of land-use regulations could take the form of removing building height restrictions and other regulations in low-density areas around the CBD. This mild densification program should intensify gradually, as population increases and the demand for residential floor space causes housing prices to rise even further. Once this occurs, low-density areas other than those surrounding the CBD can be incorporated in the densification program. For example, these areas could include the low-density areas within the isthmus. Alternatively, such a program may take the form of a marginal relaxation of density regulations in the entire urban fabric.
- **Delay the development of disconnected areas.** Focus development in urban areas rather than periurban areas. Accommodate a larger part of the current housing demand with infill development.
- **Prepare the ground for widespread densification programs to be introduced in the long run**. Accommodating both a large increase in population and the strong preference for low-density development is likely to be incompatible with the goals of housing affordability and transport decarbonisation. A widespread densification program, which is going to be necessary to curb house price growth in the long run, should be introduced gradually. Local and national authorities need to prepare the ground for this transition by aligning their policies and harmonising their objectives. This process may be subject to multiple rigidities and sources of inertia, thus preparation for densification programs should be made early on.

5.3.5. The long-run (2030-2050) environmental performance of policy packages

This subsection presents the findings from policy simulations run for the second period considered in the study. This period is referred to as the long run and spans the years between 2030 and 2050.

The environmental impacts of packages for the promotion of public transport, electric vehicles and the combination of both are displayed in Figure 5.20. All packages provide considerable reductions from the reference level of emissions in 2050. The magnitude of these reductions are comparable to those obtained in the mid-term.

However, the capacity of the same measures to reduce emissions in the mid- and the long run differs widely. For instance, the “promote public transport” package, which is found to reduce greenhouse gas emissions by 49% in the mid-term, is found to be somewhat less efficient in the long run. The same holds for the policies designed to promote electric vehicles (43% versus 32%).

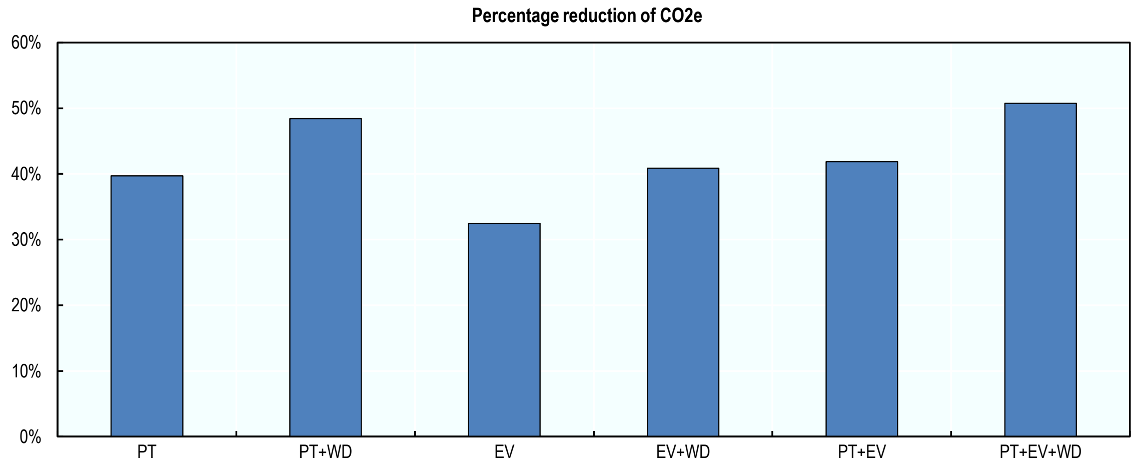
Fuel efficiency is the main driver behind the reduced environmental effectiveness of packages in the long run. As conventional vehicles become more fuel-efficient, they consume less gasoline for a given distance, which in turn offsets part of the tax burden imposed by the two packages.

A widespread densification program, which is shown to induce large improvements in welfare, can play an important role in restoring the long-run effectiveness of the examined packages. For example, Figure 5.20 shows that combining widespread densification with the promotion of public transport reduces greenhouse gas emissions by 48.4%. That value lies very close to the one reported for the “promote public transport” policy package in the mid-term (49%). Therefore, promoting a compact urban form may be part of the answer to the declining environmental performance of transport policies in the long run.

A widespread densification program, as described in Chapter 2, does not increase density proportionally across urban space. In contrast, more residential floor space is generated in central, than in peripheral areas. This is because the program adjusts the density coefficients in a way that produces more additional residential space in land plots containing attached single family or multifamily buildings. Typically, the areas where these types of (denser) development are more prevalent are also the areas that are served relatively more frequent by public transport. Very often, these areas also lie closer to large employment hubs. Therefore, by densifying these zones further, widespread densification reduces car dependency and the vehicle kilometres travelled.

Figure 5.20. Emission reductions from promoting public transport, EVs and widespread densification in the long run (2030-2050)

Estimated percentage of emissions eliminated by promoting public transport, EVs, or both (2030-2050). Percentage values are relative to emissions in the reference case in 2050.



Note: PT refers to the "promote public transport" policy package; EV refers to the "promote electric vehicle" policy package; WD refers to a widespread densification program; TD refers to a targeted densification program; different combinations of the packages are denoted with '+'.
Source: Generated by the authors, using results of simulations from MOLES.

The "promote public transport" and "promote electric vehicle" policy packages change the shares of vehicle ownership and passenger-kilometres travelled by different types of vehicles. These results are reported in Table 5.2. Changes in vehicle ownership rates in response to policies remain moderate. This is due to the persistence of the non-modelled advantages of ICE vehicles over EVs (see subsection 5.2). The various disadvantages of public transport services also contribute also to the limited increase in EV ownership. In spite of this, the policy packages induce considerable changes in the share of passenger kilometres realised by public transport modes and EVs.

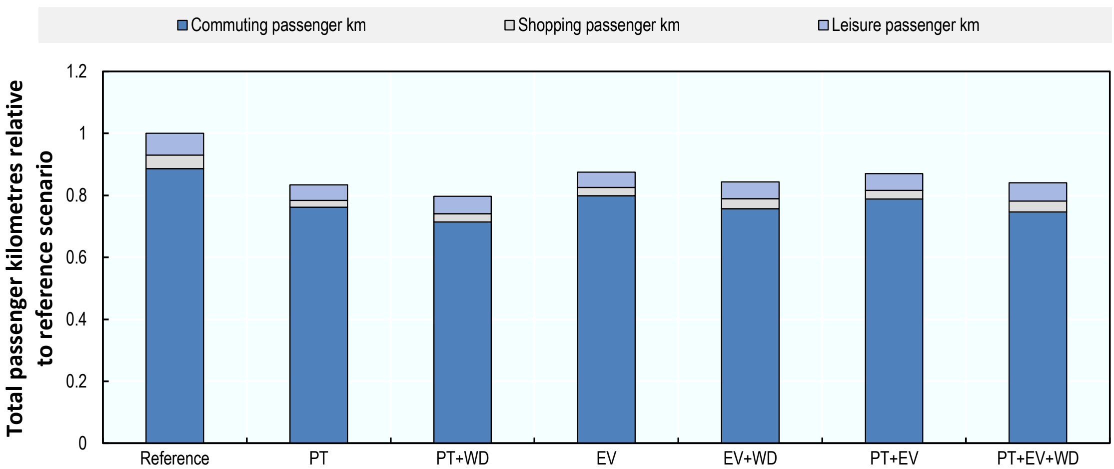
Table 5.2. Key modal split changes induced by the "promote public transport" and the "promote electric vehicles" policy packages

	Reference	PT	EV	PT + EV
% not owning a private vehicle	10.7%	13.8%	11.4%	12.9%
% km generated with public transport	7.6%	33.6%	20.8%	26.8%
% owning an EV	10.6%	10.6%	13.3%	15.1%
% km generated with an EV	11.3%	8.9%	17.4%	20.1%

Note: PT refers to the "promote public transport" policy package; EV refers to the "promote electric vehicle" policy package.
Source: Generated by the authors.

In addition to the changes reported in Table 5.2, the policy packages also affect the total distances travelled. All policy scenarios tested in the model significantly reduce the total passenger kilometres travelled. The main mechanism responsible for the reduction of passenger-kilometres in the "promote public transport" and "promote electric vehicles" packages is the presence of significant pricing measures. Combining widespread densification with a transport policy scenario reduces travelled distances even further while the relative shares of commuting, shopping and leisure trips do not change, as presented in Figure 5.21.

Figure 5.21. Split of total passenger kilometres by mode and trip category



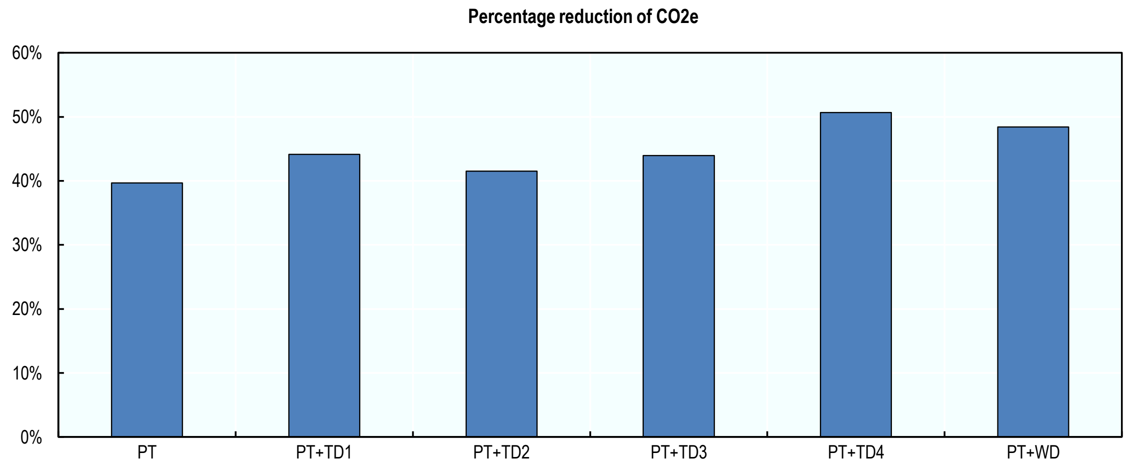
Note: PT refers to the "promote public transport" policy package; EV refers to the "promote electric vehicle" policy package; WD refer to a widespread densification program; different combinations of the packages are denoted with '+'.
Source: Generated by the authors, using results of simulations from MOLES.

The environmental effects of targeted densification packages, when these are combined with the "promote public transport" package, are displayed in Figure 5.22. All targeted densification packages provide significant additional cuts in transport CO_2e emissions. The largest cuts originate from combining the promotion of public transport with the "job-surrounding densification". The latter package is the densification program that induces an increase in the provision of housing supply in areas around the largest employment hubs. The associated reductions in passenger kilometres are shown in Figure 5.23.

An important finding of the analysis is the synergetic effect between targeted densification programs and the transport policy package. The multiplicative effect of targeted densification policies can be seen clearer by comparing: (i) the emission reduction potential of these packages as stand-alone policies and (ii) the additional emission reductions they generate when they are combined with the "promote public transport" package. For instance, the "job-surrounding densification" package (TD4) has the potential to reduce emissions from commuting by 6.7% as a stand-alone policy, but its contribution becomes much larger when it is combined with measures in the "promote public transport" package. That is, in the latter case it has a much stronger marginal effect, causing emissions to drop by more than 10%. A similar effect is found for the rest of the targeted densification packages. For example, the analysis shows that the "CBD-surrounding densification" package (TD1) causes emission reductions of 2.8% as a stand-alone policy and of 5% when it is combined with public transport support measures.

Figure 5.22. Emission reductions from promoting public transport and densification in the long run (2030-2050)

Estimated percentage of emissions eliminated in the long run by promoting public transport, with or without densification policies. The environmental effectiveness of displayed policies is considerably lower than in the mid-term. Percentage values are relative to emissions in the reference case in 2050.



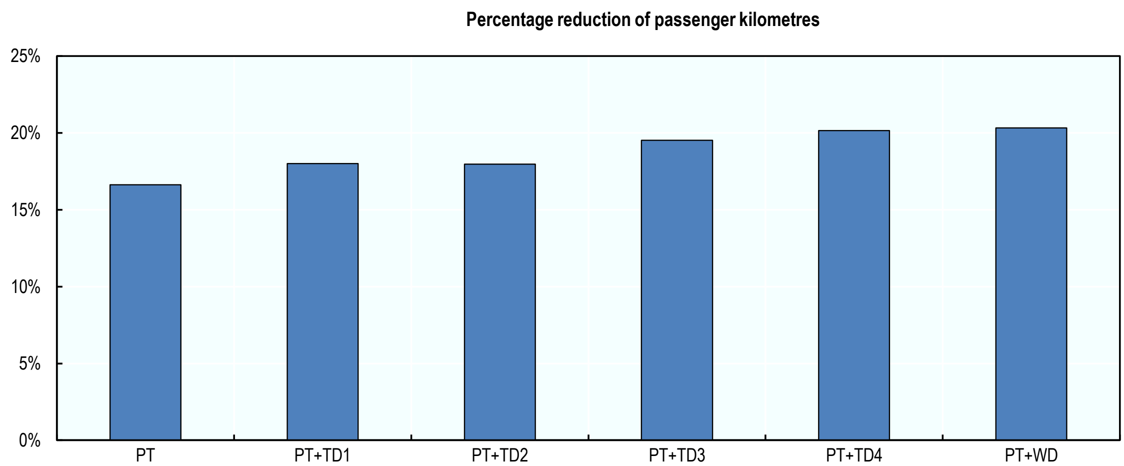
Note: PT refers to the "*promote public transport*" policy package; WD refers to a *widespread densification* program; TD refers to a *targeted densification* program; TD1 refers to further densification of already-dense areas lying close to major employment hubs and public transit nodes; TD2 refers to densification of low-density zones surrounding the central business district; TD3 refers to densification of low-density areas in Auckland's isthmus; TD4 refers to densification of areas in close proximity to employment hubs; combinations of the packages are denoted with '+'.
Source: Generated by the authors, using results of simulations from MOLES.

Densification decreases distances and thereby reduces travel time. In turn, this makes individuals more likely to respond to the price incentives the package incorporates. This is because as travel time falls, individual responses to price incentives become more elastic. Therefore, inducing people to switch transport modes is much easier than it would be, had the distances and travel times associated with public transport been longer.

The multiplicative effect of densification on the effectiveness of promoting public transport can be highlighted further with a closer look to the "job-surrounding densification" package (TD4). The analysis shows that densification around major employment nodes causes a non-negligible, but nevertheless limited increase (1.2 percentage points) in the share of kilometres undertaken by public transport. However, the same densification package causes the share of kilometres travelled on public transport to rise by 10.0 percentage points when this densification occurs alongside the "promote public transport" package. The reverse is also true: promoting public transport has a large effect in the share of passenger kilometres undertaken by public transport (26.0 percentage points) but that effect becomes even larger (34.7 percentage points) when TD4 is implemented. Similar findings can be reported for the rest of the densification policy packages.

Figure 5.23. Reduction in passenger-kilometres from promoting public transport and densification in the long run (2030-2050)

Estimated percentage of passenger kilometres reduced in the long run by promoting public transport, with or without densification policies. The environmental effectiveness of displayed policies is substantially lower than in the mid-term. Percentage values are relative to emissions in the reference case in 2050.



Note: PT refers to the "*promote public transport*" policy package; WD refers to a *widespread densification* program; TD refers to a *targeted densification* program; TD1 refers to further densification of already-dense areas lying close to major employment hubs and public transit nodes; TD2 refers to densification of low-density zones surrounding the central business district; TD3 refers to densification of low-density areas in Auckland's isthmus; TD4 refers to densification of areas in close proximity to employment hubs; combinations of the packages are denoted with '+'.
Source: Generated by the authors, using results of simulations from MOLES.

A large part of the environmental potential of densification may be undermined by strong and inelastic preferences for private open space (backyards). These preferences are relevant because a steep increase in building density implies a smaller amount of private open space (backyard) per unit of residential floor space. Therefore, when preferences for private open spaces are strong, densified areas become substantially less attractive. That increases the likelihood that a densification program will fail.

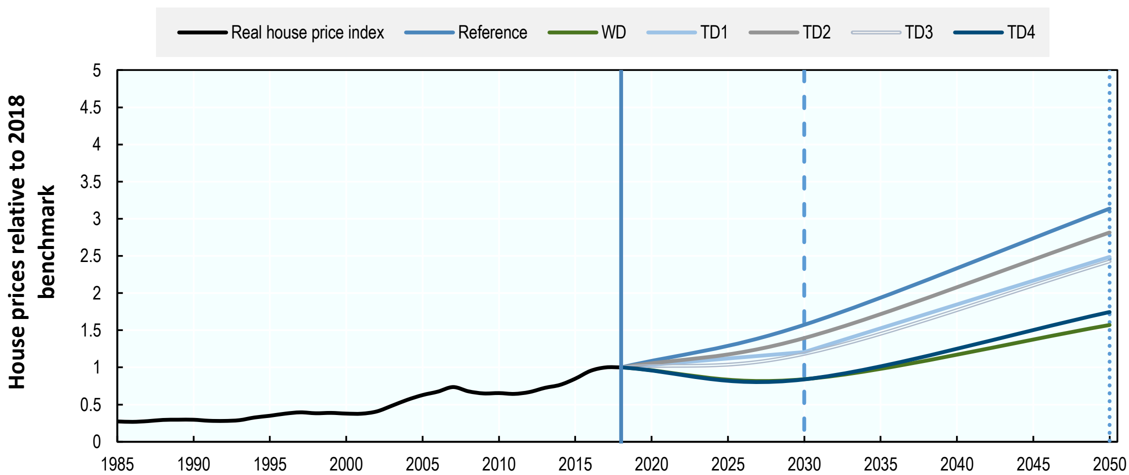
From an international viewpoint, the emission reductions induced by densification programs, as they are displayed in Figure 5.20 and Figure 5.22, can be seen as lower bounds in the decarbonising potential of these policies. This is because the preferences for private open space in New Zealand are particularly strong. The modelling exercise takes the structure of preferences into account, i.e. it assumes that large compensations are necessary to make up for any loss of private open space. As a result of that, all densification programs do not have the result that they would have in a context with more elastic preferences for private open space. The effect of weakening preferences for open space for the model results are tested in Chapter 6.

Finally, the modelling exercise understates the environmental potential of densification programmes, as jobs and facilities tend to follow the labour force. The reported results assume that the employment densities in the various locations evolve because individuals may change job locations. However, a more compact urban form would also induce jobs to move closer to the labour force. In turn, this would likely lead to a considerable decline in the kilometres generated by private vehicles in commuting.

5.3.6. Densification strategies and the housing market in the long run (2030-2050)

Figure 5.24. House price evolution

The evolution of house price index under the reference and counterfactual scenarios based on densification.



Note: TD refers to one of four targeted densification programs; TD1 refers to further densification of already-dense areas lying close to major employment hubs and public transit nodes; TD2 refers to densification of low-density zones surrounding the central business district; TD3 refers to densification of low-density areas in Auckland's isthmus; TD4 refers to densification of areas in close proximity to employment hubs; WD refers to a widespread densification program.
Source: Generated by the authors, using results of simulations from MOLES, (The Economist, 2019[3]).

Apart from facilitating the reduction of urban transport emissions, the various densification packages examined in the study are key to determining long-run housing affordability. Figure 5.24 displays the evolution of mean real housing prices from 1985 to the present, and the projected increase in these prices from 2018 to 2050. The historical data are based on numbers from The Economist (2019[3]), while the projections are results of simulations from MOLES.

Without a drastic policy intervention, the cost of housing in Auckland will continue growing along the current trajectory. The results of the reference scenario suggest that real house prices will be 60% higher by 2030 and at least 200% higher in 2050, compared to their levels in 2018. House price increases will affect all types of housing in a similar manner. Therefore, housing will become substantially more expensive in the long run.

The house price increases are likely to have a large distributional impact. Rising house prices benefits the segments of the population with a net positive income from rents to the detriment of renters with limited access to borrowing mechanisms.

For this reason, a widespread densification program is a necessary ingredient in a long-run policy response to the challenge of housing affordability. This type of densification has the potential to prevent housing prices from reaching levels that will cause further public discomfort. The simulations employed in the study show that widespread densification can limit real house price growth in the period 2018-2050 to 58%. That change lies slightly above the growth in the projected average income in New Zealand.

Targeted densification programs are the necessary intermediate steps between today's low-density urban form and a substantially more compact city in the future. Certain targeted densification programmes are welfare improving even in the short run, as shown in Figure 5.19. For example, introducing substantial densification in the isthmus area can limit the overall price growth until 2030 to 20%, i.e. much lower than the projected growth in the reference case, which is 60%.

The next subsection demonstrates that keeping housing prices on an affordable trajectory is key to long-run welfare.

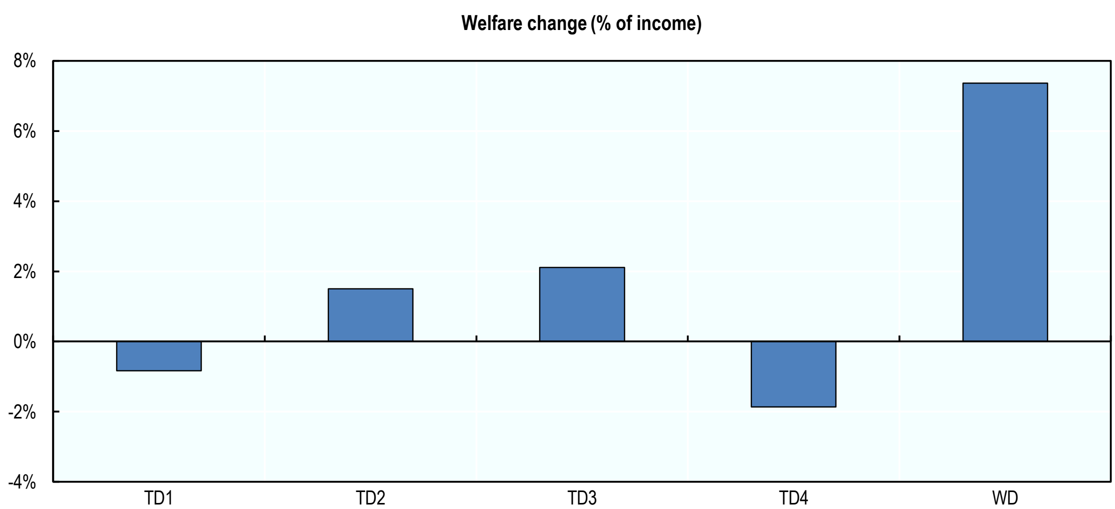
5.3.7. The long-run welfare impact of policy packages (2030-2050)

The capacity of widespread densification to slow house price growth translates into substantial welfare gains. Reduced upward pressure on housing prices allows households to allocate spending to other areas, which increases welfare. The methodology used for the calculations of welfare impacts is detailed in Chapter 3.

The annual welfare gains of widespread densification amount to approximately 7.4% of income in 2050. This is the largest annual welfare gain computed by any policy or combination of policies in the study. Thus, addressing housing affordability through widespread changes to land-use regulations should be a key policy priority.

Figure 5.25. The long-run (2030-2050) economic impact of recommended land-use policies

The annual welfare gains or losses *per capita* from various densification programmes.

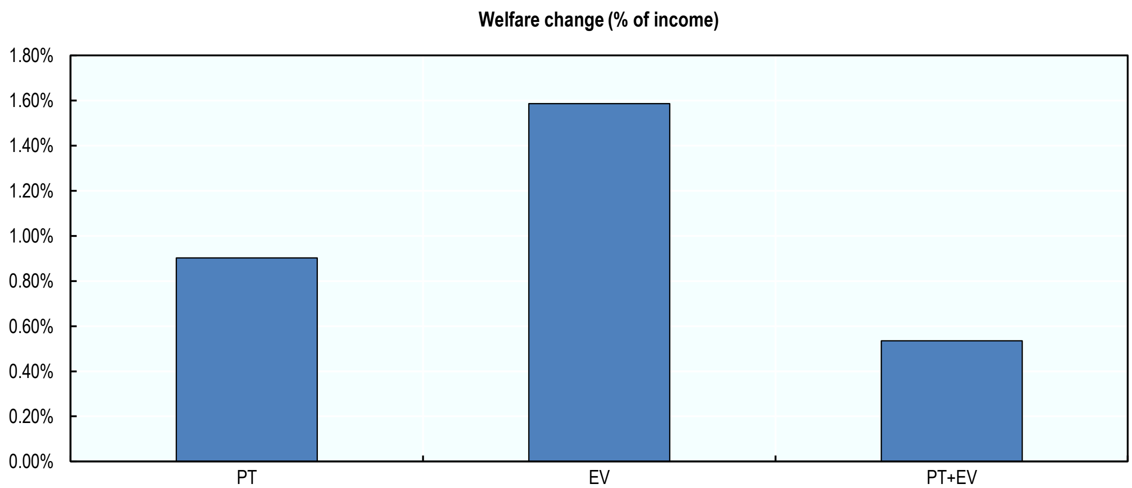


Note: TD refers to one of four targeted densification programs; TD1 refers to further densification of already-dense areas lying close to major employment hubs and public transit nodes; TD2 refers to densification of low-density zones surrounding the central business district; TD3 refers to densification of low-density areas in Auckland's isthmus; TD4 refers to densification of areas in close proximity to employment hubs; WD refers to a widespread densification program.
Source: Generated by the authors, using results of simulations from MOLES.

The transition to a more compact urban form is not likely to occur in a short time window. Rigid regulations, natural frictions in the transformation of a developed urban fabric and opposing views on the socially desirable urban development pattern will delay that process. Figure 5.25 shows that densification packages TD2 and TD3 generate substantial welfare gains, slightly below and above 2% of net income respectively. This implies that the welfare benefits from densifying the inner part of the urban area outweigh the losses from the decrease in the supply of private open space. Thus, a considerable part of the welfare gains of widespread densification can be seized with a targeted densification program. This programme would focus initially on the areas surrounding the central business district and subsequently on areas of low density within the isthmus area. However, restricting policy action to partial densification will not comprehensively address the issue of diminishing housing affordability, as the evolution of the housing market under different scenarios presented in Figure 5.24 suggests.

Figure 5.26. The long-run (2030-2050) economic impact of recommended transport policies

The annual welfare gains *per capita* from promoting public transport, EVs and both.



Note: PT refers to the "*promote public transport*" policy package; EV refers to the "*promote electric vehicle*" policy package; PT+EV refers to the combined implementation of the two policy packages.
Source: Generated by the authors, using results of simulations from MOLES.

The annual *per capita* welfare impact of transport policies is shown in Figure 5.26. Promoting public transport, electric vehicles or both will all generate considerable welfare gains in the period from 2030 to 2050.

Public transport subsidies incorporated in the "promote public transport" package could be more efficient in increasing the share of passenger kilometres travelled via public transport in the long-run than they are in the mid-term. This is because the non-modelled advantages that cars possess over public transport diminish by 2050, as shown in Figure 5.5.[2] However, the latter effect is outweighed by the increasing fuel efficiency of ICE vehicles.

5.3.8. Policy recommendations for the long run (2030-2050)

- **Implement a widespread densification program.** The simulations show that a widespread densification program will be effective in reducing greenhouse gas emissions and in curbing house price growth. In[3] spite of the strong preferences for open space, the model results indicate that a generalised relaxation of building heights and other density regulations will generate significant welfare gains.

- **Gradually increase the level of the fuel tax to offset the improvements in the fuel economy of ICE vehicles.** The level of the ETS component of the fuel tax should be aligned with the environmental objectives it serves. It could, for example, be linked to the average fuel efficiency of New Zealand's vehicle fleet, so that in the long-run that tax is automatically adjusted to offset the introduction of more fuel efficient vehicles.

- **Increase the flat kilometre tax, aligning it better with the increasing external costs of congestion.** Congestion externalities will very likely worsen over time. This is because a greater number of vehicles will be using the road infrastructure, which will not expand at the same pace. Furthermore, rising income implies a higher value of time. This means that every minute lost due to traffic will also have a higher social cost. Government can play a role by preparing the ground for tax instruments that will both offset an expected increase in congestion and charge the social cost of vehicle use to those using them. The existing kilometre tax is an example of such an instrument. It will have to be adjusted to match the cost of congestion and other traffic externalities more closely.

- **Increase public transport subsidies once the quality of public transport service has been substantially improved.** Public transport subsidies are more effective once the public transport system has been adjusted to improve service frequency, reliability and connectivity. Under these conditions, a switch from private vehicles to public transport can be achieved with relatively smaller public transport subsidies. That will be facilitated further by the emergence of a more compact urban form. The latter will increase public transport ridership and the occupancy rate in modes of public transport, which is currently low. In turn, that will further reduce the deficits of the public transport system. The study suggests that generous subsidies in public transport fares can be fully financed by the increase in the flat kilometre tax.

- **Further incentivise the switch to electric vehicles.** Direct and indirect subsidies to EVs will be more effective once the underlying technological differences between ICE and electric vehicles have been reduced. In the long-run, a flexible system of subsidies to EVs should be designed. Such a scheme should provide moderate subsidies, possibly financed by an increase in the annual ownership cost of ICE vehicles. However, the study suggests that such a scheme could have only moderate effects if the technological gap between the two vehicle types is not narrowed substantially.

- **Combine support for electric vehicles with public transport subsidies.** The EV subsidy scheme could also be combined with an active policy that promotes public transport in a way that minimises potentially antagonistic effects. For example, moderate EV subsidies could be provided in areas that will remain sparse and therefore hard to cover efficiently by public transport, while public transport subsidies could be higher for trips within a denser urban core.

- **Allow further expansion of the city only if future urban areas are well connected to the public transport system.** The social cost of future urban expansion will depend on whether future urban areas are well connected to public transport corridors and other forms of critical infrastructure.

Notes

[1] One of the study's limitations is that the fiscal costs of increased use of public transport are not considered in the welfare calculations. The implications of this are discussed in Chapter 6.

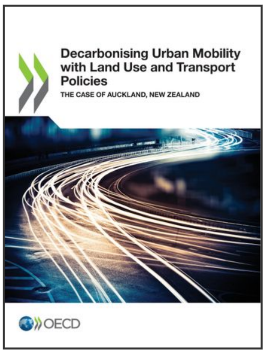
[2] That change represents an overall improvement in the public transport system of Auckland that cannot be explicitly modelled in the study. The planned infrastructure investments in transport suggest that this improvement will be sizeable.

References

Auckland Transport (2018), *Auckland's Low Emission Bus Roadmap*. [2]

The Economist (2019), *Global cities house-price index*. [3]

Tikoudis, I. and W. Oueslati (2017), "Multi-objective local environmental simulator (MOLES 1.0): Model specification, algorithm design and policy applications", *OECD Environment Working Papers*, No. 122, OECD Publishing, Paris, http://dx.doi.org/10.1787/151cf08a-en. [1]



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