CIVITAS
Sustainable and smart mobility for all

2030

Developing Transition Pathways towards Sustainable Mobility in European cities by 2050

Introduction and User Guide to the Carbon Reduction Strategy Support Tool.

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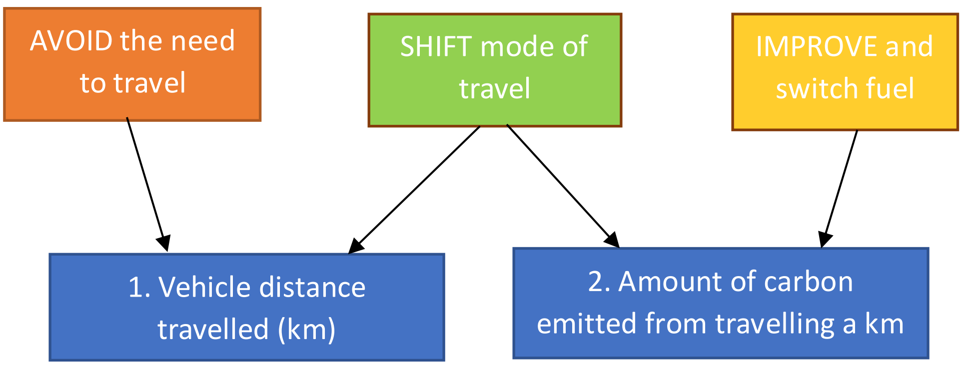
1. Introduction to the Carbon Reduction Strategy Support Tool

The Carbon Reduction Strategy Support Tool has been developed in the SUMP PLUS project to provide cities with better intelligence on the impacts of different mobility policy strategies on carbon emissions over a 30-year timespan. The tool allows backcasting from a future vision of defined carbon reduction targets by highlighting the high-level policy strategy mix that will achieve the target. A "high-level policy strategy mix" means that strategies are defined at a general level to form a package that is complementary overall, rather than defined in terms of specific measures (as per the SUMP).

The high-level policy strategy mix for carbon reduction includes 3 main policy areas based on the A-S-I (Avoid, Shift, Improve) framework. Inspired by the principles of sustainability, the A-S-I approach structures policy strategies focusing on the mobility needs of people instead of car infrastructure. This approach is appropriate for cities seeking to achieve significant GHG emission reductions, reduced energy consumption, less congestion, with the final objective to create more liveable cities. It also allows mobility and carbon impacts from policy strategies applied in other sectors to be captured (i.e. those sectors that generate mobility demands or whose activities impact on transport carbon emissions).

Within their strategic long-term planning, cities need to decide how much emphasis to place on which policy area (Avoid, Shift, and Improve) to achieve 2030 and 2050 carbon reduction targets. This is not about providing technical guidance on emissions modelling related to a particular measure in a specific city. Instead, the tool is showcasing the range of contributions to 2030 and 2050 carbon reduction targets estimated for broad application of Avoid, Shift and Improve policies. From this, cities can make more informed decisions on the policy mix most appropriate to their circumstances at different points in time (up to 2050).

Fundamentally there are 2 factors that influence carbon emissions from transport. These are the vehicle distance travelled and the amount of carbon emitted from travelling a km defined by the fuel efficiency and carbon intensity of the vehicle used. Reducing carbon requires reducing vehicle distance travelled by Avoiding the need to travel and by Shifting mode of travel from car to more sustainable alternatives, and/or Improving engine efficiency/carbon intensity of fuel so that each kilometre of travel emits less carbon.



Within each policy area are a small number of identified key policy strategies that impact on carbon reduction.

AVOID policy – 4 strategies

Avoid the need to travel by substituting physical travel with digital access to services/home delivery

a. commuting trips avoided due to home working
b. personal business trips avoided due to digital access to services (GP's, banking)
c. shopping trips avoided due to home delivery

Avoid the need to travel long distances through localisation

d. daily trips for shopping, leisure, personal business, education activities localised within 15-minute walkable neighbourhood

SHIFT policy - Shift mode of travel from car to sustainable modes.

a. <3km: promote shift from car to walk / cycle
b. 3km-8km: promote shift from car to cycle / PT
c. >8km: promote shift from car to PT / carpool

IMPROVE policy - impact on average gCO2e/km

a. Improving fuel efficiency of conventional petrol/diesel engines,
b. Improving fuel emissions by switching vehicle fleet to battery electric,
c. Improving electricity generation by switching to renewables,
d. Improving energy efficiency of electric batteries.

For each of the above strategies, a range of application circumstances have been identified that significantly affect the level of carbon emissions resulting from implementing any given mix of the avoid, shift or improve policies.

These include:

i) the current car driver mode share by trip purpose,
ii) the relative trip distance per trip purpose in different types of area,
iii) the share of journeys by distance band in different area types,
iv) the current proportion of electricity generation from fossil fuels compared to renewable/nuclear sources
v) the current fuel efficiency of conventional vehicles on the road
vi) the current battery efficiency of electric vehicles

The Carbon Reduction Strategy Support Tool, developed in Excel, allows the user to identify several possible policy strategy mixes that could deliver defined carbon reduction targets. It does this by allowing the user to vary the scale of input/uptake of each policy strategy to better understand the impact this has on overall carbon emissions, how it contributes to carbon reduction targets, and its relative significance in comparison to other policy strategy choices. It then assists the user in undertaking the first three steps in the 4R validation process (see below) while also producing as output information on the necessary strategy timings that will assist in the fourth step of assessing whether changes required to institutional capacity, organisational structures, regulations, and financial resources are realistic.

4R Validation Process

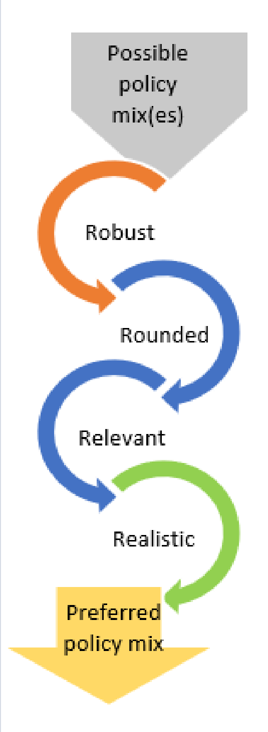
To identify a **preferred policy strategy mix** requires assessing the different possible policy strategy mix options through the 4R validation process:

a) Is the selected policy strategy mix **ROBUST** in the face of alternative futures related to key exogenous factors and trends?

b) Is the selected policy strategy mix **ROUNDED** when assessed against other key objectives in the city vision? They reinforce rather than conflict with other objectives (in addition to carbon reduction).

c) Is the selected policy strategy mix **RELEVANT** when assessed against spatial variation within FUA?

d) Are the selected policy strategy mix and timings **REALISTIC** when assessed against changes required to institutional capacity, organisational structures, regulations, and financial resources?



The next section forms a user guide for the tool, providing more detail and description on how to use the tool, what inputs are required and what outputs to expect.

2. Carbon Reduction Strategy Support Tool - User Guide

The Carbon Reduction Strategy Support Tool has been developed in Excel and is available free to use by any city. The intention is to provide cities with indicative quantification of the carbon reduction potential of possible policy strategy choices in order to help inform workshop discussions and decision making when developing their strategic policy plans and Transition Pathway.

The tool is structured in 4 linked worksheets as follows:

1. **Identify policy strategy mix** that achieves carbon targets
2. **Stress test strategy mix**
3. **Establish timings** of strategy implementation to achieve intermediate milestones
4. **Assess** strategy mix **against non-carbon objectives**

Having obtained an initial policy strategy mix, the resilience/robustness of the strategy choices can be stress tested in the face of alternative futures by exploring the impacts of changes in key external factors.

The timings of strategy implementation can also be explored by viewing how changes to this can affect overall (cumulative) carbon emissions as well as contributions to intermediate targets prior to 2050.

Finally, a framework for assessing the impact of carbon focussed policy strategy choices on other objectives is provided to ensure they the carbon focussed choices are rounded and reinforce rather than conflict with other non-carbon objectives.

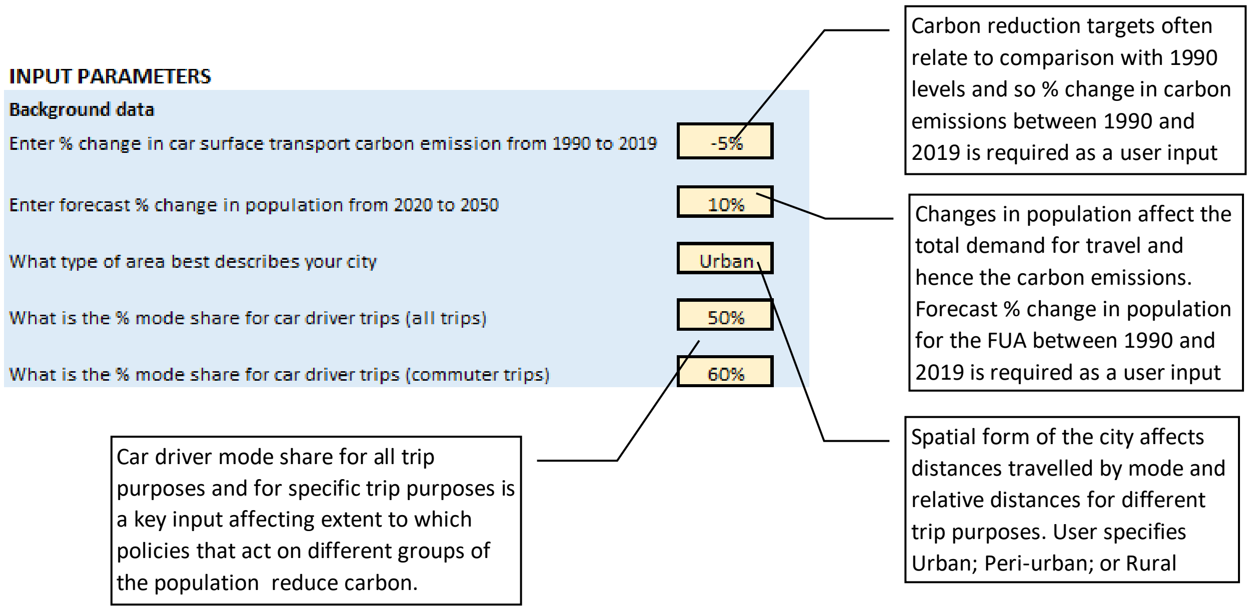
2.1 Worksheet 1: Strategy Mix for Carbon Targets

Users of the tool will have already established the carbon reduction targets up to 2050 (and any intermediate targets) for their city. A guiding principle here are the EU targets for carbon reduction compared to 1990 levels.

- EU ‘Fit for 55’ strategy aims for 55% reduction in GHG in 2030 compared to 1990 levels
- The EU Green Deal targets a 90% reduction in transport emissions by 2050 compared to 1990 levels

The tool will then help users gauge the potential contribution to carbon reduction from different strategies related to avoid, shift and improve policies. This enables them to make more informed choices on the mix of policy strategies, also taking account of effects from the timings of these, that will deliver the carbon reductions required to meet the targets at key points in time up to 2050.

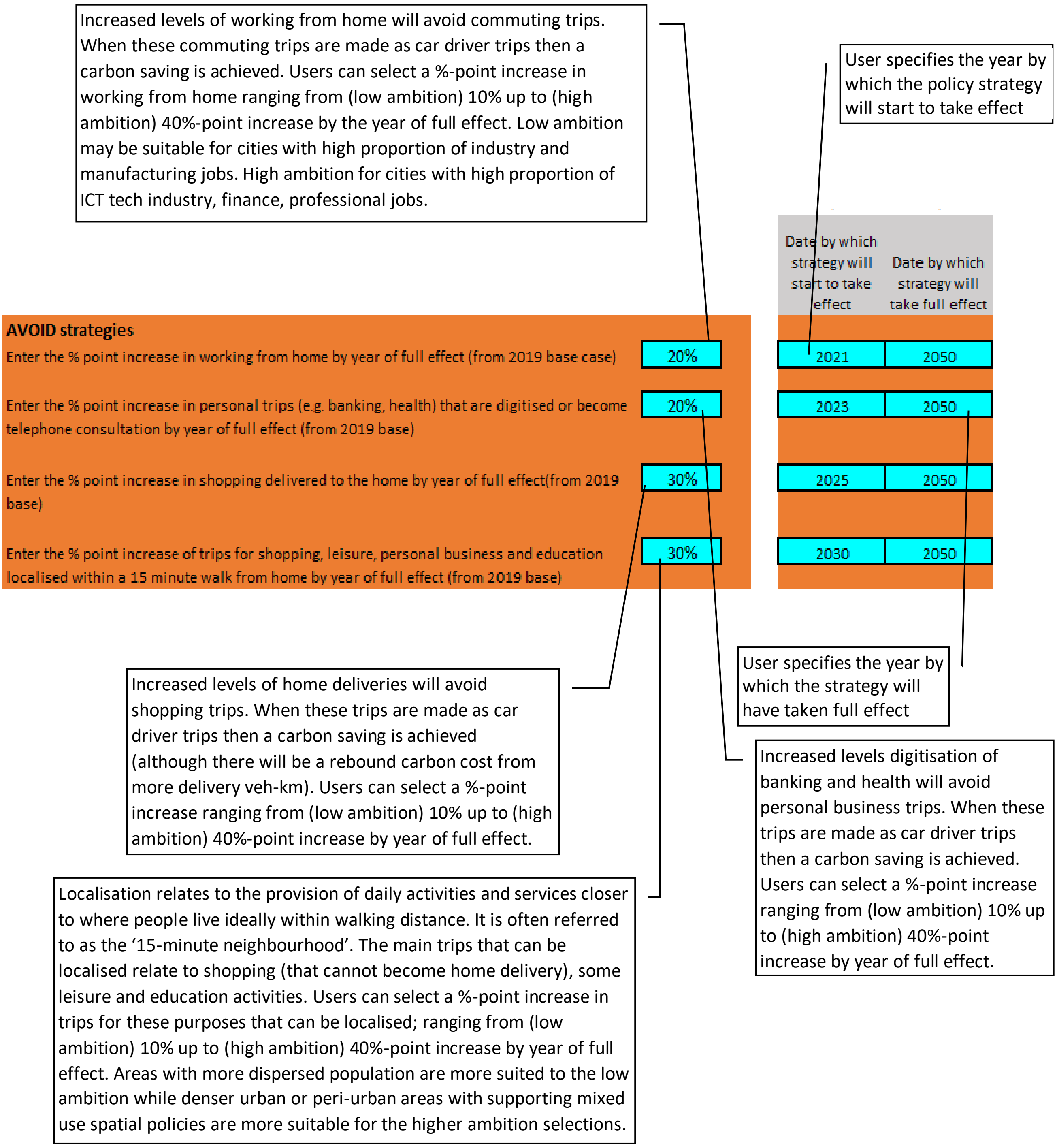
Users start by entering some basic input data to the tool as explained below.



Next, the user enters the changes in key behaviours and technologies relating to Avoid, Shift, Improve strategies that they consider possible to achieve in their FUA by the year they specify as taking full effect.

Based on the input options described below, for each policy strategy, the user can select from a range of uptake scenarios (%-point increases) or improvement scenarios (% change) that they wish to explore.

The user is also asked to provide the year by which the policy strategy will start to take effect and the year by which it will provide its full effect. The growth in take-up is assumed to be linear between the start and full effect years. This information is used to estimate the carbon emissions reduction in each year between 2021 and 2050.



Users can select a %-point shift from car driver mode share to alternative modes ranging from (low ambition) 5%-point shift up to (high ambition) 20%-point shift by year of full effect.

SHIFT strategy

Trips < 3km: Enter the % point shift from car driver mode share to alternative modes by year of full effect (from 2019 base case)	15%	2021	2050
Trips 3 to 8km: Enter the % point shift from car driver mode share to alternative modes by year of full effect (from 2019 base case)	15%	2021	2050
Trips > 8km: Enter the % point shift from car driver mode share to alternative modes by year of full effect (from 2019 base case)	10%	2021	2050

The user is not asked to state the mode to which the shift will occur. The %-point shift is applied to the proportion of car drivers in each of three distance bands (<3km; 3-8km; >8km) to estimate the car veh-km removed. From this, associated carbon reductions are derived. For trips less than 3km, cities will focus policy towards walk and cycle initiatives, trips between 3km and 8km will prompt a policy focus on cycle and public transport, and trips above 8km will require a policy focus on public transport and carpooling. The results therefore provide carbon reduction impacts resulting from the shift policy for each of these three distance bands to give an understanding of where the greatest carbon reduction benefits can be achieved.

User enters the % of electricity currently generated from renewables and nuclear rather than from fossil fuel sources.

Carbon intensity of electricity varies greatly depending on fuel source. As a rough guide coal has a carbon intensity of about 1,000g CO_2/kWh, oil is 800g CO_2/kWh, natural gas is around 500g CO_2/kWh, while nuclear, hydro, wind and solar are all less than 50 g CO_2/kWh. The carbon intensity of grid electricity is determined by the fuel mix used in generation. As a result, there is a vast difference between countries in % electricity generated from renewables (+nuclear). For example:

- ➔ EU27 has 38% renewables, 25% nuclear, 37% fossil fuels;
- ➔ Poland has 17% renewables and 83% fossil fuels;
- ➔ Germany has 45% renewables, 11% nuclear, 44% fossil fuels;
- ➔ UK has 42% renewables, 17% nuclear, 41% fossil fuels;
- ➔ France has 23% renewables, 67% nuclear, 10% fossil fuels;
- ➔ Sweden has 68% renewables, 30% nuclear, 2% fossil fuels;

https://ourworldindata.org/grapher/carbon-intensity-electricity

User can select the % improvement in fuel efficiency of conventional petrol and diesel engine cars on the road. Options of 10%, 20% and 30% improvement are provided.

The fuel efficiency of the average car on the road in 2020 in the UK was 138 gCO_2/km. The average age of cars on the road was 8.5 years. The average fuel efficiency of new conventional cars in 2020 was 124gCO_2/km. This is already about 10% improvement on the average car on the road. Given the lifespan of cars It is likely that this will become the average fuel efficiency of conventional cars on the road by 2030. By 2037 it is expected to reach around 100 gCO_2/km (about a 30% improvement). No further improvements are expected after 2037 as manufacturers will have transitioned to electric vehicles.

User can select the % electricity that will be generated by renewables (+nuclear) by year of full effect. A full range of possibilities from 0% to 100% is offered.

IMPROVE strategy		Date by which strategy will start to take effect	Date by which strategy will take full effect
Enter the % of electricy generated from renewables (including nuclear) 2019 base	30%		
Enter the % of electricy generated from renewables (including nuclear) by year of full effect	70%	2021	2050
Enter the % improvement in ICE fuel efficiency of conventional cars on the road by year of full effect (from 2019 base case) - [expected to be 30%]	20%	2021	2037
Enter the % improvement in electric battery efficiency by year of full effect (from 2019 base case) - [expected to be 40% by 2050]	20%	2025	2050
Electric vehicle takeup by year of full effect	60%	2023	2050

User can select the % improvement in electric battery efficiency by year of full effect. Options of 20%, 40% and 60% improvement are provided.

The 2020 average electric battery energy consumption is expressed in kWh/km and is a function of the battery capacity and its range. The average for electric cars in 2020 used is 0.189 kWh/km. Battery efficiency is expected to continue increasing (extending range for same charge), however this will be tempered to some extent by the increased availability of larger electric vehicles.

This is multiplied by the carbon intensity of electricity generation to determine the gCO_2e/km for electric vehicle use.

User can select the % of the car fleet that will be battery electric by year of full effect. A range of possibilities from 0%; 10%; 20%; 40%; 60%; 80% to 100% is offered.

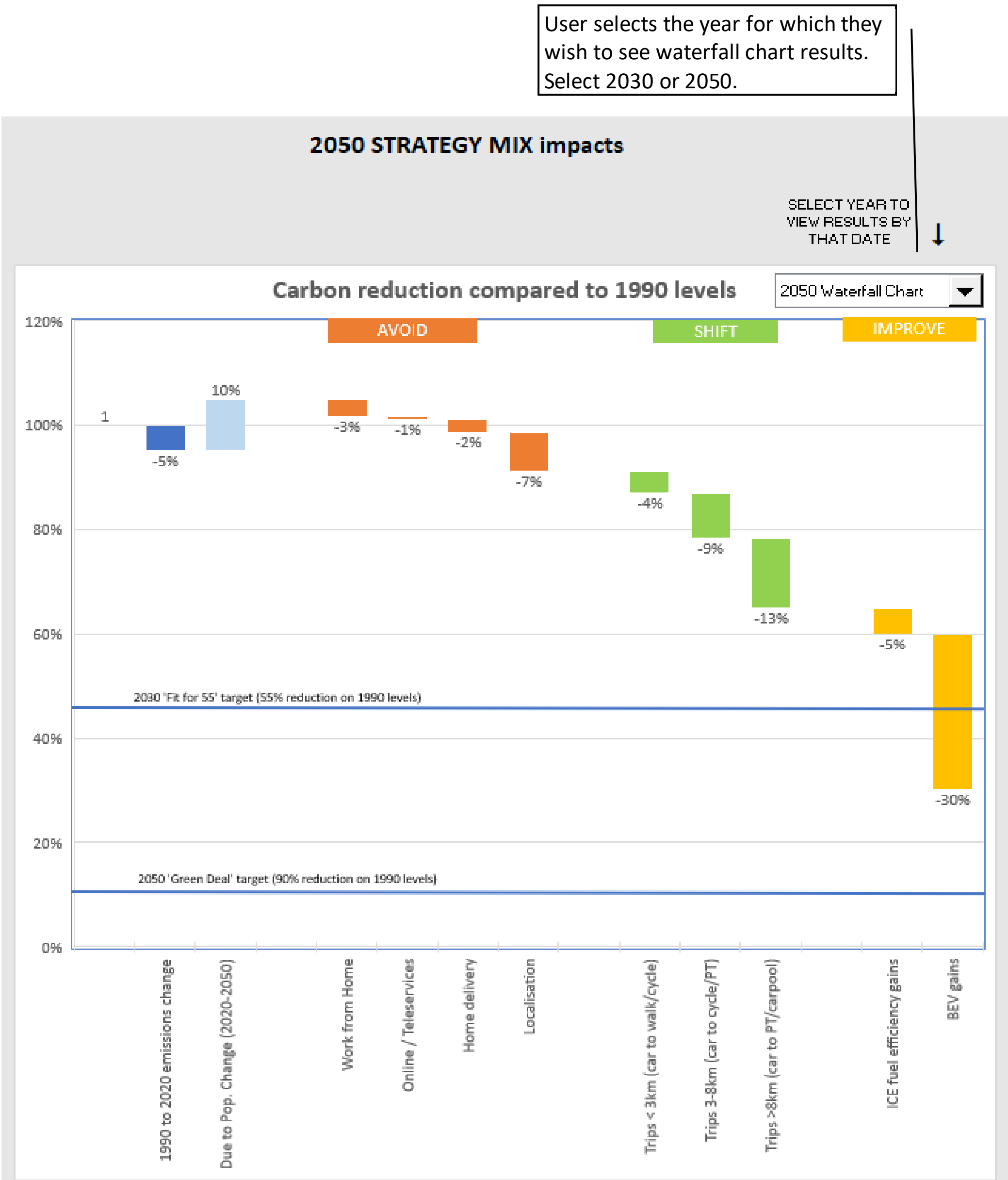
Given the above inputs, a set of waterfall charts are produced showing the % reduction in carbon emissions (compared to 1990 levels) associated with each policy strategy by a given year.

Users can choose between 2030 and 2050 as these are the years where the EU has set key targets for carbon reduction compared to 1990 levels.

- EU 'Fit for 55' strategy aims for 55% reduction in GHG in 2030 compared to 1990 levels
- The EU Green Deal targets a 90% reduction in transport emissions by 2050 compared to 1990 levels

These visualisations present indications of the impacts on carbon reduction from the avoid, shift, improve policy strategies, for the levels of uptake/improvement chosen for each. Users can immediately gauge the extent to which their selections are likely to achieve 2030 or 2050 targets. They can increase or decrease the levels (% point change in uptake/use or % improvement) for the various strategies to understand the significance of the carbon reduction impact this will have.

Figure 1: Waterfall chart showing estimated % carbon reduction in 2050 (compared to 1990 levels) likely to be delivered by each policy strategy for the initial user input

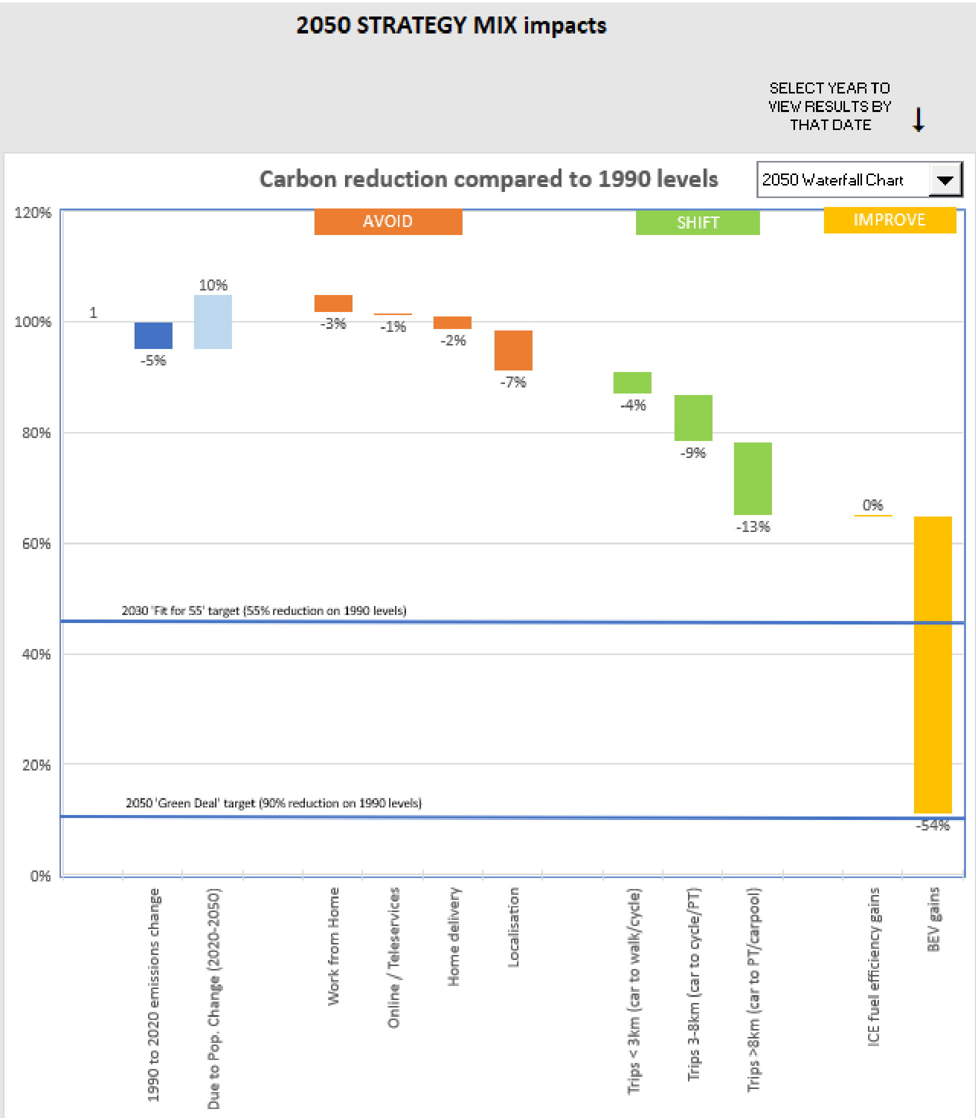


The waterfall diagram in Figure 1 shows the estimated % carbon reduction at a single point in time, in this case 2050 (compared to 1990 levels), likely to be delivered by each policy strategy given the inputs (levels of uptake/improvement) specified by the user. It shows that the Green Deal target of 90% reduction by 2050 will not be achieved with the levels of uptake in avoid, shift and improve strategies selected by the user.

By adjusting the levels of uptake/improvement associated with different strategies, the user can establish what mix of policy strategies and their levels of uptake are needed to achieve the established targets. This allows users to 'backcast' from the future target to the present (2020) to understand the policy strategy mix and levels of uptake/improvement associated with each strategy in the mix that achieve the future target.

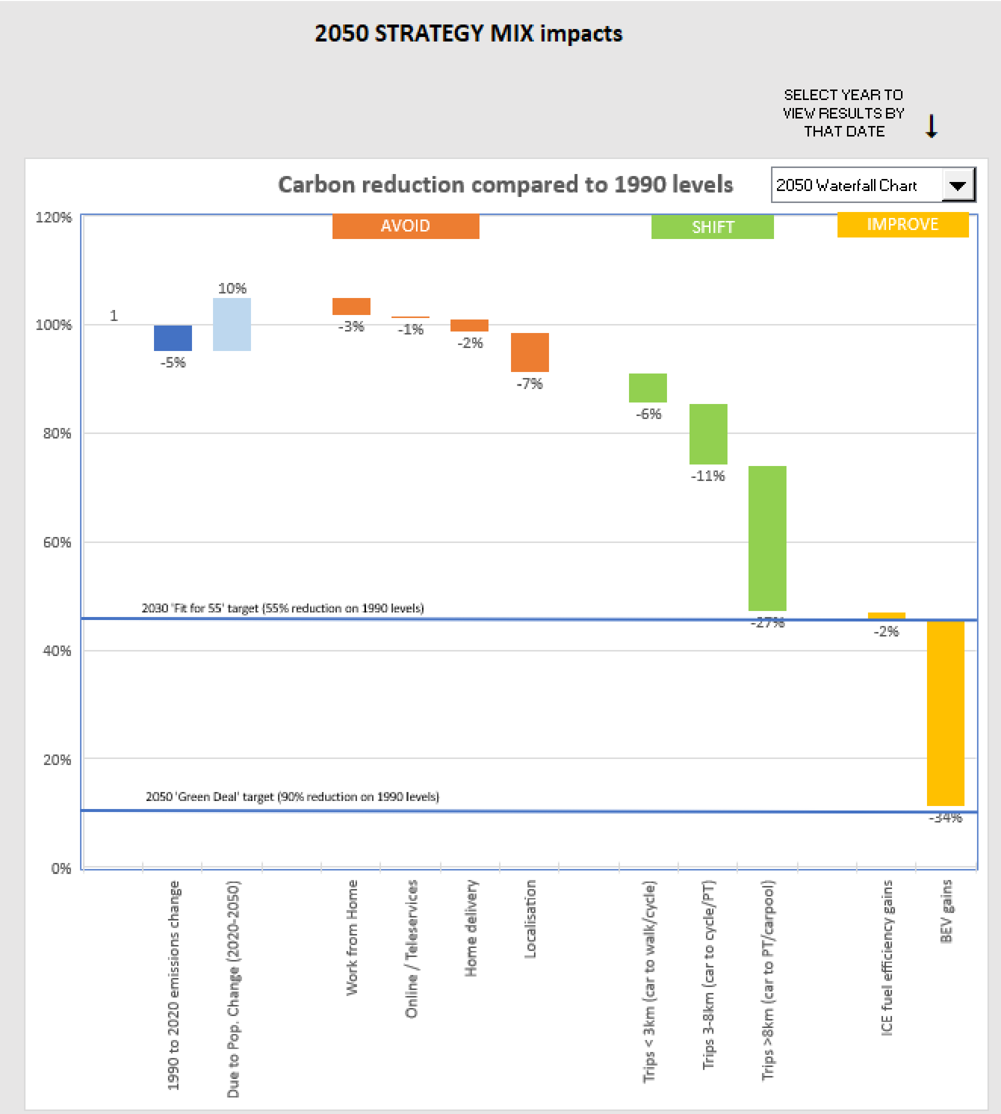
The waterfall diagram in Figure 2 illustrates the results from increasing the input parameters: 'electric vehicle take-up' from 60% to 100% by 2050 and increasing the '% electricity generated from renewables by 2050' from 70% to 80%. This achieves the Green Deal target of 90% carbon reduction on 1990 levels.

Figure 2: Waterfall chart showing estimated % carbon reduction in 2050 (compared to 1990 levels) likely to be delivered by each policy strategy with adjusted user inputs



Alternatively, the waterfall chart in Figure 3 shows the results from increasing the % point shift from car driver to alternative modes from 10% to 20% combined with increasing the electric vehicle uptake from 60% to 80%. This mix also achieves the Green Deal target, but in a different way, highlighting what else would need to be done to achieve the target if 100% electric vehicle take-up was not achievable. This demonstrates that there can be more than one different pathway to achieve the carbon reduction target, each with a different emphasis in the mix of avoid:shift:improve strategies.

Figure 3: Waterfall chart showing estimated % carbon reduction in 2050 (compared to 1990 levels) likely to be delivered by each policy strategy with alternative adjusted user inputs



So, users can experiment with changes in the input parameters to understand the levels of uptake/use/improvement associated with different policy strategies (avoid, shift, improve) that will achieve the GHG emission reduction targets. This approach is based on the principles of vision and validate back-casting and can be undertaken to obtain possible different pathways to achieve the carbon reduction target, each with a different emphasis in the mix of avoid:shift:improve strategies.

2.2 Worksheet 2: **Stress Test** Strategy Mix

Worksheet 2 in the Carbon Reduction Strategy Support Tool involves stress testing the possible strategy mix (established in Worksheet 1) to ensure the mix is robust/resilient in the face of alternative futures related to key exogenous factors and trends. If the stress testing reveals the strategy mix to be weak in the face of plausible alternative futures, then, if possible, the strategy mix inputs should be adjusted in Worksheet 1 to strengthen resilience to change.

This worksheet allows the user to 'stress test' the effects of moderate to extreme changes in the following factors (see Figure 4) on the carbon impacts of the strategy mix. A slider bar is provided for each factor allowing the impact from changes in the levels of each factor to be explored.

Figure 4: Stress Testing inputs

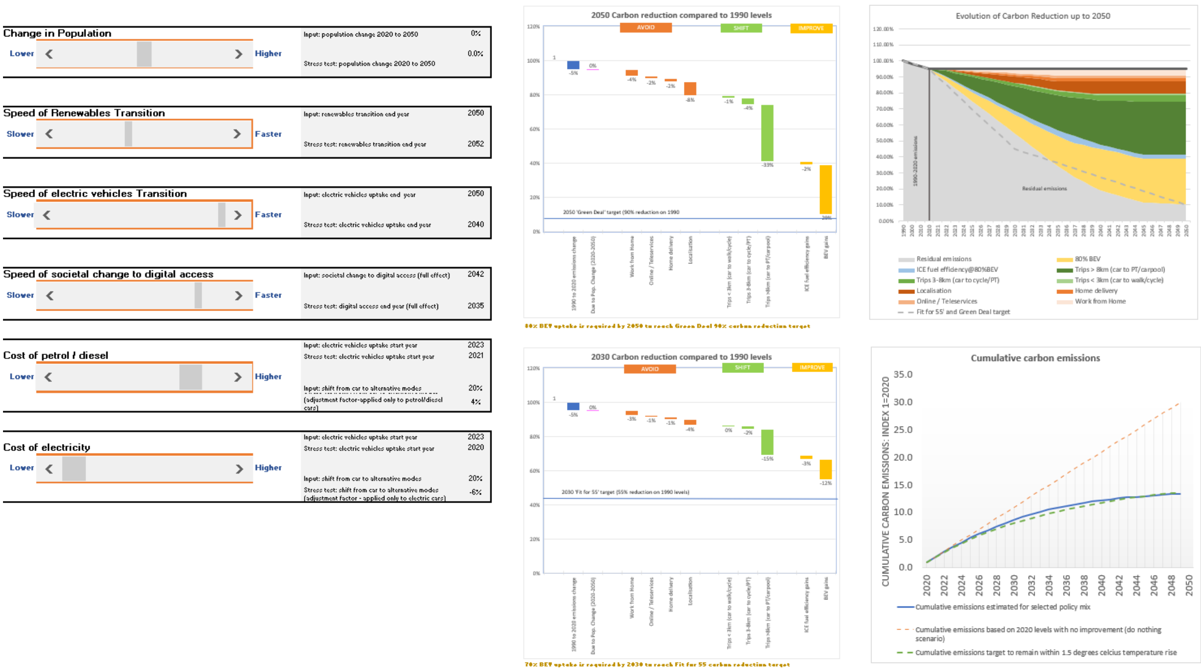
Changes in the factors have either a direct or indirect impact on one or more of the policy strategy inputs. In some cases, it is a direct change to an input value, such as change in population 2020 to 2050, or a direct change in the year by which a strategy takes full effect (e.g., faster or slower renewables transition). For factors relating to changes in cost of petrol/diesel or cost of electricity the impacts are more complex. For instance, increasing cost of petrol/diesel is likely bring forward the uptake of electric vehicles as the increased operating savings of electric relative to petrol/diesel begin to outweigh the higher purchase cost for electric vehicles. At the same time, higher cost of petrol/diesel will also likely increase the shift from car drivers to alternative modes. Suitable adjustment factors are applied by the tool based on cross price elasticity of demand data related to fuel costs and PT use.

Figure 5 illustrates the Tool outputs relating to the Stress Testing. Using the slider bars, the user can explore the effects of different futures. The diagrams to the right of the slider bars illustrate the impact of the different futures. These present the waterfall diagrams (for 2050 and 2030) relating to the future scenarios. This allows the user to view the robustness of their policy strategy selections to changes in key factors that reflect different possible futures.

In addition to the waterfall diagrams showing the carbon reduction estimates for specific points in time (i.e., 2030 and 2050), another two outputs are produced. The top right diagram (see also Figure 6) illustrates the year-to-year evolution of carbon reduction between 2020 and 2050 for each strategy, given the input selections combined with the stress testing factor adjustments.

The bottom right diagram (see also Figure 7) illustrates the cumulative carbon emissions from 2020 up to 2050.

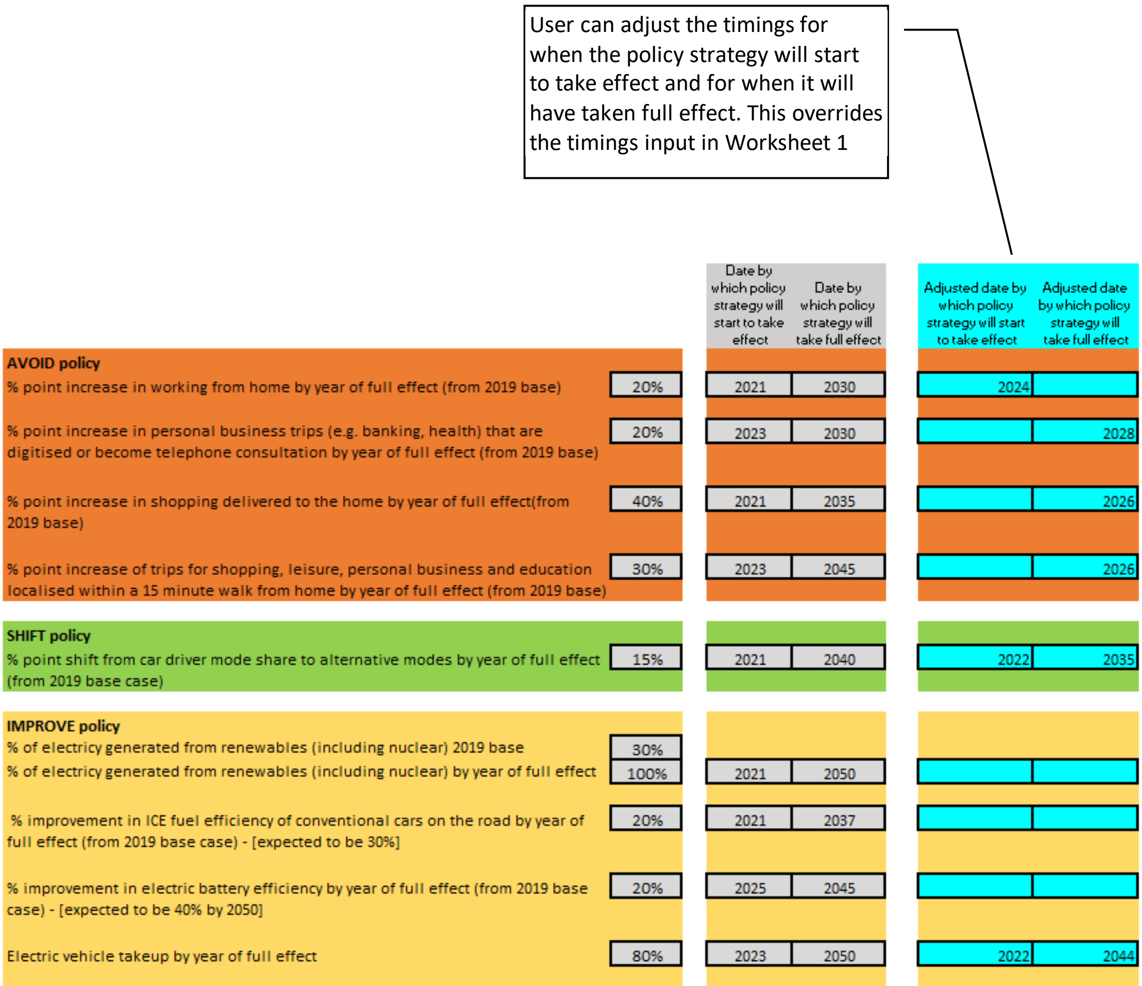
Figure 5: Stress Testing worksheet outputs overview



2.3 Worksheet 3: Adjust **Strategy Timings**

The third worksheet allows the user to visualise the effects of their policy strategy choices (levels of uptake/improvement and timings of implementation) on carbon reduction over time between 2020 and 2050.

The dashed line in Figure 6 shows the necessary reduction in carbon for each year to remain on target to achieve the ‘Fit for 55’ target by 2030 and Green Deal target of 90% reduction in GHG emissions by 2050 compared to 1990 levels. If the dashed line is not reached by the policy strategy selections, then the user is offered the possibility to adjust the implementation timings for the various strategies. This allows the user to understand not only the level of uptake/improvement for the strategy, but also the timings for when the strategy should commence and when it is required to take full effect.



		Date by which policy strategy will start to take effect	Date by which policy strategy will take full effect	Adjusted date by which policy strategy will start to take effect	Adjusted date by which policy strategy will take full effect
AVOID policy					
% point increase in working from home by year of full effect (from 2019 base)	20%	2021	2030	2024	
% point increase in personal business trips (e.g. banking, health) that are digitised or become telephone consultation by year of full effect (from 2019 base)	20%	2023	2030		2028
% point increase in shopping delivered to the home by year of full effect(from 2019 base)	40%	2021	2035		2026
% point increase of trips for shopping, leisure, personal business and education localised within a 15 minute walk from home by year of full effect (from 2019 base)	30%	2023	2045		2026
SHIFT policy					
% point shift from car driver mode share to alternative modes by year of full effect (from 2019 base case)	15%	2021	2040	2022	2035
IMPROVE policy					
% of electricy generated from renewables (including nuclear) 2019 base	30%				
% of electricy generated from renewables (including nuclear) by year of full effect	100%	2021	2050		
% improvement in ICE fuel efficiency of conventional cars on the road by year of full effect (from 2019 base case) - [expected to be 30%]	20%	2021	2037		
% improvement in electric battery efficiency by year of full effect (from 2019 base case) - [expected to be 40% by 2050]	20%	2025	2045		
Electric vehicle takeup by year of full effect	80%	2023	2050	2022	2044

Figure 6: Evolution of carbon reduction between 2020 and 2050 for each strategy

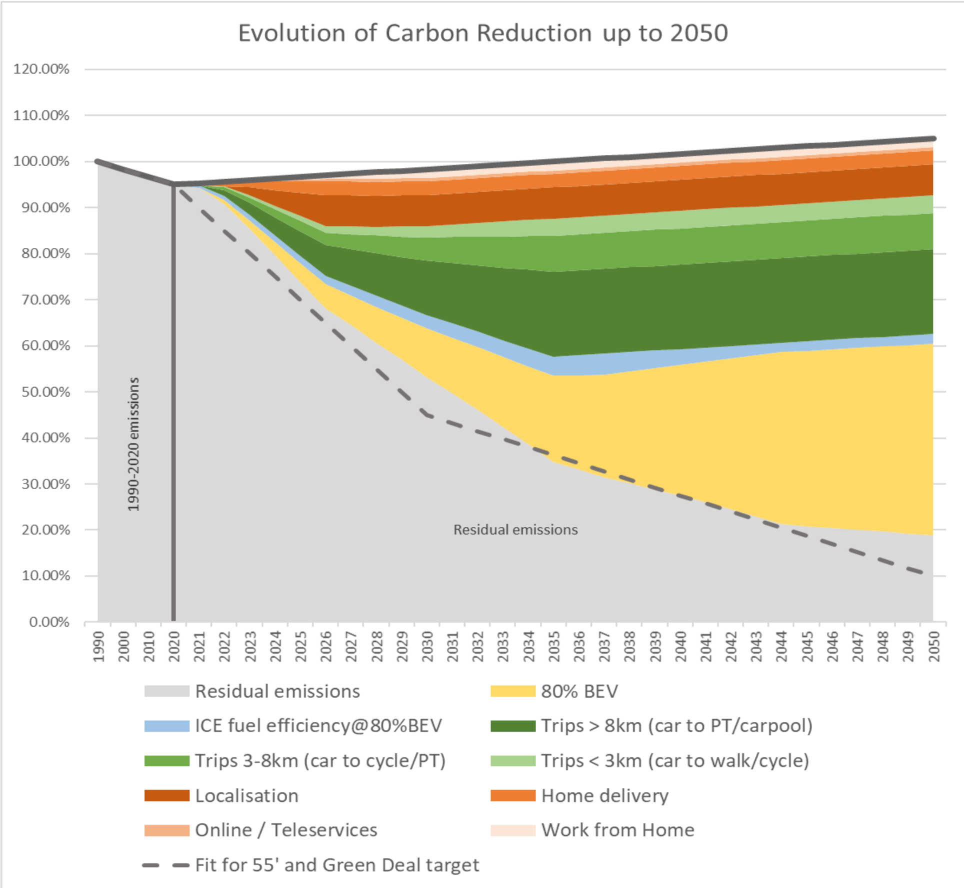
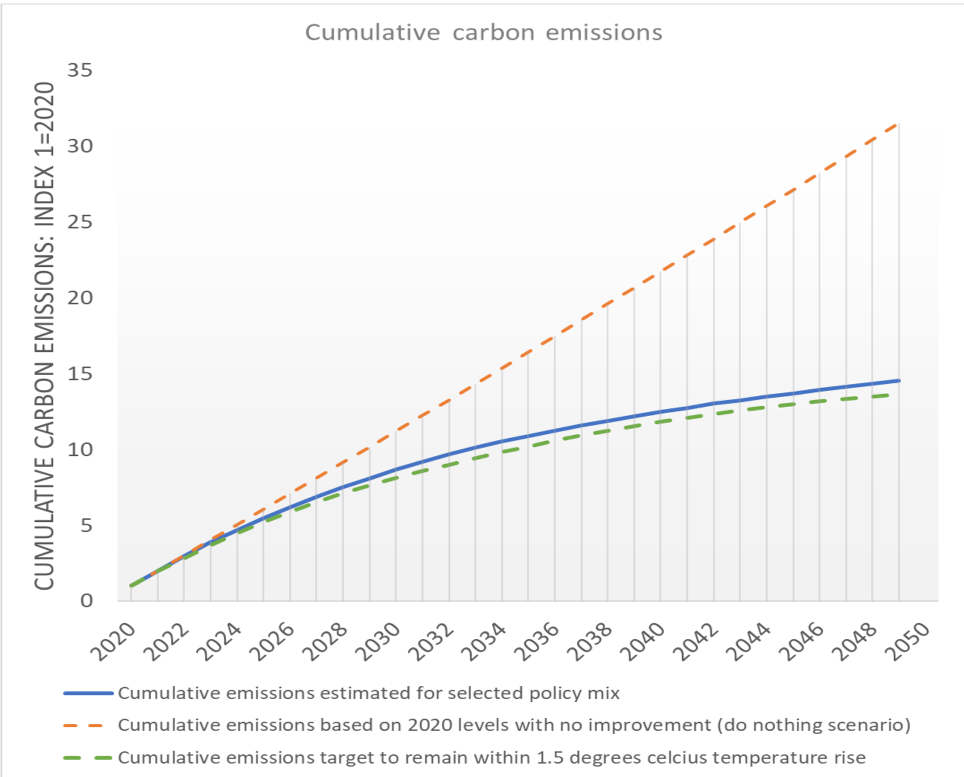


Figure 7: Cumulative carbon emissions from 2020 up to 2050 for the selected policy strategy mix inputs



The blue line on the chart in Figure 7 represents the cumulative emissions estimated for the selected policy strategy mix inputs. The red dashed line reflects the do-nothing scenario and shows cumulative emissions if no improvements were made compared to 2020 rates of emissions (i.e., emissions remain at 2020 levels until 2050 and are only affected by changes in population). The green dashed line reflects the cumulative emissions limit if global temperatures are to remain within a 1.5°C temperature rise (i.e., achieving the 'Fit for 55' target by 2030 and Green Deal target of 90% reduction in GHG emissions by 2050 compared to 1990 levels). In this chart the cumulative emissions are indexed to the 2020 values of emissions as a % of 1990 levels. For the example in Figure 7, we see that by 2050 the selected policy strategy mix is estimated to produce cumulative emissions of around 13.5 times the 2020 emissions while the do-nothing scenario would have resulted in 30 times the 2020 emissions.

These two diagrams (Fig 6 and Fig 7) viewed together can be helpful in ascertaining the optimal timings of policy strategy delivery to check that intermediate targets and milestones are being met and that cumulative emissions are within the prescribed targets needed to limit temperature rises to 1.5°C. The information in these charts can highlight the need to bring forward the commencement of a particular strategy, or the need for it to take full effect sooner. For instance, if the waterfall diagram for 2050 indicated that the Green Deal target will be met, but the blue line in Fig 7 is above the green dashed line at 2050, then there is a need for some strategies to be brought forward in time for their impacts to be delivered sooner. If this is the case, then users should adjust the timings for strategy implementation within this third worksheet.

This information helps establish the timings for strategy delivery needed to meet the expected targets up to and including 2050.

2.4 Worksheet 4: Impacts on other objectives

The next step in the Carbon Reduction Strategy Support Tool is to consider the impact of carbon focussed avoid, shift and improve policy strategies on the range of other mobility objectives that may be included in a cities vision to ensure the selected policy strategy mix is **Rounded** and not simply carbon focussed. A simple assessment framework is provided in Worksheet 4 allowing the user to select between positive (+1), neutral (0) or negative (-1) impact ratings. Note that when making a judgement on the impact that each strategy can have on a particular objective, it is useful to consider the geographic location and scale within the FUA that the strategy would take effect. It is also important to think about the impact of the strategy on different groups of the population identifying those that may be adversely affected and considering the ways in which they can be protected or shielded from potentially negative effects to ensure just transitions for all.

The Worksheet 4 assessment should be undertaken within a 'strategy assessment workshop' involving representatives of different municipal departments within the FUA and including the active engagement of a broad range of city stakeholders including local political leaders, public and private representation from other sectors, and civil society organisations. This qualitative assessment can take account of spatial variation within the FUA highlighting the need for, or inevitability of, more contribution from one policy area and less in another (e.g. more avoid and less improve in dense urban areas of the FUA and vice versa in more rural areas).

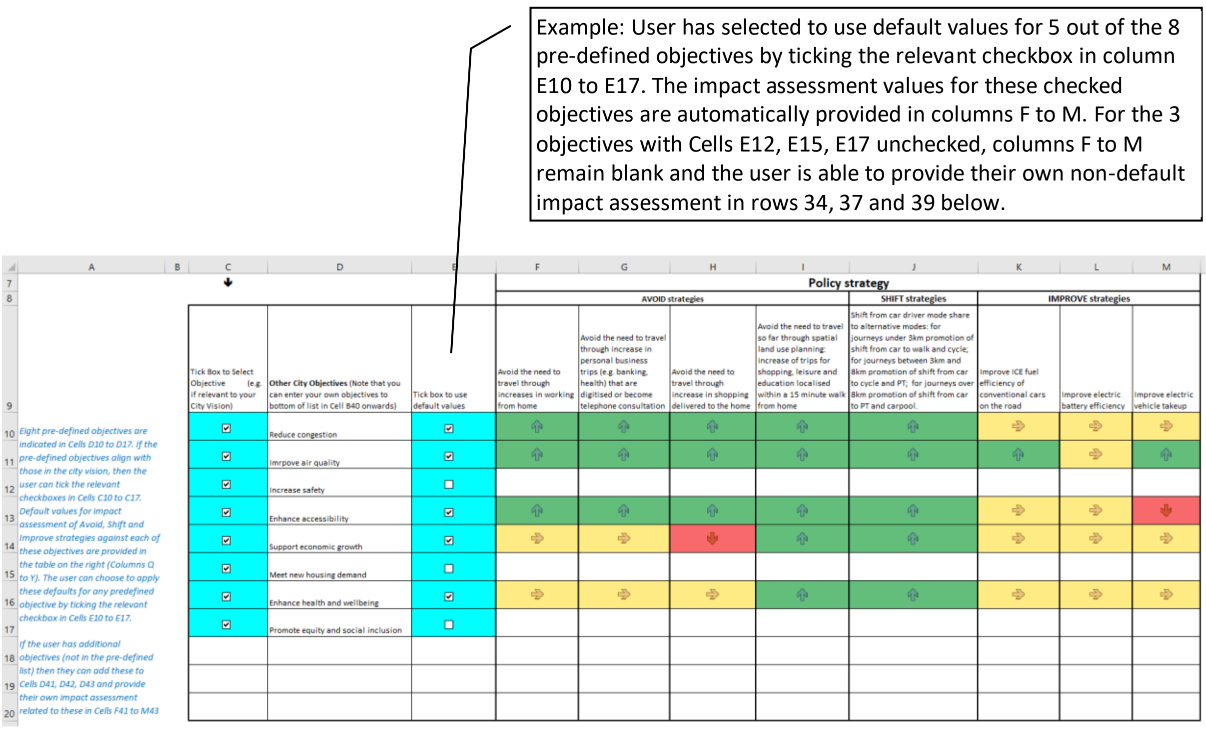
The assessment framework provided in Worksheet 4 identified eight pre-defined objectives, indicated in Cells D10 to D17. If the pre-defined objectives align with those in the city vision, then the user can tick the relevant checkboxes in Cells C10 to C17. Default values for impact assessment of Avoid, Shift and Improve strategies against each of these objectives are provided (see Figure 8). The user can choose to apply these defaults for any predefined objective by ticking the relevant checkbox in Cells E10 to E17. If the user has additional objectives (not in the pre-defined list) then they can add these to Cells D41, D42, D43 and provide their own impact assessment related to these in Cells F41 to M43

Figure 8: Default values for impact assessment of Avoid, Shift, Improve strategies against other city objectives

[positive (green), neutral (yellow) or negative (red) impact ratings]

DEFAULT VALUES	Policy strategy							
	AVOID strategies				SHIFT strategies	IMPROVE strategies		
	Avoid the need to travel through increases in working from home	Avoid the need to travel through increase in personal business trips (e.g. banking, health) that are digitised or become telephone consultation	Avoid the need to travel through increase in shopping delivered to the home	Avoid the need to travel so far through spatial land use planning: increase of trips for shopping, leisure and education localised within a 15 minute walk from home	Shift from car driver mode share to alternative modes: for journeys under 3km promotion of shift from car to walk and cycle; for journeys between 3km and 8km promotion of shift from car to cycle and PT; for journeys over 8km promotion of shift from car to PT and carpool.	Improve ICE fuel efficiency of conventional cars on the road	Improve electric battery efficiency	Improve electric vehicle takeup
Reduce congestion	↑	↑	↑	↑	↑	→	→	→
Imrpove air quality	↑	↑	↑	↑	↑	↑	→	↑
Increase safety	↑	↑	→	↑	→	→	→	→
Enhance accessibility	↑	↑	↑	↑	↑	→	→	↓
Support economic growth	→	→	↓	↑	↑	→	→	→
Meet new housing demand	↑	→	→	↑	↑	→	→	→
Enhance health and wellbeing	→	→	→	↑	↑	→	→	→
Promote equity and social inclusion	→	→	→	↑	↑	→	→	↓

If the user may prefer to make their own impact assessment rather than use the default values provided for a particular objective. If this is the case, then they should leave the relevant checkbox in Cells E10 to E17 unticked and then provide their own impact assessment in rows 32 to 43. When making their assessment the user can consult the notes on "things to consider" provided in the adjacent table to the right (reproduced in Table 1 below).



Example: User has selected to specify their own impact assessment for 3 objectives ('Increase safety', 'Meet new housing demand', 'Promote equity and social inclusion'). The user then enters their own assessment of the Avoid, Shift, Improve strategies against these objectives to rows 34, 37, and 39. When making their assessment the user can consult the notes on "things to consider" provided in the adjacent table to the right on the Excel worksheet (and reproduced in Table 1 below).

Make your own assessment of your selected objectives

The presence of an arrow in Column C indicates objectives where the user has indicated they wish to make their own impact assessment rather then use the default values provided. When making their assessment the user can consult the notes on "things to consider" provided in the adhjacent table to the right.

			Policy strategy							
			AVOID strategies				SHIFT strategies	IMPROVE strategies		
	Other City Objectives (Note that you can enter your own objectives to bottom of list in Cell D41 onwards)		Avoid the need to travel through increases in working from home	Avoid the need to travel through increase in personal business trips (e.g. banking, health) that are digitised or become telephone consultation	Avoid the need to travel through increase in shopping delivered to the home	Avoid the need to travel so far through spatial land use planning: increase of trips for shopping, leisure and education localised within a 15 minute walk from home	Shift from car driver mode share to alternative modes: for journeys under 3km promotion of shift from car to walk and cycle; for journeys between 3km and 8km promotion of shift from car to cycle and PT; for journeys over 8km promotion of shift from car	Improve ICE fuel efficiency of conventional cars on the road	Improve electric battery efficiency	Improve electric vehicle takeup
		IGNORE THIS ROW								
		IGNORE THIS ROW								
⇨	**Increase safety**	Enter non default impact assessment in cells F34 to M34								
		IGNORE THIS ROW								
		IGNORE THIS ROW								
⇨	**Meet new housing demand**	Enter non default impact assessment in cells F37 to M37								
		IGNORE THIS ROW								
⇨	**Promote equity and social inclusion**	Enter non default impact assessment in cells F39 to M39								

The intention of this assessment is to flag where particular strategies are likely to have an overall negative impact on any other objective. Where this is the case, then within the strategy assessment workshop, cities need to consider how the negative impacts can be mitigated or avoided through regulatory or fiscal interventions (e.g., protections or subsidies for particular groups that are adversely affected). If this mitigation is not possible, then the policy strategy mix selected in Worksheet 1 of the Carbon Reduction Strategy Support Tool should be reviewed and where possible adjusted to remove or at least reduce the scale of choices that are likely to cause intractable negative impacts on another objective.

The final output from the use of the Carbon Reduction Strategy Support Tool is a preferred policy strategy mix for achieving long-term and intermediate carbon reduction targets up to and including 2050. This preferred strategy mix includes defined levels of uptake/improvement and timings for implementation of the avoid, shift, improve strategies within this mix.

The next step is to then assess the preferred policy strategy mix to ensure that the strategy selections are realistic and realisable in the context of the existing governance capacities and the achievable governance reforms that would be required to deliver the new policy strategy. An 'enabling actions' workshop should be held with appropriate stakeholders to map the governance reform necessary to be able to deliver the identified policy strategies effectively at different timeframes.

Table 1: Things to consider when assessing impact of Avoid, Shift, Improve strategies on other objectives

Some things to consider when assessing the impact of Avoid, Shift, Improve strategies on other objectives.	**AVOID strategy**				**SHIFT strategy**	**IMPROVE strategy**		
	Avoid the need to travel through increases in working from home	**Avoid the need to travel through increase in personal business trips (e.g. banking, health) that are digitised or become telephone consultation**	**Avoid the need to travel through increase in shopping delivered to the home**	**Avoid the need to travel so far through spatial land use planning: increase of trips for shopping, leisure and education localised within a 15 minute walk from home**	**Shift from car driver mode share to alternative modes: for journeys under 3km promotion of shift from car to walk and cycle; for journeys between 3km and 8km promotion of shift from car to cycle and PT; for journeys over 8km promotion of shift from car to PT and carpool.**	**Improve ICE fuel efficiency of conventional cars on the road**	**Improve electric battery efficiency**	**Improve electric vehicle takeup**
Reduce congestion	As commuter car trips are avoided through increased working from home, peak hour congestion is reduced. The higher car mode share for commuter trips, the higher the potential for congestion reduction.	Removing the need to travel reduces trips. How much this reduces congestion depends on level of car use for the trips avoided and the congestion levels at the time of day and in the locations where the trips were previously made.	Removing the need to travel for shopping reduces the number of cars on the road. How much this reduces congestion depends on level of car use for the trips avoided and the congestion levels at the time of day where car trips have been removed from. Home deliveries does generate trips by delivery vehicles. The extent to which this contributes to congestion depends on the level of linked deliveries that can be achieved and the underlying congestion levels at the time of day the deliveries are made.	The more daily amenities and services that can be provided within walking distance from home, the less is the need for car trips. The extent to which this contributes to congestion relief depends on the underlying congestion levels at the time of day and in the locations the previous car trips are removed from.	Shifting mode for short journeys from car trips to walk and cycle may have significant impacts in city centres where congestion is likely to be worst. In local suburban neighbourhoods congestion is less likely to be an issue except at particular times of day in particular locations (e.g. around schools at start and end of school day). Switching short trips education related trips to walk and cycle will relieve local congestion but will have limited impact city wide. Removing cars from the network for medium length journeys through switching to cycle or PT can alleviate congestion on main roads at the busiest times. Shifting from car to PT or carpooling for longer journeys is likely to have most impact on congestion along main arterial corridors into city centres during peak hours.	No significant impact on reducing congestion. Lower fuel consumption may encourage slightly more car use.	No impact on reducing congestion.	No significant impact on reducing congestion. Lower fuel costs may encourage slightly more car use.
Imrpove air quality	Avoided commuter car trips result in less NOx and Particulate (PM) emissions and improved air quality. The higher car mode share for commuter trips, the higher the potential for air quality improvements. As electric vehicle uptake increases there is less net benefit to improved air quality from avoided trips.	Avoided trips result in less NOx and Particulate (PM) emissions and improved air quality. The higher car mode share for personal business trips, the higher the potential for air quality improvements. As electric vehicle uptake increases there is less net benefit to improved air quality from avoided trips.	Avoided car trips for shopping result in less NOx and Particulate (PM) emissions and improved air quality. The higher car mode share for shopping trips, the higher the potential for air quality improvements. As electric vehicle uptake increases there is less net benefit to improved air quality from avoided trips. Some of the air quality benefit from removing cars trips will be eroded by the delivery vehicles trips that replace them. To minimise the negative impact on air quality of delivery vehicles these should use clean fuels.	Avoided car trips or reducing the distance of car trips result in less NOx and Particulate (PM) emissions and improved air quality. The higher the car mode share for daily trips to shopping, leisure, education, the higher the potential for air quality improvements. As many of these activities are centred around congested city centre high streets, or around schools, the air quality benefits from avoiding these trips are likely to be high. As electric vehicle uptake increases there is less net benefit to improved air quality from avoided trips.	Switching from car to walk and cycle has positive impacts for air quality. Switching from car to PT is also liklely to result in positive impacts where clean engine technology is utilised on PT vehicles. Where old diesel engine buses still operate improvements in air quality will be reduced. As electric vehicle uptake increases within the private car fleet there is less net benefit to improved air quality from avoided trips.	Slight improvement in air quality where fuel efficiency improvements also include improvements in NOx and Particulate (PM) emissions.	Neutral - improvements accounted for in initial electric vehicle take-up.	Strong positive impact - Electric cars have zero tailpipe emissions which means a 100% reduction of NOx and Particulate (PM) emissions compared to conventional exhaust in the local area. However vehicles also create PM emissions from 'Non Exhaust' sources which are tyre, brake, clutch and road surface wear.
Increase safety	The more car trips removed from the network the lower the risk of accidents involving cars.	The more car trips removed from the network the lower the risk of accidents involving cars.	In general, the more car trips removed from the network the lower the risk of accidents involving cars. However, the increased presence of larger delivery vehicles may result in additional safety risk for vulnerable road users in residential neighbourhoods.	In general, the more car kms removed from the network the lower the risk of accidents involving cars. Reducing car presence around schools will be especially beneficial for increasing safety. Encouraging more walk and cycle trips rather than car use will improve safety as long as well designed infrastructure and traffic management protecting these users from cars is in place.	In general, the more car kms removed from the network the lower the risk of accidents involving cars. However, the increased presence of larger public transport vehicles that frequently stop and start may result in additional safety risk for cyclists where shared bus and cycle lanes exist. Additionally, where there is increased interaction between cars and pedestrians or cyclists, there is heightened risk of accidents. Well designed infrastructure and traffic management protecting these users from cars is needed.	No impact on increasing safety.	No impact on increasing safety.	No impact on increasing safety.
Enhance accessibility	Increased working from home removes physical limits on accessing workplaces. This means more people have the opportunitiy to access more jobs. Broadband infrastructure and speed may limit access to working from home for those in certain rural areas.	Digital access to personal services removes constraints and barriers to accessing physical locations. This means more people have the opportunitiy to access services in a more convenient fashion. Broadband infrastructure and speed may limit digital access to personal services for those in certain rural areas.	On-line access to shopping services removes constraints and barriers to accessing physical shop locations. This means more people have the opportunitiy to access more goods in a more convenient fashion. Broadband infrastructure and speed may limit digital access to shopping services for those in certain rural areas. Availability to receive deliveries at convenient times may limit access to on-line shopping for some.	Bringing the location of daily amenities and services closer to where people live enhances accessibility. For those who are mobility impaired and unable to walk, suitable transport should be provided though use of mobility scooters or door-to-door accessible public transport.	The more cities are designed for walking, cycling and public transport the more amenities and services become accessible to those without access to cars. Where destinations are too far to walk or cycle expanding the coverage and frequency of the accessible public transport network is needed. Where destinations are close then providing safe and attractive walk and cycling infrastructure is necessary.	No impact on enhancing accessibility.	No impact on enhancing accessibility.	Electric vehicles are not accessible for everyone due to higher cost of purchase and in some city locations limited facilities for off-street charging (flats and housing without driveways).
Support economic growth	Research on working from home has revealed that productivity levels tend not to suffer and can increase when homeworking. Time saved by not travelling can be put to more productive purposes. Less cars on the network leads to reduced journey times which has economic benefits, but there will be a drop in fuel tax revenues associated with less private veh-km. Businesses located within centres of employment where office jobs are located suffer from lower demands as more people work from home. This may lead to staff redundancies or business closures. Some businesses will relocate to local neighbourhoods where daytime consumers may have increased as home workers now shop and leisure activities in their local neighbourhood.	The transition to on-line and teleservices, while delivering more efficiencies in costs of provision, is likely to also result in some job loses.	The transition to on-line shoping and home delivery, will likely result in structural changes in the retail sector with less high street and supermarket store locations and more consolidation centres for direct distribution to homes. While this is likely to result in some job loses in stores, there will be more jobs created in the delivery chain. Redundant store locations may be repurposed to entertainment outlets (food and drink, leisure) or developed for housing.	Time saved by not travelling can be put to more productive purposes. Less cars on the network leads to reduced journey times which has economic benefits, but there will be a drop in fuel tax revenues associated with less private veh-km. More vibrant and economically prosperous local neighbourhoods may emerge at the cost of a decline in economic output of city centres. City centres could refocus some activities and services towards visitors and tourism.	Achieving a shift from car to alternative modes and providing priority to these alternative modes reduces journey times and improves journey time reliability for all road users. Fare revenues for PT will increase, although there will be a drop in fuel tax revenues associated with less private veh-km. Access to job opportunities may be enhanced by for those withour access to private cars. Less car dominated cities and better connections may support growth in visitors and tourism in the city.	No significant impact.	No significant impact.	While electric cars have a higher initial cost than ICE cars, they are usually more affordable in the long-term. The relative costs are likely to more strongly favour electric vehicle ownership in the future. This means there is likely to be more disposable income to spend in the wider economy compared to ICE alternative. Related to this there will be a drop in petrol and diesel fuel tax revenues. It is also likely that there will be less demand and need for jobs in the after sales vehicle servicing, mainteance and parts industries.
Meet new housing demand	Increased working from home can disperse the demand for housing away from city centres where the largest numbers of jobs are physically located. This can ease the demand for new housing in the areas where housing is in short supply and there is no space for new housing. Working from home may create more demand for larger houses with spare rooms/home offices.	Unlikely to have any effect on housing demand.	Unlikely to have significant effect. Redundant store locations may be redeveloped for housing.	Spatial land-use planning centred on mixed use developments that support local living can provide a model for meeting new housing demand. This can include densification of existing urban areas where good local amenities already exist, while also ensuring new developments have a wide range of local services and amenities which are within walking distance. This could break the cycle of car dependency and support more sustainable housing development.	Good quality frequent public transport extending out of the main city may support transit oriented developments outside the main urban areas in existing peripheral towns or to new town developments (where space is available). These new developments should be mixed use, encouraging walk and cycle for local trips and built around mobility hubs providing fast and efficient connections to the main urban areas.	No significant impact.	No significant impact.	No significant impact.
Enhance health and wellbeing	Working from home can give more flexibility in working hours allowing for leisure breaks during the day. It may also allow more healthy eating habits to be developed. Many people find the isolation and lack of social contact when working from home difficult to adjust to, leading to mental helath prolems and deterioration in wellbeing. People who previously walked or cycled to work may find they are less active.	Unlikely to have much effect on health and wellbeing. Provision of telehealth services may increase availability and reduce wait times for initial health consultations which could lead to earlier diagnosis of conditions.	Unlikely to have much effect on health and wellbeing. The act of shopping is seen as cathartic by some but stressful for others. Boutique shops and clothes retailers where browsing is important will likley remain as physical outlets. Shopping for more mundane items and regular purchases most likely to move on-line. The social aspect to shopping and the physical aspect of walking while shopping is lost when shopping on-line - this may have small negative consequences on health and wellbeing.	This is likely to have a strong positive effect on helath and wellbeing. Local availability of daily amenities and services encourages more walking and cycling and less car trips. Vibrant neighbourhood communities enhances feelings of belonging and provides social meeting points for more of society. Less time spent travelling longer distances means more time for social and leisure activities.	Shifting from car to walk for short trips or to cycle for short and medium length trips has obvious health benefits. Shifting from car to public transport for longer journeys also involves some walking to and from PT stops, and more than when using the car. However, increased journeys times and long waits associated with poor quality PT services may impact negatively on wellbeing compared to the convenisnce of using the car.	No significant impact.	No significant impact.	Better air quality associated with electric vehicles compared to ICE vehicles leads to health benefits. This is accounted for in the air quality objective. No other benefits.
Promote equity and social inclusion	Certain vulnerable groups who are less PC literate may be disadvantaged by moves to homeworking. Emloyees without suitable equipment at home or without a quiet space in which to work (office of spare room) may be disadvantaged. Homeworking is advantageous for workers that may have childcare responsibilities (proportionally more women). Not all jobs are possible to work from home. Research (McKinsey, 2020) indicates that in total across all sectors there is an estimated effective potential (effective potential includes only activities that can be done remotely without losing effectiveness) for working from home of 33% in the UK, for Germany it is 30% and for France it is 28%. The finance, management, professional services and information sectors were found to have the highest potential for remote work.	Digital and teleservices remove the need to travel and so inequities associated with the transport system and the wide variation in ability to travel to destinations where personal services are provided are no longer an issue. Certain vulnerable groups who are less PC literate or without suitable technology at home may be disadvantaged by moves to digitise access to personal services. Poor broadband connections may disadvantage people in some areas. Ability to pay for broadband may be a barrier for some.	On-line shopping and home delivery remove the need to travel and so inequities associated with the transport system and the wide variation in ability to travel to shopping destinations are no longer an issue. Certain vulnerable groups who are less PC literate or without suitable technology at home may be disadvantaged by moves to digitise access to shopping. Poor broadband connections may disadvantage people in some areas. Ability to pay for broadband may be a barrier for some. Lack of presence at home to receive deliveries or lack of a secure place to leave deliveries may disadvantage some people and deter them from on-line shopping.	Local availability of daily amenities and services means better access to essential goods, services and activities for more of society. Stronger and more vibrant local communities can feel more inclusive and caring for isolated and vulnerable members of society.	Designing for walk, cycle and public transport ahead of the car has obvious equality and inclusion benefits for non-car owners and generally there will be positive impact related to this objective. However, not everybody has equal ability to walk or cycle and so suitable mobility alternatives must also be provided where these modes are prioritised. Similarly public transport vehicles, infrastructure and operations need to be accessible, empathetic and safe for vulnerable persons and affordable to those on low incomes.	No significant impact.	No significant impact.	The higher cost of electric vehicle purchase is a significant barrier to electric vehicle ownership for many. Subsidies should be considered to remove this barrier. Lack of access to off-street charging points also creates inequity: on-street charging points are limited in number and more expensive to use. Residents in flats and higher density housing without driveway parking do not have the same opportunity for electric vehicle charging.

2.5 Configuration Settings Worksheet

The configuration settings worksheet allows users to adjust the default values for a number of parameters used in the tool. This allows more locally relevant values to be defined. If the user enters a local value for any of the parameters in the configuration settings sheet, then this overrides the defaults applied by the tool.

Setting locally relevant parameter values

This file allows users to adjust the default values for a number of parameters used in the tool. This allows more locally relevant values to be defined.

User should define a local value if they do not wish to use the default value.

If you want to use the default value, make sure the local value cell is empty (delete any values previously entered to the relevant

Parameter	Distance band	Area	Local Value	Default Value	Units	Comment / Source
Base-case CO2 emissions from ICE cars on the road		All areas		138	gCO2/km	The fuel efficiency of the average car on the road in 2020 in the UK was approx. 138 gCO2/km. The average age of cars on the road was 8.5 years. The average fuel efficiency of new conventional cars in 2020 was 122gCO2/km (Department for Transport https://www.nimblefins.co.uk/average-co2-emissions-car-uk#nogo). Carbon dioxide emissions per car steadily declined every year between 2001 and 2018, decreasing by around 2.7 g/km each year.
Commuting trip distance as % of total trip distance (within particular area type)		Urban		24%		Default values derived from Nationl Travel Survey data analysis on trip distance by trip purpose for England. Table NTS9912 provides data for Rural/Urban class
		Peri-urban		26%		
		Rural		28%		
Personal business trip distance as % of total trip distance (within particular area type)		Urban		7%		
		Peri-urban		8%		
		Rural		10%		
Shopping trip distance as % of total trip distance (within particular area type)		Urban		15%		
		Peri-urban		16%		
		Rural		18%		
Shopping, leisure, education, and personal business trip distance as % of total trip distance (within particular area type)		Urban		50%		
		Peri-urban		45%		
		Rural		40%		
% of trips within 1km of home that are walked, cycled or use public transport		All areas		90%		Default value derived from NTS0308 - Average number of trips by trip length and main mode: England 2019
% of all trips by distance band (within particular area type)	<3km	Urban		46%		Default values are derived from Table NTS9911 - Average number of trips (trip rates) by trip length, region and Rural-Urban Classification: England, 2018/2019 (Department for Statistics, Nation Travel Survey).
	3 - 8 km			26%		
	> 8 km			28%		
	<3km	Peri-urban		37%		
	3 - 8 km			20%		
	> 8 km			43%		
	<3km	Rural		24%		
	3 - 8 km			26%		
	> 8 km			50%		
Average carbon intensity of renewable electricty generation (wind, solar, hydro,		All areas		10	gCO2e/kWh	Carbon intensity of electricity varies greatly depending on fuel source. As a rough guide coal has a carbon intensity of about 1,000g CO2/kWh, oil is 800g CO2/kWh, natural gas is around 500g CO2/kWh, while nuclear, hydro, wind and solar are all less than 50 g CO2/kWh. The carbon intensity of grid electricity is determined by the fuel mix used in generation. e.g. More coal and less use of gas in the grid electricity mix will result in higher carbon intensity of fossil fuel generation.
Average carbon intensity of fossil fuel electricty generation (coal, lignite, oil, gas)		All areas		690	gCO2e/kWh