

# Achieving net zero carbon transport in our cities:

Key issues for policy makers

Helen Heinz, Clemens Marggraf & Kostas Galanakis INDEPENDENT TRANSPORT COMMISSION

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# Foreword

The challenge of climate change has required a robust response from the UK Government, committing the nation to a net-zero carbon economy by 2050. This ambition will require wholescale changes to how we live as well as the vehicles we use to travel around. The role that our cities have to play in meeting this target is crucial, given the status of the UK as a highly urbanized economy. Fortunately, the challenge has been embraced by many UK cities which have begun to develop roadmaps for becoming zero-carbon locations, many with a target date ahead of that laid out in the national legislation.

The Independent Transport Commission (ITC), with its remit to explore both transport and land use policy questions, has a keen interest in this topic. In particular, it is important to understand whether the policy measures necessary to achieve low-carbon cities differ according to the scale and location of an urban area. To explore this question we have been pleased to engage a research team from Nottingham Business School, as part of their wider research study funded by the European Union's impressive Horizon 2020 scheme.

This important study has explored the challenges faced by policy makers in a range of scales of city, from an international mega-city such as London, to a small historic city such as Durham in north-east England. The researchers show that scale matters in terms of the policy responses required to achieve low-carbon transport, due to the different travel needs and infrastructure in each location. They also demonstrate that governance structures are crucial, since urban areas with the strongest local powers and most robust funding sources are in a better position to meet the net-zero carbon challenge, and in many cases are further ahead on their roadmap to achieving this.

We commend these findings to national and local policy makers in helping them achieve the most effective roadmaps to low carbon urban transport. In particular, the findings suggest that consideration should be given to increase the powers and funding of city authorities: these are often best placed to tailor policy to meet the particular needs of their residents and urban infrastructure. The researchers have also provided a helpful analytical tool which can be used by policy makers, and gives due attention to social value criteria. Ensuring that low-carbon policy measures are fair and equitable, particularly to low-income groups, will be essential if such policies are to be successful.

#### Terry Hill CBE

Chairman

Independent Transport Commission October 2022

## Achieving net zero carbon transport in our cities: Key issues for policy makers

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# Executive Summary

## Introduction

- 1. The Independent Transport Commission (ITC) has a central interest in the connections between transport and land use policy. The imperative to decarbonise our transport systems in order to mitigate dangerous climate change is one of the greatest policy challenges the nation faces. This challenge was explored in the UK Government's paper *A Better, Greener Britain* (2021) which laid out the ambition to make our transport networks zero carbon by 2050. In the highly urbanised society of the UK, the role that our cities have to play in meeting this challenge will be crucial. At the same time, our cities are of great variety in size and function, and it is important to understand to what extent low carbon transport policies will need to be tailored to take these differences into account.
- 2. To explore this important topic, the ITC commissioned a research team based at Nottingham Trent University to examine the challenges cities face in decarbonising surface transport. The researchers are experts in low carbon infrastructure systems, and were set a number of key objectives in this paper. These included the identification of key initiatives necessary for moving urban surface transport towards net zero carbon targets, the priorities for policy makers to achieve this transformation, and an assessment of the funding needs and social fairness aspects of the policies to be adopted.

### Methodology

- 3. The research team chose as case studies three cities across England of different sizes. These cities were selected to represent urban areas of different scales, demographic characteristics, function and geography. London was chosen as an example of a global mega-city; Nottingham was selected as an example of a midsize city; and Durham, including its UNESCO World Heritage Site, was used to look at the needs of small-scale historic cities. These case studies were used to explore how local authorities can facilitate the transition to low carbon transport, as well as the barriers faced in delivering national and local objectives. The research team used interviews (conducted remotely as a result of ongoing Covid19 measures) with key stakeholders in each of the case study cities to investigate policy challenges and explore the needs of each urban area.
- 4. A guiding framework was devised by the research team to evaluate the measures towards low carbon transport undertaken in each city area. This analysis is based on the Avoid-Shift-Improve framework increasingly adopted by local authorities, which aims at: i) reducing or avoiding people's need to travel; ii) shifting people's travel choices towards low-carbon modes, and iii) improving the provision of low-carbon transportation options. The researchers used these three pillars as part of their assessment, alongside exploring the funding needs required for these policies and their inclusiveness or social fairness. A traffic light model was used to review progress on each of these measures.

## Key Findings for each city

- 5. In the case of London, as a global mega-city, the researchers noted the ambitious nature of the Mayor of London's Transport Strategy and its aim to make surface transport carbon-neutral across the city by 2030. London was judged to have a clearly devised implementation plan for reducing travel and especially car journeys through the development of a 15-minute neighbourhood planning strategy with a focus on local amenities. Shifting travellers onto low-carbon modes was also evaluated to be backed by clear implementation policies in London, through mechanisms such as the congestion charge, the low emission zones, and the efforts being made to increase the affordability and accessibility of passenger transport. Good policy progress was also judged in London on improving low-carbon transport provision, through measures such as supporting the transition to a low-carbon vehicle fleet, and support for an improved city-wide electric vehicle charging infrastructure.
- 6. At the same time, concerns were expressed over the funding mechanism used in London which has left Transport for London financially stretched, and dependent upon emergency grants from central Government. New revenue streams, and collaboration with the private sector will be necessary to provide the necessary investment to achieve zero-carbon transport ambitions. London has made excellent progress in achieving an inclusive and accessible transport network, but the researchers indicated that its policies could be made more human-centric, encouraging democratic citizen engagement in order to serve the needs of the wide range of individuals both living in and visiting London. The researchers concluded that the case study of London demonstrated that large mega-cities require robust funding mechanisms and an ability to integrate a wide range of policies if they are to achieve low-carbon transport objectives.
- 7. For Nottingham, as an example of a mid-sized city, the researchers noted the imaginative and proactive approach of local policy makers in moving towards low-carbon transport. The city's local transport plan is sensibly aligned with its local development framework, helping to reduce the need for travel by providing more amenities in local neighbourhoods using the 15-minute city framework. Nottingham has also made strong progress in shifting transport modal choice through promotion of its active travel programme, as well as its park-and-ride schemes and mobility hubs. The researchers also praised the city's implementation plan for improving low-carbon transport by investing in electric vehicle charging infrastructure, and supporting the transition of the city's vehicle fleet to biofuels and battery power.
- 8. The researchers noted that Nottingham has a high level of income deprivation, and a significant minority of the city's households do not own a car and are reliant on other forms of transport. However, they praised the city for making human factors central to its decarbonisation strategy, such as the investment in Mobility as a Service (MaaS) schemes which are seen as being more inclusive and accessible to households without a car. A concern was raised, however, at the insufficient funding that Nottingham (and other similarly-sized cities in England) have to implement their plans. The reliance on short-term grants from central Government is a hindrance to local city authorities in England in developing holistic decarbonisation policies.

At the same time, Nottingham was making good process in finding alternative revenue sources, such as through its workplace parking levy scheme. Overall, Nottingham was praised as a good example of the progress that a mid-sized city can make towards zero carbon transport, when local policy makers are innovative and engaged in progressing these ambitions.

- 9. The case study of **Durham**, as a **small**, **historic city**, was instructive in showing the challenges that smaller cities face in achieving zero-carbon transport. Durham's situation, as centre for tourism with an UNESCO World Heritage Site, and its position with a large rural hinterland, results in a high level of car usage to access the city. A key problem is that the city does not control its own transportation policy, this being determined by the wider regional authority, although it does have a city neighbourhood plan for future development. The researchers judged that current plans are insufficient to reduce travel demand and to shift modal choice away from the car onto other modes. Durham's current park-and-ride system is valuable, but the existing road user charging scheme is very limited. While there are ambitions to improve electric vehicle infrastructure, low household incomes in the region make electric vehicle uptake too expensive at present for many people.
- 10. The funding system in Durham was judged to be particularly insufficient to achieve zero-carbon transport targets. The local authority in County Durham is strongly focused on the needs of its rural residents, and the city has to rely on grants to implement low carbon schemes. The researchers therefore argue that sustainable mobility in the city requires more substantial funding resources if zero-carbon policies are to be successfully implemented. However, the researchers praised Durham's focus on socially equitable and inclusive transport solutions, and the recognition by local politicians that sustainable transport policies should not negatively impact disadvantaged groups in one of the lowest income regions of the UK.

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## Conclusions

- 11. Different scales of city require tailored low-carbon transport policies that can account for their different contexts and needs. Large and medium-sized cities have more opportunities to direct policy due to having more powerful city authorities, whereas smaller cities in England can find their transport policy dictated by a larger authority with different priorities. Due to their scale, larger cities also are better able to promote concepts such as the 15-minute neighbourhood, and often have more sophisticated passenger transport networks that allow more opportunities for encouraging modal shift. Measures to move car users onto other transport modes, through policies such as congestion charging and workplace charging levies, are likely to be more effective in larger cities where modal alternatives are more extensive.
- 12. At the same time, larger cities face additional challenges due to the complexity of their transport systems, and the wider variety of needs of different communities across their urban areas. The researchers conclude that the most pressing problem facing all the English cities studied is the limitations on their funding models, and the need for additional resources to meet their decarbonisation objectives. This is a challenge for national Government, which should find ways to provide more financial resources and autonomy for local authorities, as well as powers that can be used to develop integrated zero-carbon policies.

### Recommendations

- **13.** Recommendations from the study for policy makers are summarised in Table 1.1 following. These include the need to promote shorter trips by making more amenities available locally, and nudging citizens towards active mobility. Investment in the public transport system and in electric vehicle charging infrastructure will be crucial to achieve zero carbon transport targets. The researchers recommend generating strategies that implement new technologies equitably. To do this, social-value criteria should be applied to policies, and pilot studies to test emerging technologies should be encouraged. Crucially, all local authorities will be more successful if they have improved fundraising mechanisms to allow widespread capital investment. Place-based solutions, which require a focus on local travel based on 15-minute neighbourhoods, will be essential.
- 14. The guiding framework devised by the researchers provides a useful means of analysing the coherence and likely success of urban zero-carbon policies. The framework highlights the importance of giving attention to each of the three policy pillars of avoid, shift, and improve, which can enhance the productivity and flexibility of the transport system. Such a framework can enable local authorities to capture the complexity of their local urban surface transport network and to identify initiatives, infrastructure, and salient investment priorities needed for the transformation towards net-zero transportation while also ensuring inclusiveness and social coherence. Further research would be welcome into the decarbonisation pathways of UK cities using scenarios and sensitivity analysis.

Avoid	Shift	Improve
<ul> <li>Replace the need for travel through:</li> <li>Local solutions beyond transport</li> <li>City planning and place-based planning.</li> <li>15-min Neighbourhood and polycentric city concepts.</li> <li>Consistent and clear messaging across planning and communication actions.</li> </ul>	<ul> <li>Shift trips away from private cars and direct towards active, public, and shared transport through: <ul> <li>Walking and cycling infrastructure and promotion.</li> </ul> </li> <li>Accessible and affordable public transport network.</li> <li>Multi-modal travel and integrated ticketing.</li> <li>Car &amp; bike sharing, and mobility hubs.</li> <li>Changing road design and effective car parks way from city centres and towards integrating them with public transport.</li> <li>Consistent and clear messaging across planning and communication actions.</li> </ul>	<ul> <li>Any trips that still need to be done by car; they should be made by improved technology:</li> <li>Low carbon vehicles (private, public, business).</li> <li>Sustainable alternative fuels (electricity, hydrogen, biofuel).</li> <li>The uptake needs to be encouraged through incentives, attractive refuelling infrastructure, and sustainable energy supply.</li> </ul>

#### Table 1.1: Key recommendations for achieving zero-carbon urban transport

**Funding needs:** Leveraging public and private investments as a tool to overcome funding challenges that are set by the governmental structure and possible lack of powers:

- Focus beyond road schemes and direct funding towards avoid, shift, and improve according to city needs.
- Establish partnerships between public and private sector for increased clarity, communication, and cooperation between the two parties.
- Support private investors who are already interested to fund charging infrastructure that is economically attractive, while public funding could be used for social equity, inclusiveness, and affordability of infrastructure
- Counteract grant-driven behaviour which creates funding and time constraints, through additional revenue streams such as the Workplace Parking Levy scheme can help local authorities
- Long term visibility of funding.
- Testbed of new technologies with clear scale-up funding options.
- Pathway for raising funds at city level through a Green Investment Bank.
- Achieve a level of flexibility and long-term planning and receive revenue for continues improvement of the infrastructure.

**Inclusiveness:** inclusiveness and social coherence are the underlining notion of all avoid, shift, and improve initiatives, infrastructure improvements, and investment decisions for the transition to net zero urban surface transport:

- Identify struggles e.g., high level of households with no car ownership, high need of connectivity, or complexity of the transport system, to target them,
- Be aware of effect of transformation on multitude of individuals (residents, commuters, tourists) with different needs,
- Ensure affordability and accessibility during the transforming process and in the future,
- Move away from "traditional habits" towards creating a future proof liveable, attractive, urban environment with provision of inclusive transport opportunities,
- Improve infrastructure in a way that it is inclusive, increase quality of life, but not give reason for transport poverty.

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## I. Introduction

## I.I The Current Context

The UK government launched the 'A Better, Greener Britain' decarbonising transport strategy in 2021. This strategy outlines a long-term aim for transitioning to zeroemissions transport by 2050. As part of the strategy, the UK aims to decarbonise all forms of transport by encouraging a decrease in transport demand, an increase in a modal shift, and an increase in vehicle and transportation infrastructure efficiency <sup>(11)</sup>. Hence, the Transport Decarbonisation Plan presents key milestones and interventions required for infrastructure and investments to decarbonise every form of transport such as the UK's commitment to end sales of new petrol and diesel cars and vans by 2030, and new hybrid cars and vans by 2035.

The UK was the first country in the world to set in law the requirement to reduce net emissions of GHG by 100% relative to 1990 levels, by 2050. The transportation sector contributes 27% of the UK's greenhouse gas (GHG) emissions<sup>[2]</sup>. The breakdown of surface transport emissions showcases the dominant contribution of cars in transport emissions with 61% (in 2019)<sup>[3]</sup> as they are still the most common mode of travel. Figure 1.1 shows that the decarbonisation goal means immense reductions in GHG emissions in the next 30 years to reach net zero. Transportation demonstrated a 2.8% reduction in emissions during 2018 and is considered as lagging in the overall efforts for decarbonisation since the sector is still dependent on fossil fuels for 97% of its energy needs<sup>[1, 4]</sup>.

Figure 1.1. Decrease of carbon dioxide emissions of cars (urban driving) from 1990 until 2018 with projected needed decrease starting from 2020 until 2050 for decarbonising urban road transport.



Source: Synthesised from UK emissions data selector - NAEI, UK. 2022. Carbon Dioxide as Carbon, Road transport – cars – urban driving; and IEA. 2021. Net Zero by 2050 – A Roadmap for the Global Energy Sector. International Energy Agency. Table A.4: CO<sub>2</sub> emissions.

Notably, to reach these challenging targets<sup>[5]</sup>, there is an urgent need to address how rapid decarbonisation is going to be achieved and support investment in low carbon transport infrastructure at both national and local levels<sup>[6]</sup>. Urban transport often struggles to achieve sufficient funding<sup>[7]</sup>. Local authorities' financial capabilities are often limited; hence identifying solutions that fit their regional or urban context will require collaboration between the public and private sector<sup>[8]</sup> and support from the central UK government<sup>[1]</sup>. Publications such as the Treasury's Net Zero Review, the Prime Minister's Ten Point Plan for a Green Industrial Revolution, or the Future of Mobility Urban Strategy are anticipated to bring more clarity to the actions needed to reduce carbon emissions to a net-zero target by 2050 at the local level. In addition, the Institution of Civil Engineers points out the importance of accelerating the modal shift and active mobility, decarbonising road vehicles, and identifying placebased solutions, valuing local differences<sup>[9]</sup> for the transition towards sustainable transportation. The 2035 delivery plan to decarbonise cars and vans demonstrates a road map with various regulatory changes, actions, initiatives, and infrastructure which are needed to achieve this transition and make zero-emission cars and vans affordable and attractive<sup>[10]</sup>. In fact, this transition pathway needs to enable inclusive mobility and consider evolving technology, behaviour, and policy<sup>[1]</sup>. To address all these factors of the transition to zero-emission urban surface transport, local authorities frequently follow the concept of "avoid, shift and improve" to achieve inclusive urban sustainable mobility<sup>[11]</sup>.

### I.2 Aims and Objectives of the report

This report aims to provide a guiding framework for infrastructure and investment strategies that are required for achieving local transport decarbonisation goals in urban contexts. This framework can be used by local actors as a monitoring tool for the level of progress of current strategies and actions, as well as highlighting aspects of inclusiveness, or topics that have not yet been considered.

In order to achieve the aim of the report the following objectives have been set:

- To identify key initiatives and infrastructures that are necessary for moving surface transport to local net zero emission targets covering avoid, shift, or improve (alternative fuels – electricity, hydrogen, and biofuel) options in different urban contexts;
- To associate priorities for public and private investments that are necessary for achieving the above transformation at the city level;
- To reflect upon inclusiveness and social coherence in interventions and connect with possible required behavioural change to accelerate and ensure a just transition pathway.

Three cities across England with different sizes and characteristics (London, Nottingham, and Durham) have been used as case studies to explore how local authorities facilitate the transition to low carbon transport. The cases demonstrate barriers faced in delivering national and local objectives towards this transition. The three case studies have been selected to represent different scales, demographic characteristics, to cover geographically the length of the country, the different considerations of the planning system, and the distinctive needs of the type of the city that they represent.

#### A representative case for a large city and metropolitan areas across the UK and Europe: the London case

- Vibrant metropolis and financial powerhouse; Dynamic economic and population growth, one of the largest urban zones in Europe; Median age of the population is 35.8 years;
- Complex transportation system coordinated primarily by Transport for London and gradually transitioning to sustainability to meet London's net-zero target by 2030;
- London Underground is the most important mode of public transportation; High level of EV charging infrastructure and amount of electro/ hydrogen buses and taxis;
- Significant congestion problems are due to, among other things, the use of a high number of private cars. Congestion Charge in the centre of the city;
- £ Long-term planning regarding funding is not possible due to the central government funding system. Fundings of low emission zones are used to improve public transportation.

## A representative case for mid-sized, core cities in England: the Nottingham case

- Medium-sized city in the Midlands; High level of income deprivation; Median age of the population is 29.7 years;
- A sizable energy management staff with proactive engagement in energy transition and the goal to decarbonise urban transport by 2028;
- Careful integration of the bus and tram systems and ride and park facilities; 120 biogas double-deck buses and 58 electric buses;
- Workplace Parking Levy used to fund transport infrastructure such as parts of the electric bus charging infrastructure;
- financial resources create issues regarding long-term planning.
   Fundings from the parking levy are used to maintain public transport.

## A representative case of small cities/ historical towns of international interest: the Durham case

- Small city in the North of England with prestige and vast countryside; Bordering the Sunderland Nisan Facility; Historic County Town (UNESCO World Heritage site); Median age of the population is 42 years;
- Durham City Sustainable Transport Delivery Plan sees decarbonisation of transport as an opportunity, however, the full decarbonisation goal will be 2050;
- Buses are the only form of inner public urban surface transport and privately operated; Public transport not yet decarbonised;
- Durham Peninsula charging zone designed for decreasing level of traffic in the city centre; Infrastructure developments heavily dependent on funding from central government;
- The funding is heavily affected by central grant-based funds with planning at the county level.

This report begins with Chapter 1 which sets this study into context to then present aims and objectives. Chapter 2 of the report illustrates a review of the national context for the development of decarbonisation pathways through the avoid, shift, improve concept. Detail is given on alternative fuels regarding the current state of development, and the challenges for electrification, hydrogen, and biofuels, including the deployment of the necessary infrastructure. The projection against the official targets based on these actions illustrates the magnitude of the challenge that the transport sector is facing. Chapter 3 gives the methodological overview of this research, followed by Chapters 4, 5, and 6, which reflect on how different interventions would be applicable in the context of three different sized cities. That is, big, medium, and small cities are represented by the cases of London, Nottingham, and Durham, respectively. This reflection allows the identification of different priorities based on the local conditions and needs. The case studies are followed by a discussion and recommendations on the key infrastructure and investment interventions necessary for decarbonising the transport sector in Chapter 7. This paper concludes with the presentation of an overall guiding framework that could support the planning of strategies for net-zero urban surface transportation.

# 2. Transport decarbonisation pathways for policy makers

## 2.1 The Avoid-Shift-Improve framework

Covid-19 has changed travel behaviour, resulting in the avoidance of public transport and preference for private modes<sup>[12]</sup>. Nevertheless, projected travel data in studies made before the pandemic demonstrated that the share of private vehicles could decrease from around 60% in 2019 to below 40% in 2030 through measures such as decarbonisation and city planning<sup>[13]</sup>. In order to decarbonise the urban surface transport system, a balanced, place-based approach is needed between three equally important pillars to address all traveller needs<sup>[11, 13]</sup>:

- Avoid Transportation Needs To avoid or reduce the need for transportation and travel, transport policies have to be combined with other urban policies that seek a compact development<sup>[11]</sup>. National and local policy makers frequently separate spatial and transport planning<sup>[14]</sup>, while the combination of both offers opportunities for attractive living and working places, especially in an urban context. Travel needs and length of the trips can be reduced by effective city and land planning, developing concepts such as the 15-minutes neighbourhood, or polycentric cities<sup>[15]</sup>.
- Shift Transportation Mode An active role of shift measures toward public transportation and active and shared mobility is the second pillar of the decarbonisation effort. Local authorities and bus operators are required to work hand in hand to provide a rapid, efficient, reliable, accessible, and affordable bus network within their city<sup>[16]</sup>. Cycling and walking infrastructure are included under the shift measures, as is improving connectivity and security<sup>[1]</sup>, and prioritising pedestrians and cyclists instead of cars<sup>[17]</sup>.
- Improve Transportation Stock Nevertheless, for many people, private transportation is necessary for their daily business or personal needs. Therefore, the improvement of transportation stock is essential. UK's transport decarbonisation plan presents that this means the adoption of low carbon vehicles that are fuelled by alternative fuels (either electricity, hydrogen, or biofuel). This transition though still requires significant encouragement through incentives and attractive refuelling infrastructure<sup>[1]</sup> and renewable energy production<sup>[18]</sup>.

The public sector expenditure on transportation has increased significantly over the last years<sup>[19]</sup>. From 2018/19 until 2020/2021 the central government provided 78% of funding in infrastructure investment in the transport sector, with a further 10% coming from the budget of local authorities with the remaining coming from the private sector and other mixed funding<sup>[20]</sup>. However, the UK Government argues that costs for the needed infrastructure cannot be covered by public financing alone and requires both **public and private investments**<sup>[21]</sup>. The government argues that it recognises its role in establishing long-term policy certainty, attractive incentives and other policy tools

that provide signals for the direction of the transition<sup>[22]</sup>. However, the private sector is required to identify business opportunities and models that will mobilise private funds to initiate and accelerate their actions<sup>[23]</sup>. For instance, the UK Infrastructure Bank (UKIB)<sup>[21]</sup> and also the UK Green Investment Bank plc (GIB)<sup>(0)</sup> could have an increased role to mobilise private finance<sup>[24]</sup> for the transformation of the mobility and transportation sector. Also, the government itself aims to make more accessible and flexible funding to local authorities<sup>[9]</sup>. Local authorities need to consider the infrastructure needs and the associated investment costs more specifically shaped to their area<sup>[11]</sup>, identifying a funding model allowing long-term planning for their priorities regarding avoid, shift, and improve measures.

At the same time, the transition has the potential for additional economic, social, and environmental benefits in urban areas, as citizens will benefit, among others, from less polluted air, lower fuel costs, and lower vehicle operating costs. Still, this will not be enough. Inclusiveness and social coherence measures are required to be integrated into all initiatives and infrastructure interventions so that an equal, accessible (regardless of age, gender or disabilities) and fair transition to sustainable mobility can be achieved<sup>[25, 26]</sup>. The UK government has started to recognise this issue by publishing the "Inclusive Transport Strategy"<sup>[27]</sup>, however, inclusiveness and social coherence are lacking in the national transport decarbonisation strategy.

### 2.2 Avoid and shift measures in the national context

The national decarbonisation strategy demonstrates clear thinking that achieving netzero transportation cannot just be car-led but requires a balanced approach which also supports the increase of trips taken by cycling, walking, and public transport<sup>[21]</sup>. Interventions and infrastructure to support avoid and shift measures should make effective use of road space and provide more sustainable mobility options<sup>[1]</sup>.

According to the "National Planning Policy Framework"<sup>[28]</sup> published by the Ministry of Housing, Communities and Local Government, planning policies and decisions should acknowledge the role that town centres play as the core of local communities by taking a positive approach to their growth, management and development, and transforming them into secure, inclusive, and healthy places. Urban planners should promote an adequate mix of uses in different kinds of areas to reduce the number and length of trips required for employment, shopping, leisure, education, and other activities. An attractive walkable and bikeable urban environment can also connect well with other transport modes for transits, following the first-mile, last-mile priority scheme<sup>[29]</sup>. Thus, planning policy supports the idea of the 15-min Neighbourhood concept<sup>[30]</sup> to cluster social life and daily needs within a certain district or a closer radius, creating polycentric cities.

The Department of Transport identifies active transport as a key component to mitigate emissions. Thus, the promotion of cycling and walking is one main focus of the "Transport decarbonisation plan"<sup>[1]</sup> and the national "Cycling and walking plan"<sup>[31]</sup>.

<sup>&</sup>lt;sup>(0)</sup> Launched in 2012 by the UK Government and designed to support the energy transition it was the first institution of its type in the world. The government sold the UK's original Green Investment Bank to Australian bank Macquarie in 2017, still the bank is actively involved in sustainable investments such as into wind energy which at some point will be needed to sustainably power electric vehicles. (Source: <a href="https://www.greeninvestmentgroup.com/en/who-we-are/our-mission.html">https://www.greeninvestmentgroup.com/en/who-we-are/our-mission.html</a>)

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The Government will invest over £2 billion over the next 5 years to increase the attractiveness of these transportation modes with the aim that by 2030, up to half of the journeys are made by cycling and walking<sup>[21]</sup>. Multiple planned interventions support this vision. For example, in collaboration with small or medium-sized cities, the government wants to create a zero-emission transport system with an extensive, safe, continuous, and inclusive cycling and walking infrastructure. In addition, a new funding body and inspection authority "Active Travel England" has been set up to impose standards and improve performance generally. Furthermore, the "Active Travel Fund"<sup>[32]</sup> has already been noticed as a fundamental funding source for local authorities<sup>[11]</sup>. UK cities could target cycling becoming as popular as in Copenhagen, Denmark, where there are more bicycles than inhabitants in the centre of Copenhagen (520,000 inhabitants and 560,000 bicycles)<sup>[33]</sup>, supporting the shift of up to 14% of car journeys to active travel and 24% to public transport by 2050 <sup>[34]</sup>.

The National Bus Strategy lays out the vision for the future bus network and how to achieve its transformation. This vision includes among others modernisation, bus priority zones, multi-operator ticketing, demand-responsive services (e.g., shuttle services that are available in addition to the traditional public transport, that can be called by citizens matching their unique needs), and multi-modal travel to overall increase connectivity while ensuring affordability and accessibility<sup>[16]</sup>. At the same time, support for shared mobility is expected to increase the average car occupancy from 1.6 today to 1.9 by 2050<sup>[34]</sup>. Further practices and social acceptance experiences can be learned from projects across Europe. For example, Vauban (Freiburg, Germany) is promoted as a car-free neighbourhood, where attractive walking, cycling and car-sharing infrastructure has been created, where public transport links the district to the city centre, and where there are no parking spots in the streets just a parking garage at the border of the district<sup>[35]</sup>. This approach aims to limit emissions, and give road space to citizens rather than cars, creating an inclusive, liveable environment<sup>[36]</sup>.

### 2.3 Improve measures in the national context

The Coalition for Urban Transitions foresees two key national measures to positively impact urban areas towards the target of net zero transportation:<sup>(i)</sup> the deployment of zero-emission public and private vehicles; and<sup>(ii)</sup> the production and distribution of alternative fuels. In 2020, fossil fuels account for approximately 95% of the global transport energy demand (including road, shipping, and aviation)<sup>[37]</sup>. This needs to be replaced by a mix of sustainably sourced electricity, green hydrogen, and biofuels, with fossil fuels to be reduced to less than 12% of the total use by 2050<sup>[37]</sup>.

#### **Vehicle Electrification**

Electrification of vehicles, primarily passenger cars, vans, buses, and commercial vehicles are widely considered the most energy and cost-efficient pathway for decarbonisation of road transportation<sup>[38, 39]</sup>. All major passenger and light-weight vehicle manufacturers are investing in modifying their vehicle mix, preparing themselves for increasing demand for EVs<sup>[40]</sup> and the new ICE car ban across UK and EU by 2030 and 2035. Despite the increase of electric vehicles in the UK (Figure 2.1), their proportion among the total number of 31.7 million cars in the UK still represents just 0.8% of licensed cars<sup>[41]</sup>. Bloomberg's New Energy Finance EV Outlook, for example, forecasts 10 million EV cars in the UK by 2025 and 28 million by 2030<sup>[42]</sup>. These projections exceed the National Grid planning projections which are based on reaching the 30 million EVs by 2050. This exponential increase in EV numbers indicates an urgent need for cities to prepare and invest proactively in relevant charging infrastructure, which currently is unevenly developed across the country<sup>[43, 44]</sup>. The government set out a commitment to invest £1.3 billion to accelerate the deployment of EV charging infrastructure for homes, streets, and motorways, including the roll-out of rapid charging points<sup>[45]</sup>. The Climate Change Committee (CCC) recommends a strategy for the widespread deployment of charging infrastructure across the UK in the Transport Decarbonisation Plan, that encourages an increased level of both public and private investment. Furthermore, the CCC highlights the importance of a clear plan for effective implementation of residential on-street charging infrastructure, as 33% of households do not have offstreet parking, and two-thirds of those are living in social housing.

## Figure 2.1 Increase of different registered Ultra Low EVs in UK between 2010 and 2021.



Source: SMMT cited from RAC (2022)

The forecast of the number of charging points needed for a future inclusive transport system varies depending on the growth assumptions. Figure 2.2 illustrates a variety of forecasts from the International Council on Clean Transportation (ICCT), Climate Change Committee (CCC), Delta Energy & Environment (Delta EE), Transport & Environment (T&E) regarding the number of charge points that will be required to support the growth in EVs. Due to uncertainties in the forecasts, there is a high degree of variability in estimates of the infrastructure needed; for instance, the CCC predicts we will need 280,000 charging points while T&E predicts 480,000 charging points by 2030. The central estimate is that up to ca. 500,000 public charging points could be required by 2050<sup>[34]</sup>: an increase of 15 times that of the current number of about 30,000 charging points<sup>[46]</sup>.

Figure 2.2: Current (2010 -2020) and projected number of required public vehicle charging points (dotted line from 2020 -2050) in Britain to achieve net zero carbon.





#### Source: Policy Exchange

The government takes a location-neutral approach in investing in the uptake of the EV infrastructure network. As a result, EV charging points are disproportionality located across the UK. There are significant differences between the nations, regions and local authorities, e.g., most devices per person are in London and Scotland<sup>[47, 48]</sup>. The Future of Transport programme acknowledges that there is the need to identify barriers, overcome regulatory hurdles that lead to poor uptake of existing schemes<sup>[21]</sup>, and ensure that further investment and infrastructure are accessible to all rural and urban areas of the country<sup>[49]</sup>.

The government argued that one of the reasons for the low uptake of the introduced schemes, is a lack of in-house expertise within some local authorities, impacting their ability to bid for funding<sup>[21]</sup>. A study on EV infrastructure barriers from CENEX, however, found that most often the key barrier was the complexity in the interpretation of government guidance for local authorities applying to the scheme<sup>[50]</sup>. The private sector can support the transition by providing EV infrastructure, e.g. transforming petrol stations into EV charging hubs<sup>[51]</sup>.

Furthermore, two key market areas are currently undeveloped which may reduce the mass ownership of EVs. The first area refers to the second-hand market for EVs, which is practically non-existent as the current incentive policies cover only new vehicles<sup>[11]</sup>. In 2021, about 40,000 used EVs were sold, while about 190,000 new EVs were sold<sup>[52, 53]</sup>. The second area refers to the electrification of taxis and light business and utility vehicle fleets (e.g. police, courier etc). Several examples across the country, for example, demonstrate how local authorities can work together with the taxi industry and logistic companies to provide attractive incentives, policy changes, and infrastructure for the deployment of purely electric taxis and trucks,<sup>[54, 55]</sup>.

In parallel, the government and local authorities are engaged in discussions for attracting investment in battery production facilities, for reducing the dependency on foreign-based supply chains<sup>II</sup>. The Society of Motor Manufacturers and Traders (SMMT) projects that Britain needs 60GWh of battery plants just to maintain the current production volume of EVs, and creating generous incentives for business investment. Further examples are the planned 38 GWh battery facility in Sunderland and the planned British Volt factory in Blythe<sup>[56, 57]</sup>. In addition, the generation of enough green electricity in the UK for the increasing demand is a further issue. 39.3 % of the total UK electricity generation is produced by renewable sources in 2022<sup>[58]</sup>.

#### **Hydrogen-based Vehicles**

The UK government has identified Hydrogen as a major technology to reduce emissions in the transport decarbonisation strategy, aiming to raise the low-carbon<sup>III</sup> hydrogen production capacity from 1GW in 2025, to 80GW by 2050<sup>[45, 59]</sup>. One significant advantage is that in combination with a fuel cell, it only produces water, electricity, and heat. The main advantages over EVs are fast refuelling, high energy density, and long ranges. Thus, hydrogen may be a potential solution for longer-term, long road transportation needs, heavy vehicles, and marine and rail transportation<sup>[1]</sup>.

<sup>&</sup>lt;sup>II</sup> 40-50% of the value of EV cars derive from the battery system and a further 20% from the related electric drive electronics. Furthermore, ensuring a domestic supply chain will allow UK based manufacturers to cover the no-tariff requirements that derive from the UK-EU Trade and Cooperation Agreement. (Source: <u>https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/three-surprising-resource-implications-from-the-rise-of-electric-vehicles)</u>

<sup>&</sup>lt;sup>III</sup> 'Green Hydrogen', produced by renewables, or 'Blue Hydrogen', produced by methane or natural gas and combine CO<sub>2</sub> capture and store facilities. (Source: <u>https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\_data/file/1011283/UK-Hydrogen-Strategy\_web.pdf</u>)





Figure 2.3: Hydrogen Refuelling Station Locations in the UK.

#### Source: ukh2mobility.co.uk, 2021 [62]

In 2020 Germany already had 738 hydrogen vehicles in comparison to the UK with 228 and France with 385. However, if one takes these figures in relation to the number of charging stations, a different picture emerges, as France has 24 hydrogen charging stations per car, while the UK has 19 and Germany only 8<sup>[60]</sup>. Therefore, the UKH2Mobility<sup>[61]</sup>, a consortium of three Government Departments, and industrial participants from the utility, gas, infrastructure, and global car manufacturing sectors, have developed a phased programme to expand the hydrogen refuelling stations for light-duty and HGVs. At the moment, most hydrogen refuelling stations can be found in urban areas in the south of England (Figure 2.3)<sup>[62]</sup>. The focus is to achieve nationwide coverage to enable 50% of the population to refuel close to home and major roads with 330 hydrogen refuelling stations by 2025, expanding to 1,150 by 2030<sup>[63]</sup>.

However, three major challenges exist regarding the deployment of hydrogen infrastructure. Firstly, the comparatively high cost and planning conditions might limit the construction of the building of hydrogen stations<sup>[64]</sup>. Currently, it costs between \$1 million (about 850,000 GBP at mid-2022 exchange rates) and \$2 million (about 1,700,000 GBP), while an ultra-fast-charging EV station equipped with a single 350-kW charger costs ca. \$200,000 (170,000 GBP)<sup>[65]</sup>. Secondly, costs and expertise are needed for the maintenance of hydrogen vehicles. In London, all maintenance is undertaken in-house at the Transport for London (TfL) depot, and there is no

experience among any major external contractors<sup>[66]</sup>. Due to the high costs involved in developing such skills, cities might not be able to afford the investment. Lastly, while the government has published a rudimentary roadmap for blue and green hydrogen production, there are still doubts about the scale of production, especially of the latter, to meet the 2050 target<sup>[67]</sup>. Currently, most hydrogen production is based on fossil fuels in the UK<sup>[68]</sup>.

Nonetheless, the UK government supports a range of measures, including a £240 million Net Zero Hydrogen Fund to signal a strong UK commitment as part of the Net Zero target and convince all kinds of stakeholders to invest in direct actions such as: building new production capacity and replacing combustion engine based public transportation vehicles with hydrogen ones – for example, the creation of a hydrogen centre of excellence with Wrightbus in Ballymena, Northern Ireland<sup>[69]</sup>. Under the National Bus Strategy, cities are encouraged to deploy hydrogen buses, showcasing the use of hydrogen vehicles in the urban context<sup>[70]</sup>. Therefore, £120 million has been invested in 2021/22 to start delivering these buses. Cities across the country have participated in the European scheme, Joint Initiative for hydrogen Vehicles (JIVE), to initiate the transition. For example, Birmingham was able to purchase 20 new hydrogen Double Decker5F<sup>™</sup> buses on the combined funding<sup>[71]</sup>. Besides buses, other hydrogen-powered HGVs (heavy good vehicles) are targeted, with a £20 million fund in freight trials to develop, amongst other things, hydrogen lorries<sup>[45]</sup>.

#### **Biofuel-based Vehicles**

Biofuels<sup>v</sup>, also known as low-carbon or renewable fuels, make 5.1% of the total supplied road fuel in the UK, contributing significantly to UK transport's GHG emission reduction<sup>[72]</sup>. In 2020, about 1.9 million litres equivalent of renewable fuels were verified, with biodiesel accounting for 60% of the supply and bioethanol 25%<sup>[73]</sup>. The Renewable Transport Fuel Obligation (RTFO), in 2018, set the target for increasing the biofuel share to 12% by 2030. The usage of higher biofuel blends is considered a necessary part of the transport decarbonisation strategy<sup>[11]</sup> (E10 petrol is the current standard in the UK, i.e. petrol with 10% content of bioethanol), as they can be integrated into the existing fuel supply chain for all types of existing vehicles<sup>[74]</sup>. Furthermore, they do not raise additional maintenance costs. Examples such as biomethane bus fleets in Nottingham, Bristol, and Reading<sup>[72]</sup> showcase the feasibility of this transition in a short period of time.

Biofuels are produced on the outskirts of cities or in the countryside, but a significant amount is imported<sup>[75]</sup>, with 23% of biofuels coming from China<sup>[73]</sup>. This fact raises fears about the unregulated nature of production adding to national concerns about sustainability regarding the local biofuel production. For instance, the production

<sup>&</sup>lt;sup>IV</sup> It has been funded through OLEV (Office for Low Emission Vehicles), GBSLEP (Greater Birmingham & Solihull Local Enterprise Partnership), Birmingham City Council and JIVE project funding from the FCH JU (European Funding from the Fuel Cell Hydrogen Joint Undertaking) under grant agreement No 735582. (Source: <u>https://cordis.europa.eu/project/id/735582</u>)

<sup>&</sup>lt;sup>v</sup> There are various kind of biofuels, such as biodiesel, bioethanol, and biomethane, that differ in production and use. For instance, biodiesel is often produced from waste-based raw materials (e.g. brown grease, tallow oil, and used cooking oil) through transesterification. Distributed blends from 20% (B20) biodiesel to 100% (B100) can be used by diesel powered vehicles. However, Natural gas-powered vehicles can use biomethane. This biofuel is produced from organic waste materials via anaerobic digestion. (Source: <u>https://www.zemo.org.uk/assets/reports/ZEMO\_Renewable\_Fuels\_Guide%20\_2021.pdf</u>)

requires increased land use, and some crops can indirectly lead to increased emissions<sup>[72]</sup>. Therefore, the government has introduced sustainability criteria<sup>vi</sup> and a cap that limits the maximum contribution that biofuels can make to the government's renewable transportation fuel targets, when produced from agricultural crops, stimulating future investments in waste-based fuels<sup>[76]</sup>.

Biofuel production from waste (e.g. grease, cooking oil and fats waste) has a lower cost in comparison to production from biomass feedstocks<sup>[77]</sup> and increases local production. This production approach can enable sustainable waste management in urban areas and stimulate a local circular economy<sup>[72]</sup> with an active collaboration between city councils, end-users, and sources of waste<sup>[78]</sup>. For example, Cornwall Council's HDV fleet is powered by locally sourced biomethane. The service provider collaborates with the county's dairy farmers to produce sustainable biofuel based on agricultural waste, which promotes the local circular economy<sup>[72]</sup>.

### 2.3 Overview of the Guiding Framework

The national context provides the fundamental operational framework for each local authority to design their strategic plans to decarbonise their local urban surface transport network. Funding and inclusiveness aspects together with the three pillars of avoid, shift, and improve compose the guiding framework for urban areas, used in this report (Figure 2.4). This guiding framework is applied in the three cities of different sizes, London, Nottingham, and Durham, and presented in the next three chapters. The different cities present different scales, contexts, and needs, however, the guiding framework allows the creation of a complete picture of possibilities and opportunities for initiatives and infrastructure for urban transport decarbonisation pathways which can be adapted to the cities.

Avoid	Shift	Improve		
Avoid, reduce, or replace the need for travel by solutions beyond transport, such as doing things locally or organising them online supported by city planning and place-based planning.	Trips shift away from private cars and adopt sustainable modes of travels e.g., non-motorised transport (active), public, and shared transport.	For trips that cannot be done without vehicle: Improve vehicle and fuel efficiency, implement needed infrastructure, and ensure overall sustainability of alternative energy.		
<b>Funding needs:</b> Public and private investments are needed to enable urban transport decarbonisation pathway. While public funds have dominated infrastructure investments increased private sector investments will be needed and leveraged.				
<b>Inclusiveness</b> : Interventions and infrastructure for future sustainable mobility need to be inclusive and socially coherent to adapt to the growing population and its diversity while not causing poverty. Behavioural changes may be needed across all stakeholder groups to ensure it.				

#### Figure 2.4 The framework of key points of analysis for the study.

<sup>&</sup>lt;sup>VI</sup> EU sustainability criteria for biofuels and bioliquids help guarantee real carbon savings and protect biodiversity. (Source: <u>https://wayback.archive-it.org/12090/20220405002735/https://energy.ec.europa.eu/topics/renewable-energy/biofuels/sustainability-criteria\_en</u>)

# 3. Methodological Overview

This report is based on published information and policy strategies and actions for developing a guiding framework of analysis at the local level. The conceptual framework allows for assessing all the areas of infrastructure and investment strategies that are required for achieving local decarbonisation goals. Based on the proposed guiding framework we present and evaluate the maturity of infrastructure and investments for a sustainable urban mobility system in the three cases, London, Nottingham, and Durham. These cities have been chosen to serve as representatives for other large, medium, and small-sized cities with similar characteristics and contexts. The focus of this research is to look at the transport decarbonisation pathways of the different cities and learn from them in a broad way and not to compare the cities.

Secondary data has been the primary material for informing the city-specific details on interventions, strategies, and actions regarding the different categories presented by the conceptual framework, namely, avoid, shift, improve public and private investments, and inclusiveness. This material has been enriched with perceptions from local stakeholders through a series of interviews, contributing to the assessment of the city's transport decarbonisation pathway. For the assessment, a traffic light system demonstrates the level of progression for each element in the conceptual framework for the particular case. Finally, based on the data analysis and discussions in relation to the research questions, the conceptual framework, and priorities that could be identified in the different cities a set of proposals have been developed to guide similar activities in cities across the UK.

Table 3.1 presents the interviews that were conducted in 2021 with experts in their field to gather perceptions about the decarbonisation efforts in the three cases and establish a contextual understanding. These perceptions have been used to triangulate the assessment of the published strategies and actions towards sustainable mobility. The participants were identified based on a snowball selection approach, representing a diverse set of relevant stakeholders for the transition of the local urban transport systems. The elements of interest represented in the conceptual framework were used to develop the interview themes and questions. For London and Durham, the interviewees represented the following stakeholder groups: local authorities (3 interviews), technical/ industry experts (1 interview), citizen group representatives (2 interviews), business/ investment experts (2 interviews), transport planners (2 interviews), and researchers (3 interviews). For Nottingham, 1 technical/ industry expert participated in an interview, while 3 academic researchers were engaged in unstructured interview discussion with the support of published documents.

## Table 3.1. Details on interview participants for each city or just for national contextual understanding.

Case Study	Interview Participants
Large City (London)	Local authority (2 interviews) Researcher (1 interview) Transport planner (1 interview) Business/investment expert (2 interviews)
Medium Sized City (Nottingham)	Technical/industry expert (1 interview) unstructured interview discussions with support of published documents with academic researchers (3)
Small City (Durham)	Local authorities (1 interview) Researcher (1 interview) Citizen group representatives (2 interviews) Transport planner (1 interview) Technical/industry expert (1 interview)

The gathered secondary (progress reports and studies relevant to the case) and primary data (interviews) detailed a list of possible actions for each case under the key categories of the guiding framework. Each of these actions ('Action and intervention details' in the Performance Indicator Tool<sup>vii</sup>, Table 3.3) were then evaluated by the researchers using a qualitative index, which codified under a "traffic light system" (Table 3.2) 'Green - the city has a clear thinking' on the particular action, 'Amber – the city needs to review some areas', or 'Red – the city has not considered this action'. Examples of advanced practices across Europe (for large, medium, and small cities) and the reflection from the participants in the interviews have been used to triangulate the performance index allocated for each action in the three cases. The research team finally, reflected on the collective detailed actions evaluation to propose the 'overall category' evaluation index for each of the key elements of the guiding framework, creating a snapshot representation of the status of progress for each case (Figure 4.1, Figure 5.1 and Figure 6.1).

The advantage of the traffic light system approach is that it allows for evaluation of the relevant performance, which is universally understood. While the universal understanding helps the diverse application of the tool, the qualitative nature of this approach sets limitations to the results as the evaluation could be subjective or data collection could have missed information. To eliminate uncertainties, the researchers used multiple data resources for triangulation, compared with other cities with advanced practices, discussed the evaluations within the research team, and had the results proof-checked by an interview participant for each case.

In conclusion, the proposed Guiding Framework and Performance Indicator Tool established the criteria and basis for the qualitative evaluation which could be adopted to different cities allowing to consider the local context.

The approach allows to demonstrate local and structural achievements and shortcomings in different contexts, hence, is applicable to large, medium, and small cities, each presenting different possibilities and priorities for interventions, actions, and infrastructure.

#### Table 3.2. Criteria and basis for evaluation as traffic-light system.

2		
Green	Amber	Red
The city has clear thinking and implementation plan for the element. This could include several interven- tions, actions, and actual infrastructure planned and implemented.	The city needs to review some areas of the element further e.g., on the side of planning or imple- mentation strategies. Some interventions, actions, and infrastructure might be more elaborated than others.	The city has not yet considered this element, demonstrating a clear absence of thinking and solutions.

Overall category for consideration of urban surface transport decarbonisation	Detail of category which schould be detailed by the city's actions and interventions and then be evaluated	Action and intervention details (what has been done and what has not been done)	Detail evaluation (to be evaluated through traffic light system)	Overall category evaluation (traffic light as the average of the detailed evaluations)	Examples of advanced practices across Europe which can serve as an inspiration or comparision in order to position and evaluate the city's performance
Avoid					
Avoid, reduce, or replace the need for travel by solutions beyond transport, such as doing things locally or organising them online. This can be supported by city planning and place-based planning.	<ul> <li>15-min neighbourhood concept: having 'everything' in walking distance</li> <li>Policentric city concept</li> </ul>				The Hunziker Areal in Zurich, CH, or the district of Vauban in Freiburg, DE, are both examples how districts can be designed in order to avoid transportation. In fact, both districts do not allow cars within the district, or if so, just with special permission. The districts include residential housing but also work places, shops, and leisure
Shift					
Improve vehicle and fuel efficiency, implement needed infrastructure, and ensure overall sustainability of alternative energy to allow for trips thant cannot be done without vehicle.	<ul> <li>Promotion of active mode travelling through citizen engagement and information</li> <li>Future proof and attractive walking and cycling infrastructure</li> <li>Public bike hire scheme</li> <li>Future proof and attractive public transport network</li> <li>Accessible and affordable public transport</li> <li>Support multi-modal travels and activities</li> <li>Mobility hubs that Support multi-model travel</li> <li>Promotion of car pooling or usage of car sharing schemes</li> <li>Back to base or flexible car sharing</li> <li>Road charging schemes</li> <li>Effective planning of car parks</li> </ul>				Tübingen successfully manages between private and public investment and engagement. Tübingen provides an extensive public transport network with buses available at all day times, 380 bus stations and 38 different routes, and free transportation on Saturdays . This creates an attractive public transport network where citizens do not need to change buses. Additionally, a business provides 90 vehicles over 40 car sharing stations across the city . The local energy utility incentivises E-bikes. The number of E-bikes grew from below 50 in 2010 to over 1000 in 2020. The city also developed the innovative concept of having 'Mitfahränke', which are benches where people can sit and wait and other citizens that pass by in their car stop and give them a ride.

Table 3.3. Screenshot of the performance indicator tool, showing avoid and shift category, their detailed elements that describe the framework of analysis, and the categories for analysis.

# 4. London: the decarbonisation pathway of a large mega-city

Greater London is home to about 9 million people, covers 1,569 sq km and has 2.6 million registered cars<sup>[79]</sup>. Streets make up around 80% of London's public space and play an essential role in transportation. Most Londoners' inner-city trips are related to leisure (ca.28%), shopping and personal business (26%) and workplace (ca.19 %<sup>[80]</sup>. Furthermore, as a major tourist destination, before the pandemic London was attracting about 21 million overnight international tourists, and more than 55 million domestic tourism day trips<sup>[81]</sup>. In 2019, an average of 27.0 million journeys per day were made to, from or within London<sup>[82]</sup> and it is estimated that 33 million journeys will take place every day by 2041. This level of transportation demand results in increased road congestion and poor air quality. Currently, transportation emits 6 million tonnes of carbon dioxide. While this is an improvement compared to 2005 (about 8.5 million tonnes), the city has much further to go if it is to achieve its net zero targets<sup>[82]</sup>.

The London Boroughs, the Mayor of London, and Transport for London (TfL) <sup>viii</sup> play a central role in promoting actions and investments around sustainability. In particular, the Mayor's Transport Strategy<sup>[83]</sup> and various action plans published by TfL set the course for a range of interventions to promote sustainable urban mobility, supporting the city to become carbon-free by 2030. The main priorities are measures to reduce emissions from road transport, the expansion of public transport, and the promotion of active modes of transport such as walking and cycling. Still, the priorities while demonstrating clear considerations of population and economic growth also focus on inclusiveness and increasing the quality of life of the citizens. However, due to the complexity of London, the ambitions for its future sustainable mobility system require high levels of communication and coordination among the stakeholders. All stakeholders are aware of the high economic value of the city, making the city an attractive location for private investments.

Avoid has been characterised as having 'clear thinking and a good implementation plan': In London, six in ten car trips are made for shopping, leisure and personal business purposes, and 67% of all car trips are below 5km<sup>[84]</sup>. Therefore, London does not only support the shift to a more sustainable transportation mode but also strategies to avoid trips in the first place. In the long term, every resident of a London borough can meet their daily needs within a short walk or bike ride<sup>[85]</sup>. The Mayor's 'High Street for all' plan supports the concept of 15-minute neighbourhoods through various measures, such as promoting local employment and work close to home<sup>[86]</sup>. The 15-min neighbourhood concept is a valuable concept for big cities as an approach to address the cities' complexity by transforming the city at the district level. Already, the Mayor supported the plan by announcing a £2 million in funding for 15 projects related to the development of High Streets<sup>[87]</sup>.

VIII TfL is controlled by a board whose members are designated by the Mayor of London. A special feature of TfL is also the composition of the local authority which is unique in the UK. It is a combination of private concessions and public administration. For example, specific services, such as bus operations, are contracted out to private companies but remain under the control of TfL. (Source: <u>https://tfl.gov.uk/corporate/about-tfl/how-we-work/how-we-are-governed</u>)

However, there is not a clear financial plan covering the long-term costs regarding the required investments. Nonetheless, this thinking and development are in line with other metropolitan cities such as Paris (France), Portland (USA), and Stockholm (Sweden) which are also actively working on the development of the adaption of the 15-minute Neighbourhood concept<sup>[88]</sup>. The 'Street Moves' project in Stockholm shows that this development could, however, involve redesigning streets and strategic urban planning, which sets at its centre the citizen engagement and communication<sup>[88]</sup>. London could do more in engaging citizens in its transformation process.

**Shift** has been characterised as having **'clear thinking and a good implementation plan':** Transport for London (TfL) identifies active mobility as a key element to reduce congestion in London due to the growing travel demand<sup>[89]</sup>. Currently, the new east-west and north-south cycle routes in the city carry 46% of the people on just 30% of road space<sup>[90]</sup>. However, TfL predicts that 70% of all citizens will live within 400 metres of the London-wide cycle network by 2041<sup>[91]</sup>. Therefore, TfL published action plans for walking and cycling to attract more citizens to use these transportation modes in particular by extending the active mode infrastructure and integrating walking and cycling with public transport. The city also established a "Try Before You Bike scheme"<sup>[92]</sup>, and TfL regularly conducts surveys and consultations to gather feedback from different stakeholders, such as residents, on the "Healthy street hub" or the "London Living Streets" project. Even though London's active transport infrastructure has made significant progress in recent years, the pace of implementation is criticised by some stakeholders (Interview: Transport planner).

Based on the size of London, public transport is a popular option for getting around. In addition, the city utilises new technologies, such as apps, and mobility hubs<sup>[93]</sup> to support multi-modal transportation<sup>[94]</sup>. This allows great comfort and flexibility for Londoners and increases the willingness to use sustainable transportation modes. It also connects active transportation modes with public transportation, which is also a key element that London has identified to reduce emissions. In addition, London aims to ensure affordability and accessibility, of public transport such as through step-free connections<sup>[89]</sup>, the Freedom-Pass<sup>[98]</sup> or demand-responsive shuttle services<sup>[96]</sup>. These measures contribute to London having very affordable public transport compared to other major cities in the UK (Interview: Local Authority representative 2). Nevertheless, the city could emulate some measures from other metropolises in terms of affordability. For example, Vienna (Austria) introduced an annual pass where citizens can use public transport for only one euro (ca. £ 0.83) a day, and this has significantly increased the use of public transport<sup>[97]</sup>.

Also, a variety of car clubs, ranging from traditional 'back-to-base' returnable models to flexible one-way models with dedicated parking bays and areas, are implemented throughout the city<sup>[98]</sup> as a short-term solution, while the long-term goal has been to reduce overall car traffic.

There are currently three road charging schemes in London (Congestion charge, Low Emission Charge Zone and Ultra-low Emission Zone), which have

been introduced in the city during the last two decades, with increased public acceptance<sup>[99]</sup>. All charging schemes aim to reduce emissions, mitigate traffic congestion, and raise revenue, and a Workplace Parking Levy (similar to the one in Nottingham) to further decrease the congestion has been suggested<sup>[100]</sup>. Based on the size of the city, there are no true park and ride schemes in the London area. Instead, London's strategies demonstrate a strong focus on promoting and facilitating the use of public transport with a trade-off between environment and fairness.

Overall, the broad mix of alternatives in London's strategy helps to reach all socioeconomic groups, requiring only a few incremental adaptations for targeting them even more effectively.

Improve has been characterised as having 'clear thinking and a good implementation plan': London's priorities in converting its vehicle fleet are primarily a combination of hydrogen and electric technologies. London tends to rely on the individual advantages of the various technologies, e.g., the large energy storage capacity of hydrogen tanks is particularly useful for heavyweight vehicles. Other metropolises do not consider the variety of technologies that prevent a high level of flexibility in the transformation process. For example, hydrogen plays rather a subordinate role in Berlin's transport decarbonisation plan (Germany)<sup>[101]</sup>.

In addition, the city's climate goal states that a clean generation of energy is required, for example by sustainable local green hydrogen production<sup>[102]</sup> or V2G technology<sup>[103]</sup>.

London has set an example worldwide through the ambitious and thoughtful implementation of the gradual replacement of the public vehicle fleet with clean technologies. There are also measures that create incentives for the private sector to switch to environmentally friendly technologies<sup>[104, 102, 105]</sup>. Notably, 500 electric and 20 hydrogen buses operate in the city at the moment, improving air quality and reducing noise levels<sup>[106]</sup>. Among other things, scrappage schemes are offered to encourage companies, like taxi operators, to invest in zeroemission vehicles through subsidies<sup>[107]</sup>. However, to increase the uptake of EVs from citizens, the central government and the local government of London need to a) better educate and engage citizens about the advantages and technical possibilities of EVs, b) ensure that the infrastructure is convenient and reliable as the majority of the people will rely on public charging (Interview: Business expert). The business expert also added that to drive the EV adoption the vehicles themselves need to improve in terms of availability, cost, and performance, and that until these challenges have been tackled the deployment of the infrastructure will happen over time.

In line with this opinion, the city seeks expansion of the already vast charging infrastructure<sup>[108]</sup> for hybrid- and electric vehicles evenly across the metropolitan area in the following years. In order to promote cooperation between the public and private sectors, the Mayor has established an electric vehicle task force in 2018, composed of representatives from both sectors, to promote a more efficient roll-out of electric infrastructure<sup>[109, 110]</sup>. However, frequent changes in

local government are higher in cities like London than in smaller cities (Interview: Second representative of the local authority), which could be a problem in the implementation of decarbonisation strategies.

Funding needs has been characterised as having 'some areas with regard to planning or implementation strategies should be reviewed further': London receives a huge amount of public funding much of which is spent on public transportation<sup>[19]</sup>, demonstrating its dependency on national government grants. This creates funding challenges stressed by all stakeholders causing uncertainty of long-term financial sources to plan over a long period of time. TfL's funding sources are based on revenue from fares, 'user pays' sources (e.g. congestion charge) and grants<sup>[111]</sup>. Thus, compared to other transportation providers across major cities in Europe, TfL is the only one without regular state subsidies to cover day-to-day operations. Covid 19 has even further tightened the situation regarding funding, which means that there will be budget restrictions in the coming years<sup>[112, 113]</sup>. There is still inflexibility, which leads to the current financial predicament in which TfL finds itself despite the existence of a transparent financial plan for the transition. In fact, the investment expert recommends considering different kind of funding structures for the different technologies. London has identified collaboration [114] and new revenue streams<sup>[115]</sup> as important measures to better identify and avoid potential barriers regarding investments, apply new technologies, and ensure safety and integration. This is possible, due to the interest from the private sector given London's worldwide reputation and metropolitan status (Durham Interview: Industry expert). However, there is also lots of competition in London, wherefore medium-sized cities would be more attractive for investments (Interview: Investment expert). In any case, the private sector can bring their funding from large infrastructure banks to fund projects for public bodies and public usage e.g. to deploy EV charging stations or for buses, but would need local authorities to sign long-term contracts to manage the early stage risk and ensure bankability (Interview: Business expert / Investment expert). Nonetheless, it is crucial that the city sends clear signals of long-term commitment in order to convince the private sector to invest (Interview: Business expert). The interviewees emphasised that nonetheless, there need to be common goals, clear values, and fewer obstacles for private investments which could leverage London's funding challenges and lack of power to coordinate investments.

Inclusiveness has been characterised as having 'some areas with regard to planning or implementation strategies should be reviewed further': Inclusiveness and social coherence have been considered to a large extent in the various plans of the city, especially with regard to walking and cycling, and public transport infrastructure through increased connectivity and affordability. However, the plans could be made more human-centric, encouraging democratic citizen engagement in order to address the diversity of individuals living, commuting, and visiting the city. The interviewees, also, highlighted the importance of social acceptance in the whole transformation process, starting from for example consultation or educational campaigns to reduce misconceptions regarding the new technologies. Nonetheless, affordable public transport and its connectivity are of major concern for London<sup>[83]</sup>. Furthermore, TfL examines in part the impact of the intervention on different socio-economic groups to mitigate possible negative effects in the transformation towards net-zero urban surface transport<sup>[116]</sup>. Additionally, a scrappage scheme for cars is designed to benefit low-income and disabled people<sup>[117]</sup>. As London already cooperates with different private and public actors that seek different environmentally friendly solutions for its urban transport system<sup>[118]</sup>, the understanding is that citizens need to change to sustainable mobility driven behaviour<sup>[83]</sup>. In fact, congestion charge schemes are seen as a major driver for citizens' behavioural change<sup>[119]</sup>. The business expert supports these schemes but warns that considerations are needed to include low-income households who live in higher density urban environments such as London, depend on parking in streets, and cannot afford EVs. There is a lack of thinking regarding more inclusive solutions, engagement and participation of citizens, which implies a possible need for a change of thinking among London's policymakers and transport planners. Low-income households could make most cost savings from using an EV, for them leasing vehicles instead of directly buying is a possibility (Interview: Business expert).

To reach net-zero in the future a combination of technologies will be needed, in particular, in London, to adapt to the different profiles of people (Interview: Investment expert). The synthesis of the interventions and funding measures shows how difficult it is for a city as large and complex as London to undertake a holistic transformation to a net-zero carbon city. The transformation of the city's urban surface transport system should tackle traffic congestion, decrease emissions, and improve air quality. To ensure implementation, stakeholders need to collaborate and maintain collaboration over the long term and to guarantee that the burdens and benefits are shared equitably across all partners. The diversity of measures with a clear approach to initiatives and infrastructure, combined with the support of the private sector, could make it possible to achieve the 2030 decarbonisation targets. Indeed, despite its increased access to public and private funding, even a large city such as London still faces funding shortfalls which need to be approached strategically. At the same time, for increased public acceptance and a democratic, fair system, also large cities would need to put even more emphasis on inclusiveness and citizen engagement. The large population, commuters, and tourists make this a complex task, wherefore initiatives that start at the district level can be a useful tool to reach citizens with information and also to receive feedback. Figure 4.1 summarises the key points in the guiding framework.



#### Figure 4.1: Assessment framework for London representing priorities and status of a current sustainable mobility strategy.

Avoid: High Street for all	<b>Shift:</b> public transport, cycling, and walking	Improve: EV infrastructure, hydrogen (and biofuels)
The 15-min neighbourhood concept is a valuable concept for big cities as an approach to address the cities' complexity by transforming the city at the district level. London does not only support the shift to a more sustainable transportation mode but also strategies to avoid trips in the first place. The 15-minute concept has been identified as one key intervention by establish- ing 600 inclusive, flourishing and resilient high streets and local employment that are easily accessible to citizens.	The promotion of public transport, walking, and cycling is crucial in London to address growing travel demand and reduce congestion. London is already working on several projects that promote active mobility, for instance: + "Healthy street hub" or the "London Living Streets" project to engage citizens in active mobility; + Special access busses and affordable public transport tickets; + multi-modal travel; + mobility hubs and car clubs; + different road charging schemes.	TfL has many ideas, engages in different initiatives, and already implements some infrastructure, such as: + London considers different technology solutions and alternative fuels for their pathway to net-zero transportation. They have already implemented EV chargepoints across the city and plan for more; + Public vehicle fleets, taxis and other business vehicles are being replaced by electric or hydrogen vehicles; + sustainable supply of EV chargepoints. However it lacks initiatives and infrastructure for:
	nowever it there is slow progress on: Expanding cycling routes.	- Citizens need to be informed and educated more to increase

and educated more to increase the uptake of EVs.

Funding needs: Around half of the charging points are funded by the private sector . However, the Mayor's Transport Strategy and the different strategies of TfL demonstrate the immense awareness that the goal of London becoming carbon neutral by 2050 is a costly and requires both public and private investments. Therefore, engagement with different stakeholders, such as authorities, external transport operators, and the private sector, on international, national, or local levels helps the city to carry out the decarbonisation plan in a more efficient way. This is supported by the fact that London is an attractive business location for many companies. Furthermore, TfL's funding sources are based on revenue from fares, 'user pays' sources (e.g. congestion charge) and grants. Financial support from several funds from the national government such as for on-street residential chargepoints or for ultra-low emission taxi infrastructure was also necessary for the already implemented infrastructure. Nonetheless, all stakeholders are convinced that the financing strategy needs improvement.

Inclusiveness: Despite the many interventions to render transportation emission-free, inclusiveness and social coherence have been considered in the various plans of the city. For example, the scrappage scheme is designed to benefit low-income and disabled people as well. But especially public transport is designed to be inclusive and accessible for all. The Mayor and TfL seek to include citizen's opinions through surveys or engagement on their website. Furthermore, TfL examines in detail the impact of the intervention on different socio-economic groups to counteract possible negative effects. At the same time, two major elements in The Mayor's Transport Strategy is the promotion of cycling and walking. Thus the local government demonstrates a future proof mind-set towards active mobility. Similarly, businesses have changed their mind-set towards sustainability in the last decades., but do not yet consider inclusiveness and customer satisfaction to the same extent as economic value.

# 5. Nottingham: the decarbonisation pathway of a mid-sized city

One of the UK's core cities<sup>[120]</sup>, Nottingham is a mid-sized, compact city with 20 wards<sup>[121]</sup>, located in the East Midlands region, covering an area of 75 square kilometres<sup>[122]</sup>. The total population of Nottingham is around 340,000, expected to grow by 4.2% by 2030. Nottingham hosts around 45,000 University students, making the overall share of young citizens, aged between 18 to 29, 30% of the total <sup>[123]</sup>. The city's main tourist attractions registered a total of 1.87 million visitors in 2015<sup>[124]</sup>. One issue the city faces is the high level of income deprivation<sup>[125]</sup> Especially elderly (ca. 24%) and children (ca. 30%) are affected by living in low-income deprived households. According to the Census 2011 around 44% of Nottingham's households do not own a car<sup>[126]</sup>. Nonetheless, transport is one of the largest polluters, contributing 30.5% of Nottingham's total CO<sub>2</sub> emissions in 2017<sup>[127]</sup>.

The integrated transport system of the city is run by a collaboration of different private and public operators, including the City Council<sup>[128]</sup>. One task of the Nottingham City Council is coordinating the Robin Hood Network, a cross-modal ticketing system for the bus, tram and rail network [128] which is evolving e.g., now to contactless payment. The city has set the goal to become a net carbon-neutral city by 2028<sup>[129]</sup>. While this target seems "very unlikely" it creates a level of emergency that encourages Nottingham to act (Interview: Technical/industry expert). For instance, already, Nottingham City Council has proactively engaged in decarbonising and improving its local transport since 2011 according to its local transport plan with a horizon until 2026<sup>[127]</sup> with a new one being under development. Considering its local circumstances, Nottingham's transformation targets parallel sustainability (of transport) and improving quality of life, with the aim of enabling economic growth, alleviating poverty, and increasing inclusiveness. However, the city's action plan lacks projections of future levels of modal-split journeys while demonstrating awareness of the future increase in population, traffic, and economic value. Hence, the City Council aims to provide a sustainable system with a series of measures across the three pillars of avoid, shift, and improve to comply with the different transport needs of its citizens.

• Avoid has been characterised as having 'clear thinking and a good implementation plan': Nottingham's local transport plan highlights the importance of interventions supporting citizens to avoid journeys. Already 75% of the surveyed university students in Nottingham (2019) travel by foot to the University, due to its proximity to their homes<sup>[130]</sup>. The citizens across the city should have access to services and facilities by public transport, walking or cycling within 30 minutes travel time and no more than 400m walking distance to a bus stop<sup>[131]</sup> In fact, the city aligns its transport plan with its local development framework, which puts a focus on the proximity of services in the context of urban development<sup>[132]</sup>. The plans also consider projections for population growth and expansion of the city, transferring the idea among urban planners and developers<sup>[133]</sup>. Overall, the city demonstrates clear thinking about the need to

avoid transportation and works on the first implementation strategies to plan under the concept of the 15-minute neighbourhood. For example, the private housing developer Conyar has been promoting the development of the "Island Quarter", which is becoming a new neighbourhood in line with the 15-minute neighbourhood concept<sup>[134]</sup>. A similar approach is used by Utrecht (Netherlands) which published a special strategy for 2040 that considers population growth and aims to have services and facilities within a 10-minute distance for the citizens<sup>[135]</sup>.

Shift has been characterised as having 'clear thinking and a good implementation plan': Nottingham identifies the promotion of active transport infrastructure as one key element for reducing emissions, principally through engagement with citizens (e.g., feedback and suggestions), through providing information to the population (e.g., walking guide<sup>[136]</sup> and "Keep Nottingham Moving"<sup>[137]</sup>)\_and through collaboration with private providers. All these are important measures for the city to increase active mobility. For example, citizens were asked what temporary measures the city should introduce to make the space safer and more attractive for active transport<sup>[138, 139]</sup> Nottingham not only plans to expand and improve its cycling corridors across the city but also to increase cross-boundary cycle routes<sup>[140]</sup>. The city has established a bicycle hire scheme which includes e-bikes<sup>[141]</sup>.

In parallel, affordable and accessible<sup>[142]</sup> public transportation is of high importance for the city council, due to the difference in mobility choices between different socio-economic groups<sup>[127, 143]</sup>. Nottingham has invested in retrofitting buses to make them barrier-free (low-floor or demand-responsive buses, and smart ticketing), safer, and more comfortable. Nottingham is extending its public transport network is reaching a connectivity level such as best-practice public transport in Bilbao (Spain) <sup>[144]</sup>. Furthermore, Nottingham has identified car clubs as a possibility to support lower-income households to get access to cars<sup>[127]</sup>.

In addition, the city promotes the use of public transport and 9 park-and-ride facilities<sup>[145]</sup> and mobility hubs across the city help to reduce congestion in the city centre, especially for aiming at commuters and visitors. Nottingham also adopted a unique intervention for the UK, the Workplace Parking Levy (WPL) <sup>[146]</sup>, to incentivize citizens to shift to alternative transportation modes for accessing the city centre and providing a significant revenue stream for the city for improving its public transportation fleet. Possibly, there could be other direct charging schemes that provide more effective revenue, but the WPL was a practical measure for Nottingham (Interview: Technical/industry expert). For instance, more radical steps such as the car-free and parking-free zones that have been demonstrated in other European cities, e.g., the city of Freiburg (Germany)<sup>[147]</sup>, have not been prioritised. Still, the city adopts a multifaceted approach with considerations of local context and inclusiveness which will enable it to reach the decarbonisation targets.

Improve has been characterised as having 'clear thinking and a good implementation plan': Nottingham prioritises electrification and biofuel over hydrogen in the conversion of its vehicle fleet, especially buses, and it has engaged in trials of these technologies and supportive initiatives since 2020<sup>[127]</sup>. The diversity of technological solutions is also represented in Nottingham's approach to ensuring renewable energy supply through e.g., exhaust energy from district heating, local biogas production, or Vehicle2Grid technology<sup>[128]</sup>. In parallel, Nottingham collaborates with the Distribution Network Operator and through the CleanMobilEnergy project that considers the investment in sustainable energy supply for their charging points<sup>[148]</sup>.

Engaging in the energy transition, Nottingham has improved its vehicle fleet efficiency with 120 double-deck biogas buses and battery electric buses<sup>[149, 150]</sup>, with increasing emphasis on electric (Interview: Technical/industry expert). The Council provides EV hire through the City Car Club and 50 vans as an approach to encouraging the uptake of EVs through prior testing<sup>[151]</sup>. The special focus on taxi operators increasingly shows success, through the already more than 150 electric taxis driving through the city<sup>[152]</sup>. The "Hackney Carriage and Private Hire Vehicle Strategy"<sup>[153]</sup> includes several interventions such as incentives and a dedicated EV charging infrastructure for taxis<sup>[154]</sup>. Approaches such as the 'Ride and Drive' initiative<sup>[155]</sup>, a special road for EVs<sup>[141]</sup>, and the local authority's Electric Vehicle Service centre should further encourage those citizens who can afford it, to transition to EVs.

The city does not only invest in vehicles but also in the charging infrastructure with an implementation plan that sets out possible support schemes and funding sources<sup>[156]</sup>. EV charging points have been installed at locations such as community spaces open to the public<sup>[157]</sup>. To further extend the network the Council contracted BP Chargemaster to supply, install, operate, and maintain the charging network<sup>[127]</sup>, and it collaborates with the Local Enterprise Partnership <sup>[141]</sup>. In fact, local authorities should facilitate charging infrastructure and work with local organisations, while the central government should incentivise the uptake of EVs (Interview: Technical/industry expert).

Although, compared to other UK cities, the current public charging infrastructure demonstrates high levels of implementation<sup>[108]</sup>, it is frequently unfit for purpose and does not match demand since its position is based on the availability of space, rather than users' needs. A users' data-driven approach is required in the roll-out of the charging infrastructure. Examples of such approaches from Europe e.g. the city of Utrecht (Netherlands) demonstrate how such approaches could provide a more efficient way of prioritising areas of higher need<sup>[158]</sup>. Nonetheless, Nottingham is aware that the EV network is not yet sufficient and seeks to address barriers to overcome this issue<sup>[159]</sup>. In conclusion, Nottingham has an integrated plan for EVs and EV charging infrastructure; however, the set time scale and solutions are still not enough and need to set an urgency for action.

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- Funding needs has been characterised as having 'some areas with regard to planning or implementation strategies should be reviewed further': Findings from discussions with local representatives from academia and the local technical/industry expert show that the centralised system of the UK government leads to fundamental issues that local authorities, including Nottingham, face, such as insufficient decision powers, insufficient autonomy, insufficient financial resources to discharge their responsibilities<sup>[160]</sup>. As an approach to planning available public funding resources, the Council has published an implementation plan for its local transport plan, which sets out the needed and available funding to deliver the planned initiatives and infrastructure over a 3-year horizon (April 2019 to March 2022)<sup>[156]</sup>. Nonetheless, according to the local transportation plan, substantial investment can only be secured in the long run by collaborations between the public, private and voluntary sectors. Thus, Nottingham has established various partnerships with the private sector which supports increasing private sector investment and coordinates investment streams toward the city's priorities<sup>[129, 161, 162, 163, 164]</sup>. Nottingham and its neighbouring authorities in Derby, Derbyshire and Nottinghamshire form a Local Enterprise Partnership (LEP) to help boost local economic development in various ways including bringing different sustainable technology industries to Nottingham<sup>[129]</sup>. At the same time, Nottingham, in parallel to relevant government grants, utilises the revenue from the Workplace Parking Levy<sup>[165]</sup> (currently around £10 million per year), which gives the city a certain level of flexibility regarding its investments ('match' funding) and access to various grants and funds. On the one hand, the reliance on short-term grants and funds still hinders the city in its ability to plan and prioritise its activities according to its needs for the long-term decarbonisation horizon. On the other hand, the funding actions are driven by the local authority's decarbonisation goals and the flexible funding allows the local authority to adapt to the still exploratory decarbonisation pathway. Still, a balance of actions and funding between local and central governments could support effectively working together to reach decarbonisation targets (Interview: Technical/industry expert).
- Inclusiveness has been characterised as having 'clear thinking and a good implementation plan': Nottingham recognises that human factors play an important role in the transition to sustainability, especially in the transport sector. Social cohesion and inclusion of all groups are central to the spirit and actions of the Local Transport Plan. One reason why the city is investing in Mobility as a Service (MaaS) is that this service enables low-income households to participate in social life<sup>[166]</sup>. For a similar reason, Nottingham promotes car sharing and car clubs<sup>[127]</sup>. Furthermore, the city promotes and supports cycling initiatives by working with stakeholders, such as the health and voluntary sectors and national and local national cycle organisations and engaging with citizens<sup>[127,</sup> <sup>167]</sup>. A bike recycling scheme also supports citizens who want to start cycling but cannot afford a bike of their own. Furthermore, the city actively engages with citizens through information, public consultations, and activities. Nottingham has some politicians that are ambitious regarding the city's decarbonisation including the urban surface transport and that adopt a forward-looking perspective<sup>[168]</sup>, with an understanding of needed behavioural changes across all stakeholders and efforts on inclusiveness.

The assessment of interventions and funding measures shows that a medium-sized core city such as Nottingham can take many actions to make the city carbon-free. Notably, Nottingham has recognised early on the need to diversify interventions, consistently supporting initiatives and infrastructure for avoid, shift, and improve measures. To achieve its plans the emphasis on collaboration with different stakeholders has moved the city forward, an approach that can be adopted by other medium-sized cities. However, despite the Workplace Parking Levy (WPL), Nottingham relies on government funds. Hence, one of the biggest problems is securing long-term funding for the measures and the capital-intensive initial investment for medium-sized cities. A solution needs to be found here with the government and in collaboration with city authorities across the country. Nonetheless, the local authority has little influence on an individual's behaviour or on the transformation of all vehicles to alternative fuels (Interview: Technical/industry expert). Consequently, even though the city has strong plans and clear thinking in most areas, the goal of full decarbonisation by 2028 remains very ambitious. Figure 5.1 summarises the key points and their evaluation into the framework which guided the analysis.



## Figure 5.1. Framework filled out for Nottingham representing priorities and status of a current sustainable mobility strategy.

Avoid: Districts	<b>Shift:</b> cycling, walking, and public transport	<b>Improve:</b> EV infrastructure, biogas
Liked with its transport decarbon- isation goals, Nottingham published a spatial strategy for 2040 which demonstrates the clear thinking of having services and facilities in proximity for its citizens. The city council support- ed the first development of a 15-min Neighbourhood of a private housing developer. Furthermore, the city launches public consultations to receive feedback from the citizens on future developments.	The promotion of increased use of public transport and active mobility is a key aspect of Nottingham's strategy. Notting- ham is already working on several projects and plans for more in short- and long-term, for instance: + "Keep Nottingham Moving" campaign, + Improvement of cycling corridors across the city and also cross-boundary cycle routes; + Bicycle hire scheme, "Try before you buy" scheme for e-bikes, and a bike recycling scheme for people who can not afford a bicycle; + First improvements of public transport network; + Barrier-free transport and affordable public transport tickets; + Workplace Parking Levy (WPL); + Car clubs; + 9 park and ride carparks.	The city has many ideas, engages in different initiatives, and already implements some infrastructure, such as: + Nottingham focuses on electrification and biogas for their pathway to net-zero transporta- tion, but also plans to investigate hydrogen options; + Starting from their own fleet, the city has 120 double deck biogas buses and 58 electric buses; + Many initiatives for business vehicles such as taxis; + Implementation of renewable energy supply and exploration of additional, innovative options. However it lacks initiatives and infrastructure for: - Charging infrastructure does not match demand, distribution could follow e.g., data-driven approach.

**Funding needs:** Nottingham is aware that to cover the substantial investment costs that the transformation of their urban surface transport system requires will require several funding sources. Therefore, the city already collaborates with the private sector in various partnerships and also works together with neighbouring Councils. For instance, Nottingham and several other city councils in the UK have launched together a Local Enterprise Partnership (LEP) to help boost local economic development by bringing different sustainable technology industries to Nottingham. Even though Nottingham still highly relies on government grants, the city published an implementation plan demonstrating a clear thinking of relevant grants and already used funding. Additionally, Nottingham uses revenue from the Working Parking Levy charge as a funding stream which helps Nottingham to have a certain level of flexibility in its investments and opportunity to actively plan for maintenance and monitoring costs.

**Inclusiveness:** Nottingham is aware of the high level of income deprivation in its city. To ensure equality, high quality of life for all citizens, and no transport poverty, human factors play an important role in the transition to sustainability especially in the transport sector of Nottingham. The aim for improved walking, cycling, and public transport infrastructure aims to create connectivity, accessibility, and affordability for all citizens. Similarly, car clubs and Mobility as a Service (MaaS) are seen as tools to enables low-income households to participate in social life and use cars even if they cannot afford one themselves. Furthermore, the city engages with citizens not only for the promotion of cycling, but also through transparency and information, asking for opinions and feedback on proposals for the city and transport development.

# 6. Durham: the decarbonisation pathway of a small, historic city

The city of Durham is a small historic city in the County of Durham (Northeast England), the central part of which is a UNESCO World Heritage Site. The city measures ca. 2.3 km<sup>2</sup>, with an estimated population of 56,920 citizens in 2020<sup>[169]</sup>. The city has a relatively young population<sup>[169]</sup>, with approximately 53% of its residents being students<sup>[170]</sup>. Durham City is the major employment centre in the County and an attractive leisure and tourism destination<sup>[171]</sup> with over 36,000 inward commuting journeys every day<sup>[172]</sup>. Therefore, cars are needed for people coming to the city from rural areas, but there is also a high level of internal journeys causing traffic congestion<sup>[172]</sup>. Future traffic increases would also increase journey times<sup>[172]</sup>. There will be challenges for actions to counteract this phenomenon such as the uptake of cycling and walking, due to the unique local context of the city, being hilly and rural but compact, having famous historic sights, and having many narrow streets. Infrastructure and behavioural changes are needed to reach the County's targets to become carbon neutral by 2050, since in 2019, transportation still contributed 33.6% of the County's total CO<sub>2</sub> emissions<sup>[173]</sup>.

Durham City does not control the local transportation system, as plans, policies, and initiatives for transport decarbonisation are allocated at the County Council and Northeast combined authority. The Durham City Sustainable Transport Delivery Plan (DCSTP) of 2018<sup>[171]</sup> provides some major measures to counter traffic congestion and air quality. The city of Durham has developed the 'Durham City Neighbourhood Plan 2020 to 2035<sup>[174]</sup> and a companion document 'Looking Forwards – Durham as a creative and sustainable city, and it outlines demands, actions, and timescales for the overall city transformation, supporting the County's goal to become carbon neutral by 2050. All plans focus on supporting active travel modes, improving the road network and to investment in electrified private and public transportation. The city wants to be sustainable to remain an attractive tourist destination in the future. Like that, the County Council envisions that the future sustainable mobility in the city will support businesses and economic growth as well as comfortable living for its citizens.

• Avoid has been characterised as having 'some areas with regard to planning or implementation strategies should be reviewed further': The local context of Durham provides possibilities for the concepts of a 15 min neighbourhood and a polycentric city. Durham is a small city, where one-third of its citizens could walk to work, and the marketplace in the city centre can be reached in an average 20 min walk. For Durham being a polycentric hub<sup>[175]</sup> that enables people from the rural villages to be similarly connected to the city's facilities it is in competition with larger centres such as Newcastle. Decentralising retail and services however should not forget about internal urban travel and connectivity needs, as current actions have rather led to an increase of car traffic (interview: Citizen representative 2). While Durham recognises the need for improved urban planning, neither these concepts nor others that demonstrate a clear strategy have been published. Durham envisions becoming a creative and sustainable city, which maintains its historical context, relieves traffic in its centre, and makes its neighbourhoods attractive, healthy, and affordable.

However, the Durham City Neighbourhood plan emphasises the disparity between the current situation and the vision, with the need for change. Emphasis is given to increased listening to the views from residents before making planning decisions<sup>[176]</sup>. The people-centred projects in the Finnish cities of Nikkilä and Mikkeli demonstrate how engagement with residents can create inclusive solutions for an urban living while maintaining the heritage of the places<sup>[177]</sup>.

Shift has been characterised as having 'some areas with regard to planning or implementation strategies should be reviewed further': The city's focus is on plans that are directed mainly on shift measures, encouraging walking, cycling, and the use of public transport. Currently, cars are used for most trips, while public transport (buses) are a considered transport mode for trips of various distances, but mostly used for trips between 3km and 16km<sup>[172]</sup>. Additionally, the Market Place in the centre of Durham can be reached within 30 walking and 15-20 cycling minutes<sup>[178]</sup>. The current park and ride network<sup>[179]</sup> and the small road charging scheme<sup>[180]</sup> (that covers just the road leading from the marketplace to the Cathedral) have been recognised as successful concepts to remove traffic from the city centre and connect commuters and tourists.

The County Council has supported initiatives such as the "Go Smarter Go Active"<sup>[181]</sup>, "borrow a bike" and the "Living Streets"<sup>[182]</sup> initiatives to promote citizen engagement for active mobility and plans to improve the infrastructure. However, there is still no coherent cycling route across the city, and without a car, there is still limited opportunity to travel within Durham. Much more work needs to be done (Interview: Citizen group representatives 1 and 2). At the same time, the local authority representative highlighted that narrow streets, high traffic, or broken glass on the cycling paths make cycling in certain areas unattractive and unsafe<sup>[183]</sup>.

Even though the Arriva public transport tickets make some journeys more affordable<sup>[184]</sup>, the various buses are not available during all times and in all places, tickets are not inter-available between operators which makes trips more expensive, and there is no consideration of multi-mobility hubs or car clubs. These facts make travelling by public transport complicated (Interview: Citizen group representative 2), especially for connections with the surrounding rural villages. This issue is not yet fully addressed in future infrastructure development plans. Partially, due to the private bus operators that connect the city with the wider County<sup>[185]</sup>.

Durham could explore examples such as the city of Tübingen in Germany, which has created an attractive and extensive public transport network where citizens do not need to change buses and travel for free on Saturdays<sup>[186]</sup>. In Taunusstein (Germany) flexible and on-demand shuttles complement traditional public transport<sup>[187]</sup>. Additionally, a local business in Tübingen provides car clubs in the city<sup>[188]</sup> and Tübingen's local energy utility promotes an E-bikes scheme for supporting the use of bikes in its hilly streets<sup>[189]</sup>. These examples of other similar-sized cities show that the overall approach adopted by Durham Council is vague, and it can only be considered as being at an early stage of planning.

- Improve has been characterised as having 'some areas with regard to planning or implementation strategies should be reviewed further': The priorities of the County Council are clearly laid on electrification of all vehicles and has planned several "EV actions"<sup>[190]</sup>. However, there is no clear plan for biofuels or hydrogen as solutions for bridging these technologies for heavy-duty vehicles of their fleet and creating a diverse fuel mix. The proposed "Solar Car Port" that combines the provision of a car park, sustainable energy<sup>[171]</sup>, and electric charging stations for cars and buses demonstrating the clear thinking about sustainable energy production for the transition. In parallel, the County Council offer businesses a "try before you buy" for triggering businesses such as taxi companies to an EV uptake (Interview: Local authority and industry expert). However, it is difficult for the local authority to initiate the transition of the public transport buses as they are privately owned<sup>[190]</sup>. The County Council is also eager to make their own vehicle fleet sustainable to become a leader and ambassador for the transition as "this is a straightforward thing to do" for the Council (Interview: Local authority). Simultaneously, the County Council is convinced that the implementation of EV charging infrastructure will support the uptake of EVs. seeking to install charging infrastructure in rural and economically unattractive areas to support commuters and an overall fair transition<sup>[191]</sup>. Currently, 121 public charging points exist in the county<sup>[108]</sup>. The interviewed industry expert however sees this focus on EVs critically, highlighting three areas: a) as currently EVs are still considered an expensive solution in comparison to the average income of the local households in Durham, which are often dependent on the trends in the second-hand car market. The interviewee points out that it will take time until these households in Durham gain access to a second-hand EV market, as bigger cities will be served first, b) local authorities do not have the powers to distort the car market and provide alternative solutions to their citizens and c) challenges (incl. internal resources and money) hinder the implementation of convenient and strategic public EV charging points. In conclusion, Durham's local authority has many ideas, engages in different initiatives, and already implements infrastructure, but there could be further considerations for diverse sets of actions and ambitions to put them all together in a coherent plan.
- Funding needs has been characterised as having 'absence of clear thinking and solutions': The County Council heavily relies on government grants. The rural context of the County still creates a focus on spending on connectivity and road improvements<sup>[19]</sup>, as this is considered more urgent to tackle for the benefit of citizens, making climate change considerations to a second-level priority. Still, the interviewee from the County Council stated that they aim to tackle this prioritisation by implementing vehicle charging infrastructure projects in connection to the social value that they bring, leaving economically viable locations for businesses to explore further. Relying entirely on grant funding is unwise (Interview: Industry expert), but it is mainly caused by the lack of powers and structural elements of the County Council. Spending on active mobility and its promotion could be attractive, and the city's Neighbourhood Plan<sup>[174]</sup> starts this process through a shift away from road schemes toward cycling and walking infrastructure.

All interviewees agreed that the sustainable mobility plans lack substance on how to deliver the interventions, providing actual numbers and salient budget, accountability, and transparency. According to the County Council's plans, the transition opens up new

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markets and opportunities. For instance, a private innovative initiative is the business model of ZMOVE<sup>[192]</sup>, a local company from Newcastle. Public-private partnerships, such as with the local supplier and installer of EV charging infrastructure, Elmtronics, who is a partner of the Council in the Innovate UK projects, showcase the success of collaborations. Nonetheless, there is still a lack of communication and partnerships between businesses and between the public and private sectors, especially when it comes to EV charging infrastructure. In conclusion, key activities of the County Council require more investment; however, they are not yet strategically and systematically planned or budgeted.

Inclusiveness has been characterised as having 'clear thinking and a good implementation plan': The measures and plans for Durham City's sustainable mobility present clear thinking about inclusiveness and social coherence, but also engage citizens and aim to increase communication in order to ensure city development according to citizen needs. Durham's local authority and the regional transport planners are aware that not all people can use public transport, walking, or cycling, and some are heavily reliant on their car (Interview: Transport planner) and that the transition should not increase transport poverty. This is why the County Council plans to increase the level of connectivity of public transport within the city and connect the rural areas with the city, to increase overall accessibility, and provide fares for increased affordability<sup>[171, 184]</sup>. At the same time, the County Council implements EV charging infrastructure with a focus on rural areas and socially inclusive locations, leaving economically attractive locations to the private sector (Interview: Local authority). The interviewees representing local authorities and transport planners have demonstrated a great awareness that behavioural change in this transition is not only necessary for the citizens and businesses but also for their stakeholder group. Still, the industry expert wishes for more innovative thinking by the local authority and even more prioritisation of promotional measures for active travel modes.

The analysis of all these elements has demonstrated the combined assessments and efforts that are currently taking place or are planned for Durham's sustainable mobility infrastructure and investments. At the moment, the inclusiveness of measures characterises the Council's ambitions on their pathway to sustainable urban mobility. However, taking all stakeholders on board, strategically planning practical measures, and how to finance them all need further consideration. The County Council has launched several initiatives to engage citizens in active mobility, but more public engagement is needed in the planning of future infrastructure. Overall, there is a plan for the city to transform its urban surface transport system in an inclusive way, that will simultaneously tackle traffic congestion, decrease emissions, and improve air quality. Nonetheless, given the limited powers and possibilities of the small city, through its set intermediary goals it will be possible to support the County's decarbonisation goal of 2050 through a sustainable transport system. Figure 6.1 summarises the key points and their evaluation into the framework which guided the analysis.

Figure 6.1 Framework filled out for Durham representing priorities and status of	
a current sustainable mobility strategy.	

Avoid: city centre	Shift: cycling, walking, and public transport	Improve: EV infrastructure
Durham is a small city, where one-third of the citizens could walk to work, and the market- place in the city centre can be reached in an average 20min walk, therefore the 15-min neighbourhood concept is almost present due the local context itself.	The promotion of public transport, walking and cycling is crucial in Durham City and Durham County. Durham County Council is already working on several projects, for instance: + "Go Smarter Go Active Initiative" or "Living Streets" aim to involve citizens and engage them to walk or cycle, + Special access busses and affordable public transport tickets, + Durham Peninsular charging Zone However it lacks initiatives and infrastructure for: - Car sharing and car pooling, - multi-modal travel and mobility hub, - Increased public transport network for improved level of connectivity. With all areas needing more specific implementation strategies.	The Council has many ideas, engages in different initiatives, and already implements some infrastructure, such as: + Durham County Council focuses on electrification for their pathway to net-zero transporta- tion. They implement EV charging in areas which is unattractive for the business sector. + The Council engages and aims to influence the uptake of private and business EVs, starting from their own fleet + Through solar car ports they seek to combine the infrastructure with sustainable energy. However it lacks initiatives and infrastructure for: - Strategies for hydrogen and biofuels - There are only few EVs (private, business, and public) that already travel through the city. - And the charging infrastructure lacks of a thought-through implementation and distribution.

**Funding needs:** Durham County Council's is grant-driven, where they bid for funding – best not match-funding – and then think about how to spend the money. The other way around with a proper strategy would lead to more consistency and financially achieving the net-zero targets. The Council uses different funds for different projects. However, it becomes clear that they should focus on active mobility as there more and more funding will be available. Funding should no longer be used for road schemes. The private sector starts to adapt its business model by e.g. implementing EV charging points. This becomes increasingly interesting even though the profitability is a long-term perspective. Therefore, leaves putting EV infrastructure in the City to the businesses. There is little to no communication with the Council. However, this could help more strategic planning for infrastructure investments for both sides. Also, partnerships with the Council have been proven successful (Elmtronics).

**Inclusiveness:** Durham's Local authority and the regional transport planners demonstrate awareness that not all people can use public transport, walking, or cycling and heavily rely on their car. Throughout the measures and plans for Durham City's sustainable mobility present a clear thinking about social coherence and inclusiveness. They implement EV chargepoints in areas which are unattractive for the business sector, but where the social value is high. Local authority and transport planners demonstrate a great awareness that behavioural change in this transition is not only necessary from the citizens and businesses but also by their stakeholder group. Still, there needs to be more innovative thinking in the Council and even more prioritisation of promotional measures for active travel modes.

# 7. Key policy aspects and different decarbonisation pathways

## 7.1

# How scale and context affects urban decarbonisation pathways

Large, medium-sized, and small cities have urban areas with different contexts, different needs and different levels of complexities, including location-specific issues, spatial characteristics, socio-economic demographics, the scale of interventions, and financial factors. However, it is possible from our case studies to identify a range of achievements and opportunities towards a pathway of urban transport decarbonisation. The case study cities, London, Nottingham, and Durham demonstrate that each urban area should be considered in its own particular context.

The case study cities have set different carbon neutral deadlines (including urban surface transportation) for their respective governance areas (Table 7.1): London has a target of 2030, Nottingham of 2028 and Durham 2050. Nottingham has been a forerunner in its ambitions to tackle climate change, with an aim to be carbon neutral by 2028, a target even earlier than London. The local authorities of London and Nottingham are proactive in challenging themselves and their neighbouring Councils to take action, giving signals of urgency, more so than is the case of the City of Durham. However, despite the active implementation of infrastructure and interventions the targets in Nottingham and London are considered highly ambitious and difficult to fully achieve by the local actors, while Durham's target is considered to be a more realistic one based on its local capacity and resources. Overall, our analysis shows some room for improvement for all three cases, especially on the need for place-based solutions, achieving safe and reliable funding sources for long-term planning, and ensuring inclusiveness when making a wide range of interventions across the avoid, shift and improve pillars of low carbon mobility.

Whilst large and medium-sized cities, such as London and Nottingham, actively promote journey-saving concepts, such as the 15-minute district, this concept has not been actively used in Durham, due to the small size of the city. All cities emphasise the importance of active transport and public transport schemes that are inclusive, accessible, and affordable. The cities are aware that increases in walking and cycling will be needed to reach decarbonisation targets. Therefore, all cities, no matter their size, increasingly dedicate investments not only to the improvement of infrastructure but also promotional actions. All three selected cities demonstrate awareness of the importance of improving cycling lanes and increasing safety. However, cities on the scale of London require a concept that captures the higher complexity of the transport system and the greater level of traffic to really encourage cycling across the whole city, through creating a sense of safety for cyclists. Furthermore, London and Nottingham demonstrate an increasingly effective network of public transport, which becomes the backbone of the shift measures. Compared to these two cities, Durham does not yet have the same level of accessibility of public transport within the city and this is not especially well-connected to the rural countryside. The County Council, which has to respond to both rural and urban needs, is confronted with many different private bus operators, and there is a lack of financial and political power to coordinate its actions.

Discouragement measures to reduce the use of private vehicles, through congestion charge zones or parking levies, exist in all three representative cities. The charging zones in London are helping to reduce the number of private cars in the city centre, but there are still questions about inclusivity in terms of the impacts on poorer citizens. Nottingham has been a pioneer with the Workplace Parking Levy that charges employers rather than citizens directly. While this concept is relevant for London as well, it may be less appreciated in smaller, rural cities such as Durham, where the public transport network is not yet sufficient to be an alternative for car usage. In fact, strategically planned car parks and park and ride facilities, which are becoming interchange hubs, can become important cross-boundary travel schemes for commuters and tourists.

Car sharing and car clubs have been considered and implemented at different scales in different cities. These have partially been seen as a solution to increase the inclusiveness of transportation, considering the high cost of EVs and their unaffordability for low-income households. For instance, Nottingham, having many no-car households, implemented EV car clubs to enable such households to use more sustainable vehicles. The local authority in Durham, however, has not yet considered this as an option.

This study revealed that larger cities such as London and Nottingham are better placed to prioritise various sustainable technologies (electrification, biofuels, green hydrogen) to decarbonise private and public vehicles, while Durham relies exclusively on EVs. The case of London demonstrates that, especially in the complex transport system of a mega city, focusing only on one technology would be inefficient, since different modes of transport require different low carbon technologies. However, even focusing on covering the need for EV charging infrastructure proves to be a challenge, with both the examples of Nottingham and Durham unable to match the demand, because of limits in the availability of finance and skills. Nonetheless, cities of all sizes have started the EV transition with their own vehicle fleets to send a clear signal to their citizens. All the case study cities are also considering including a shift to locally-generated renewable energy supply as part of their mix of measures.

A city's size is not the sole determining factor for decarbonising transport policies, since it must also consider its citizens' multitude of different needs, possibilities, and priorities. While large and medium sized cities seem to be able to provide more transport opportunities for its citizens to shift to sustainable transportation, smaller cities seem rather limited in the options for their citizens. With regard to improvement measures, all cities try to influence citizens to buy EVs, however, the actual influence on people's behaviour seems to be limited. The general thinking among the cities is that EV uptake relates to the provision of infrastructure, and sometimes issues such as socio-economic factors and the availability of second-hand markets are neglected.

Nonetheless, analysis of these case cities demonstrates that no matter what size and context a city has, addressing all its citizens' daily problems should be the underpinning consideration for the transformation. Smaller cities such as Durham,

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or cities with high levels of income deprivation such as Nottingham, require strong efforts to generate a high level of public acceptance and engagement. Moreover, efforts are required to keep citizens connected to the narrative of the net-zero carbon transformation and ensure the quality of life and economic growth in the long term. Inclusiveness, social coherence, and awareness require behavioural changes in the citizens but also mindset changes in those responsible for policy and designing the planning strategies of the local authorities. Nottingham and Durham aim to maintain a high level of communication and engagement with their citizens, emphasising local priorities and needs. In the case of London this becomes more challenging due to its scale and complexity. However, both policy makers and citizens in London have a clear sense of the urgency of the net-zero transition.

The most urgent issue for all cities is the lack of long-term visibility when it comes to funding resources. This is strongly related to the national Government's funding system and priorities: which currently a) do not provide enough local authority funding, b) mostly allow only for the temporary funding of schemes, and c) result in a dearth of fundraising powers by local authorities, which limits their ability to direct the transition to net-zero urban transport. In comparison with a small city like Durham, London has much easier access to both public funding and private financiers through partnerships as a result of the attractiveness of its market and its massive scale. The case studies demonstrate how small and medium-sized cities can either tackle funding challenges by establishing new revenue streams (that allow for can matched funding), or re-prioritising, for instance by focusing on social needs rather than the urgency of the net zero transition. At the same time, however, the different structures of local governance, frequent changes in those structures and differences in ownership structures, especially over public transport, influence the power and the breadth of each local authority's actions and strategies. Our comparison shows that coherent, multifaceted strategy and planning, tailored to the local context and scale, together with long-term financial viability is crucial to achieve all three pillars of avoid, shift and improve.

	Large City (London)	Medium City (Nottingham)	Small City (Durham)
Decarbonisation Goal	2030	2028	2050
Areas of policy and interventions that are considered at a mature level ('green')	<ul> <li>Effective city planning including 15-min Neighbourhood concept</li> <li>Intense focus on walking and cycling infrastructure despite longer travel distances;</li> <li>Adoption of modern technologies for multi- mobility hubs and connectivity of services;</li> <li>Intense focus and considerations on connectivity, accessibility, and affordability of public transportation;</li> <li>Strategically planned car parks and park and ride facilities;</li> <li>A high degree of diversity of technologies and infrastructure.</li> <li>Effective EV charging network with a high level of distribution and availability.</li> <li>Considerations of renewable energy production.</li> </ul>	<ul> <li>Effective city planning including 15-min Neighbourhood concept;</li> <li>Intense focus on walking and cycling infrastructure for inside and cross-border travel;</li> <li>Accessibility and Affordability of public transportation;</li> <li>Successful Workplace Parking Levy;</li> <li>Car clubs for inclusiveness of transportation;</li> <li>Strategically planned car parks and park and ride facilities;</li> <li>A high degree of diversity of technologies and infrastructure.</li> <li>Considerations of renewable energy production;</li> <li>Considerations on inclusiveness and citizen engagement through public consultations.</li> </ul>	<ul> <li>Promotion of walking and cycling;</li> <li>Successful Durham Peninsula charging zone;</li> <li>Strategically planned car parks and park and ride facilities;</li> <li>Understanding to initiate transition with own vehicle fleet and first approaches for influencing private and business vehicles;</li> <li>Considerations of renewable energy production;</li> <li>Considerations on inclusiveness underpin actions and intense focus on citizen engagement and communication.</li> </ul>
Areas of policy and interventions that are considered at a adequate level but require further elaboration ('amber')	<ul> <li>Successful congestion charging schemes, but need for alternatives and increased inclusiveness;</li> <li>High coverage of car clubs due to private sector initiatives;</li> <li>Established partnerships and increased private sector investments but are still dependent on government grants;</li> <li>Considerations on inclusiveness are increasing however lack of citizen engagement.</li> </ul>	<ul> <li>Increasing EV charging network that still does not match demand;</li> <li>Established partnerships and some private sector investments are still highly dependent on government grants.</li> </ul>	<ul> <li>Aim for effective city planning but no strategic linking with avoidance concepts;</li> <li>Intense focus on walking and cycling infrastructure in and around the city but lack of implementation;</li> <li>Intense focus on accessibility and affordability of public transportation (especially for rural area connectivity) but lack of implementation and multi-mobility.</li> </ul>
Areas of policy and interventions that have not been included in the local thinking ('red')			<ul> <li>First car clubs and first awareness of its usefulness, but also lack private sector initiatives;</li> <li>Lack of thinking regarding the diversity of technologies and alternative fuels;</li> <li>Lack of structural elements for partnerships and private sector investments that support the independence of government grants.</li> </ul>

Table 7.1. Overview of areas of policy and interventions that have been considered to a mature (green), an adequate with the need for further elaboration (amber), and an insufficient (red) level within the local

decarbonisation strategies for London, Nottingham, and Durham.

## 7.2 Key actions for policy makers

Considering the three cities of different scale under our guiding framework, a series of key recommendations can be identified. These recommended actions have been grouped into: (i) Urgent actions to be prioritised; (ii) Collaborative, medium-term implementation actions; and, (ii) Structural, longer-term actions.

#### **Urgent: actions to be priortised**

- The public transport system remains the backbone of any net-zero transport scheme. Despite the different complexities in each city (e.g. with different types and ownership of public transport), high levels of capacity and availability, accessibility, affordability, connectivity, and quality are required. These are the essential elements for achieving a high level of usage, prompting citizens to shift towards public transport. A combination of scheduled and demand-responsive buses, trams, underground, and taxis can help to address different citizen needs (e.g., varieties of distances to cover or timings to travel) and it allows for flexibility in transport choice. In that sense, consideration of concepts such as multi-modal transport hubs and on-demand services with increasing combination with smart technology and applications are important tools for implementing a sustainable and future-proof, attractive public transport system. Similarly, the private sector can play a significant role in the efforts to shift transportation, with alternatives to car ownership, including concepts such as car-sharing schemes, car clubs and mobility as a service.
- → Local authorities and providers with large vehicle fleets (e.g. the police, NHS, taxi providers and courier services) can be pioneers by moving their fleets to low or zero carbon vehicles. Most local authorities are on the move towards replacing their own fleet of vehicles, although this is a large capital investment for them. Furthermore, they can initiate and drive this transition in the private sector through such schemes and campaigns as the test drive, becoming the pioneers for the necessary mindset change across all stakeholders. However, the initial capital cost is significant for both the publicly financed and private actors. A national-level finance strategy for such green investment is required which will be easily accessible for both private and public actors. A Green Investment Bank could play such a role. While local government has limited tools to influence people's behaviour regarding EV uptake, the national government needs to support the cities through the provision of inclusive subsidies that are accessible to all citizens. Subsidies could also be given to low-income households to access the second-hand EV market. Furthermore, local authorities are recommended to share their experience with the private sector to retrofit light utility and business vehicles.
- → Local authorities and private transport operators require long-term funding of schemes. A range of alternative streams of funding can be identified for gradual improvements and maintenance of fleets and charging stations. However, the initial capital investment requires a national-level response.

Widening access to bank loans, opening new streams of funding, e.g. through a public-owned UK Green Investment Bank and providing clear powers for raising capital funding at a local or regional level should be implemented as soon as possible.

- → Local authorities in parallel are required to provide consistent signals towards the wide range of alternatives to traditional private vehicle transportation, using tools such as road or parking charging schemes, and strategically planned car parks and park and ride facilities for the promotion of active mobility and public transport. The different initiatives and infrastructure are required to be designed from the perspectives of the variety of users in a city, including for example citizens' daily business or leisure needs, commuters, and tourists.
- → A key factor for supporting the wide adoption of EVs is the availability of an extended, reliable and convenient charging infrastructure. Cities are facing different conditions and requirements of public EV charging infrastructure and these need to complement private and off-road individual charging solutions. Considerations of location, technology evolvement, charging behaviour, economies of scale and inclusiveness issues are required to be combined in private- and public-led actions and partnerships for designing and implementing the network of EV charging infrastructure. Due to the high level of heterogeneity amongst cities, local authorities should be given the responsibility regarding the provision of charging stations, rather than the national government.

#### **Collaborative, medium-term implementation actions**

- → Advertising initiatives, communication campaigns and the organisation of activities across cities have been proven to be equally important for nudging citizens towards active mobility through the construction of a widespread, safe and attractive cycling and walking network. Local authorities have been prompted to consider green and active mobility from the perspective of a healthy lifestyle for their citizens. However, these also need to consider the particular characteristics of their urban structure, such as size, population, and topology. For instance, e-bikes and e-scooters can support the adoption of active travel modes in larger cities with long distances to cover, or help in smaller, hilly cities.
- $\rightarrow$ As for all technological solutions, an effective transition to emission-free vehicles is required to be considered. Local councils are encouraged to consider technological lifecycles and generate strategies that integrate these technologies gradually (e.g. using different types of battery based vehicles, fuel-cell based vehicles etc) across the different types of users. This means infrastructure and investments need to be leveraged over the timeframe towards net-zero targets. A focus on merely one lowcarbon fuel option could be risky and inefficient, considering the fast pace of change of the relevant technologies. However, this gradual transition should not be an excuse to wait forever for an imagined 'perfect' technological solution. In parallel, incentives are required at the national level to attract international business and investors, to develop the market for alternative fuel vehicle supply chains (both for new and second-hand market) as well as develop the network capacity for powering those vehicles. This strategy should be developed at the national level to avoid bringing local authorities into a competitive race against each other, diverting scare resources and ultimately resulting in infrastructure inequalities across the country.

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- → The complexity of the infrastructure investments required will also need continuous communication between the local authorities and private actors. New fuelling or charging networks need to be designed and developed in an economical, efficient, and equally convenient way as the existing fossil-fuel based refuelling stations. At the same time, the transition must be designed to be socially inclusive and avoid the phenomenon of energy or transport poverty. The latter cannot be ensured by just leaving the initiative to the private sector. All private and public investments are required to have in their design social-value criteria in parallel to assessments of economic and environmental benefit, while the government should support risk-taking activities from new business initiatives through a set of guarantee schemes.

#### Structural, longer-term actions

- → To promote trip avoidance in a city, urban planners are required to consider concepts such as the 15-minute neighbourhood or the creation of a polycentric urban system that ensures by design that facilities and services for work, leisure, or business purposes are accessible and well connected for everyone without the need to use private vehicle transportation. Such designs should take account future trends (e.g. demographic changes or an ageing population), and their key characteristic is that they are human-need-centric instead of technology- or infrastructure-centric.
- → While large cities more easily attract private investment due to their national and international importance, medium and small-sized cities and the districts of larger ones can play the role of a **testbed of early technologies** and innovative business schemes. As these technologies are at an early stage of development this is an opportunity for local authorities to establish local proof-of-concept and incubation schemes, to provide an environment that encourages collaboration between small businesses and public bodies. Furthermore, such schemes might provide the environment to de-risk such early propositions and attract more private equity investment. Private investment will be needed for both large- and small-scale investments to create the conditions to achieve avoid, shift, and improve policies. Especially at this early stage of transforming our transport systems, the private sector has an opportunity to initiate and design innovative business models.

# 8. Conclusion

This policy paper examines how cities can to support decarbonisation in the UK in the case of urban mobility. The proposed guiding framework is a tool for analysing the coherence of urban transport decarbonisation strategies in different contexts (Figure 8.1). It is important to highlight that the three pillars of the framework avoid, shift, and improve - must be considered in parallel. Together the 'avoid' and 'shift' propositions enhance the "productivity" and flexibility of the transport system. The 'improve' pillar ensures that the latest type of technology is deployed for decarbonisation. Therefore, the framework can potentially be used as a tool for strategic planning, alignment, and transparency of all the factors in the decarbonisation strategies. The framework enables local authorities to capture the complexity of their local urban surface transport network and to identify initiatives, infrastructure, and salient investment priorities needed for the transformation towards net-zero transportation while ensuring inclusiveness and social coherence. Even though opportunities, challenges, and needs may differ depending on the size and context of the city, all cities can apply these points accordingly and set salient priorities.

Our analysis demonstrates that there are already successful examples of transitioning to low-carbon transport across different city scales and contexts. The case study areas have demonstrated innovative approaches and different solutions for actions across the three pillars, ensuring at the same time inclusiveness for a fair and socially coherent transition to a new urban transport system. Large, medium-sized, and small cities may have different structural and financial systems to achieve transport decarbonisation, but all three cities demonstrate that solutions can be found and timelines for the decarbonisation pathways can be set. Through additional support from the central government and the private sector, we are confident that local authorities will be able to strategically reduce their transport emissions to net zero, even if this does not happen within the very ambitious target dates that have been set. However, the speed of this transformation will be different not only across UK cities, but also internationally. Nonetheless, UK cities are moving and working in the right direction, supporting the UK Government's 2050 carbon neutral goal.

The analysis demonstrates that the present planning and funding system raises the most serious barriers to urban transport decarbonisation across all city types. Initial capital investment is significant, but currently the private sector often does not add significant amounts of investment. A clear signal is required by central government to synchronise public and private investment and help guide the alternative financial streams for local authorities. In parallel, it demonstrates that place-based solutions will be key for the prioritisation, acceptance, and the realistic implementation of policies to decarbonise urban transport. As a result each city will have a different pathway for its avoid, shift and improve schemes. To help achieve this local authorities need to be given more powers and flexibility to achieve their particular pathways.

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To improve the knowledge of place-based solutions, future research would be helpful using scenario-led and sensitivity analysis to investigate the transport decarbonisation timeline and needs of individual cities. Furthermore, more research on the social implications of the net-zero transition would be beneficial. For example, the phasing out of private internal combustion engine vehicles in a city could disproportionately affect lower income households since they tend to keep their vehicles for longer and often rely on the second-hand market as mentioned in the cases of London and Durham. This consideration will be important for the inclusiveness of the decarbonisation process.

Finally, this study found that behavioural changes are not only needed from the citizens to avoid, shift, and improve, but also by transport planners, government, and the private sector. Therefore, future research could investigate how transport planners, the government, and the private sector could better collaborate, participate, engage, and invest in the strategic decarbonisation of urban surface transport.

Avoid	Shift	Improve
<ul> <li>Replace the need for travel through:</li> <li>Local solutions beyond transport</li> <li>City planning and place-based planning.</li> <li>15-min Neighbourhood and polycentric city concepts.</li> <li>Consistent and clear messaging across planning and communication actions.</li> </ul>	<ul> <li>Shift trips away from private cars and direct towards active, public, and shared transport through: <ul> <li>Walking and cycling infrastructure and promotion.</li> </ul> </li> <li>Accessible and affordable public transport network.</li> <li>Multi-modal travel and integrated ticketing.</li> <li>Car &amp; bike sharing, and mobility hubs.</li> <li>Changing road design and effective car parks way from city centres and towards integrating them with public transport.</li> <li>Consistent and clear messaging across planning and communication actions.</li> </ul>	<ul> <li>Any trips that still need to be done by car; they should be made by improved technology:</li> <li>Low carbon vehicles (private, public, business).</li> <li>Sustainable alternative fuels (electricity, hydrogen, biofuel).</li> <li>The uptake needs to be encouraged through incentives, attractive refuelling infrastructure, and sustainable energy supply.</li> </ul>

#### Figure 8.1: Findings of key aspects framed within the guiding framework of this study.

**Funding needs:** Leveraging public and private investments as a tool to overcome funding challenges that are set by the governmental structure and possible lack of powers:

- Focus beyond road schemes and direct funding towards avoid, shift, and improve according to city needs.
- Establish partnerships between public and private sector for increased clarity, communication, and cooperation between the two parties.
- Support private investors who are already interested to fund charging infrastructure that is economically attractive, while public funding could be used for social equity, inclusiveness, and affordability of infrastructure
- Counteract grant-driven behaviour which creates funding and time constraints, through additional revenue streams such as the Workplace Parking Levy scheme can help local authorities
- Long term visibility of funding.
- Testbed of new technologies with clear scale-up funding options.
- Pathway for raising funds at city level through a Green Investment Bank.
- Achieve a level of flexibility and long-term planning and receive revenue for continues improvement of the infrastructure.

**Inclusiveness:** inclusiveness and social coherence are the underlining notion of all avoid, shift, and improve initiatives, infrastructure improvements, and investment decisions for the transition to net zero urban surface transport:

- Identify struggles e.g., high level of households with no car ownership, high need of connectivity, or complexity of the transport system, to target them,
- Be aware of effect of transformation on multitude of individuals (residents, commuters, tourists) with different needs,
- Ensure affordability and accessibility during the transforming process and in the future,
- Move away from "traditional habits" towards creating a future proof liveable, attractive, urban environment with provision of inclusive transport opportunities,
- Improve infrastructure in a way that it is inclusive, increase quality of life, but not give reason for transport poverty.



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