Chapter 1. The challenges related to decarbonising transport in low-density urban areas

This chapter frames the overall importance of decarbonising transport in low-density urban areas, the responses available to policy makers and their anticipated impact. The challenge is considerable, as cities are currently home to 50% of world's population but are responsible for 60-80% of global CO2 emissions. Urban policy action is imperative, since city populations and global urban land cover will continue growing and technological solutions alone will not suffice to offset that growth. Rapid policy interventions on the areas detailed in the report should therefore be prioritised if the targeted emission reductions are to be achieved.

1.1. Why is urban transport important in tackling climate change?

Urbanisation has been one of the cornerstones of economic expansion in the 20th century. For decades, uninterrupted economic growth has fuelled, and been fuelled by, growth in urban areas and urban populations. Slowly, a series of interrelated challenges have emerged, exerting pressure on the ability of cities to generate prosperity. Climate change is at the forefront of these issues and its impacts on natural systems and human communities are already being felt (IPCC, 2018[1]).

The economic, geographic and demographic prominence of cities makes them central to climate change mitigation. By 2050, about 70% of the world's population is expected to live in urban areas, a figure that could be as high as 85% in OECD countries. Over the same period, global urban land cover is projected to increase five-fold: from approximately 600 000 km^2 in 2011, to 3 million km^2 of land in 2050 (Angel et al., 2011[2]). Given these trends, cities will play an increasingly central role in the effort to reduce greenhouse gas emissions from human activities.

There are critical differences in the consumption patterns that underlie urban and rural lifestyles. People in urban areas have higher incomes, use energy-intensive services for transport, housing and recreational purposes and benefit from the provision of energy-intensive facilities that often do not exist in rural areas. These characteristics make cities particularly relevant for efforts to reduce greenhouse gas emissions. Furthermore, road travel in urban areas often takes place on congested roadways at low average speeds, leading to greater fuel consumption and emissions per kilometre travelled, relative to optimal conditions. As a result, the *per capita* carbon footprint of urban populations is larger than that of rural populations: cities are currently home to 50% of world's population but are responsible for 60-80% of global CO_2 emissions (OECD, 2010[3]). This share is likely to increase as urbanisation continues uninterrupted. Therefore, climate action at the city level is an essential element of policy portfolios to limit the rise in global average temperature.

Decarbonising urban transport is a crucial part of such policy action, as reducing emissions in this sector is particularly challenging. Greenhouse gas emissions from transport make up approximately one third of total urban greenhouse gas emissions in major cities and constitute a significant obstacle in the pursuit of emissions reduction targets (C40, 2019[4]). Transport-related emissions have risen faster than in any other sector over the past three decades. Reducing the emissions generated by the transport sector will require a shift away from fossil fuel powered vehicles and a move towards public transport and electric vehicles. Decarbonising the power generation sector is an important component of strategies that shift transport towards electromobility.

1.2. What policies can be deployed to reduce transport emissions at the urban level?

Policies can reduce emissions from the transport sector through multiple channels:

1. Reducing the emissions intensity per *passenger kilometre* travelled, by encouraging a shift from private vehicles to public transport, biking or walking and by incentivising carpooling or car sharing.
2. Reducing the emissions intensity per *vehicle kilometre* travelled, through measures that encourage shifts from fossil fuel-powered cars to electric vehicles (EVs).

3. Reducing the emissions intensity per *vehicle kilometre* travelled, through incentives to use more energy-efficient vehicles.
4. Reducing the emissions intensity per *vehicle kilometre* travelled with electric vehicles, by investing in less carbon-intensive modes of electricity generation.
5. Reducing the *total number of kilometres* travelled, by encouraging fewer trips, for instance by making trips more expensive or by incentivising teleworking.
6. Reducing the *total number of kilometres* travelled, by shortening trip distances, for instance by incentivising compact urban forms.

The primary focus of the report is on policies that reduce emissions *mainly* through channels 1, 2, 5 and 6. Such policies make use of the following instruments: kilometre taxes on the use of private vehicles; fuel taxes; road pricing; annual circulation fees; public transport subsidies; exemptions of EVs from various pricing mechanisms; purchase subsidies to EVs; non-pecuniary incentives for EV use, such as the right to use bus lanes; building-height restrictions; and private open space regulations.

Most of the above *transport policies* affect the decision to own a vehicle, the choice of vehicle type and the way that vehicle will be utilised. Therefore, they have an impact on the ownership rates, the shares of different vehicle types in the fleet and the overall level of traffic. Transport policies play a key role in determining the average carbon footprint of a passenger and a vehicle kilometre. Furthermore, these instruments affect the *modal split*, i.e. the percentage of trips or kilometres traversed by each mode of transportation.

Policies whose primary aim is to reduce private vehicle ownership could lower emissions through their impact on the size of the vehicle fleet. Such policies increase the generalised cost of owning and operating a private vehicle. For instance, they can increase registration and annual circulation fees, fuel taxes, parking fees and other relevant road use charges. They could also include measures such as transit fare subsidies, which increase the attractiveness of public transport.

Policies whose primary target is a shift in modal split should be part of the overall effort to decarbonise urban transport. Such policies increase the relative cost of private vehicle use *vis-à-vis* other, greener forms of urban mobility, like public transport, but also cycling and walking. This change in relative cost can be achieved either by increasing the generalized cost of car use, for instance through parking fees and road use charges, or by reducing the generalised cost of public transport and soft mobility options. For instance, investments in dedicated bike roads and in infrastructure for pedestrians can be included in the latter category.

Policies that mainly promote EVs are also key, as these vehicles can play a major role in reducing greenhouse gas (hereafter, GHG) emissions generated from urban road transport. This is particularly the case in countries like New Zealand, where the carbon intensity of electricity generation is very low (Transpower, 2018[5]). Provided this, a switch to electric vehicles will entail a drastic reduction in transport-related GHG emissions. However, in order for this transition to occur, the cost of owning and operating an EV must fall steeply relative to a conventional internal combustion engine vehicle (hereafter, ICE vehicle). Convergence to parity between ICE vehicles and EVs through technological development is a slow process, calling for policies that increase the generalised cost of ICE vehicles vis-à-vis EVs. Typically, such policies subsidise the purchase of EVs, grant them preferential treatment with respect to their daily use and exempt them from pricing mechanisms that apply to ICE vehicles.

Land use and urban planning policies have a less obvious but considerable effect on urban transport emissions, particularly in the long run. These policies determine the spatial distribution of economic activity and population density and therefore have an impact on transport demand and long-run travel patterns. If these policies foster sparser residential development and discourage mixed land use, an urban development pattern characterised by larger distances between residences, jobs, shopping and leisure locations is more likely to emerge. In turn, greater sprawl implies greater use of motorised transport and more dependence on private vehicles. This has significant environmental implications, underlining the importance of land use and urban planning tools.

Urban structure has long been known to affect the carbon footprint of a city. The predominance of a low-density residential development pattern, also known as *urban sprawl*, is statistically associated with a steep increase in *per capita* GHG emissions from the transport sector. Cities with a lower average population density are in general more dispersed, as their key points of economic activity (jobs, residences, shopping malls, leisure hubs) lie at larger distances from each other (OECD, 2018[6]). Thus, the number of *per capita* passenger kilometres is generally higher in sprawled urban areas. The same is true for the carbon intensity of the average passenger kilometre in sprawled cities, as these are often highly dependent on car use and highly congested. Due to their low density, these cities are also less likely to offer extensive public transport systems whose services efficiently cover the urban fabric. The literature has explored various other channels through which the negative relationship between density and transport-related energy consumption is formed.

The environmental ramifications of urban development patterns are significant. This holds true because the relationship between density and transport-related energy consumption is highly non-linear: very high fuel consumption is observed in areas of low population density (Newman and Kenworthy, 1989[7]). As population density increases, the corresponding fall in fuel consumption grows progressively smaller. This means that an increase in population density in a low-density area is associated with a larger decrease in fuel consumption, than the same increase in an area of high population density (Newman and Kenworthy, 1989[7]; Mindali, Raveh and Salomon, 2004[8]).

Moreover, urban development patterns are an integral part of successful public transport systems, namely because these systems are more expensive to provide in low-density areas. Thus, policies that increase population density may reduce the subsidies public transport requires (OECD, 2018[6]). As a result, policy reforms targeting a greener modal split are more effective in compact settings, where public transport services and soft mobility infrastructure can be provided at a lower social cost. However, a more compact urban form, in which multi-family dwellings are the predominant type of development, may present certain barriers to the widespread adoption of EVs. This holds true especially if the development pattern is characterised by a lack of private parking spaces, where EVs can be recharged. In that sense, densification policies may be synergistic or antagonistic with respect to other policies intended to decarbonise urban transport. A more comprehensive understanding of these potential interactions is therefore warranted.

Policies that promote a more compact urban form are fundamental in the long-run success of urban transport decarbonisation strategies. Such policies may include the relaxation of building height restrictions and the acceleration of infill development. The former measure allows buildings to be higher, resulting in more residential floor space in the long run. The latter measure reduces private open space, e.g. backyards between buildings or dwellings. Both measures can be spatially differentiated, i.e. they can be applied only in designated areas where densification is environmentally relevant and economically efficient. For example, governments can prioritise densification in areas where land use is mixed, i.e. in areas where residences coexist with jobs, shopping facilities and other key points of economic activity. By increasing housing supply in these areas, policy makers bring a larger part of the population closer to areas of economic activity, thereby shortening average trip length. In turn, the reduction of trip distances could lead to sizeable reductions in vehicle kilometres and thus in greenhouse gas emissions. Similarly, policy makers may choose to postpone densification in remote suburban residential areas that lie far from the key points of economic activity.

Each of the policies examined in the report can reduce emissions through multiple channels. For instance, increasing fuel taxes may trigger higher shares of carpooling and biking or it may cause some car users to switch to public transport, reducing the carbon footprint of each kilometre they travel. Additionally, increased fuel taxes may also generate incentives for people to acquire more fuel-efficient cars, vehicles that do not use conventional fuel, e.g. EVs, or to relocate their residence closer to the end destination of their trips. Therefore, each of the aforementioned policies could have an impact on more behavioural margins than the ones it was initially designed to affect.

Different policies take effect across different time horizons. Typically, the effects of transport policies are quick to manifest, while the effects of land-use policies are slower to materialise. In the short run, changes in driving behaviour, such as adjustments in speed and vehicle route, can have an direct impact on fuel consumption and, consequently, on emissions from urban transport. Policies including road pricing and parking fees may also affect behaviour in the near term and are likely to relocate traffic and reduce its external effects. The various impacts of policies, as they materialise in the short, medium and long term, should be carefully evaluated in order to design socially desirable policies that accelerate the transition to green mobility.

The exact social cost of decarbonising urban transport with the measures described in this chapter is highly context-specific, i.e. it depends on the urban area under examination. For example, promoting public transport in compact urban areas comes at a significantly lower social cost than in sprawled cities characterised by fragmented public transport systems. The greater social cost incurred in sprawled urban areas arises primarily from the fact that populations living in these areas are more likely to depend on private vehicles. Therefore, increasing the pecuniary cost of car use in these areas may cut down tailpipe emissions, but it is also likely to reduce the well-being of those without a viable alternative to car. Promoting public transport through fare subsidies will not necessarily lower the social cost of such reform, as these subsidies have to be financed through taxes. Additionally, fare subsidies have to be of a considerable magnitude in order to induce significant changes in urban mobility patterns. This narrative is possibly much different in a compact urban area, in which the aforementioned policies could thrive much easier. This example illustrates the degree to which the success of transport policies is contingent on existing land use patterns.

Therefore, the various general strategies for decarbonising transport proposed in this report have to be tailored to the exact context of each specific city. The optimal mix of decarbonisation policies in a city depends on its spatial layout, the configuration of its networks and its various land use and transport regulatory mechanisms. Importantly, optimal decarbonisation strategies also depend on the wider socioeconomic background of the area and on key technological parameters that characterise the energy sector. The city case study elaborated in this report carefully controls for the above considerations. It takes into account the various idiosyncratic characteristics and gauges the extent to which these distinctive elements drive the key findings. With this approach, the report provides both overarching policy recommendations, applicable to numerous urban areas around the world, as well as more detailed proposals that apply to the urban area of Auckland, New Zealand.

1.3. Policy context and approach

This report provides an in-depth examination of various decarbonisation strategies for the urban transport of Auckland, the biggest and fastest growing city in New Zealand. Auckland faces a series of structural and demographic challenges common to many cities around the world. These challenges include low population density, which is associated with high costs of public transport provision, and car dependency, which acts as a barrier to reducing the city's future carbon footprint (OECD, 2018[6]). The above characteristics contribute to the share of greenhouse gas emissions generated by road transport in Auckland (37.6%), which is high but comparable to that of other sprawled cities (Xie, 2017[9]; Auckland Transport, 2018[10]). Furthermore, New Zealand has the highest rate of car ownership in the OECD and has a relatively old and inefficient car fleet (OECD, 2017[11]; Ministry for the Environment & Stats NZ, 2019[12]). As a result, emissions from road transport make up 39% of all carbon dioxide emissions, which is significantly higher than in many other developed countries (Ministry for the Environment & Stats NZ, 2019[12]).

Auckland's low population density, high degree of car dependency, and inefficient provision of public transport are closely related to the issue of diminishing *housing affordability* in the city. Between 1990 and 2017, real house prices in Auckland rose by 300% (The Economist, 2019[13]). Growth in house prices has been more rapid than growth in wages: between 2002 and 2014 the median house price in Auckland increased by 159%, while the median income increased by just 46% (Tuatagaloa, 2017[14]). Rapid population growth and stringent land-use regulations are the primary drivers of rising housing prices. While some land-use regulations in Auckland are motivated by the local importance of volcanic view shafts and the need for stormwater disposal, they have prevented housing supply from meeting the growing demand (New Zealand Social Investment Agency, 2017[15]). As such, the regulatory mechanisms that generate the conditions for car dependency also contribute to higher housing prices. This means that policy initiatives regarding land-use regulation could both reduce greenhouse gas emissions from mobile sources and address the issue of housing affordability.

The study assesses a series of policies, presented in detail in the previous section, which can be grouped into three broad categories. The first category contains policies set to induce a massive switch from private vehicles to public transport, essentially through pricing and subsidy instruments designed to increase the cost of the former relative to the latter. Through a similar set of measures, a second category attempts to generate a massive switch from ICE vehicles to EVs. Finally, the third category includes instruments that aim to develop a compact urban form in the long run, in which trip distances will be smaller and daily travel much less energy demanding.

The report assesses these policies from various viewpoints. First, it reports the environmental impact of each policy by calculating the associated change in greenhouse gas emissions and by converting that change into a monetised measure of social welfare. Second, it computes the social welfare benefit and cost of the aforementioned policies. In particular, the study monetises the impacts from changes in congestion, housing prices and household budgets. Finally, the study gauges the fiscal effect of each proposed policy by calculating its impact on the revenue generated by key existing taxes. For instance, the analysis contains calculations of the effect of a change in the kilometre tax on the revenue generated by fuel taxes. Through this approach, the report estimates the social value of the fiscal surpluses or deficits a policy induces.

The analysis is carried out with the use of the Multi-Objective Local Environmental Simulator (MOLES), an urban Computable General Equilibrium (u-CGE) model constructed by the OECD in order to examine the environmental effectiveness and economic efficiency of urban policies targeting land use and transport. The report presents a specific version of MOLES that has been tailored to account for the particular characteristics of Auckland. The urban area's spatial layout, the physical configuration of its transport networks, the mobility patterns of its population and the prevailing traffic conditions are some of the key elements that the model either uses as input or is calibrated to reproduce.

1.4. Key questions, findings and the contribution of the report

The report seeks to provide answers to three overarching questions:

- Will technological change in the electric vehicle industry lead to significant reductions in urban tailpipe emissions?
- What is the role of transport and land use policies in reducing urban greenhouse gas emissions?
- Are these policies welfare improving, once their wider impact on the economy and society is taken into account?

The study thoroughly investigates the first question, which is key since a switch to electromobility could significantly reduce transport sector emissions. That is, the analysis goes beyond providing an answer for the case of New Zealand, where the carbon intensity of a kilometre driven by an EV is particularly low. It also attempts to provide insights from a global perspective, in which the electricity used to power EVs is on average much more carbon intensive.

With respect to the second question, the report examines the degree to which policies targeting land use and transport are effective means of reducing greenhouse gas emissions. In line with that, the analysis offers several insights on the behaviour changes that may occur with the implementation of these policies. The report explains how each policy works and why some of the considered policies may fail to deliver the results they were hoped to. The underlying modelling approach factors in the interaction between national policies, such as taxes on gasoline and electricity, and local policies, such as parking fees and urban road pricing. Furthermore, it examines the degree to which these findings depend on the most important working assumptions through an extensive sensitivity analysis, which facilitates comparison with other studies.

The third question regards the aggregate social costs and benefits of the examined land use and transport policies. While a considerable share of this report's focus lies on the environmental effectiveness of various policies, their socioeconomic impacts – whether positive or negative – can be substantial. This is primarily because the policies considered in the study affect private budgets, as well as land and housing prices, and thus alter housing affordability and the daily cost of living. The report controls for this aspect by assessing each policy's economic efficiency, i.e. the associated social cost stemming from these wider impacts. Furthermore, many of the investigated policy instruments are essentially taxes whose adjustment alters the base of other important taxes. For instance, an adjustment of the flat kilometre tax – a policy the report places emphasis on due to its widespread use in New Zealand – causes a change in the level of car use and thus affects the revenue of the fuel tax. In this way, the analysis explicitly accounts for the social costs stemming from the erosion of tax bases. The above impacts are then incorporated into detailed cost-benefit calculations, resulting in the construction of a single welfare measure. That measure captures the environmental effectiveness, economic efficiency and fiscal impact of each policy. Given that the measure permits the direct comparison of policies whose various impacts differ widely, it is highly relevant as a tool for policy development.

The report highlights the overall importance of targeted mitigation policies as a complement to technological progress and innovation. It finds that substantial policy interventions are required to reduce total emissions from urban transport. Although technological developments will likely decrease urban transport emissions *per capita*, they will offset only a part of the expected rise in total emissions from urban transport. Under the reference scenario, in which no substantial policy change occurs, total emissions from road transport will continue increasing. In 2050, technological progress – as it is projected to occur in the reference scenario of the report – will have lowered *per capita* emissions by only 40% relative to 2018. Therefore, the projections show that technological evolution *per se* will be far from sufficient to ensure carbon neutrality by 2050.

The results indicate that promoting the use of public transport offers one major pathway to emission reductions. Measures aiming to increase the private cost of vehicle ownership and to decrease the private cost of public transport use could yield significant reductions in aggregate emissions. Policies that promote public transport can reduce *per capita* emissions from urban transport by 25% relative to their levels in 2018. The latter reduction comes on top of the 40% reduction stemming from expected technical progress. The analysis shows that in order for policies promoting public transport to be successful from a social viewpoint, they will have to combine a set of substantial increases in the kilometre cost of car use with sizeable public transport fare subsidies. A successful combination of these policy elements could generate welfare gains that account for 1% of income.

One of the most striking findings of the report is that the pecuniary-based public transport policies such as fare subsidies or private vehicle road pricing are unlikely to induce a massive shift away from private car ownership, especially in urban areas like Auckland. Many cities around the world remain heavily car-dependent, as the population density in a large share of their footprint is low, travel distances within them are long and public transport services are inefficient or unreliable. Dependency on private vehicles limits the degree to which policies promoting public transport can successfully increase public transport use in these areas. This limitation will subside only after the key characteristics of their public transport systems, such as spatial coverage, connectivity, comfort and reliability, improve substantially.

The degree to which a shift to public transport can ensure a substantial reduction in greenhouse gas emissions depends on the composition of the fleet of public transport vehicles. The extent to which public transport is electrified is important, as public transport in many cities around the world remains heavily reliant on diesel-powered buses. The carbon intensity of the electricity grid is also important, as a switch to public electromobility entails a larger reduction in greenhouse gas emissions when the consumed electricity has a lower carbon footprint.

Promoting the use of electric vehicles may offer another path to considerable reductions in emissions from urban transport. The findings show that the associated policies increase the ownership rate and use of electric vehicles and reduce the respective figures for ICE vehicles, leading to a 20% reduction in the *per capita* greenhouse gas emissions from urban transport.

The report also highlights the extent to which an accelerated adoption of EVs will significantly reduce greenhouse gas emissions, as this reduction depends on the carbon intensity of the electricity-generating sector. For instance, the mitigation potential of EV adoption can be drastic in New Zealand, where the share of renewable energy in the electricity grid is very high. However, that is not necessarily the case in other parts of the world, where the carbon intensity of electricity generation is higher. That conclusion is supported by the fact that the amount of CO_2 emitted to produce one kilowatt-hour of electricity in New Zealand is lower than the OECD average by a factor of four (IEA, 2017[16]). In countries with a lower share of energy generated from renewable sources, emissions from electricity generation could undermine the potential of policies promoting electromobility to reduce greenhouse gas emissions. Therefore, policies supporting electric vehicles should be accompanied by a decarbonisation of the electricity generation sector.

One of the study's most notable findings is that land-use policies have substantial long run potential to reduce urban transport emissions. The analysis reveals that a general relaxation of density regulations, which gives rise to a more compact urban form, may act as an effective complement to policies that promote public transport. When the latter policies are present, densification policies eliminate a further 5% of total emissions from urban transport. This figure, which is derived within the context of Auckland and its expected development to 2050, can be much higher if densification is combined with restrictions on the development of remote suburban areas.

Apart from their environmental impact, the report highlights the wider social benefits that reforms in land use regulations may bring. For instance, the results indicate that widespread densification, which implies an increase in housing supply, slows the growth in the cost of housing. The associated welfare gain of such a policy is substantial, as the report finds that it exceeds 7% of net income in Auckland in 2050. Cities with comparable characteristics are likely to be able to achieve similar outcomes.

The policies examined in the report do not suffice to eliminate greenhouse gas emissions from urban transport. That is, the expected technological growth and the various land-use and transport policies eliminate up to 70% of the *per capita* emissions by 2050. Eliminating the remaining 30% of emissions requires substantial investments in public transport infrastructure, as well as in research and development (R&D) that has a potential to accelerate innovation in key areas relevant to the transport sector. Speeding up technical progress in the electric vehicle industry, solving energy storage challenges and developing cheaper batteries will accelerate the penetration rate of electric vehicles.

This report outlines pathways for cutting greenhouse gas emissions from urban transport in Auckland and in other areas with similar characteristics. Looking ahead to 2050, policy action to reduce emissions from the transport sector is critical for achieving the targets set under the Paris Agreement and the SDGs. Land use and transport policies are slow to take effect on the urban structure of a city and the composition of its vehicle fleet. The report highlights the areas in which there is a need for rapid policy action if the targeted reductions are to be achieved.

1.5. Navigation through the report

The report is developed in two parts. The first part, which spans Chapters 2 to 4, lays out the methodological context of the analysis. It provides a detailed description of the various scenarios, data sources, the way they were processed and their role in the study. It also describes, in a non-technical manner, the model used in the policy simulations and its ability to reflect the empirical regularities of Auckland and New Zealand. The second part, which spans Chapters 5 and 6, presents the findings of the analysis and their sensitivity to the working assumptions made *a priori*. It therefore provides a series of policy insights that apply to Auckland and to other urban areas facing similar challenges.

Chapter 2 presents the baseline scenario, as well as the various counterfactual scenarios examined in the study. The former scenario is also referred to as the reference scenario, since it constitutes the reference case in which all currently implemented policies are kept fixed and all currently announced policies for the period from 2019 to 2050 materialise. In contrast, the chapter presents various counterfactual scenarios that introduce new land use and transport policies in the same period.

Chapter 3 provides a non-technical description of MOLES, an urban CGE model OECD developed to evaluate the environmental and economic impact of land use and transport policies. The chapter presents a version of MOLES that is tailored to incorporate a number of important characteristics of Auckland's urban area in the analysis. It details how the behaviour of households and real-estate developers is modelled and elaborates on the way housing and land markets function in the model. It also describes how the various outcomes of the modelling exercise, which include transport, emission, welfare, housing and fiscal indicators, are calculated.

Chapter 4 provides a navigation of the various data sources and model calibration. The first part of the chapter describes and visualizes how land use and travel survey data are combined to create a stylised representation of Auckland's spatial layout. The chapter elaborates on the use of other data sources, such as traffic, census and vehicle fleet data. exhibits the fit of the model to the empirical regularities of Auckland and New Zealand. The second part of the chapter provides details on the various stylised facts MOLES simulations yield in the benchmark year of the study, i.e. 2018. These include the way households spend their income and allocate their time, as well as their travel behaviour and its sensitivity to changes in price and income.

Chapter 5 exhibits the key findings of the report, i.e. the results from the evaluation of reference and counterfactual scenarios. These include the environmental, housing, fiscal and welfare implications of the various scenarios in which different transport and land use policies are implemented. The results also highlight the impacts of policy inaction, which is evaluated with the use of the reference scenario. The environmental and economic impact of the various interventions is shown to be particularly diverse: the various policies may yield very different welfare effects, whose magnitude depends on the time frame in which these policies are implemented. Therefore, the analysis does not only focus on highlighting the policies that curb greenhouse gas emissions and increase welfare, but also on identifying the optimal timeline for implementing these policies.

Chapter 6 explores the degree to which the key policy recommendations of the study are applicable beyond the case of Auckland. To this end, it demonstrates the effect of changing several key assumptions on the projected reductions in greenhouse gas emissions. Moreover, the chapter offers an extensive sensitivity analysis with respect to various model parameters. This analysis identifies the factors and parameters that have an important impact on the key conclusions of the report. It also facilitates the adjustment of key policy recommendations to other contexts, i.e. in settings where these factors and parameters may differ substantially from Auckland. Finally, the chapter enumerates a series of methodological limitations of the analysis and the impact they have on the key conclusions.

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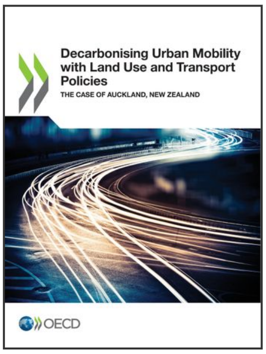

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