Travel Demand Management Options Study

Final Report

Prepared for: Transport Scotland

Project number: 60686513

March 2023

Delivering a better world

Table of Contents

Executive Summary

Scotland's Climate Change Plan update (CCPu) sets out an ambitious emissions reduction pathway for transport in order to meet the legally binding targets committed to in the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 – to achieve net zero emissions by 2045 and a 75% reduction by 2030.

Work undertaken to quantify the extent of the challenge has estimated that meeting the reductions targets will require rapid decarbonisation of passenger and freight vehicle stock, a reduction in vehicle kilometres through modal shift, and reduced demand, through trip shortening and trip avoidance. Reducing car kilometres travelled is therefore a key policy commitment of the Scottish Government, with a target of a 20 per cent reduction from 2019 levels by 2030. The second Strategic Transport Projects Review (STPR2) sets the course of Scotland's transport future for the next twenty years and identifies a range of recommendations which, together, will enable the required shift to a transport system which meets the net zero target. However, over the timescales required, the recommendations of STPR2 will not create a shift large enough without some form of downward pressure on car use. This downward pressure is commonly referred to as Travel Demand Management (TDM) and includes a range of measures including development planning and road space reallocation as well as familiar fiscal measures such as congestion charging.

The current dominance of car transport does not represent the most equitable solution to the transport and social issues Scotland faces today. 60% of the lowest income households and 46% of those with a long-term health problem or disability do not have access to a car, while young people, older people, women and certain ethnic minority groups are less likely to have access to a car. Meanwhile, people living in poor neighbourhoods also experience the greatest impact of traffic in terms of air pollution and road traffic accidents, in particular, more children and young people from deprived areas.

This research explores ways in which TDM measures could be applied equitably, in order to meet the requirements of the CCPu emissions reduction pathway, fulfilling part of the route map to achieving 20 percent reduction in car kilometres by 2030. The options presented here are intended to demonstrate the range of measures that could feasibly induce the required reduction in car kilometres in an equitable way. It provides an estimate of the costs and the potential revenue implications and assess the overall impact of each option against established transport appraisal methodology.

Initially, a literature review was undertaken to establish the full range of practical options, drawing from UK and international examples as well as relevant research studies. From this review, a long list of options was created to encompass all reasonable options for TDM in Scotland. This long list was sifted against the primary research objective – to reduce car kilometres by 20% by 2030 – as well as established transport assessment criteria, deliverability considerations and policy alignment. The resulting shortlist of options then underwent a preliminary appraisal to further focus in on the most appropriate and effective options. The unintended consequences and possible equality impacts of each option were then carefully considered in order to refine each one and package it alongside allowances, exemptions, and complementary measures. As a result, all options assume exemptions for blue badge holders and discounted rates for those on low incomes and living in remote rural areas, with less opportunity to change their travel behaviour.

By this process, this research has arrived at a focussed range of options for TDM which all employ an element of road pricing – charging drivers to travel by car, either within certain areas or over distances. The two broad options assessed are:

- **Local:** a daily charge for driving in all large urban areas in the Glasgow conurbation, Edinburgh, Dundee and Aberdeen and implemented by local authorities under existing legislation
- **National:** a distance charge per kilometre driven on any road and implemented by the Scottish Government.

The indicated effectiveness of each TDM option is outlined in the Table below:

Charge type	Charge	2030 Car km reduction	2030 Revenue	Car emissions reduction	Equity impacts and mitigation
Area	£15 per day, (£7.50 discounted)	-25%	£1,300m	-26%	Greater impacts on those living within the charged area, who are potentially more able to substitute
	£10 per day, (£5 discounted)	-21%	£1,100m	-22%	
	£5 per day, (£2.50 discounted)	-14%	£800m	-15%	
Distance	10p per km, (5p (discounted)	-26%	£2,300m	-27%	Lower charges mitigate the impact on remote rural communities who find it most difficult to switch modes
	6.5p per km (3.3p discounted)	-17%	£1,700m	-17%	
	3p per km (1.5p discounted)	-8%	£875m	-8%	

The assessment of these options shows that both distance and area-based charging could be designed to achieve the 20% reduction in car kilometres, and at a cost to individual drivers which is not unreasonable.

The estimated impact of area-based charging would be dependent on all large urban areas in Glasgow conurbation, Edinburgh, Dundee and Aberdeen implementing charges simultaneously. However, at present, it is unlikely that all large urban areas would be in a position to implement area-based charging in the timeframe necessary to achieve the required reduction.

Further exploration and feasibility analysis will be required in order to take forward any of the options presented. However, a broad assessment of deliverability has been made which ensures that a technological and practical route to delivery exists. The delivery of any TDM option will require the use of technology which could include ANPR cameras – currently widely adopted for a variety of traffic enforcement applications – or Global Navigation Satellite Systems (GNSS) to record driver mileage.

Local area charges could be technically easier and quicker to introduce, as local authorities already have to powers to implement these charges, while a national distance based charge is more complex requiring further policy development.

The key recommendation from this work is that a Framework for Implementation is created to ensure local and national government can operate together, in an efficient and equitable way, when introducing TDM schemes at either national or local level.

This report concludes that TDM has the potential to achieve the Scottish Government's target of reducing car kilometres by pricing transport use in a fairer way, in line with Scotland's geographic and social needs. TDM has the potential to raise significant levels of revenue which can be reinvested in enhancing public and active transport, enabling Scotland to meet its net-zero targets.

1. Introduction

AECOM has been commissioned by Transport Scotland to conduct a study into options for Travel Demand Management (TDM) schemes to disincentivise private car use in Scotland, and to provide an assessment of the potential impacts on different groups of people, as well as the wider impacts on the environment and the economy.

The headline objective of this study is to support the Scottish Government commitment to reduce car kilometres travelled in Scotland by 20% by 2030, identified as one of the key policy outcomes of the 2020 Update to Climate Change Plan[1], the approach to delivery of which was set out in the corresponding route map[2]. Importantly, the route map recognises that interventions designed to reduce car use and encourage more sustainable travel must be both realistic and fair, particularly in recognising the constraints on travel choices for disabled people and those living in rural areas. The 20% reduction target is defined relative to 2019 levels and covers all types of car, including zero emission vehicles. The route map sets out various actions including reducing the need to travel, living well locally, switching modes, and combining trips or sharing journeys. However, only by taking a combined approach which includes measures to reduce demand for transport can Scotland's climate targets be met[3].

The conventional aim of demand management is to manage congestion on the road network in order to address the key externalities associated with private car transport, such as journey time delays, air and noise pollution, road danger, physical inactivity, and community severance. While the overriding aim of this study is to employ demand management solely for the achievement of climate change targets by reducing car use in absolute terms, any demand management measure considered is likely to also have further benefits in these areas.

This report will summarise the key finding of this study and present the final recommendations. The report is structured into the following sections:

- **Section 2 – Background Evidence Review** – Details the key problems, opportunities, and constraints which have emerged from a review of literature around implementing TDM measures in both the UK and internationally.
- **Section 3 - Option Generation and Preliminary Appraisal** – Summarises the process of option generation, sifting, and preliminary appraisal undertaken in order to produce options for detailed investigation and appraisal.
- **Section 4 – Option Development and Packaging** – Details the further option development and packaging, and additional sift that has been undertaken, based upon the preliminary appraisal and the results of a stakeholder workshop to identify any further unintended consequences.
- **Section 5 – Detailed Appraisal** – Summarises the detailed appraisal against the research objective, deliverability criteria, STAG criteria, Policy Alignment, and Sustainable Investment Hierarchy. The appraisal discusses any design considerations which could impact performance against criteria, informing further option development.
- **Section 6 – Conclusions and Recommendations** – summarises options and discusses considerations for next steps in implementing measures.

2. Background Evidence Review

This chapter summarises the background and evidence review undertaken to inform the generation and assessment of demand management options. The review identifies the problems and opportunities relating to car use in the Scottish context and the summarises the relative effectiveness and impacts of TDM measures from a range of UK and international examples.

2.1 Problems, Opportunities and Constraints

2.1.1 Problems

Three key problem groups were determined through a literature review, discussions with stakeholders, and analysis. These problems have been defined as:

High and Increasing Demand for Car Travel:

- Increases in vehicle kilometres between 2009 and 2019 disproportionally higher than population growth[4].
- Post COVID-19 recovery of car traffic to much stronger than for public transport[5].
- 65% of car kilometres travelled are on the longest 20% of journeys (over 19.62km)[6].
- Transport is the largest emitter of CO2 emissions and targets will not be met unless there is a reduction in vehicle kilometres and demand for car use[7].
- Negative economic impact of congestion.
- Disruptive technology such as MaaS and Autonomous Vehicles.

Decreasing Revenue from Fuel Duty and Vehicle Excise Duty (VED):

- Due to freezing of rates since 2010 and trend towards more efficient vehicles – decreasing revenue will only accelerate as sale of new petrol and diesel vehicles is phased out by 2030[8].
- Though VED will apply to Electric Vehicles (EVs) from 1 April 2025, no mechanism exists for taxing the electricity used for vehicle charging.
- Falling revenue will reduce the taxation intake, impacting all areas of public spending.

Transport Inequality:

- Lack of alternatives in some areas puts people in a situation of forced car ownership[9].
- Those on higher incomes contribute more to the total car kilometres than those on lower incomes[10].
- Nearly 30% of households have no access to a car and for the lowest income households this rises to 60%[11].
- Rural areas have a higher car mode share and people make longer trips than those in urban areas[12].
- For people with a long-term health problem or disability, 46% have no access to a car[13].
- Strong links between road traffic accidents and areas of deprivation, with children in Scotland's poorest communities at three times higher risk of death or injury while out walking or cycling[14].

2.1.2 Opportunities

The review also identified a number of opportunities for implementing a TDM scheme in Scotland in the present context:

- Changing attitudes around climate, sustainability and data sharing.
- Low uptake of EVs to date – making it easier and more acceptable to create a new charge applicable to EVs prior to mass ownership.
- Political Context – reducing car kilometres is a central Scottish Government policy.
- New Technology – advances in in-vehicle telematics and mobile apps for administration.

2.1.3 Constraints

Governance represents the main constraint around implementing TDM measures in Scotland. Currently powers over motoring taxation are reserved to the UK Government while powers relating to road user charging on local authority roads and parking is devolved to local authorities[15]. The Scottish Government only has direct control over the trunk road network, through its agency Transport Scotland. This limits the influence the Scottish Government can have on policy making and implementation in these areas. A further constraint is the timescales of net zero targets and the 20% car kilometres reduction target, meaning any proposal should be operating effectively by 2030 at the latest.

2.2 Research Objective

The problems identified were used to validate the research objective as set in the Climate Change Plan of reducing car kilometres by 20% by 2030. Figure 2-1 below shows the alignment between identified problems, the research objective and other assessment criteria.

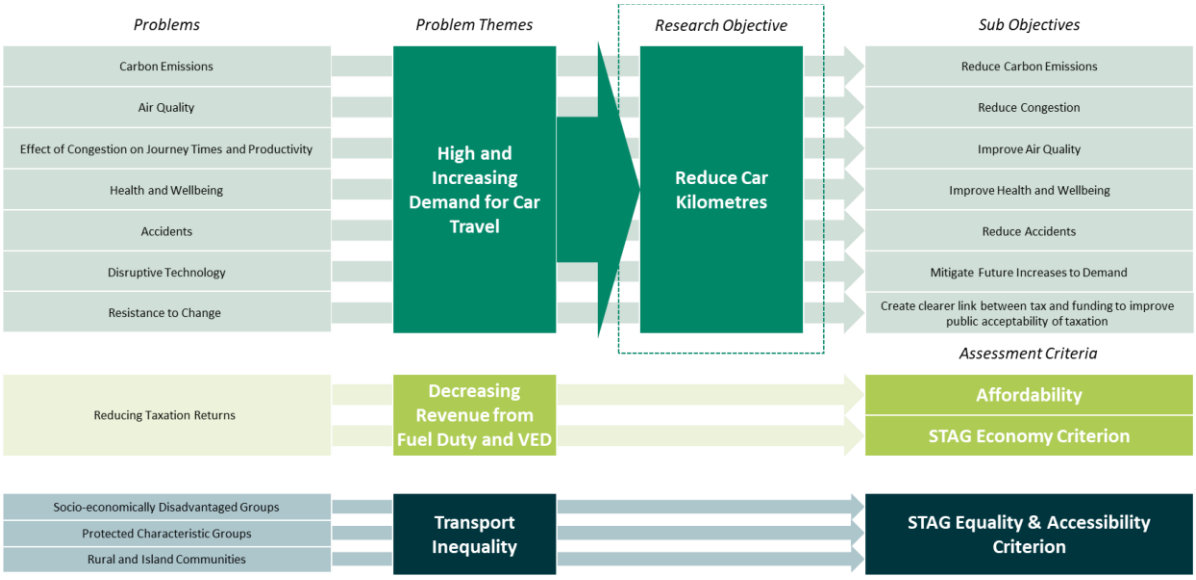

Figure 2-1: Objective Alignment with Problems

The research objective is well aligned to addressing the problem of high and increasing demand for car use and achieving the research objective will directly link to improvements in the individual problems identified, such as high carbon emissions, air pollution, congestion and accidents.

The problem themes of 'Decreasing Revenue from Fuel Duty and VED' and 'Transport Inequality', while important factors in the success of any proposed TDM measures, have not been developed into research objectives. Impacts against these problem themes will be assessed through existing STAG and Deliverability criteria and highlighted throughout the assessment as critical success factors.

Like all Transport Planning Objectives, the research objective as provided in policy documents has been strength tested through SMART principles:

- **Specific**: The objective relates to contributing towards a key government target of a 20% car use reduction compared to 2019 levels.
- **Measurable**: This metric is published annually by Transport Scotland in Chapter 5 of the Scottish Transport Statistics.
- **Achievable**: It is believed that the target, though ambitious, is achievable. Specific steps to be taken to meet the target are outlined in 'A route map to achieve a 20 per cent reduction in car kilometres by 2030'.
- **Relevant**: The objective addresses problems relating to high and increasing demand for car travel as outlined in 2.1.1.
- **Time-bound**: A 2030 date for the target to be met is linked directly to meeting the targets of the Climate Change Plan pathway to net zero by 2045.

2.3 Literature Review

The literature review has drawn on extensive range of demand management typologies to understand their potential impact on reducing vehicle kilometres and other impacts within the Scottish context. This section summarises the key findings from the literature review for each TDM typology identified.

2.3.1 Cordon and Area Based Charging

In London there has been a successful area based charge in place since 2003. This scheme was implemented by TfL, a public agency responsible for all of the city's transport network, that developed a focused business case which led to early commitment for funding and resource. The zone where the charge applies is relatively small central area of the city. The London scheme uses ANPR cameras as enforcement, which require significant capital investment to install and a large back office requirement for successful operation. It has had the following impacts:

- Reduced the volume of traffic entering the charging zone by 31%[16]. However, its impact has diminished over time, with a particular exemption for taxis resulting in more congestion and reducing bus patronage as apps such as Uber have grown[17].
- Net income of £156 million, with 51% of this spent on collection cost. Revenue is relatively small compared to the annual TfL streets budget of £725 million[18].
- Positive environmental impacts with NOX and PM10 decreasing by 18% and 22% respectively, and greenhouse gas emissions reducing by 16%[19].
- Between 40 and 70 per cent fewer accidents which resulted in personal injury within the zone[20].
- Economic benefits for businesses and freight operators as better network performance resulted in journey time reductions[21].

A cordon charge in Milan saw a 29% reduction in car trips, and when the scheme was temporarily halted a two month spike in traffic occurred[22]. The scheme also demonstrated how implementing vehicle restrictions in historic city centres can have marked benefits for pedestrian and cyclists and improve the economic vibrancy of the city centre.

In recent times, existing area-based schemes have looked towards replacing conventional ANPR enforcement systems with more technological solutions which allow more responsive and tailored charging regimes to be implemented, which incorporate distance-based charging. Brussels has begun piloting an app-based charge within the greater Brussels area, which provides real time price information and links users to multimodal alternatives[23]. Research has also been undertaken into a similar system to replace the existing network of infrastructure used to enforce the congestion zone in London[24]. Such app-based systems provide the opportunity for greater levels of feedback and integration with other initiatives such as smart ticketing and mobility as a service. This approach could also significantly reduce running costs, compared to systems solely based on ANPR enforcement.

The Transport (Scotland) Act 2001 provides local authorities discretionary power to implement local road user charging schemes, however, additional primary legislation would be required to implement a road user charge on trunk roads. Public appetite for congestion charging has, so far, only been fully tested once in Scotland, and not in the recent past. In 2005, in Edinburgh a cordon scheme was proposed, voted on in a referendum and rejected. There are many factors identified in the rejection of the Edinburgh's congestion charging plans, including perceptions of unfairness and a lack of clarity on what the revenue generated would be used for. There is evidence that public acceptance increases post implementation of a scheme – in London prior to implementation support for congestion charging was 40%, which rose to 59% post implementation[25].

Research for a scheme in Wellington, New Zealand found cordon charging targeted on trips to a Central Business District is more likely to affect higher income households relative to low income households[26]. Additionally the London area based charge includes exemptions for various vehicle types and users such as blue badge holders, vehicles with nine or more seats, electric and hydrogen fuel cell vehicles and a 90 per cent reduction for residents within the zone[27].

2.3.2 Distance Based Charging

Distance based charging, with a variable parameter for vehicle characteristics, can be an effective way to reduce air pollution. Similarly, if the charge varies with time of day, this could reduce congestion at peak times and more accurately account for the external costs of driving. Dynamic pricing can also optimise the scheme to make it more equitable[28].

In the UK distance-based charging was proposed in 2007 as a replacement to existing motoring taxes. This would have used in-vehicle telematic technology such as Global Navigation Satellite Systems (GNSS) to monitor the distance driven[29]. The majority of fleet operators in the UK now employ telematics tracking in their vehicles to track fuel efficiency, accidents and vehicle health[30]. Some vulnerabilities remain with GNSS technology which may allow the system to be bypassed. GNSS enforcement would therefore need to be supported by a secondary system, such as ANPR. Any mandated use of GNSS tracking is likely to receive significant public opposition due to privacy concerns. A survey of 3,000 people found that, even among supporters of road user charging, 48% are opposed to having a mandatory tracking device installed in vehicles[31]. Conversely, evidence used in the feasibility study for the 2007 UK nationwide scheme found 62% did not consider privacy concerns with satellite technology a major issue[32].

A voluntary approach, using an app-based system of charging is currently being trailed in Brussels and offers a test-case for how tracking of individual milage could be introduced in a way which could engender public support by incentivising alternative forms of transport[23]. Similarly, Oregon's OReGO scheme was launched in 2015 on a voluntary basis, allowing motorists to pay a per mile charge instead of fuel tax. Private sector partners provide the platform for in-vehicle devices and payment[33].

A model of a distance based charge for Greater London resulted in fewer trips from outside existing charging zones but actually increased car trips inside existing charging zones given the short nature of these trips results in the distance charge being lower than the existing area based charge[34].

Quantitative analysis of a distance based road pricing scheme for Auckland, New Zealand found lower income households, households with children, and single parent households were likely to

experience the largest financial burden, relative to income of a scheme, with the magnitude of impacts varying by location[35].

A nationwide distance based charge would need to take into account the differences in transport availability between urban and rural areas for the scheme to be equitable. A study in Serbia concluded that a universally applied TDM policy across a country with a mix of urban and rural areas would "deepen material and transport deprivation"[36]. In Ireland the Five Cities Demand Management Study did not recommend a simple per km charge because the flat rate would be unfair on rural areas where driving distances are greater and these is less availability of alternatives[37].

2.3.3 Tolls

Historically tolls have been introduced on particular infrastructure to recoup the costs of construction or contribute to the maintenance budget. Their effectiveness at reducing car kilometres can be questioned as evidence from the Mersey Tunnels in Liverpool show similar car mode shares for journeys between the Wirral and Liverpool to un-tolled journeys such as Fife to Edinburgh. (NOMIS, 2011)[38]. There is also potential for diversion and displacement of traffic to unsuitable local roads or longer distance routes to avoid the charge.

2.3.4 Parking

Using parking as a TDM measure can be done in multiple ways including traditional parking charges at destinations, workplace and retail parking levies, where businesses are charged per space they supply to their employees, or customers and residents parking permits.

Parking enforcement is controlled by many local authorities in Scotland and for some raises revenue. Edinburgh and Glasgow bring in £12.2 million and £2.7 million respectively from annual parking charges, while 71% of other local authorities in Scotland enforce parking at a loss[39].Recent polling suggests any increase in parking charges would be heavily opposed by the public[40].

Workplace Parking Levies (WPL) can be effective at encouraging behaviour change, both for employers who are more likely to relocate businesses to locations with better public and active travel links, which makes providing less parking acceptable, or employees if the charge is passed on to them. In Nottingham 80% of employers pass the charge on to employees and the levy has had the following impacts:

- 40% mode shares for public transport, with 50% of people citing the WPL as the reason for their reduced car use[41].
- Nottingham has raised revenue to fund significant public transport improvements[42].
- The city has been able to meet air quality obligations without the need for a clean air zone[43].
- Job creation in the city has occurred at a faster rate than comparable cities[44].
- £25.3 million revenue generated with 5% administration cost (much lower than comparable cordon and area based charges)[45].

A WPL is also considered a progressive measure as the majority of people on low incomes do not drive to work and benefit from improved public and active transport the WPL helps to fund[46]. Dynamic parking charges could disproportionally impact those on lower incomes as this group has less potential to retime their journeys due to less work flexibility[47].

A Retail Parking Levy was proposed in the New Future for Scotland's Town Centres review for out of town sites to encourage high street revitalisation and provide revenue for local authorities to improve public and active travel. Legislation does not currently exist to enable local authorities to implement such a scheme. Current practice of providing free parking at retail sites is highly regressive as all customers ultimately pay for the provision, while it only benefits those who drive to the sites[48].

2.3.5 Taxation

While the policy areas of road maintenance and usage is fully devolved to the Scottish Government, existing forms of motoring taxation, namely VED and Fuel Duty are reserved to Westminster. Fuel Duty, if used correctly, could be an effective TDM tool: in Beijing a moderate increase in fuel prices led to a 7% reduction in traffic volume[49]. However, in the UK levels have been frozen since 2010 and will not be compatible with the trend towards cleaner and zero emission vehicles, with evidence suggesting revenue from fuel duty could fall to near zero by 2050[50]. An alternative could be a surcharge on electricity used to charge Electric Vehicles, however this would involve significant costs of new infrastructure to detect what household electricity is being used for. Additionally this could encounter significant public acceptability issues as owners of EVs have benefited from paying no tax on their motoring, and increasing the cost of running an EV could have a negative climate impact by slowing the transition to cleaner vehicles[51].

An added complication to using existing motoring taxations as a wider TDM tool is the powers over these taxes are reserved to the UK Government and creating new taxes or surcharges in these areas may not be within the devolved competency of the Scottish Government. Additionally existing motoring taxes are perceived as among the most unfair and increasing these will be very unpopular[52].

Fuel duties are not well targeted to areas where air pollution is a particular problem, as drivers pay the same regardless of where they drive[53]. Additionally they impact low-income households more than high incomes, given low income households tend to own older and therefore more highly polluting vehicles[54].

2.3.6 Low Emission Zones

Low Emission Zones (LEZ) have experienced a high profile in recent years, given they have been introduced in four Scottish cities in May 2022, with enforcement starting in Glasgow in 2023 and the other three cities in 2024. They utilise similar technology to area based charging, as cameras are used to monitor number plates and ensure only vehicles compliant with certain emission standards are allowed within the zone. Scottish LEZs do not operate as per the typical charging LEZs elsewhere – instead of paying a low daily charge to enter, non-compliant vehicles incur a significant penalty charge notice. This should act as a deterrent and together with the LEZ Support Fund is expected to encourage modal switch.

While LEZs could be considered a ‘springboard’ towards further interventions such as cordon or area based road pricing, their efficacy as a tool for reducing the amount of car kilometres is uncertain. While compliant vehicles have no disincentive for use, owners of noncompliant vehicles are more likely to change their travel behaviour[55].

2.3.7 Road-space Rationing

Road Space rationing is a method for managing transport demand by restricting access to the road network for different users on different days. Most common is alternate day driving, where only certain cars are allowed to use the road network on certain days or times. Common examples include even-odd number plate driving days, where around half the registered vehicles in a given area are banned from the road network on alternating days. Schemes of this nature have been introduced in cities such as Mexico City, Beijing, and Paris.

However, in all these cases, road space rationing was introduced to curb air pollution problems, and sometimes only introduced temporarily while air pollution was at its most dangerous levels[56]. Additionally schemes of this nature can be very inequitable, favouring those wealthy enough to purchase two vehicles which ultimately leads to the road space taken up by vehicles increasing[57]. Furthermore, the deterrent for breaking the regulation can be low: in Paris the fine is €22, around £18 and only £8 more than the Daily London Congestion Charge.

2.3.8 Road-space reallocation

Rebalancing of urban living environments away from traffic and towards creating more healthy and liveable places can be achieved by restricting through traffic from residential areas by either physically blocking vehicles (with bollards or one-way streets) or by imposing charges, enforced via cameras. Such area-wide traffic reduction schemes are becoming commonly known as low traffic neighbourhoods (LTNs)[58]. Recent meta-analysis of motor traffic changes across 46 LTN schemes in London has demonstrated that LTNs have been successful in reducing car traffic within LTNs without evidence of displacement of congestion onto neighbouring streets[59]. Other forms of road space reallocation can include reducing traffic lane widths, removing lanes and installing cycle lanes or public transport priority measures. Evidence has shown that reducing road space for private cars can lead to overall and significant reductions in the amount of traffic[60]. A more recent approach to traffic reduction stemming from similar principles as LTNs are traffic circulation plans, which aim to segment towns and cities and prevent inter urban traffic crossing between segments, forcing them out onto the strategic road network instead. This approach has been successfully adopted in Ghent[61] and is soon to be implemented in Oxford[62]. Again, this approach could be implemented physically, using bollards and road closures, or via camera enforcement. As such, the ‘traffic circulation plan’ approach could be considered a variation of the area-based road pricing model but where the boundaries are drawn in segments rather than concentric rings.

3. Option Generation and Preliminary Appraisal

This chapter summarises initial list of options generated, the initial sift of these options, and the preliminary appraisal of the options identified. The early qualitative appraisal of high-level options was undertaken, providing an initial indication of performance against criteria, and identifying design considerations and areas where mitigation may be required to inform further option development and packaging.

3.1 Option Long List

Options have been generated based on the suite of examples examined within the literature review. These examples were further discussed and consolidated into a list of options which constitute all reasonable theoretical instruments which could be applied to address the central research question.

The overarching options are:

- **Cordon-based charging:** Any charge imposed for entering a pre-defined area by passing over a cordon, typically a ring around a particular area, route, or corridor. This could include any charge for using specific roads, such as the trunk-road network or structures, such as bridges. As such, cordon-based schemes could be imposed on longer distances, via cordons placed at access points to the trunk road network or specific pieces of road infrastructure, or to specific areas, via cordons at access points to those areas.
- **Area-based charging:** Any charge imposed for moving within a pre-defined area, captured by ANPR, and charged per day. Most congestion charge models would be considered under this option. Area based charging is suited to local schemes in and around a specific urban centre. LEZs are an example of a type of area charge which is already in use in Scotland.
- **Parking Charges:** This option includes consideration of any change to the cost of parking via either public parking charges, workplace or out-of-town parking levies, or residents permits.
- **Vehicle Levy:** A charge which applies to the ownership of a vehicle enabling targeting of different vehicle types or sizes.
- **Fuel Levy:** Charges which apply to the consumption of fuel or energy enabling targeting of consumption which is linked to vehicle use.
- **Levies on Consumables:** Adding a charge to environmentally damaging car consumables, such as tyres and brake pads could reduce demand and promote more conservative driving behaviour. Such a measure could also incentivise companies to make improvements to tyre and brake pad durability.
- **Distance based charging:** A charge which can be imposed according to any length of journey on any part of the road network. A more innovative or theoretical model of national road user charging which enable specific journeys to be charged at individual rates would fall under this option.
- **Time-based charging:** This option considers any charge based on the time spent travelling, rather than the length or location of the journey.
- **Vignettes:** Permits to use a particular road or road network for a given period, ranging from a week to a year.
- **Road-space reallocation:** Road-space reallocation encompasses any option which specifically seeks to manage car demand by removing road capacity.

- **Road-space rationing:** Any option which limits the number of vehicles allowed to use the road during certain times, either by an arbitrary allocation or on dedicated 'car free days'.
- **Development planning:** This option would be implemented though review of local development planning standards to reduce or eliminate parking provision from urban centres.

3.2 Consolidation and Sifting

Options considered within the literature review which do not appear in the list of options generated above, have been judged to be complementary measures rather than stand-alone TDM interventions. These interventions will be considered during Option Development, which will include packaging of options in order to mitigate negative impacts identified within the appraisal. These include:

- Vehicle occupancy charging and priority.
- Behaviour change programmes.
- Incentives.

Five of the options generated have been sifted out prior to the appraisal as they are judged to be an inappropriate way of achieving the intended objective and addressing the identified transport problems directly. These are:

- **Levies on consumables:** This option could be of significant benefit to reducing the overall environmental impact of consumables such as tyres and brake pads while providing a consistent revenue stream. However, as these consumables are an infrequent purchase, the cost of the levy would need to be set at such a level as to be unacceptable to the public in order to contribute significantly to the reduction in car kilometres. In addition, the measure could potentially lead to people driving with tyres and brake pads in worn and unsafe condition.
- **Time-based charging:** This option has been sifted out due to the likelihood that it would incentivise unsafe road user behaviour, principally, the risk of speeding.
- **Vignettes:** The use of vignettes is being phased out across many countries which had previously used them in favour of distance-based charging, as vignettes do not reflect actual road use and are highly regressive in the way the charge is distributed.
- **Road-space reallocation:** Road-space reallocation takes place as a consequence of the ongoing process of re-balancing transport infrastructure away from private vehicles and towards more sustainable and inclusive modes, via introduction of bus lanes, wider pavements, trams and cycleways in line with the sustainable investment hierarchy. However, road-space reallocation is rarely implemented in isolation as a specific means of transport demand management and should be considered as complementary to any TDM measure. It is considered that the suite of public and active travel projects recommended within STPR2 would encompass some element of road-space reallocation and help provide this mitigation.
- **Road-space rationing:** Road-space rationing has been introduced in certain locations, such as Mexico City, as an emergency measure, in response to dangerous levels of air pollution. As such it is not considered to be a long term and sustainable way of managing demand.
- **Development planning:** Development planning must encompass a range of considerations specific to the needs of the local area, housing type, and community need. It is likely that local authorities will review their housing requirements and parking standards in line with the guidance set out in NPF4. However, demand reduction as a result of changes in development planning, such as reduction in parking provision, would be a long term effect and is unlikely to directly address the objective of reducing car use in the timeframe required.

3.3 Preliminary Appraisal

Each option was assessed qualitatively against the following appraisal criteria:

- Research Objective
  - Reduce Car Kilometres by 20% by 2030
- Deliverability
  - Feasibility
  - Affordability
  - Public Acceptability
- STAG Criteria
  - Environment
  - Climate Change
  - Health, Safety and Wellbeing
  - Economy
  - Equality and Accessibility
- Policy Alignment
  The appraisal will also consider the option's performance in the Sustainable Investment Hierarchy

Assessment against the research objective, STAG criteria and policy alignment was assessed against a seven point scale. For the deliverability criteria, a risk-based assessment approach was used. The assessment scales were defined as follows:

Seven-point Scale	
Major Positive	+++
Moderate Positive	++
Minor Positive	+
Neutral	0
Minor Negative	-
Moderate Negative	--
Major Negative	---

Deliverability Risk Scale
High
Medium
Low

Table 3-1 overleaf sets out the summary of the assessment, and Table 3-2 shows the decision and rationale for each option, alongside design considerations and proposed mitigation and packaging where applicable.

Table 3-1: Preliminary Appraisal Summary

	Research Objective	Implementability (Risk)			STAG Criteria					Policy Alignment	Position in Sustainable Investment Hierarchy
	Reduce Car km by 20% by 2030	Feasibility	Affordability	Public Acceptability	Environment	Climate Change	Health, Safety & Wellbeing	Economy	Equality & Accessibility		
Cordon Charging	+	Medium	Medium	High	++	+	+	+	-	++	Makes better use of existing capacity
Area Charging	+	Medium	Medium	High	+++	+	+	+	-	++	Makes better use of existing capacity
Parking Charges	0	Low	Medium	Medium	+	+	0	-	-	++	Makes better use of existing capacity
Vehicle Levies	+	High	Low	Medium	+	+	+	+	--	++	Makes better use of existing capacity
Fuel Levies	++	High	High	Medium	+	+	0	+	-	++	Makes better use of existing capacity
Distance Charging	+++	Medium	Medium	Medium	+	++	+	+	0	++	Makes better use of existing capacity

Table 3-2: Preliminary Appraisal Decision, Rationale, Design Considerations, Mitigation and Packaging

	Decision	Rationale	Design Considerations	Mitigation and Packaging
Cordon Charging	**Retain**	• Targets most congested areas; maximising efficiency, reducing accident risk and improving air quality • Targets short distance trips which are easier to shift and more likely to shift to active modes with health benefits	• Best suited to urban areas • Equality and accessibility risks due to affordability • Public acceptability risks amongst residents • Feasibility / affordability risks with ANPR procurement / installation	• Targets high concentration, short distance urban trips but could be combined with other options to increase effectiveness • Discounts or exemptions to mitigate affordability / acceptability risks
Area Charging	**Retain**	• Targets most congested areas; maximising efficiency, reducing accident risk and improving air quality • Targets short distance trips which are easier to shift and more likely to shift to active modes with health benefits	• Best suited to urban areas • Equality and accessibility risks due to affordability • Public acceptability risks amongst residents • Feasibility / affordability risks with ANPR procurement / installation	• Targets high concentration, short distance urban trips but could be combined with other options to increase effectiveness • Discounts or exemptions to mitigate affordability / acceptability risks
Parking Charges	**Retain as a complementary measure**	• Mitigates boundary effects of area or cordon charging	• Most effective where there isn't cheap alternative parking • Effectiveness dependent on charge type / enforcement • Equality and accessibility risks due to affordability • Public acceptability risks amongst residents / businesses • Affordability risks due to enforcement costs	• Effective in urban areas and key destinations but could be combined with other options to increase effectiveness • Discounts or exemptions to mitigate affordability / acceptability risks
Vehicle Levies	**Do not retain**	• Disincentivises vehicle ownership but unlikely to be feasible in required timeframe due to political and constitutional issues	• Most effective in locations with good alternatives to car • No disincentive to travelling long distances once yearly charge has been paid • Equality and accessibility risks due to affordability • Public acceptability risks would be lower for a hypothecated charge reinvested in transport improvements than for a tax • Feasibility risks for both a tax, which would require further devolution, and a charge, which would require new primary legislation.	• N/A
Fuel Levies	**Do not retain**	• Disincentivises fuel consumption which is linked to distance travelled but unlikely to be feasible in required timeframe due to political and constitutional issues and feasibility risks in adapting to EV charging	• Disincentivises fuel consumption which is directly linked to carbon emissions • Equality and accessibility risks due to affordability, particularly rural areas with fewer alternatives and typically longer travel distances • Feasibility and affordability risks, with uncertainty around how electricity used for vehicle fuel could be differentiated and the potential implementation costs	• N/A
Distance Charging	**Retain**	• Disincentivises distance travelled, linking directly to research objective • Could be implemented on a local or national level and monitored / tailored to meet the needs of urban and rural communities equitably and to target specific journey.	• Requirement to measure / estimate milage which could be done using in-car telematics or regular milage submissions via an online portal. • Feasibility risks with universal adoption of on-board devices and installation of a backup and checking system	• Targets longer journeys but could be done in combination with other options to increase effectiveness • Discounts or exemptions to mitigate affordability / acceptability risks

4. Option Development and Packaging

This chapter summarises the option development and packaging and additional sift that has been undertaken based upon the preliminary appraisal and results of a stakeholder workshop to identify any further unintended consequences

4.1 Unintended Consequences

During the preliminary appraisal process, a workshop was undertaken to build upon the understanding of possible impacts of any potential TDM options in terms of:

- Communities of place (urban/rural, remote, island).
- Communities of interest (protected characteristics, socioeconomic disadvantage).
- Impacts on business and the wider economy.
- Intersectionality – a concentration of impacts based on convergence of multiple social and environmental determinants.
- Public Acceptability.
- Environmental impacts.

A variety of Scottish Government and external stakeholders representing the interests of local government, taxation, health, accessibility, freight and logistics, a just transition, public transport and the low carbon economy attended the session. Key questions asked during the workshop were:

- **Who?** Identify populations which may be affected by implementation of the option.
- **What?** Identify potential impacts which may unintentionally result from the measure.
- **How?** Establish the causal link between the two.
- Can positive impacts be maximised and negative impacts mitigated?

For the purposes of the workshop, the options retained from preliminary appraisal were placed into two broad categories:

- Geographically Defined Options: Cordon and Area Based Charges.
- Nationwide Options: Distance Charging.

The findings from the workshop are presented in Figure 4-1.

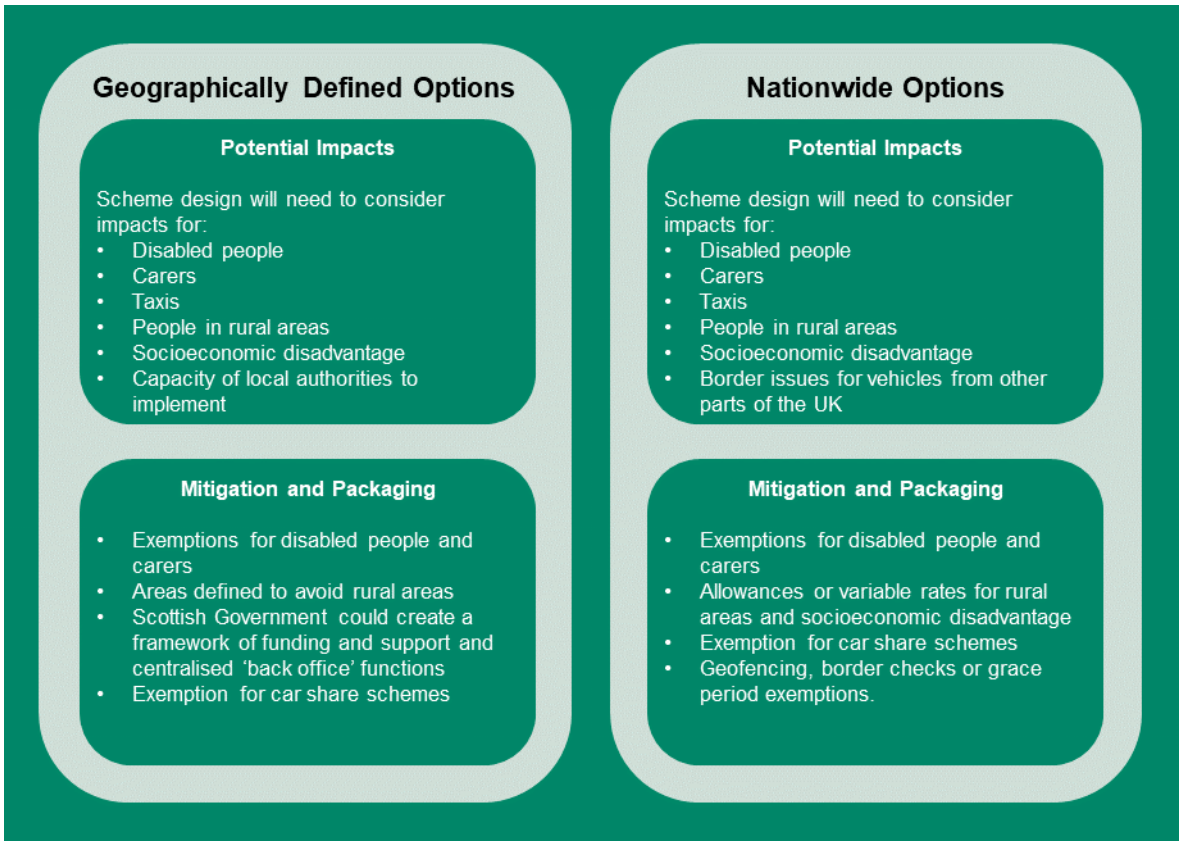

Figure 4-1: Findings from Unintended Consequences Workshop

4.2 Option Refinement and Definition

The options taken forward from Preliminary Appraisal were further refined in line with the findings of the unintended consequences workshop. For each option, suitable mitigations for identified unintended consequences were applied as iterative sensitivity tests to refine the option. Where significant residual impacts persisted after mitigation, the option was sifted out. Wider complementary measures, such as recommendations from STPR2, were not explicitly considered. Figure 4-2 below sets out this iterative process.

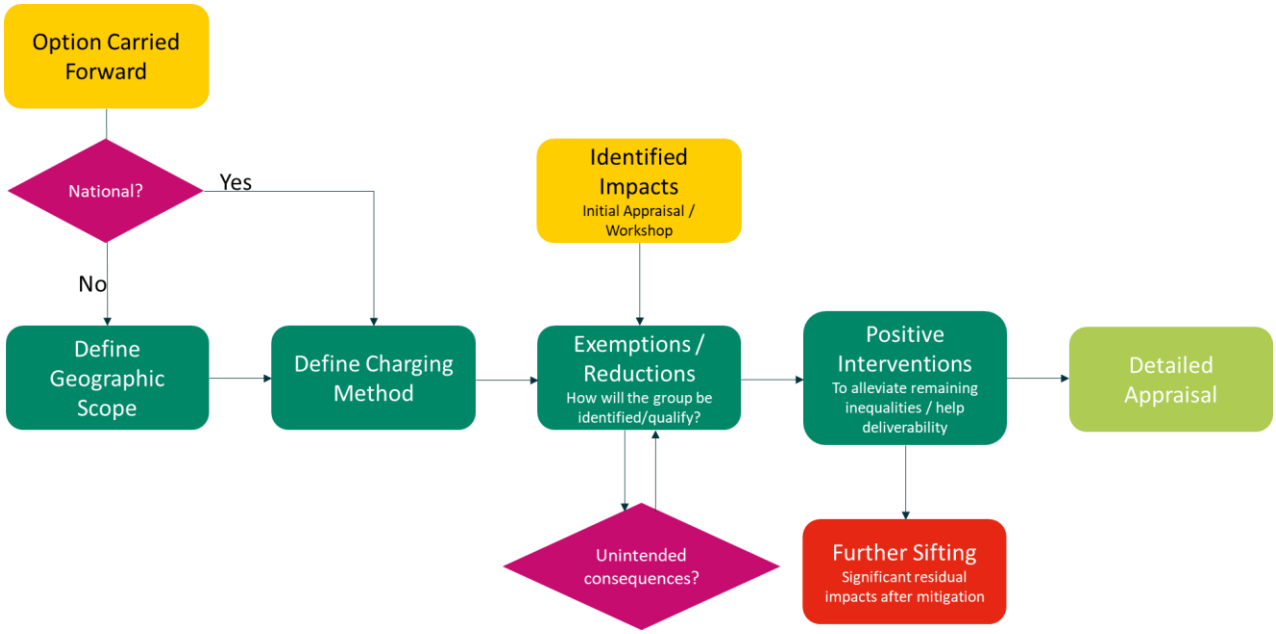

Figure 4-2: Option Development Process

4.3 Packaging

A number of options were considered for taking forward to detailed appraisal. They consist of the two Geographically Defined Options (Cordon and Area) and five possible options for implementing distance charging. The possible options for distance charging, and rationale for an additional sift are shown in Table 4-1 below.

Table 4-1: Distance Based Charging Options

Option	Description	Sifting Rationale
Flat Rate, No Allowance	Fixed flat rate per kilometre	Sift out – Inequitable – significant disadvantage to rural poor populations
Flat Rate, Fixed Allowance	Fixed allowance of free kilometres per vehicle, Fixed flat rate per kilometre above allowance	Sift out – Inequitable - significant disadvantage to rural poor populations
Flat Rate, Variable Allowance	Variable allowance of free kilometres per vehicle, determined by owner's/registered keeper's income and geographical location, Fixed flat rate per kilometre above allowance	Retain
Flat Rate, Individual Allowance	Variable allowance of free kilometres per individual, determined by income and geographical location, Fixed flat rate per kilometre above allowance	Sift out – Undeliverable – administrative burden of charging/applying allowance to a person as opposed to a vehicle.
Geographically Variable Rate	Variable rate applied based on vehicle owner/registered keeper characteristics and time/location of journey.	Retain

4.4 Options Taken Forward

The options identified for detailed appraisal are outline below under two broad categories:

- Those which would be applied on a local basis, over a geographically defined area and implemented by local authorities.
- Those that would be applied on a national basis and implemented by the Scottish Government.

The two broad approaches are not mutually exclusive and could be run concurrently but administered separately. However, employing both approaches could lead to drivers being charged twice, unless a more technological approach were employed which ensured interoperability. An overview of the potential for each option to reduce car kilometres, reduce greenhouse gas (GHG) emission and generate revenue is presented in Table 5-1 in section 5.

The option descriptions that follow are presented under the following headings:

- Option as modelled – describing the option explicitly represented by the model outputs, including specific assumptions in regard to the discounts and exemptions to the charging scheme.
- Additional considerations – describing the measures that are considered essential to delivering a scheme in practical terms.

In order to maintain consistency with the car kilometre reduction target and route map, all options have been appraised in kilometre units. However, in practical terms, it is recognised that these units would need to be quoted in miles for any scheme that is taken forward.

4.4.1 Cordon-Based

Option as modelled: A charge applied per day for crossing a boundary into or out of large urban areas as defined by the Scottish Government 6-fold Classification including Glasgow, the upper Clyde Valley, Edinburgh, Aberdeen and Dundee, as shown in Figure 4-3. As current legislation precludes local schemes from being applied to trunk roads, these have been excluded from the zone, with off-slips modelled as a zone entry. A discounted rate applies to those in the lowest 20% income group within "remote rural" areas only. An exemption would also be applied for people with a disability affecting their mobility, as indicated by membership of the blue badge scheme. This assessment has assumed a proportion of exemptions based on the number of blue badge holders in the population and has applied this to the trip making characteristics of those answering ‘yes’ to the question: Does your condition or illness reduce your ability to carry-out day-to-day activities? in the Scottish Household Survey.

Additional considerations: To ensure that possible boundary effects are avoided, the option would be likely to require accompanying parking charges at boundaries. The time of day that charging would apply could also mitigate against negative effects potentially encountered by shift workers. Car share schemes would be exempt and could provide access to a car for those in socioeconomically disadvantaged areas. Cordon-based schemes, such as those already implemented in greater London, are typically enforced and operated by Local Authorities, using existing powers and likely implemented by ANPR technology. Existing legislation states net proceeds should be used to support objectives of the local transport plan

4.4.2 Area-Based

Option as modelled: A daily charge applied for driving into or within large urban areas as defined in Figure 4-3 and including Glasgow, the upper Clyde Valley, Edinburgh, Aberdeen and Dundee. As current legislation precludes local schemes from applying to trunk roads, these have been excluded from the zone, with off-slips modelled as a zone entry. A discounted rate would be applied to of the lowest income group within "remote rural" areas only. An exemption would be applied for people with a disability affecting their mobility, as indicated by membership of the blue badge scheme**Error! Bookmark not defined.**.

Additional considerations: To ensure that possible boundary effects are avoided, the option would be likely to require accompanying parking charges at boundaries. The time of day that charging would apply could also mitigate against negative effects potentially encountered by shift workers. Car share schemes would be exempt and could provide access to a car for those in socioeconomically disadvantaged areas. Existing legislation states net proceeds should be used to support objectives of the local transport plan

4.4.3 Distance (Geographically Variable Rate)

Option as modelled: A rate applied per kilometre travelled which is discounted for those in the lowest income group and living within “remote rural” areas only – as shown in Figure 4-3. An exemption would be applied for people with a disability affecting their mobility, as indicated by membership of the blue badge scheme**Error! Bookmark not defined.**.

Additional considerations: The option would be accompanied by geofencing or a grace period exemption for vehicles from out with Scotland. Second cars could incur a higher rate and there would be potential for vehicle allowances to be traded. The use of GNSS technology could allow for the rate to vary by vehicle location and time of journey. Allowances or lower rates could also be applied to car share schemes in order to provide greater access to those on lower incomes. Revenues generated from a national distance-based scheme could be hypothecated to national transport portfolios, such as those set out in the Strategic Transport Projects Review 2 (STPR2), and in line with the sustainable investment hierarchy.

4.4.4 Distance (Flat Rate, Variable Allowance)

Option as modelled: The indicative car kilometre and carbon emission reduction, and revenue raising potential, has been modelled using the same assumptions as the Distance (Geographically Variable Rate) option. This variation of distance-based charging is implemented as a relatively high fixed rate applied per kilometre travelled nationwide with a variable yearly free allowance of kilometres defined by income group and geographical location. A greater allowance would be applied to the lowest income group within "remote rural" areas only – as shown in Figure 4-3. An exemption would be applied for people with a disability affecting their mobility, as indicated by membership of the blue badge scheme**Error! Bookmark not defined.**.

Additional considerations: The option would be accompanied by geofencing or a grace period exemption for vehicles from outwith Scotland. Allowances would not be provided for second cars and there would be potential for vehicle allowances to be traded. Additional allowances could also be applied to car share schemes in order to provide greater access to those on lower incomes. Revenues generated from a national distance-based scheme could be hypothecated to national transport portfolios, such as those set out in the Strategic Transport Projects Review 2 (STPR2), and in line with the sustainable investment hierarchy.

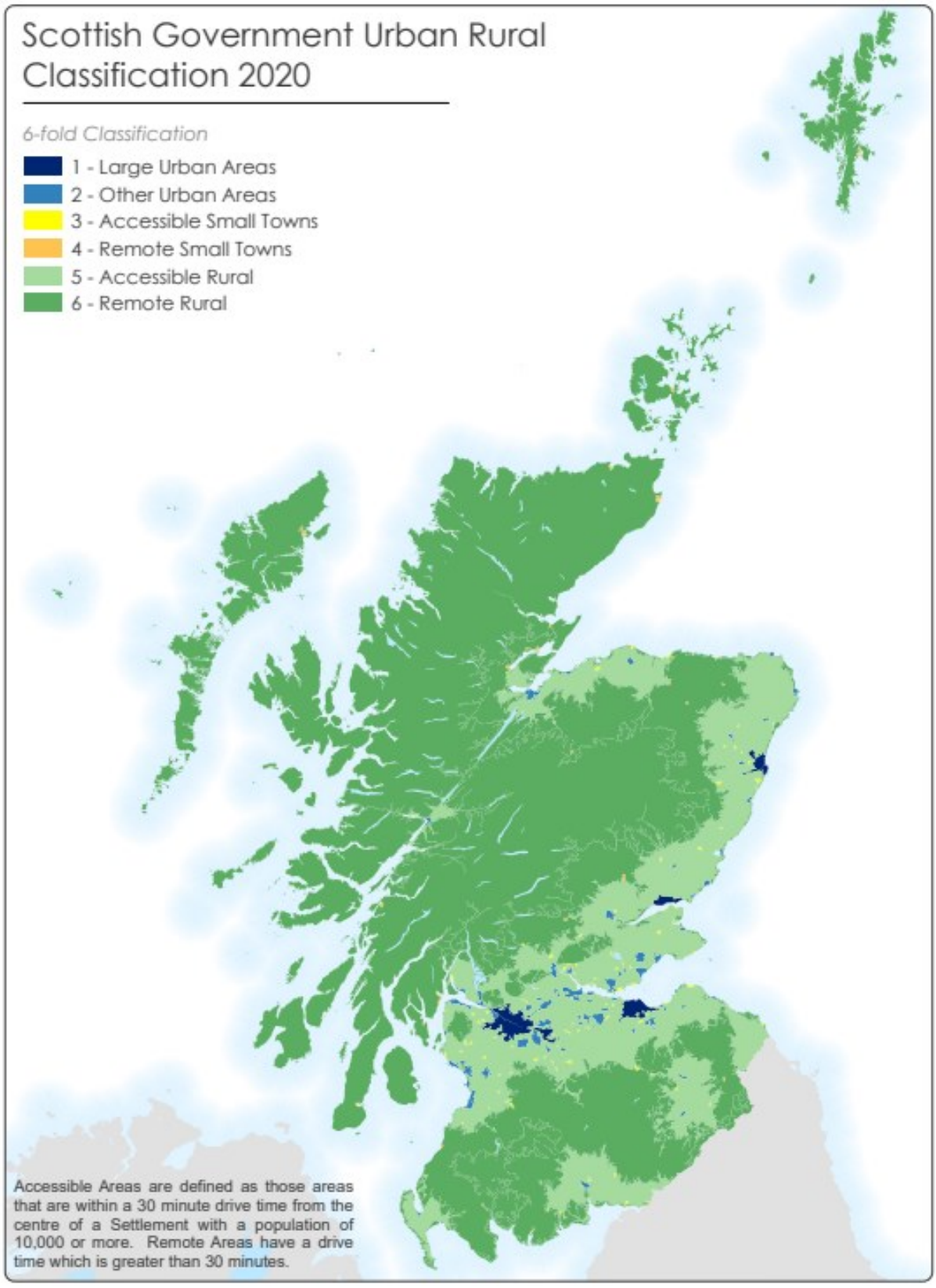

Figure 4-3: Scottish Government 6-Fold Urban Rural Classification 2020

5. Summary of Appraisal

This chapter summarises the Detailed Appraisal, which quantitively and qualitatively assessed the four shortlisted options for a range of example charge levels, as set out in Section 4.4 against the research objective, deliverability criteria, STAG criteria, Policy Alignment and Sustainable Investment Hierarchy.

The vehicle and emissions reduction estimates forecast are given as a percentage change against a given future situation without charging, rather than as a percentage change from 2019 (as expressed in the wording of the 20% reduction target). This allows the appraisal to focus on the impact of charging only, rather than the other external factors that may also influence trip making (including electric vehicle adoption rates, home-working patterns, land use or changes in technology)

The appraisal process marshals all the available evidence, including the modelled outputs, in order to produce a balanced comparison of the different potential charging options.

5.1 Option Overview

An overview of the quantitative performance of each option against three key criteria points is summarised in Table 5-1 below:

Table 5-1: Options Overview

Charge type	Charge (per day for Area & Cordon, per km for Distance)	2030 Car km reduction (compared with 2030 without charging)	Car emissions reduction (CO_2e) in 2030 (compared with no charge scenario)	2030 Revenue (in 2022 Q3 prices)
Cordon	£15, £7.50 (discounted)	-16%	-17%	£915m
Cordon	£10, £5 (discounted)	-12%	-13%	£775m
Cordon	£5, £2.50 (discounted)	-7%	-7%	£550m
Area	£15, £7.50 (discounted)	-25%	-26%	£1,300m
Area	£10, £5 (discounted)	-21%	-22%	£1,100m
Area	£5, £2.50 (discounted)	-14%	-15%	£800m
Distance	10p, 5p (discounted)	-26%	-27%	£2,300m
Distance	6.5p, 3.3p (discounted)	-17%	-17%	£1,700m
Distance	3p, 1.5p (discounted)	-8%	-8%	£875m

Note: discounted rate applied only to the lowest income group living within "remote rural" areas within the 6-fold urban/rural classification.

5.2 Option Appraisal Summaries

5.2.1 Cordon Based Charging

Research Objective	Implementability (Risk)			STAG Criteria					Policy Alignment	Position in Sustainable Investment Hierarchy
Reduce Car km by 20% by 2030	Feasibility	Affordability	Public Acceptability	Environment	Climate Change	Health, Safety & Wellbeing	Economy	Equality & Accessibility		
+	Medium Risk	Medium Risk	High Risk	++	+	+	+	-	++	Makes better use of existing capacity

Cordon-based charging has the potential to reduce car kilometres at a local level. It can be used to target congested areas and re-enforce the roads hierarchy, with positive implications for environment, climate change, health and wellbeing and economy.

For feasibility and affordability reasons cordon charging would be most effective as discrete schemes in congested areas in large town/city centres.

The cost of implementing local road pricing in all Scotland's Large Urban Areas is estimated between £100 million and £500 million. Cordon charging should be towards the lower end of this estimate given the quantity of ANPR cameras required is less than area-based charging, as only the boundary require enforcement infrastructure. Operating costs for each of the four charging zones is expected to be between 20% and 50% of revenue generated.

Cordon based charging has greater impacts on those living outside the cordon given the potential for diversion effects and equity issues on the cordon boundary, whilst having little impact on those living and travelling solely within the cordon, so can be unfair. This may have implications for public acceptability and depending on the specific geographical characteristics of the area could increase or reduce inequalities.

Detailed appraisal available in section 7.2, in the Supplementary Information.

5.2.2 Area Based Charging

Research Objective	Implementability (Risk)			STAG Criteria					Policy Alignment	Position in Sustainable Investment Hierarchy
Reduce Car km by 20% by 2030	Feasibility	Affordability	Public Acceptability	Environment	Climate Change	Health, Safety & Wellbeing	Economy	Equality & Accessibility		
+	Medium Risk	Medium Risk	Medium Risk	+++	+++	+	+	0	++	Makes better use of existing capacity

Area based charging has the potential to reduce car kilometres at a local level. It can be used to target congested areas, with positive implications for environment, climate change health and wellbeing and economy.

Area charging is likely to be implemented in large urban areas with good active travel and public transport connectivity (IPPR, 2022[40]). However, people who live within the area may perceive the charging structure as unfair, since they would have to pay the charge every time they travelled by car. This could be mitigated through discounts or exemptions; however, this would reduce the effectiveness of the scheme and may also be perceived as unfair by those who live just outside the area and regularly travel within the area to access work, education and services.

The cost of implementing local road pricing in all Scotland's Large Urban Areas is estimated between £100 and £500 million. Area charging should be towards the upper end of this estimate given the quantity of ANPR cameras required is greater than cordon-based charging, as all parts of the charging area require enforcement infrastructure. Operating costs for each charging zone is expected to be between 20% and 50% of revenue generated.

For feasibility and affordability reasons area charging would be most effective as discrete schemes in congested areas in large town/city centres. More sophisticated and cost-efficient methods of local charging could be implemented if supported by national government. However, at present, it is unlikely that all large urban areas would be in a position to implement area-based charging in the timeframe necessary to achieve the required reduction. The Edinburgh City Council Draft Mobility Plan and Draft Glasgow City Council Transport Strategy both indicate a commitment to a 30% reduction in car kilometres and so area charges in these two locations could be considered as more likely. The potential for national scale car reduction and revenue generation of area-based charging in Edinburgh and Glasgow alone, based on the geographical extents shown in Figure 5-1, are indicated in Table 5-2 below.

Table 5-2: Forecast Effectiveness of Area-based Charging in Edinburgh and Glasgow

Charge for driving within Glasgow LA and Edinburgh UR6 Large Urban Charge Zone (per day, 2022 Q3 prices)	2030 Car km reduction (compared with 2030 without charging)	Car emissions reduction (CO^2e in 2030 (compared with no charge scenario)	2030 Revenue (in 2022 Q3 prices)
£15, £7.50 (discounted)	-16%	-17%	£800m
£10, £5 (discounted)	-13%	-14%	£700m
£5, £2.50 (discounted)	-9%	-10%	£500m

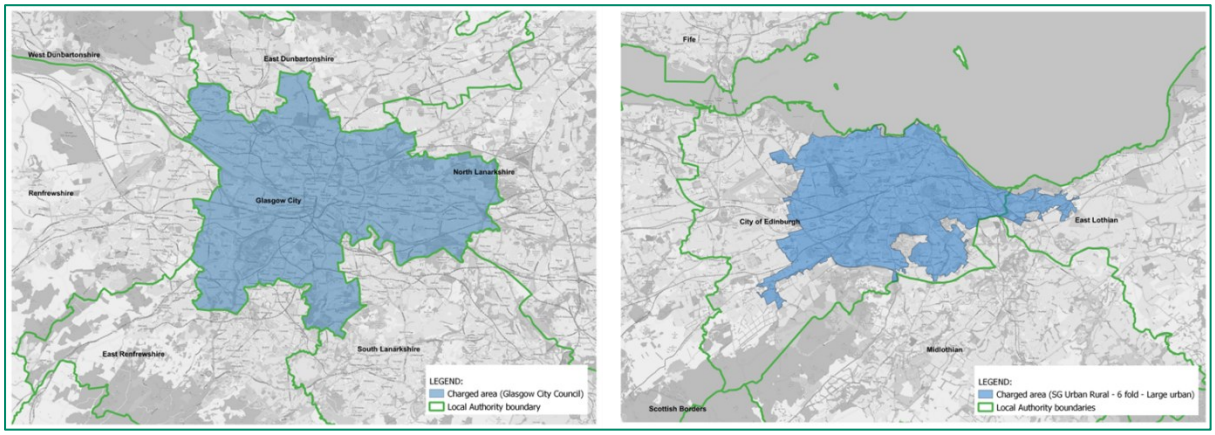

Figure 5-1; Extents of Potential Edinburgh and Glasgow Charged Areas

To produce a reduction of national significance, on the scale shown in Table 5-2, by concentrating on the two areas outlined in Figure 5-1, a disproportionate burden would be placed on Edinburgh and Glasgow. The nationally significant reduction would translate to a much steeper reduction locally and both cities would have to greatly exceed their own stated targets. For this reason, this is not seen as an equitable option.

Though discretionary powers to implement local charging schemes are provided to local authorities under Transport (Scotland) Act 2001), regulations would need to be put in place to make them enforceable. This would be likely to take up to 18-24 months, with a further estimated 12-24 months

for local authority implementation. Earliest enforcement by local authorities would therefore be around 2026.

Detailed appraisal available in section 7.3 in the Supplementary Information.

5.2.3 Distance Based Charging (Variable Rate)

Research Objective	Implementability (Risk)			STAG Criteria					Policy Alignment	Position in Sustainable Investment Hierarchy
Reduce Car km by 20% by 2030	Feasibility	Affordability	Public Acceptability	Environment	Climate Change	Health, Safety & Wellbeing	Economy	Equality & Accessibility		
+++	Medium Risk	Medium Risk	Medium Risk	+	+++	+	+	0	++	Makes better use of existing capacity

Distance-based charging has the potential to apply specific charges to use of the road network, directly related to usage. Distance based charging could be tailored to meet the needs of urban and rural communities by varying the rate of charge applied for people living in different locations. It is therefore highly likely to be able to meet the objective of reducing car kilometres, in a targeted and equitable way.

In the long-term, a more tailored variable charge which can be altered according to time of day would require the use of in-car telematics of the type currently implemented within fleet tracking, which records information about driver location, time of travel as well as distance. Test cases exist to suggest that voluntary, incentive-based approaches to introducing telematic tracking could attract greater public support than mandatory systems. For this appraisal, the measure has been designed with lower rates for those classed within the lowest 20% income group and living in a remote rural area and exemptions apply for drivers who have a disability which affects their mobility.

A comparable national scheme for the Netherlands is estimated to have a set up cost of €2.2bn and annual running costs of 250-900m euros. However, implementation costs of a national, distance-based scheme are highly dependent on the way in which it is implemented.

Significant legal work would be required to consider whether any proposals for national pricing are capable of being enacted within the Scottish Parliament's legislative competence. If primary legislation is progressed, then the earliest enforcement would likely be in 2029.

Detailed appraisal available in section 7.4 in the Supplementary Information.

5.2.4 Distance Based Charging (Flat Rate, Variable Allowance)

Research Objective	Implementability (Risk)			STAG Criteria					Policy Alignment	Position in Sustainable Investment Hierarchy
Reduce Car km by 20% by 2030	Feasibility	Affordability	Public Acceptability	Environment	Climate Change	Health, Safety & Wellbeing	Economy	Equality & Accessibility		
++	Medium Risk	Medium Risk	Medium Risk	+	++	+	+	-	++	Makes better use of existing capacity

An alternative means of delivery for distance-based charging is a set mileage allowance with a comparatively high rate for any kilometres over a set allowance. Greater allowances would be applied to lower income groups in rural areas in order to mitigate against the potential inequities imposed by higher costs of driving in the absence of alternatives. Distance-based charging with variable allowances could target those who make the largest contribution to the overall car kilometres travelled but this effect may also be offset by people feeling incentivised to use up any unused kilometres from their allowance. Distance-based charging implemented in this way is likely to be potentially more equitable and more publicly acceptable, but also less effective in reducing car kilometres than the application of a variable rate (as described above).

Modelling outputs have not been produced for this option explicitly, as it would be a variation of the distance-based, variable rate figures shown in Table 5-1 and the scale of impacts would be comparable, but lesser depending on the level of free allowance applied.

As with the variable rate option, this option could be implemented either by the use of in-car telematics of the type currently available within fleet tracking, or by regular mileage submissions (similar to meter readings for gas/electricity) paid for on regular basis and verified annually at MOT. Voluntary approaches to telematic tracking could prove more publicly acceptable than mandatory schemes. The close feedback required of any distance-based charging scheme would enable it to be targeted towards specific journeys and could be adjusted for different geographies and user groups depending on the design of the charge.

A comparable national scheme for the Netherlands is estimated to have a set up cost of €2.2bn and annual running costs of 250-900m euros. However, implementation costs of a national, distance-based scheme are highly dependent on the way in which it is implemented.

This option has been designed with an increased ‘free’ mileage allowance for those classed within the lowest 20% income group and living in a remote rural area. Drivers who have a disability which affects their mobility would be exempted from the scheme. The allowance would be applied on the vehicle itself, based on the status of the registered keeper rather than an individual given the administrative burden of differentiating between drivers. The allowance would be in the form of a yearly amount of free miles each vehicle is prescribed. Engine size/emissions could also be used to vary the flat rate charge to help encourage a shift to cleaner vehicles.

Detailed appraisal available in section 7.5 of the Supplementary Information.

6. Conclusion and Recommendations

This report has demonstrated the range of options available for TDM measures in Scotland which can contribute towards government targets of reducing vehicle kilometres by 20%. From this assessment it is likely that either locally or nationally implemented TDM schemes could achieve the 20% car kilometre reduction target in an equitable manner.

Drawing on a range of national and international examples of TDM schemes and academic research, a list of options was generated and assessed qualitatively against assessment criteria before considering unintended consequences and adversely affected groups, and what appropriate mitigations could be packaged into the options.

The four assessed options all have broadly similar performance against the STAG criteria, with positive impacts on Environment, Climate Change, Health, Safety and Wellbeing, and Economy and only negative impacts against Equality and Accessibility, though the magnitude of these impacts has been mitigated through exemptions and discounts for particularly affected groups. Additionally all options are broadly considered deliverable, as none use novel technology and are forecasted to raise enough revenue to cover their operating costs and provide funding for local or national transport priorities.

The remainder of this chapter sets out some further considerations for the next stages of detailed design of the chosen TDM measure.

6.1 Deliverability Considerations

There are a number of further deliverability considerations which would need to be addressed in order to design any deliverable TDM scheme based on the above options. These include:

- **Vehicle types** – the charging options proposed in this report apply to private vehicles as the economic responses of freight/business vehicles as a result of road user charging will differ significantly and so is subject to a separate assessment.
- **Charging zone boundaries** - As per the Transport (Scotland) Act 2001, the boundaries of local charging schemes would require to be set by each local authority. For these to reflect the modelled results presented here, each charged area would need to be ambitious and extensive, covering large parts of urban Edinburgh, Glasgow region, Aberdeen and Dundee.
- **Further definition of variable rates** – Depending on the technological path taken, adjustments to variable rates according to time, location of journey and vehicle type can be made in order to maximise the effectiveness and fairness of the charge.
- **National border considerations** – around 30,000 vehicles cross the border from England into Scotland each day and while a grace period per vehicle has been assumed, consideration will be required for how regular commuters between Scotland and England are charged and how miles travelled in the two countries are disaggregated
- **UK Wide Developments** – A 2022 report by the House of Commons recommends the UK Government looks at implementing an alternative road charging mechanism to combat the identified problem of falling fuel duty revenue. Uncertainties remain about how national pricing could interact with future UKG fuel duty successor tax, but national pricing presents an opportunity to price in the costs of Transport in a fairer way, designed in line with Scotland's geographic and population dispersal.

6.2 Framework for Implementation

Whether local or national options are taken forward, both options will require a framework to ensure their effective implementation, and will be particularly important if local authorities decide, utilising their existing powers under the Transport (Scotland) Act 2001, to implement a local charging scheme in advance of, or in addition to, a national scheme.

Therefore, a key recommendation of this work is to establish a Framework of Implementation for TDM measures in Scotland. This will ensure interoperability between different local schemes or local and national schemes. This could include the adoption of common legal, organisational, contractual, commercial, procedural and technical standards for the delivery of the service. In practice this could include shared 'back office' functions including enforcement equipment and monitoring, and support for local authorities as these measures are implemented to help meet a nationally set target.

The benefits of creating a national Framework for Implementation include:

- Implementation costs are reduced as different schemes share the same infrastructure/customer facing platform.
- Local Authorities are empowered to implement local schemes with the political backing of Scottish Government.
- Can help ensure local schemes are contributing as intended to the objective of reducing car kilometres by 20% by 2030.
- Technology standards and procurement is removed as a barrier for implementation for local authorities.
- Ensures drivers are not unfairly 'double charged' – for example a simultaneously paying higher variable rate for driving in a city with a national charge and a fee for passing a cordon or area boundary.
- Equity issues such as exemptions and discounts are dealt with consistently across the country.

In order to implement a national Framework for Implementation, the Scottish Government will be required to:

- Define responsibilities for all parties, including National and Local Government, and Agencies.
- Agree with local authorities a common set of standards and requirements.
- Consider a range of complementary measures which mitigate unintended consequences of the chosen TDM measure. This could include additional parking charges around zone boundaries, road space reallocation and mileage allowance trading.
- Define the technological approach to enforcement including possible use of telematics, app-based systems and a common pay-platform.
- Establish requirements of 'back office' functions, including staffing and contracts for providing enforcement technology and customer facing platform.
- Determine how enforcement is managed, including the role of police and courts and ways to maximise compliance.
- Continue to monitor performance of schemes against the target of reducing car kilometres by 20% by 2030.

7. Supplementary Information: Detailed Appraisal

7.1 Appraisal Criteria

Each package will be assessed against the following criteria:

- Research Objective
    - Reduce Car Kilometres by 20% by 2030
- Deliverability
    - Feasibility
    - Affordability
    - Public Acceptability
- STAG Criteria
    - Environment
    - Climate Change
    - Health, Safety, and Wellbeing
    - Economy – has two sub-criteria:

      - Transport Economic Efficiency (TEE) covers the benefits ordinarily captured by standard cost-benefit analysis – including traffic volumes, journey times, driver frustration or travel time reliability

      - Wider Economic Impacts (WEIs) refer to any economic impacts which are additional to transport user benefits. How might the option help attract new jobs, help existing businesses, open up appropriate land for development?
    - Equality and Accessibility
- Policy Alignment

The appraisal will also consider the option's position in the Sustainable Investment Hierarchy.

• Appraisal Scale

Each option will be assessed on a 7 point scale defined as follows:

- Major Positive +++
- Moderate Positive ++
- Minor Positive +
- Neutral 0
- Minor Negative -
- Moderate Negative --
- Major Negative ---

For the deliverability criteria, a risk-based approach has been used, categorising options as follows:

- High
- Medium
- Low

The assessment will be based on the quantitative analysis where available, supported by qualitative analysis.

7.2 Cordon-based Charging

7.2.1 Research Objective

7.2.1.1 Reduce Car Kilometres by 20% by 2030

Minor Positive
Cordon charges around 'Large Urban Areas' are likely to be most successful at reducing car kilometres as these capture the largest traffic flows. Modelling the effects of a cordon charge around 'Large Urban Areas' could result in reduction of vehicle km of between 7% and 16% for the range of charges studied compared to a 2030 scenario without any TDM measures. The overall magnitude of impact against a 2019 baseline would depend on wider changes in society and travel behaviour between 2019 and 2030, for example in how behaviours developed during COVID-19 do or do not persist, as well as the impact of other Scottish Government initiatives. Practically, a national framework of support would be essential to ensure all large urban areas implemented charging schemes in a coordinated and timely manner in order to achieve these levels. These figures therefore represent a best case scenario for cordon charging than would be likely in practical terms and within the timeframe necessary. Overall cordon-based charging has a minor positive impact on the research objective given, in the defined scope, it is expected to have the potential to contribute towards the 20% reduction target, but will be unable to meet it.

7.2.2 Deliverability

7.2.2.1 Feasibility

Medium Risk
There are several cordon charging schemes in operation worldwide, proving the technical and operational feasibility of discrete schemes. If cordon charging was implemented on a widespread scale, there may be challenges with procurement and installation due to the quantity of automatic number plate recognition (ANPR) infrastructure required, however, the quantity of ANPR cameras required is less than area-based charging, given only the boundary requires enforcement infrastructure. A cordon charging scheme will need boundary refinement to ensure they do not displace traffic onto unsuitable and environmentally sensitive routes. Though the Transport (Scotland) Act 2001 provides local authorities with discretionary power to implement local schemes, these can only apply to local roads, and further secondary legislation would be required so that local authorities could enforce the schemes. In order to enable all large urban areas to implement schemes in a coordinated and timely way, significant national government support would be required.

7.2.2.2 Affordability

Medium Risk
Cordon charges around 'Large Urban Areas' could raise between £525 million and £875 million for the range of charges studied, providing additional funds for local transport projects. The cost of implementing local road pricing in Scotland's Large Urban Areas is estimated between £100 million and £500 million. Cordon charging should be towards the lower end of this estimate given the quantity of ANPR cameras required is less than area-based charging as only the boundary requires enforcement infrastructure. Operating costs for each of the four charging zones is expected to be between 20% and 50% of revenue generated. A shared back office functions and financial support from Scottish Government through a transport demand management framework could reduce the cost burden on individual authorities substantially.

7.2.2.3 Public Acceptability

High Risk
All proposed charging measures, particularly those which are intended as deterrents to car travel, are likely to be met with significant public opposition. Cordon charges which are implemented in locations with an existing congestion problem are likely to be more accepted than those in locations where the problem is less obvious. People who live just outside the cordon may perceive the charging structure as unfair, since they would have to pay to travel to destinations within the cordon while people who live just within the cordon would not have to pay for the same trip. This may result in opposition due to the perception of unfairness. However only applying cordon charging in 'Large Urban Areas' improves likely acceptability given the potentially greater availability of good public and active travel connectivity. Hypothecation of any revenue can also be a particularly effective method of improving public acceptability. People who have fewer alternatives to car travel are likely to be more opposed to cordon charging, including disabled people, older people, and socioeconomically disadvantaged people who may live in areas with poorer connectivity and be reliant on a car, or who may need to travel to work at times of the day when public transport is not available. Overall Cordon Charging entails a high public acceptability risk due to the perceptions of unfairness around what journeys are charged.

7.2.3 STAG Criteria

7.2.3.1 Environment

Moderate Positive
There is evidence that cordon charging reduces car demand at a local level but could result in a shift in traffic flows to routes which are currently quieter. While an overall reduction in demand would have a positive impact on biodiversity and habitats, landscape and noise and vibration, shifting negative impacts from an existing high traffic route to a lower traffic route would have negative impacts. These quieter alternative routes are likely to be more sensitive to the impacts associated with an increase in traffic. The impact against these sub criteria is therefore considered to be minor negative. The nature of cordon charging means it is likely to be implemented in the most congested areas with the highest traffic flows, and this is likely to coincide with the worst air quality. The negative environmental impacts of air quality depend on the local concentration of pollutants, so reducing emissions in the most congested areas would have the biggest impact on air quality. There may also be some rerouting as a result of cordon charging. However, if alternative routes are close to existing routes, then rerouting may not shift emissions far enough away to make a major difference to air quality. It is also important to note that the nature of cordon charging means there is no disincentive for internal travel within the cordon. This could even encourage people to drive more within the cordon to improve value for money, which could increase emissions and worsen air quality within the cordon, which as previously noted is likely to have poor air quality and be more susceptible to an increase in emissions. The impact against this sub criterion is therefore considered to be major positive.

Cordon charging is not expected to change the physical characteristics of the existing road network, only the traffic flows, so the impacts on geology and soils, land use, ecology and flooding, and historic environment are expected to be neutral.

7.2.3.2 Climate Change

Minor Positive

As shown in Table 3-2, modelling results suggest cordon charging around 'Large Urban Areas' would result in a reduction of CO^2e emissions of between 7% and 17% for the range of charges studied.

The impacts of cordon-based charging on vulnerability to the effects of climate change and potential to adapt to the effects of climate charge are expected to be neutral.

7.2.3.3 Health, Safety and Wellbeing

Minor Positive

The nature of cordon charging means it is likely to be implemented in the most congested areas with the highest traffic flows, and this is likely to coincide with accident hotspots. Reduced traffic flows in congested areas will reduce the number of conflicts thus reducing risk of accidents. However, if the reduction in traffic results in an increase in speed, this may increase the severity of accidents. Without the mitigation of road space reallocation being guaranteed, the impact against this sub criterion is therefore expected to be minor negative.

The technology required to implement cordon charging has potential implications for security of personal data. While ANPR technology is already in use; widespread use for road pricing would increase the coverage and therefore potentially increase the level of damage if hacked or compromised. However, the likelihood of a security breach is extremely low, so the overall impact against this sub criterion is therefore expected to be neutral.

Cordon charging is expected to be implemented in areas with high congestion and thus relatively poor air quality. The negative health impacts of air quality depend on the local concentration of pollutants, so reducing emissions locally would have an overall positive impact on health. However, if sensitive receptors are located on alternative routes, health impacts may just be displaced, rather than removed. Reduced congestion may contribute to increased levels of walking and cycling, which would bring additional health benefits. The impact against this sub criterion is therefore considered to be moderate positive.

Access to health and wellbeing would be unchanged in terms of physical access. However, affordability is likely to be a barrier to access for some groups (see affordability sub criterion under Equality and Accessibility Criterion below) if the health or wellbeing infrastructure is within the cordon boundary. The impact against this sub criterion is therefore considered to be minor negative.

There is evidence that cordon charging reduces car demand at a local level but could result in a shift in traffic flows to routes which are currently quieter. While an overall reduction in demand would have a positive impact on visual amenity, shifting negative impacts from an existing high traffic route to a lower traffic route would have negative impacts. These quieter alternative routes are likely to be more sensitive to the negative visual amenity impacts associated with an increase in traffic. The impact against this sub criterion is therefore considered to be minor negative.

7.2.3.4 Economy

Minor Positive
Cordon charging has the potential to improve journey times and reliability by reducing congestion. However, potential rerouting could result in a shift in congestion from one route to another. The benefits are likely to be higher where alternative routes are not available or are also captured by cordons. The impact against TEE (Transport Economic Efficiency) is therefore considered to be minor positive. There may be some limited land use changes where people move to live within the cordon or businesses move to locations outside the cordon. This could be mitigated by other measures such as reform of non-domestic rates, out-of-town levies or planning moratorium as suggested in the 2021 Town Centre Action Plan to rebalance the costs of business location choice. The net agglomeration impacts are likely to be neutral. The impact against WEI (Wider Economic Impacts) is therefore considered to be neutral.

7.2.3.5 Equality and Accessibility

Minor Negative
Cordon charging could indirectly positively affect public transport and active travel network coverage given the existing legislation states net proceeds should be used to support objectives of the local transport plan, however this impact is lesser than other options given the revenue generation potential is significantly less. Additionally, if the scheme was successful in reducing traffic levels it could improve bus journey times and potentially enable more services to run. Similarly, if there were fewer conflicts between pedestrians/cyclists and cars then walking and cycling journey times would be reduced if there was a combination of less traffic and space reallocation. The impact against these sub criteria is therefore considered to be neutral, given the limited revenue raising potential. Comparative access by people group and geographic location would be unchanged in terms of physical access, however, affordability is likely to be a barrier to access for some groups (see affordability sub criterion below). The impact against these sub criteria is therefore considered to be neutral. As for all proposed charging measures, cordon pricing will make driving less affordable. While the impacts against disabled people and rural poor have been mitigated in the appraised scheme, due to an exemption to all charges for blue badge holders and discounted rates for those with the lowest 20% of incomes in remote rural areas, there may be other groups for which impacts cannot be fully mitigated such as those who depend on car use for travel outside the hours of operation for public transport or who do not feel safe using public or active modes. Such groups may include women, LGBT+ people, younger people, older people, people with disabilities, people belonging to ethnic or religious minority groups and those travelling with young children. Cordon charging would also have a greater impact on people with low incomes due to charges making up a higher proportion of their income. There is also an affordability impact around the cordon boundary, with potential for inequality in a 'self-sufficient' large urban area, with those within the cordon not needing to pay, but those outside travelling in being liable for the charge. Therefore, the affordability impacts will vary with the geographical and travel characteristics of the area and the design of the cordon boundary. There may be some positive effects on affordability of public transport if reduced congestion results in sufficient journey time savings to allow bus operators to operate the same service frequency with fewer buses, reducing operating costs. Bus savings are more achievable in locations such as cities and towns where congestion is having a significant impact on journey times, and where services tend to be more frequent and cover shorter distances. Cordon charging implemented in these locations is likely to result in a minor positive affordability impact in terms of public transport. Overall the impact of Cordon Charging on Equality and Accessibility is minor negative due to the differences in affordability impacts depending on whether resident inside or outside the boundary and relatively low revenue generation potential for hypothecation into public and active travel.

7.2.4 Policy Alignment

Moderate Positive
Cordon charging would contribute to the 20% car reduction target identified in the **Climate Change Plan** and aligns positively with the **NTS2** priorities to “Takes climate action” and “Improve health and wellbeing” although potentially conflicts with the priorities to “Deliver inclusive economic growth” and “Reduce inequalities”. The option has the potential to complement public transport and active travel options recommended through **STPR2**, by encouraging modal shift to sustainable and increasing the usage of such options, ultimately improving value for money. Cordon charging also aligns with planning policy outlined in the **NPF4**, which encourages increased opportunity for local living and implementation of 20 minute neighbourhoods; strengthening support for development in town centres and restricting out-of-town retail and leisure to encourage a transition away from car-dependent developments and stimulating new models of low carbon living in our rural areas as well as our towns and cities, by facilitating further investment in digital infrastructure, building in more space for people to work remotely and creating community hubs. There may be some conflicts with the **Equalities Act (2010)** and the **Fairer Scotland Duty** due to potential negative differential impacts on affordability for women, LGBT+ people, younger people, older people, people with disabilities, people belonging to ethnic or religious minority groups, and people experiencing socio-economic disadvantage. It may be possible to mitigate these negative impacts through the option design, for example through discounts, exemptions, and hypothecation of revenue to public transport and active travel improvements.

7.2.5 Sustainable Investment Hierarchy

Makes better use of existing capacity

7.3 Area-based Charging

7.3.1 Research Objective

7.3.1.1 Reduce Car Kilometres by 20% by 2030

Moderate Positive
There is evidence that area-based charging can be effective in reducing car trips. However, this is likely to be most effective in locations where most trips passing through the area have origins or destinations within the area. For trips through the area, area-based charging could encourage rerouting, which may even increase car kilometres in some cases where an alternative route is longer. However, this rerouting effect is likely to be less than for cordon-based charging. Once within the charged area there is also no financial disincentive to travelling within the area that day given the daily nature of the charge. Area-based charging may also encourage people to park their vehicles just outside the charging area, which might limit the potential reduction in car kilometres if the charging area is relatively compact. Area charges which cover all trips to, from and within 'Large Urban Areas' are likely to be most successful at reducing car kilometres as these capture the largest traffic flows. As shown in Table 3-3, the effects of area charges around 'Large Urban Areas' could result in reduction of vehicle km of between 14% and 25% for the range of charges studied compared to a 2030 scenario without any TDM measures. Practically, a national framework of support would be essential to ensure all large urban areas implemented charging schemes in a coordinated and timely manner in order to achieve these levels. In the absence of a national framework of support, with just Edinburgh and Glasgow implementing schemes as a result of local authority initiative, the model outputs shown in Table 3-4 indicate a reduction of between 9% and 16% nationally, falling short of the national target. The overall magnitude of impact against a 2019 baseline would depend on wider changes in society and travel behaviour between 2019 and 2030, for example in how behaviours developed during COVID-19 do or do not persist, as well as the impact of other Scottish Government initiatives. Overall area-based charging has a major positive impact on the research objective given, in the defined scope, it is expected to meet the 20% Car Kilometres reduction target.

7.3.2 Deliverability

7.3.2.1 Feasibility

Medium Risk
There are several area charging schemes in operation in the UK, proving the technical and operational feasibility of discrete schemes. However, if area charging was implemented on a widespread scale in Scotland, there may be challenges with procurement and installation due to the quantity of ANPR infrastructure required. Area-based charging would require more enforcement infrastructure than a cordon charge given the entire area requires monitoring. An area charging scheme will need boundary refinement to ensure they do not displace traffic onto unsuitable and environmentally sensitive routes. Though the Transport (Scotland) Act 2001 provides local authorities with discretionary power to implement local schemes, these can only apply to local roads, and further secondary legislation would be required so that local authorities could enforce the schemes. Delivering all four large urban areas within a similar timeframe would require significant support and intervention from the Scottish Government and this would be required in order to produce an impact large enough to achieve the 20% reduction target.

7.3.2.2 Affordability

Medium Risk
As shown in Table 3-3, area charges around 'Large Urban Areas' could raise between £790 million and £1.3 billion per year for the range of charges studied, providing significant additional funds for local transport projects. The cost of implementing local road pricing in Scotland's Large Urban Areas is estimated between £100 and £500 million. Area charging should be towards the upper end of this estimate given the quantity of ANPR cameras required is greater than cordon-based charging as all parts of the charging area requires enforcement infrastructure. Operating costs for each charging zone is expected to be between 20% and 50% of revenue generated. Shared back office functions and financial support from Scottish Government through a transport demand management framework could reduce the cost burden on individual authorities substantially.

7.3.2.3 Public Acceptability

Medium Risk
All proposed charging measures, particularly those which are intended as deterrents to car travel, are likely to be met with significant public opposition. Area charges which are implemented in locations with an existing congestion problem are likely to be more accepted than those in locations where the problem is less obvious. People who live within the area may perceive the charging structure as unfair, since they would have to pay the charge every time they travelled by car but the perceived unfairness for those outside the zone is less given everyone traveling within the zone is paying, not just those who have passed the area boundary as is the case with cordon charge. However only applying area charging in 'Large Urban Areas' improves acceptability given the potentially greater availability of good public and active travel connectivity. Hypothecation of any revenue can also be a particularly effective method of improving public acceptability. People who have fewer alternatives to car travel, are likely to be more opposed to area charging, including disabled people, older people, and socioeconomically disadvantaged people who may live in areas with poorer connectivity and be reliant on a car, or who may need to travel to work at times of the day when public transport is not available.

7.3.3 STAG Criteria

7.3.3.1 Environment

Major Positive
There is evidence that area charging reduces car demand at a local level but could result in a shift in traffic flows to routes which are currently quieter, although this impact is likely to be less than for cordon charging. Area charging also targets short-distance movements within the area, where cordon charging is unable to do so. While an overall reduction in demand would have a positive impact on biodiversity and habitats, landscape and noise and vibration; shifting negative impacts from an existing high traffic route to a lower traffic route would have negative impacts. These quieter alternative routes are likely to be more sensitive to the negative impacts associated with an increase in traffic. The impact against these sub criteria is therefore considered to be neutral. The nature of area charging means it is likely to be implemented in the most congested areas with the highest traffic flows, and this is likely to coincide with the worst air quality. The negative environmental impacts of air quality depend on the local concentration of pollutants, so reducing emissions in the most congested areas would have the biggest impact on air quality. While the rerouting effect due to area charging is likely to be less than for cordon charging, it could still impact on air quality. If sensitive receptors are located on alternative routes, air quality impacts may just be displaced, rather than removed.

While area charging, unlike cordon charging, targets trips with origins and destinations within the charging zone, the capped nature of area charging means there is no disincentive for further travel once that charge has been paid for the defined time period. This could even encourage people to drive more to improve value for money, which could increase emissions and worsen air quality within the area, which as previously noted is likely to have poor air quality and be more susceptible to an increase in emissions. Despite this, an area charging is likely to disincentivise short distance urban trips that should be easily substitutable and that have a disproportionate impact on pollutant emissions. The overall impact against this sub criterion is considered to be major positive.

Area charging is not expected to change the physical characteristics of the existing road network, only the traffic flows, so the impacts on geology and soils, land use, ecology and flooding, and historic environment are expected to be neutral.

7.3.3.2 Climate Change

Major Positive
As shown in Table 3-3, modelling results suggest area charging in 'Large Urban Areas' would result in a reduction of CO^2e emissions of between 15% and 26% for the range of charges studied. The impacts of area charging on vulnerability to the effects of climate change and potential to adapt to the effects of climate charge are expected to be neutral.

7.3.3.3 Health, Safety and Wellbeing

Minor Positive
The nature of area charging means it is likely to be implemented in the most congested areas with the highest traffic flows, and this is likely to coincide with accident hotspots. Reduced traffic flows in congested areas will reduce the number of conflicts thus reducing risk of accidents. Area charging also targets short-distance movements within the area, where cordon charging is unable to do so. This is likely to disincentivise short distance urban trips that should be easily substitutable and that have a disproportionate impact on accidents. However, if the reduction in traffic results in an increase in speed, this may increase the severity of accidents. Without the mitigation of road space reallocation, the impact against this sub criterion is therefore expected to be minor negative. The technology required to implement cordon charging has potential implications for security of personal data. While ANPR technology is already in use; widespread use for road pricing would increase the coverage and therefore potentially increase the level of damage if hacked or compromised. However, the likelihood of a security breach is extremely low, so the overall impact against this sub criterion is therefore expected to be neutral. The majority of air quality management areas in Scotland are in highly congested urban areas. Area charging is expected to be implemented in areas with high congestion and relatively poor air quality. The negative health impacts of air quality depend on the local concentration of pollutants, so reducing emissions or shifting emissions from a more polluted area to a less polluted area would have an overall positive impact on health. However, if sensitive receptors are located on alternative routes, health impacts may just be displaced, rather than removed. There is also a risk that once the charge has been paid there is no disincentive to travel which could even increase emissions and worsen air quality. Reduced congestion may contribute to increase levels of walking and cycling, which would bring additional health benefits. Area charging also targets short-distance movements within the area, where cordon charging is unable to do so. This is likely to disincentivise short distance urban trips that should be easily substitutable and that have a disproportionate impact on pollutant emissions. The impact against this sub criterion is therefore considered to be major positive. Access to health and wellbeing would be unchanged in terms of physical access, however affordability is likely to be a barrier to access for some groups (see affordability sub criterion under Equality and Accessibility Criterion below) if the health or wellbeing infrastructure is within the area boundary. Therefore, the impact against this sub criterion is therefore considered to be minor negative.

There is evidence that area charging reduces car demand at a local level but could result in a shift in traffic flows to routes which are currently quieter. While an overall reduction in demand would have a positive impact on visual amenity; shifting negative impacts from an existing high traffic route to a lower traffic route would have negative impacts. These quieter alternative routes are likely to be more sensitive to the negative visual amenity impacts associated with an increase in traffic. The impact against this sub criterion is therefore considered to be minor negative.

7.3.3.4 Economy

Minor Positive

Area charging has the potential to improve journey times and reliability by reducing congestion. Area charging also targets short-distance movements within the area, where cordon charging is unable to do so. This is likely to disincentivise short distance urban trips that should be easily substitutable and that have a disproportionate impact on congestion, affecting journey times and reliability. However potential rerouting could result in a shift in congestion from one route to another. The benefits are likely to be higher where the area captures the highest traffic flows and any potential alternative routes. The impact against TEE is therefore considered to be minor positive.

There may be some limited land use changes where people or businesses move outside the area. This could be mitigated by other measures such as reform of non-domestic rates, out-of-town levies or planning moratorium as suggested in the 2021 Town Centre Action Plan to rebalance the costs of business location choice. The impact against WEI is therefore considered to be neutral.

7.3.3.5 Equality and Accessibility

Neutral

Area charging could indirectly affect public transport and active travel network coverage given the existing legislation states net proceeds should be used to support objectives of the local transport plan. Additionally, if the scheme was successful in reducing traffic levels it could improve bus journey times and potentially enable more services to run. Area charging also targets short-distance movements within the area, where cordon charging is unable to do so. This is likely to disincentivise short distance urban trips that should be easily substitutable and that have a disproportionate impact on traffic levels. Similarly, if there were fewer conflicts between pedestrians/cyclists and cars then walking and cycling journey times would be reduced if there was a combination of less traffic and space reallocation. The impact against these sub criteria is therefore considered to be minor positive.

Comparative access by people group and geographic location would be unchanged in terms of physical access, however, affordability is likely to be a barrier to access for some groups (see affordability sub criterion below). The impact against these sub criteria is therefore considered to be neutral.

As for all proposed charging measures, area pricing will make driving less affordable. While the impacts against disabled people and rural poor have been mitigated in the appraised example schemes, due to an exemption to all charges for blue badge holders and discounted rates for those with the lowest 20% of incomes in remote rural areas, there may be other groups for which impacts cannot be fully mitigated such as those who depend on car use for travel outside the hours of operation for public transport or who do not feel safe using public or active modes. Such groups may include women, LGBT+ people, younger people, older people, people with disabilities, people belonging to ethnic or religious minority groups and those travelling with young children. Area charging would also have a greater impact on people with low incomes due to charges making up a higher proportion of their income.

There may be some positive effects on affordability of public transport if reduced congestion results in sufficient journey time savings to allow bus operators to operate the same service frequency with fewer buses, reducing operating costs. Bus savings are more achievable in locations such as cities and towns where congestion is having a significant impact on journey times, and where services tend to be more frequent and cover shorter distances. Area charging implemented in these locations is likely to result in a minor positive affordability impact in terms of public transport.

Overall the impact of Area Charging on Equality and Accessibility is neutral given the negative impacts of the additional cost of driving on individuals is balanced by the significant revenue generation potential which must be invested in local public and active travel measures, providing the largest benefit to those on low incomes and less likely to own a car.

7.3.4 Policy Alignment

Moderate Positive
Area charging would contribute to the 20% car reduction target identified in the **Climate Change Plan** and aligns positively with the **NTS2** priorities to "Takes climate action" and "Improve health and wellbeing" although potentially conflicts with the priorities to "Deliver inclusive economic growth" and "Reduce inequalities". The option has the potential to complement public transport and active travel options recommended through **STPR2**, by encouraging modal shift to sustainable and increasing the usage of such options, ultimately improving value for money. Area charging also aligns with planning policy outlined in the **NPF4**, which encourages increased opportunity for local living and implementation of 20 minute neighbourhoods; strengthening support for development in town centres and restricting out-of-town retail and leisure to encourage a transition away from car-dependent developments and stimulating new models of low carbon living in our rural areas as well as our towns and cities, by facilitating further investment in digital infrastructure, building in more space for people to work remotely and creating community hubs. There may be some conflicts with the **Equalities Act (2010)** and the **Fairer Scotland Duty** due to potential negative differential impacts on affordability for women, LGBT+ people, younger people, older people, people with disabilities, people belonging to ethnic or religious minority groups, and people experiencing socio-economic disadvantage. It may be possible to mitigate these negative impacts through the option design, for example through discounts, exemptions and hypothecation of revenue to public transport and active travel improvements.

7.3.5 Sustainable Investment Hierarchy

Makes better use of existing capacity

7.4 Distance-based Charging (Variable Rate)

7.4.1 Research Objective

7.4.1.1 Reduce Car Kilometres by 20% by 2030

Major Positive
Though few real-world examples currently operate, distance-based charging is considered by many research studies to represent the optimum solution to the question of efficiently pricing road usage and thereby reducing car kilometres. Distance-based charging would allow for charges to be directly placed on the amount of driving undertaken and have the greatest impact on longer length journeys which make up the majority of car kilometres travelled in Scotland. While a flat rate distance-based charge would not have the same impact in urban settings given the short distances, and consequently low charges encountered, a variable charge based on rural/urban classification would enable charging to be targeted both short and long-distance trips. As shown in Table 5-1, modelling the effects of distance-based variable rate charges indicates a reduction in vehicle km of between 8% and 26% for the range of charges appraised compared to a 2030 scenario without any TDM measures. The overall magnitude of impact against a 2019 baseline would depend on wider changes in society and travel behaviour between 2019 and 2030, for example in how behaviours developed during COVID-19 do or do not persist, as well as the impact of other Scottish Government initiatives. Evidence from the roll-out of energy smart meters suggests that the behaviour changing effect of better access to price information leads consumers to make more informed choices. Similarly, distance-based charging provides opportunity for greater levels of feedback to the consumer on the real-time cost of a journey. As such, distance-based, variable rate charging scores as major positive in respect of the research question.

7.4.2 Deliverability

7.4.2.1 Feasibility

Medium Risk
Distance-based variable rate charging requires an effective means of estimating the exact distances travelled by the individual vehicle and there are both high and low-tech solutions to this. Drivers could submit their mileage through an online portal, or through another platform for those without internet access with the possibility for checks at MOT, insurance, or police spot checks. While this is a practical option, there is a risk of illegal vehicle 'clocking' to avoid charges. Telematic technology could be used instead, and this already has widespread usage in commercial fleets and as part of some insurance schemes. However, linking devices and undertaking a mass procurement and roll out of new devices under a single system will be logistically challenging. Telematic tracking makes use of the Global Navigation Satellite System (GNSS) system and there are known ways in which this system can be bypassed – known as 'jamming' or 'spoofing'. For this reason, a GNSS based system would likely require checking and enforcement by ANPR or checks similar to the low-tech self-mileage submission option. Any form of manual checking requires a significant 'back office' of staff to monitor and process data. For these reasons, although the technology is readily available to deliver distance-based charging, the overall feasibility risk is higher than the low-tech solution.

7.4.2.2 Affordability

Medium Risk
As shown in Table 5-1, the potential revenue that could be raised as a result of implementing distance-based variable rate charging would be in the order of £1bn to £2.5bn per annum for the range of charges studied. The feasibility study for a UK national distance-based charging estimated set up costs of £3bn and annual running costs of £2-3bn[63]. The proposed Netherlands national scheme is estimated to have a set up cost of €2.2bn and annual running costs of 250-900m euros. However, implementation costs of a national, distance-based scheme are highly dependent on the way in which it is implemented. A distance-based, variable rate charging system using the option of mileage self-submission would require the development of an online portal and associated IT infrastructure to host the website and data stored which will involve significant expenditure. A telematics-based solution would be more costly given the capital expenditure required to purchase telematic devices and on the creation of a network of ANPR cameras, ongoing costs associated with maintenance of the system and revenue costs associated with the 'back office' of staff required to monitor and process the data. On board units (OBUs) commercially retail at around £30 each. Supplying one to each of the 2.5 million cars in Scotland would be in the order of £100m (assuming no economy of scale). However, smartphone app-based systems or a hybrid approach could be significantly cheaper. Because of the intricacies of such a system is its unlikely that local authorities would have the capacity to administer local distance-based charging systems. It is therefore likely that distance-based charging would be administered at the national level. The initial capital, maintenance and revenue costs would therefore be borne by the Scottish Government, while the cost of the telematic devices, if introduced, could be passed on to the user, or as a deduction from the road user charge. Collectively, the initial capital costs and ongoing revenue costs for a national scheme would be significant.

7.4.2.1 Public Acceptability

Medium Risk
The public acceptability of a distance-based variable rate charge depends on how the scheme is implemented and the level of the charge applied. There is likely to be public support for a fairer form of motoring taxation, with distance-based charging directly related to how much people drive, making for a fairer and more balanced system, if it were to ultimately replace existing fuel duties. People who have fewer alternatives to car travel, are more likely to be opposed to distance charging, including disabled people, older people, and socioeconomically disadvantaged people who may need to travel to work at times of the day when public transport is not available. However, a variable rate charge could be tailored further by geographical area and income group in order to mitigate these potential effects and improve acceptability. Additionally, there are public acceptability challenges with compelling individuals to install tracking devices in their vehicles which would pose a significant barrier to delivery. This could potentially be overcome by working with the car insurance industry to design policies which require telematics as a precondition of insurance cover. The lower-tech approach of submitting milage readings would also potentially be more acceptable. There remains a high degree of uncertainty around the exact pathway for delivery of distance-based charging. A charging design that was mindful of the availability of different travel options in different areas and hypothecation to positive alternative modes of travel could also help acceptability.

7.4.3 STAG Criteria

7.4.3.1 Environment

Minor Positive

Distance-based variable rate charging could encompass the entirety of the public road network and therefore avoid unwanted environmental impacts associated with traffic re-routeing to avoid charges. However, there may still be some re-routing from longer distance or circuitous motorways or ring roads to local roads less able to cope with high traffic volumes. The overall impact of road transport on the environment would reduce in proportion to the number of vehicle kilometres saved. Introducing a geographical variable component to the charge could well target trips most damaging to air and noise quality. Charging by distance and location alone would not shift vehicle or engine choice away from more polluting types, unless this was also a variable parameter for engine type in the charge.

Though the installation of the required ANPR infrastructure would have some impacts on the environment, effectively managing demand would reduce or eliminate the need for additional road capacity works, resulting in an overall positive impact of this option on geology and soils, land use, ecology and flooding, and historic environment.

7.4.3.2 Climate Change

Major Positive
Distance-based charging with a variable rate for different locations would be one of the most efficient ways of managing demand for road use as it effectively targets all types of car journeys. While internal combustion engine vehicles are still in use, this would have a strongly positive impact on reducing greenhouse gas emissions. As zero emissions vehicles assume the majority of the vehicles in use, the impact on greenhouse gas emissions will be less, with the level of this reduction dependent on the overall mix of energy production. As shown in Table 5-1, the reductions in CO^2e emissions as a result of variable rate distance charging would be between 8% and 27% more than would be the case without charging for the range of charges studied. The embodied carbon within vehicle production would potentially be reduced if distance-based charging led to mode switching and a reduction in the number of vehicles manufactured and purchased. The impacts of distance-based charging on vulnerability to the effects of climate change and potential to adapt to the effects of climate charge are expected to be neutral.

7.4.3.3 Health, Safety and Wellbeing

Minor Positive
A distance-based variable rate charge could reduce the number of vehicles using the road and hence the number of accidents would be expected to fall. However, any reduction in traffic volumes could lead to increased speed and increase the severity of accidents. Without the mitigation of road space reallocation, this would lead to a minor negative impact against this sub-criterion. The technology required to implement a geographically based variable distance -based charging has potential implications for security of personal data. While ANPR and in-vehicle telematic technology is already in use; widespread use for road pricing would increase the coverage and therefore potentially increase the level of damage if hacked or compromised. However, the likelihood of a security breach is extremely low, so the overall impact against this sub criterion is therefore expected to be neutral. Reduction in demand across the network and commensurate shifts in travel behaviour towards more active and sustainable modes would create an overall positive impact on health, with the level of positive impact being dependent on how these journeys were redistributed and level of road space relocation as a result of less traffic. Access to health and wellbeing would be unchanged in terms of physical access, however affordability is likely to be a barrier to access for some groups (see affordability sub criterion under Equality and Accessibility Criterion below) and has been mitigated in the option design with some exemptions.

7.4.3.4 Economy

Minor Positive
Distance-based charging has the potential to improve journey times and reliability by reducing congestion. However, potential rerouting to the shortest distance route could result in a shift in congestion from high-capacity roads such as motorways to local roads with less capacity and more vulnerable to congestion. However, variable distance-based charges provide a constant price signal to the decision maker about their journey. The impact against TEE is therefore considered to be minor positive. If a distance-based charge encourages densification of land use, there may be improvements to productivity. However, demand for transport is derived from economic activity and economic growth (GDP) and traffic growth (vehicle km) have, historically, been closely correlated. If a charge were over-applied to the extent that that the costs imposed were disproportionate to the societal benefit gained, there would be a highly negative impact on the wider economy. The impact against WEI is therefore considered to be minor positive.

7.4.3.5 Equality and Accessibility

Neutral
Distance charging could indirectly affect public transport and active travel network coverage given it is assumed any revenue generated will be spent on national transport priorities and according to the sustainable investment hierarchy. Reduced traffic levels as a result of this option could both improve bus journey times and enable reallocation of road space for active travel. The impact against these sub criteria is therefore considered to be minor positive. Comparative access by people group and geographic location would be unchanged in terms of physical access. However, affordability is likely to be a barrier to access for some groups who may be more car dependant given their health or geographic area. A variable rate can be optimised to be more equitable, giving lower income groups in rural locations residents and reduced rates for certain times of day. As for all proposed charging measures, distance-based pricing will make driving less affordable. A flat rate distance charge would disproportionately impact rural residents who need to travel further to access key services as a result of less dense land use. However, a variable charge by rural/urban classification could disproportionately affect those on low-incomes in urban areas who may lack of flexibility of workplace location or work hours when public transport provision is poor or non-existent. The impact against these sub criteria is therefore considered to be minor negative. Reduced congestion could result in sufficient journey time savings to allow bus operators to operate the same service frequency with fewer buses, reducing operating costs. Bus savings are more achievable in locations such as cities and towns where congestion is having a significant impact on journey times, and where services tend to be more frequent and cover shorter distances. Overall, the impact against Equality and Accessibility criteria is neutral given the charge can be designed to mitigate to some extent the impact on rural communities and those who find it most difficult to switch modes and has potential to generate significant revenue to fund national transport projects, providing the largest benefit to those on low incomes and less likely to own a car.

7.4.4 Policy Alignment

Moderate Positive
Distance charging would contribute to the 20% car reduction target identified in the **Climate Change Plan** and aligns positively with the **NTS2** priorities to “Takes climate action” and “Improve health and wellbeing” although potentially conflicts with the priorities to “Deliver inclusive economic growth”. The effect on “Reduce inequalities” is uncertain, there is potential within this option to mitigate negative impacts on this objective. The option has the potential to complement public transport and active

travel options recommended through **STPR2**, by encouraging modal shift to sustainable and increasing the usage of such options, ultimately improving value for money.

Distance charging also aligns with planning policy outlined in the **NPF4**, which encourages increased opportunity for local living and implementation of 20 minute neighbourhoods; strengthening support for development in town centres and restricting out-of-town retail and leisure to encourage a transition away from car-dependent developments and stimulating new models of low carbon living in our rural areas as well as our towns and cities, by facilitating further investment in digital infrastructure, building in more space for people to work remotely and creating community hubs.

There may be some conflicts with the **Equalities Act (2010)** and the **Fairer Scotland Duty** due to potential negative differential impacts on affordability for women, LGBT+ people, younger people, older people, people with disabilities, people belonging to ethnic or religious minority groups, and people experiencing socio-economic disadvantage. However, it may be possible to further mitigate these potential negative impacts through the option design, through differential costs for short and long journeys, and the hypothecation of revenue to public transport and active travel improvements

7.4.5 Sustainable Investment Hierarchy

Makes better use of existing capacity

7.5 Distance-based Charging (Flat Rate, Variable Allowance)

7.5.1 Research Objective

7.5.1.1 Reduce Car Kilometres by 20% by 2030

Moderate Positive
Charging each kilometre travelled above a prescribed allowance would allow for direct targeting of those who drive the most frequently and over the longest distances, while having little impact on those who drive less frequently or over short distances. Therefore, it is well targeted to reducing long distance trips which make up the majority of the car kilometres travelled in Scotland. Conversely it is not well targeted to discretionary short distance trips and could help to incentivise these types of trips if someone has not used up their allowance. This can be partially mitigated against if an allowance trading scheme was implemented but this would add complexity to the system. While improving acceptability, a free milage allowance would reduce the effectiveness of the measure by reducing the number of journeys affected by the charge. Evidence from the roll-out of energy smart meters suggests that the behaviour changing effect of better access to price information leads consumers to make more informed choices. However, this effect will be less applicable in cases where those who drive the least are not charged as the price signal of a trip only applies after a certain number of kilometres have already been travelled.

7.5.2 Deliverability

7.5.2.1 Feasibility

Medium Risk
Distance-based charging requires an effective means of estimating the exact distances travelled by the individual vehicle and there are both high and low-tech solutions to this. Drivers could submit their mileage through an online portal, or through another platform for those without internet access with the possibility for checks at MOT, insurance, or police spot checks. While this is a practical option, there is a risk of illegal vehicle 'clocking' to avoid charges. Telematic technology could be used instead, and this already has widespread usage in commercial fleets and as part of some insurance schemes. However, linking devices and undertaking a mass procurement and roll out of new devices under a single system will be logistically challenging. Telematic tracking makes use of the Global Navigation Satellite System (GNSS) system and there are known ways in which this system can be bypassed – known as 'jamming' or 'spoofing'. For this reason, a GNSS based system would likely require checking and enforcement by ANPR or checks similar to the low-tech self-mileage submission option. Any form of manual checking requires a significant 'back office' of staff to monitor and process data. A flat rate distance-based charged with variable allowances has a medium feasibility risk given it can be implemented with either low or high tech solutions.

7.5.2.2 Affordability

Medium Risk
As shown in Table 5-1, the potential revenue that could be raised as a result of implementing distance-based variable rate charging would be in the order of £1bn to £2.5bn per annum. A flat rate charge which only applies after a certain number of kilometres have been travelled may limit the revenue generated given only the excess kilometres will be charged as drivers would be incentivised to not drive over their free allowance. Though the potential for revenue generation would be more limited, the set up and operation costs would be very similar. The feasibility study for a UK national distance-based charging estimated set up costs of £3bn and annual running costs of £2-3bn . The proposed Netherlands national scheme is estimated to have a set up cost of €2.2bn and annual running costs of 250-900m euros. However, implementation costs of a national, distance-based scheme are highly dependent on the way in which it is implemented. A distance-based, variable rate charging system using the option of mileage self-submission option would require the development of an online portal and associated IT infrastructure to host the website and data stored which will involve significant expenditure. A telematics-based solution would be more costly given the capital expenditure required to purchase telematic devices and on the creation of a network of ANPR cameras, ongoing costs associated with maintenance of the system and revenue costs associated with the 'back office' of staff required to monitor and process the data. On board units (OBUs) commercially retail at around £30 each. Supplying one to each of the 2.5 million cars in Scotland would be in the order of £100m (assuming no economy of scale). However, smartphone app-based systems or a hybrid approach could be significantly cheaper. Because of the intricacies of such a system is its unlikely that local authorities would have the capacity to administer local distance-based charging systems. It is therefore likely that any distance-based charging would be administered at the national level. The initial capital, maintenance and revenue costs would therefore be borne by the Scottish Government, while the cost of the telematic devices, if introduced, could be passed on to the user, or as a deduction from the road user charge. Collectively, the initial capital costs and ongoing revenue costs for a national scheme would be significant.

7.5.2.3 Public Acceptability

Medium Risk
The public acceptability of a distance-based charge varies depending on how the scheme is implemented. There is likely to be public support for a fairer form of motoring taxation, with distance-based charging directly related to how much people drive, making for a fairer and more balanced system, if it were to ultimately replace existing fuel duties. A system of a free milage allowance and a flat charge for kilometres travelled beyond that similar to the personal tax allowance, would provide the potential for a more publicly acceptable option, giving motorists the opportunity to exempt themselves from any charge by moderating their car use. Only those who make excess car trips and contribute the most to the overall car kilometres travelled would encounter a charge. People who have fewer alternatives to car travel, are likely to be more opposed to distance charging, including disabled people, older people, and socioeconomically disadvantaged people who may need to travel to work at times of the day when public transport is not available. However, exemptions would be applied for people with a disability affecting their mobility and those in low income groups living in remote rural areas would be given additional mileage allowance given their lower ability to pay and greater legitimate need for travelling longer than average distances.

If tracking devices are chosen to enforce this option, these pose public acceptability challenges with compelling individuals to install tracking devices in their vehicles which would pose a significant barrier to delivery. This could potentially be overcome by working with the car insurance industry to design policies which require telematics as a precondition of insurance cover. The lower-tech approach of submitting milage readings, with checks/audits at MOTs would potentially be more acceptable.

There remains a high degree of uncertainty around the exact pathway for delivery of distance-based charging and public acceptability will depend on which pathway is chosen.

7.5.3 STAG Criteria

7.5.3.1 Environment

Minor Positive
Distance-based, variable allowance charging could encompass the entirety of the public road network and therefore avoid unwanted environmental impacts associated with traffic re-routeing to avoid charges. However, there may still be some re-routing from longer distance or circuitous motorways or ring roads to local roads less able to cope with high traffic volumes. The overall impact of road transport on the environment would reduce in proportion to the number of vehicle kilometres saved. However, in terms of noise and air quality, charging by distance alone would not shift vehicle or engine choice away from more polluting types, unless this was also a variable parameter for engine type in the charge. Given the nature of free mileage and flat rate charging for excess kilometres, the charge cannot be well targeted to areas of congestion, so will have less impact on noise and air pollution than other forms of charging which can be designed to reduce the volume of traffic in hotspots. Though the installation of the required ANPR infrastructure would have some impacts on the environment, effectively managing demand would reduce or eliminate the need for additional road capacity works, resulting in an overall positive impact of this option on geology and soils, land use, ecology and flooding, and historic environment.

7.5.3.2 Climate Change

Moderate Positive
A flat rate distance-based charge with a set free mileage allowance could effectively manage demand for road use and cut down the overall number of kilometres travelled. While internal combustion engine vehicles are still in use, this would have a strongly positive impact on reducing greenhouse gas emissions. As zero emissions vehicles assume the majority of the vehicles in use, the impact on greenhouse gas emissions will be less, with the level of this reduction dependent on the overall mix of energy production. As the potential for vehicle kilometre reduction would be lower where a free allowance, rather than a variable rate, were implemented, the potential for reduction in GHG emissions will also be lower. The embodied carbon within vehicle production would potentially be reduced if distance-based charging led to mode switching and a reduction in the number of vehicles manufactured and purchased. The impact against greenhouse gas emissions is therefore minor positive. The impacts of distance-based charging on vulnerability to the effects of climate change and potential to adapt to the effects of climate charge are expected to be neutral.

7.5.3.3 Health, Safety and Wellbeing

Minor Positive
A distance-based charge, variable allowance could reduce the number of vehicles using the road and hence the number of accidents would be expected to fall. However, any reduction in traffic volumes

could lead to increased speed and increase the severity of accidents. Without the mitigation of road space reallocation, this would lead to a minor negative impact against this sub-criterion.

If a low tech solution was implemented, relying on user submitted mileage readings, verified at MOTs there would be limited impact against the security sub criterion. However, if telematic technology was chosen, this has potential implications for security of personal data. While ANPR and in-vehicle telematic technology is already in use; widespread use for road pricing would increase the coverage and therefore potentially increase the level of damage if hacked or compromised. However, the likelihood of a security breach is extremely low, so the overall impact against this sub criterion is therefore expected to be neutral.

Reduction in demand across the network and commensurate shifts in travel behaviour towards more active and sustainable modes would create an overall positive impact on health, with the level of positive impact being dependent on how these journeys were redistributed and level of road space relocation as a result of less traffic.

Access to health and wellbeing would be unchanged in terms of physical access, however affordability is likely to be a barrier to access for some groups (see affordability sub criterion under Equality and Accessibility Criterion below) and has been mitigated against in the option design with some exceptions

7.5.3.4 Economy

Minor Positive

A flat rate distance-based charge with a set free mileage allowance may improve journey times and reliability by reducing congestions. However, the charge is not well targeted to areas where this is an issue which may limit the impact against this sub criterion. There is also potential rerouting to the shortest distance route which could result in a shift in congestion from high-capacity roads such as motorways to local roads with less capacity and more vulnerable to congestion. Unlike a geographically variable distance charge, the presence of a free allowance means that the price signal of completing a trip only emerges after a set number of kilometres have already been travelled. Therefore, the impact against TEE is neutral.

If a distance-based charge encourages densification of land use, there may be improvements to productivity. However, demand for transport is derived from economic activity and economic growth (GDP) and traffic growth (vehicle km) have, historically, been closely correlated. If a charge were over-applied to the extent that that the costs imposed were disproportionate to the societal benefit gained, there would be a highly negative impact on the wider economy. The impact against WEI is therefore considered to be minor positive.

7.5.3.5 Equality and Accessibility

Neutral

Distance charging could indirectly affect public transport and active travel network coverage given it is assumed any revenue generated will be spent on national transport priorities and according to the sustainable investment hierachy. Reduced traffic levels as a result of this option could both improve bus journey times and enable reallocation of road space for active travel. The impact against these sub criteria is therefore considered to be minor positive.

Comparative access by people group and geographic location would be unchanged in terms of physical access. However, affordability is likely to be a barrier to access for some groups who may be more car dependant given their health or geographic area. As for all proposed charging measures, distance-based pricing will make driving less affordable. A flat rate distance charge could disproportionately impact rural residents who need to travel further to access key services as a result of less dense land use. To mitigate this, an additional free allowance could be allocated for those who are both within the lowest 20% income group and living in areas defined as ‘remote rural’. This free allowance could also be extended to low-income groups in accessible rural areas and remote small towns which experience similar issues with accessing services and travelling longer distances. The exemption for people with a disability which affects their mobility would also mitigate the negative

impacts on this group. However, a variable allowance by rural/urban classification could disproportionately affect those on low-incomes in urban areas who may lack of flexibility of workplace location or work hours when public transport provision is poor or non-existent. The impact against comparative accessibility and affordability is therefore minor negative given the option is able to be tailored to mitigate the impacts on different groups and remove the need to pay altogether for a large portion of the population.

Overall, the impact against Equality and Accessibility criteria is neutral given the charge can be designed to mitigate the impact on rural communities and those who find it most difficult to switch modes. Additionally, it could be designed so as to avoid impacting the majority of drivers and focus on those who drive significantly more than average. The potential to generate significant revenue to fund national transport projects provides the largest benefit to those on low incomes and less likely to own a car.

7.5.4 Policy Alignment

Moderate Positive
Distance charging would contribute to the 20% car reduction target identified in the **Climate Change Plan** and aligns positively with the **NTS2** priorities to “Takes climate action” and “Improve health and wellbeing” although potentially conflicts with the priorities to “Deliver inclusive economic growth”. The effect on “Reduce inequalities” is uncertain, there is potential within this option to mitigate negative impacts on this objective. The option has the potential to complement public transport and active travel options recommended through **STPR2**, by encouraging modal shift to sustainable and increasing the usage of such options, ultimately improving value for money. Distance charging also aligns with planning policy outlined in the **NPF4**, which encourages increased opportunity for local living and implementation of 20 minute neighbourhoods; strengthening support for development in town centres and restricting out-of-town retail and leisure to encourage a transition away from car-dependent developments and stimulating new models of low carbon living in our rural areas as well as our towns and cities, by facilitating further investment in digital infrastructure, building in more space for people to work remotely and creating community hubs. There may be some conflicts with the **Equalities Act (2010)** and the **Fairer Scotland Duty** due to potential negative differential impacts on affordability for women, LGBT+ people, younger people, older people, people with disabilities, people belonging to ethnic or religious minority groups, and people experiencing socio-economic disadvantage. It may be possible to mitigate these negative impacts through the option design, for example through differential allowances, and the hypothecation of revenue to public transport and active travel improvements

7.5.5 Sustainable Investment Hierarchy

Makes better use of existing capacity

aecom.com

[1] Update to the Climate Change Plan 2018-2032: Securing a Green Recovery on a Path to Net Zero, Scottish Government, December 2020.

[2] A route map to achieve a 20 per cent reduction in car kilometres by 2030, Transport Scotland, January 2022.

[3] Decarbonising the Scottish Transport Sector, Element Energy for Transport Scotland, September 2021.

[4] A route map to achieve a 20 per cent reduction in car kilometres by 2030, Transport Scotland, January 2022.

[5] COVID-19 - Scotland's transport and travel trends during the first six months of the pandemic, Transport Scotland, January 2021.

[6] Scottish Household Survey – Additional Processing by Keith Hoy, 2022.

[7] Professor David Begg & Claire Haigh, Re-charging Britain's Road Policy, 2021.

[8] House of Commons Transport Committee, Road pricing Fourth Report of Session 2021–22.

[9] Curl, A., Clark, J., & Kearns, A. Household car adoption and financial distress in deprived urban communities: A case of forced car ownership? 2018 Transport Policy, 65, 61-71

[10] Transport Scotland, Annex for a route map to achieve a 20 per cent reduction in car kilometres by 2030: Reducing car use for a healthier, fairer, and greener Scotland. 2022.

[11] Transport Scotland, Scottish Transport Statistics 2015, Table 1.20.

[12] TForward, Delivering Better Roads – Wolfson Economics Prize Submission, 2017.

[13] Scotland's Census. Table LC3405SC - Car or van availability by long-term health problem or disability by sex, 2011.

[14] Quayle, Investing in cycling to tackle transport poverty and promote equity. The Scottish Transport Applications and Research (STAR) Conference, 2019.

[15] Legislation.gov.uk, Acts of the Scottish Parliament, Transport (Scotland) Act 2001.

[16] Pricing for Prosperity – Wolfson Economics Prize Submission, 2017,

[17] Badstuber, Nicole, London congestion charge has been a huge success. It's time to change it, The Conversation, 2018 (updated 2019).

[18] Silviya Barrett, Martin Wedderburn and Erica Belcher, Green Light: Next Generation Road User Charging for a Healthier, More Liveable, London.

[19] Centre for Public Impact, London's Congestion Charge, 2016.

[20] Centre for Public Impact, London's Congestion Charge, 2016.

[21] Andrea Broaddus, Michael Browne, Julian Allen, Sustainable Freight: Impacts of the London Congestion Charge and Low Emission Zones, Transportation Research Record, 2015.

[22] Silviya Barrett, Martin Wedderburn and Erica Belcher, Green Light: Next Generation Road User Charging for a Healthier, More Liveable, London.

[23] Brussels SmartMove (2023)

[24] Silviya Barrett, Martin Wedderburn and Erica Belcher, Green Light: Next Generation Road User Charging for a Healthier, More Liveable, London.

[25] Pricing for Prosperity – Wolfson Economics Prize Submission, 2017.

[26] NZ Transport Agency, Social and distributional impacts of time and space-based road pricing, 2019.

[27] TfL, Discounts and exemptions, 2022.

[28] Scott Corfe, Miles Ahead- Road pricing as a fairer form of motoring taxation, The Social Market Foundation, 2022.

[29] Department for Transport, Feasibility study of road pricing in the UK, 2007.

[30] RAC, Telematics Report, 2016.

[31] Scott Corfe, Miles Ahead- Road pricing as a fairer form of motoring taxation, The Social Market Foundation, 2022.

[32] Department for Transport, Feasibility study of road pricing in the UK, 2007.

[33] Silviya Barrett, Martin Wedderburn and Erica Belcher, Green Light: Next Generation Road User Charging for a Healthier, More Liveable, London.

[34] Silviya Barrett, Martin Wedderburn and Erica Belcher, Green Light: Next Generation Road User Charging for a Healthier, More Liveable, London.

[35] NZ Transport Agency, Social and distributional impacts of time and space-based road pricing, 2019.

[36] Jadranka Jovia, Biljana Rankovic Plazinic, Transportation Demand Management in Rural Areas, 4th International Conference “Towards a Humane City”, 2013.

[37] Department for Transport Ireland, Five Cities Demand Management Study, 2021.

[38] Nomis: Official Census and Labour Market Statistics, Location of usual residence and place of work by method of travel to work, 2011.

[39] Transport Scotland, Decriminalised Parking Enforcement: Local Authorities Income and Expenditure: 2020-2021, 2021.

[40] Institute for Public Policy Research – Fair Transition Unit, Fairly reducing car use in Scottish cities - A just transition for transport for low-income households, 2022.

[41] Simon Dale, Matthew Frost, Stephen Ison, Lucy Budd, The impact of the Nottingham Workplace Parking Levy on travel to work mode share, Loughbourgh University, 2019.

[42] Sustrans, Sustrans Response to the Transport (Scotland) Bill – Workplace Parking Levy Amendments, 2019.

[43] Fleet News, Nottingham's parking levy provides air quality advantage, roundtable reveals, 2018.

[44] Nottingham City Council, Workplace Parking Levy (WPL) Evaluation Update – April 2016.

[45] World Wildlife Fund, International Case Studies for Scotlandôs Climate Plan: Workplace Parking Levy, Nottingham, UK, 2017.

[46] Sustrans, Sustrans Response to the Transport (Scotland) Bill – Workplace Parking Levy Amendments, 2019.

[47] Victoria Transport Policy Institute, Parking Pricing, 2019.

[48] International Transport Forum, Reversing Car Dependency: Summary and Conclusions, ITF Roundtable Reports, No 181, 2021.

[49] Ping Qin, Xinye Zheng, Lanlan Wang, Travel mode choice and impact of fuel tax in Beijing, *Environment and Development Economics*, Volume 19, Issue 1, pp 92-110, 2014.

[50] Pricing for Prosperity – Wolfson Economics Prize Submission, 2017.

[51] TForward, Delivering Better Roads – Wolfson Economics Prize Submission, 2017.

[52] Stuart Adam & Rebekah Stroud, A road map for motoring taxation, 2019.

[53] OECD Taxation Working Papers No.44, Taxing vehicles, fuels and road use: Opportunities for improving transport tax practice, 2019.

[54] Mirrlees Review, Tax by Design, 2011.

[55] Tarrino-Ortiz, J., Gomez, J., Soria-Lara, J.A. and Vassallo, J.M., 2022. Analyzing the impact of Low Emission Zones on modal shift. Sustainable Cities and Society, 77, p.103562.

[56] Chilcott, S, Parisian's Ponder Road Space Rationing, 2014.

[57] Gajurel, A, Road space rationing is not the ultimate solution, Face to Face, 2019.

[58] Sustrans, What is a low traffic neighbourhood, 2020.

[59] Thomas, A & Aldred, R (2023) Changes in motor traffic inside London's LTNs and on boundary roads.

[60] International Transport Forum, Reversing Car Dependency: Summary and Conclusions, ITF Roundtable Reports, No 181, 2021.

[61] Municipality of Gent. The Circulation Plan.

[62] Oxfordshire County Council. Traffic Filters.

[63] Department for Transport (2004) Feasibility study of road pricing in the UK - Full report.