Decarbonized Transport

A Smart Growth Approach

A report by Smart Growth UK
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Smart Growth UK

Smart Growth UK is an informal coalition of organisations and individuals who want to promote the Smart Growth approach to planning, transportation and communities. Smart Growth is an international movement dedicated to more sustainable approaches to these issues.

In the UK it is based around a set of principles agreed by the organisations that support the Smart Growth UK coalition in 2013:-

- Urban areas work best when they are compact, with densities appropriate to local circumstances but generally significantly higher than low-density suburbia and avoiding high-rise. In addition to higher density, layouts are needed that prioritize walking, cycling and public transport so that they become the norm.
- We need to reduce our dependence on private motor vehicles by improving public transport, rail-based where possible, and concentrating development in urban areas.
- We should protect the countryside, farmland, natural beauty, open space, soil and biodiversity, avoiding urban sprawl and out-of-town development.
- We should protect and promote local distinctiveness and character and our heritage, respecting and making best use of historic buildings, street forms and settlement patterns.
- We should prioritize regeneration in urban areas and regions where it is needed, emphasising brownfield-first and promoting town centres with a healthy mix of facilities.
- Civic involvement and local economic activity improve the health of communities.

Smart Growth UK would like to thank the following bodies for their input and support:-

All-Party Parliamentary Light Rail Group
Campaign to Protect Rural England
Friends of the Earth
Light Rail UK
Light Rail Transit Association
Transport for Quality of Life

Executive summary

It is clear from the DfT's *Decarbonising Transport* publication that the UK needs to do much more to achieve zero-carbon (Section 1).

Current policies aim to secure the national target of "net-zero by 2050". But, as the climate emergency and responses to it develop, it is becoming clear that faster action is needed and that "net-zero" is not the zero carbon we actually need. It relies on unproven technology and "wriggle room" (Section 2).

The internationally recognised Smart Growth approach emphasis co-ordinating planning, transport and community development in ways which would avoid our default car-dependent, and truck-dependent, sprawl and seek to eliminate the high-carbon transport we use. A Smart Growth approach to spatial planning could help secure decarbonisation of transport (Sections 3.1 and 3.2).

Zero-carbon transport will need a package of investment in rail-based technologies as a move to electric cars and vans would do nothing to reduce their embodied carbon, to eliminate any of the emissions from HGVs or to reduce the non-exhaust emissions from road vehicles. We need a rail-based package of investment in urban rail, rail electrification, rail capacity, rail freight and reopening of closed lines (Section 4.1).

Few UK conurbations have comprehensive rail-based public transport networks and light-rail systems are the most obvious absentee. While all city rail transport from heavy-rail and metro down to ultra-light-rail needs substantial investment, getting every large conurbation at least its first light-rail line must be a priority (Section 4.2).

Rail electrification offers huge advantages for our railways in terms of energy consumption, capacity and carbon reduction but they have been serious victims of Government stop-start policies. We need an ongoing programme of investment aimed eventually at electrifying most or all of Network Rail (Section 4.3).

While HS2 has been sold as the answer to capacity problems on Network Rail, it is an expensive way of relieving capacity in a narrow north-south corridor. We urgently need a nationwide programme of rail capacity improvements, starting with a comprehensive study, followed by substantial investment where it's actually needed (Section 4.4).

Rail freight capacity is desperately lacking on much of the network and needs urgent investment, including reopening of some lines (Section 4.5).

Much of the country has been left bereft of urgently needed rail services by closures which took place throughout the 20th century. We need to address that by a systematic programme of reopening (Section 4.6).

Over-reliance on roads is the biggest challenge for transport decarbonisation and any advantages of electric vehicles would be swallowed up by road building and car-dependent urban sprawl. More sustainable policies are needed (Section 5.1).

There are very good public health reasons, as well as carbon reduction, for restraining traffic as the health effects of traffic in towns are wide-ranging and dangerous (Sections 5.2 and 5.3).

Most urban journeys can be made on public transport or through active travel and we need to deploy the wide range of modern techniques available to restrict traffic in towns (Section 5.4).

Decarbonizing public transport must include substantial investment in bus services and a huge expansion in facilities for active travel in cities, towns and villages is long overdue. We need a multi-billion pound programme to expand urban traffic restraint, bus services and active travel, reductions in road space and consideration of Eco Levies (Sections 5.5, 5.6 and 5.7).

Traffic restraint and moves to more sustainable modes should not be confined to urban areas as cars make a huge contribution to greenhouse gas emissions everywhere, even electrically powered ones. Major road building needs to end, investment should transfer to alternatives and the Eco Levy concept needs applying nationwide (Section 6.1).

Road freight is currently undermining efforts to decarbonize transport as there is little alternative to diesel for HGVs. If we're serious about this, we should be planning a big shift to other modes and radical changes to our distributions systems (Section 6.2).

While claims about the environmental performance of international shipping need treating with caution, opportunities for using water transport in preference to road or air should be explored (Section 7).

Aviation cannot at present be decarbonized in any meaningful way so we should abandon plans for airport expansion and begin a programme of ways to progressively reduce flying (Section 8).

The time has come to move beyond mere ambitions to decarbonize transport and start taking some tough, and potentially politically unpopular, decisions about our transport system (Section 9).

1. Introduction

The future of UK transport policy stands at a crossroads. In March, the Department for Transport published a document called *Decarbonising Transport*[1] and, while it was criticised for offering far too little and defending too much of the status quo, it showed that political will for change exists at the highest levels in Government. But the challenge is immense; as the document admitted: "Transport is now the largest contributor to UK domestic GHG emissions, contributing 28% of UK domestic emissions in 2018. Transport emissions are 4% higher than in 2013 and are only 3% lower than in 1990".

Meanwhile, the 2020 health emergency brought a temporary huge reduction in UK travel by all modes and, while symptomatic of the enormous damage being done to the economy, it also showed the benefits to the environment that can be achieved by a reduction in our normal traffic and flying levels.

The health emergency will pass; the climate emergency will go on getting worse unless we take action now.

Planning is of course underway to address the economic damage the Covid-19 pandemic has caused and one area being discussed is stimulus packages to get money and activity back into the economy. Transport will be a key area. As transport secretary Grant Shapps put it[2]: "Transport has a huge role to play in the economy reaching net zero. The scale of the challenge demands a step change in both the breadth and scale of ambition and we have a duty to act quickly and decisively to reduce emissions".

We strongly agree, but are concerned that current national transport investment priorities will do little or nothing to address that or even, in many cases, will make the position much worse. In England there are plans to expand airports and it has a £27.4bn trunk road programme. Billions more are to be spent in Northern Ireland, Scotland and Wales. The Northern Ireland Executive is most of the way through a 10-year programme[3] to invest £2.013bn in roads. In addition there are some substantial plans for road building by local highway authorities and the Government is also pouring substantial sums into new road access for housing. As ever, such investments would do little or nothing except increase traffic and sharply accelerate greenhouse gas emissions.

In England (and to some extent in the rest of the UK) the Government is promoting car-dependent housing sprawl with money for highway infrastructure to "unlock" these unsustainable developments. It also tacitly supports truck-dependent-sprawl – the vast expansion of lorry-based distribution centres around the trunk road network, particularly motorway junctions.

The biggest single transport investment proposed is HS2. No-one agrees on the likely cost, with figures of £88bn quoted within the project or £106-110bn outside it. Whatever the likely outturn over the next 20 years plus, it would necessitate huge Government borrowing and is being cited as a great potential stimulus.

Supporters of HS2 make many claims for it, but three stand out:-
1. It would reduce greenhouse gas emissions;
2. It would free up capacity on the rest of the rail network;
3. It would bring about economic regeneration in the Midlands and north of England.

These are laudable objectives, although there is bitter disagreement about the extent to which HS2 would actually secure them. We do not intend to enter that debate here; what is clear, however, is that there are better, and less costly, ways of meeting all three objectives by applying a Smart Growth approach. In the circumstances we believe the HS2 project should be paused for a *genuine* review and urgent consideration given to a Smart Growth based transport package to meet these three, and other, objectives.

What is clear from *Decarbonizing Transport* is that current policies will not achieve "net-zero" by 2050 or the actual zero emissions we need very much sooner. To be fair, the "net-zero by 2050" target was created at a time when the full gathering menace of climate change was less fully appreciated and *Decarbonizing Transport* does, implicitly at least, accept that existing policies fall at least a little short.

But we need to go much further and much faster. The Covid-19 emergency put a temporary hold on much of the high-carbon transportation we use, demonstrating how dependent we have become on much of it and how unnecessary other parts of it are. In this report we will examine current policies - and where they fall short - and make recommendations about ways of addressing these issues. Along the way we will make some big recommendations for short and/or medium term capital investment, especially in rail-based technologies. Our recommendations are not the only route to zero-carbon transport but they are *a* route and that is something that nationally is currently lacking.

2. Net-zero or actual zero?

The DfT's *Decarbonising Transport* document is clear about its ambition which is to achieve "net-zero GHG emissions by 2050 and meeting our legal commitments along the way", matching the target set by the Climate Change Act 2009 and the Intergovernmental Panel on Climate Change in 2018 (the Scottish Government hopes to achieve net-zero by 2045). The UK certainly did lead the way in legislating to secure such an outcome, but is it going to be enough?

There are no commonly agreed definitions of the terms "net-zero" or "carbon-neutral". Various people have addressed the concept of climate neutrality in different ways[4], with divergent approaches to time-frames, activities included, their climate impacts and climate mitigation approaches used like decarbonisation or use of offsets, etc.. But some definitions include various methods of greenhouse gas removal (GGR), the reliability of several of which remains to be proven. The Carbon Trust has recommended[5] that emissions should be reduced to the greatest possible extent before any GGR compensation is allowed for. It says that any definition of climate neutrality needs a more prescriptive approach, clearly stating what methods of GGR would be permitted in achieving net zero and which would be legitimate to use and limited to those which are certified for use.

Decarbonising Transport says all transport modes must decarbonise to meet the economy-wide net-zero commitment and admits: "there is no plausible path to net-zero without major transport emissions reductions". We agree, but it also says that: "carbon-capture, utilisation and storage (CCUS) will likely play a role in meeting our net-zero 2050 ambitions".

While the Government admits that international shipping and aviation emissions must be reduced and must be addressed internationally, via ICAO and IMO, "we continue to provide 'headroom' for these emissions within our carbon budgets, meaning that the UK can remain on the right trajectory for net-zero GHG emissions across the whole economy".

"Headroom" in this context is not defined in *Decarbonising Transport*, though the assertion that it allows for international aviation and shipping emissions is made three times within its pages. It is an ill-defined concept but one which Government thinking on aviation and shipping emissions and other issues has included for some years and appears to mean that other sectors must be reduced further to account for failures in the sector in question. As the objective is to reduce emissions by 100% across the board, it is hard to see the utility of this beyond providing misleading "wriggle room" for policy makers.

So, given the reliance on unproven greenhouse gas removal (GGR) and carbon-capture, utilisation and storage (CCUS) technologies, uncertainties over offsets and the flexible meaning of "headroom", there is a great deal of wriggle room in Government policy on emissions and nowhere is that more evident than in the most pressing area – transport. But there is now a growing scientific consensus that, even if "net-zero" could be achieved through a mix of cautious policy changes, offsets, GGR and CCUS by 2050, that is not going to be enough.

3. A Smart Growth approach

3.1 How Smart Growth could help

Smart Growth is an internationally recognised approach to managing our environment that grew out of concerns about urban sprawl, car dependency and the decline of traditional towns and cities. Essentially, it aims to co-ordinate planning, transport planning and community development in an environmentally sustainable way. Thus it favours compact urban communities, laid out to be permeable to active travel and well-served with public transport, rail-based where possible. It is opposed to urban sprawl which encourages car-dependency and destroys both agricultural production and biodiversity and to the growth of motorway-dependent distribution systems which bring sprawl of a different kind.

A key element of this is securing an increase in low-energy, rail-based transport for passengers and freight and a move away from road transport dependency. Thus we advocate investment in rail technology, with a mixture of light-rail, metro and heavy-rail in our cities (and around them), in heavy-rail for both passengers and freight for inter-urban and rural journeys were possible. We are not, contrary to some claims, opposed to high-speed rail but we believe there are more pressing rail investment needs which must be advanced before we even think seriously about ultra-high-speed schemes, and any such scheme must to be carefully and properly designed and scrutinised.

In this report we look at a package of the kinds of rail investment which should precede any high-speed rail system and which would go most or all of the way to meeting the claims made by HS2 about greenhouse gas emissions, rail capacity improvements and regional regeneration.

We also look at the radical changes needed in roads and airports policy and at some of the radical planning changes we need if transport is to be decarbonized.

On the roads we advocate an end to the major road building programme, limiting future schemes to access, road safety and traffic restraint measures and a big increase in active travel infrastructure. A very significant reduction in traffic in towns is now essential and practicable as the health emergency demonstrated. But there is a need to reduce traffic commuting into towns, moving between towns and even on rural journeys too. The big intractable, and the most urgent from the greenhouse gas emission point of view, is to recast our distribution and delivery systems to secure a very big reduction in lorry mileage.

Most immediate perhaps, in the planning sphere we advocate a Smart Growth approach – anti-sprawl and compact, permeable towns – which has achieved so much elsewhere

in the world. These are proven techniques which would enable us to live better and which would help us to reduce and ultimately eliminate greenhouse gas emissions.

3.2 How planning can help achieve zero-carbon transport

The potential to reduce transport emissions by reducing the *need* for people and goods to move around is immense, but there is almost nothing in the DfT's *Decarbonising Transport: Setting the Challenge* about it. It has much to say about "place-based solutions" and promises that: "We will work with local authorities and other regional bodies to identify and support place-based solutions for the greatest polluting areas, to help enable lower carbon communities. A range of potential measures will be considered to encourage progress, recognising that different areas will need different combinations of solutions".

But it is evident from the document that it's simply because emissions vary from place to place that work would be done "to consider how local management of transport system can best address emissions at a local level". There is no suggestion that our whole approach to place needs changing.

Indeed, any detailed analysis of how land use planning could interact with the transport system to lower emissions is lacking. Yet we believe this is one of the most profound opportunities to reduce greenhouse gas emissions.

For nearly a century now, our default way of creating major new developments has been what can be summed up as "car-dependent sprawl". The garden suburb type of development favoured by governments and found to be most profitable by house builders includes a range of features which ensure that the majority of its journeys are made by car:-

- low-density;
- layouts, such as cul-de-sacs, which hinder walking and cycling;
- remoteness from comprehensive rail-based public transport;
- distance from public transport stops in general and low-frequency services;
- remoteness from shops, employment and other basic infrastructure;
- remoteness from employment areas.

The Smart Growth approach rejects this kind of development and favours:-

- medium-densities;
- layouts permeable to walking and cycling;
- transit-oriented development
- brownfield-first;
- preferring development locations in existing urban areas.

On the freight side too, decades of national transport planning has left us with a distribution system hopelessly dependent on diesel-powered HGVs and, increasingly, massive distribution depots wholly dependent on road transport. This has led to a

degree of "truck-dependent sprawl close to motorway and other trunk road junctions. We urgently need to rediscover efficient distribution systems which are not dependent on high-carbon development.

We recommend that:-

- **national and local planning policy in England and the devolved administrations incorporate Smart Growth type policies designed to reduce the amount of passenger and freight movement by high-carbon modes;**
- **national research be instituted to plan ways of moving freight which progressively reduces and eliminates HGV mileage.**

4. Investing in our railways

4.1 A rail-based package of investment

Despite the national ambition for "net-zero" by 2050, it is fast becoming clear we will need to have done most of the work needed long before that. A great deal has been achieved in decarbonising the nation's electricity supply, though much remains to be done. There have been substantial achievements too in decarbonising our building stock and our industries, though in both these areas there remains a huge challenge ahead. But the area which remains to be seriously addressed is transport.

While there is growing agreement that carbon dioxide emissions from vehicle tail-pipes and from their manufacture are some of the most urgent issues to address from the climate-change point-of-view, much of the current policy is based on a move to electric cars and vans. Yet this would do nothing to remove the very high levels of carbon embodied in the manufacture and scrappage of road vehicles, nor would it do anything to remove the emissions from heavy goods vehicles (HGVs). But there is also growing awareness of the other dangers of exhaust emissions on human health; decarbonisation programmes do not include the pollutants produced by the rubber wheel/road interface as defined by the DEFRA's recent report on *Non-Exhaust-Emissions from Road Traffic*[6], so there must be considerable concern about the intention to replace cars and vans by heavier hybrid or battery vehicles. Non-exhaust-emissions (NEE) account for higher levels of harmful micro-particles than tail pipe emissions and, according to WHO, there are no safe minimum levels.

A great deal has been achieved in decarbonising the nation's electricity supply, though much remains to be done. There have been substantial achievements too in decarbonising our building stock and our industries, though in both these areas there remains a huge challenge ahead. But the area which remains to be seriously addressed

is transport and this is as true in the cities as outside. Yet, in many ways, decarbonising city transport offers quicker hits than inter-urban or rural.

If we were to invest in a major package of rail-based transport in the UK, with the objectives of reducing greenhouse gas emissions, freeing up rail capacity and stimulating economic growth in regions that need it, what would such a package look like? We suggest five areas where investment might primarily be made to produce a mixture of short and medium-term benefits:-

- Urban rail passenger services: Light rail/metro systems in all conurbations over 250,000 population. This would mean starter lines in cities that don't have them and some extensions in those that have them already. There is also scope for highly cost-effective ultra-light trams which could see smaller towns enjoying starter lines too.
- Rail electrification: The first stage would be the shovel-ready schemes, to be followed by a rolling programme to electrify all main lines and significantly trafficked routes, as well as tram-train opportunities.
- Rail capacity improvements: Starting with shovel-ready schemes awaiting funding, again as the start of a long-term rolling programme.
- National rail freight investments: To include upgraded route capacity, transhipment depots etc..
- Rail reopenings: Moving on from "Reversing Beeching" with more openings of key lines like Matlock-Buxton as the first phase of a long-term rolling programme.

4.2 Rerailing the cities

Proponents of HS2 point to the carbon benefits of people exchanging their cars on inter-urban roads for trains, but there are huge gains to be made by tackling the gridlock in our cities. Modern metro and light-rail systems, coupled with expansion of heavy rail services, could achieve this with just a small percentage of the cash earmarked for HS2. It could be done more quickly and it could be done with far less environmental damage. There are few ancient woodlands and little of our most productive farmland in our cities and neither is likely to be the site for a new tramline.

In the 40 years up to 1962, every UK city eliminated its electric tram systems; most had had little investment, they were hidebound by restrictive legislation and, worst of all perhaps, they became unfashionable. In much of the rest of the world, however, that spurred modernisation and hundreds of cities have continued to enjoy the smooth, attractive, low-energy public transport that light-rail installations offer. Hundreds more, even in the once car-obsessed United States, have installed new systems, including a handful of UK cities.

There is a degree of confusion about what exactly is meant by the terms "tram", "light-rail", "metro", "heavy rail" etc.. In recent times, the flexibility of lighter systems has been extended by the development of tram-train systems capable of running in both heavy

and light rail alignments and today technology is making available even lighter options, including “ultra-light-rail”. We do not intend to indulge in sterile debates over what is meant by which term because each town and city has its own individual needs, its own existing rail infrastructure and its own individual preferences and these are likely to include a mix of options.

Significantly under-represented in the UK, however, light-rail or tram systems (however defined) are an efficient way of moving large numbers of people in towns and cities from 150,000 citizens upwards and can cope with 2,000-18,000 passengers per hour. They have a proven record in attracting people out of cars; the rate of modal transfer from car to tram at peak times is typically around 27%. This compares with estimates of between 4% and 6.5% for quality bus investment. Levels of traffic reduction from trams are typically around six times greater than with bus schemes.

A tramway will improve the image of any city that installs one and assist urban regeneration – “shiny rails instill investor confidence”. All UK systems have had positive effects on the image of the city in which they have been built and have brought inward investment, business and tourism, sometimes to the detriment of their non-tram neighbours.

As part of an integrated public transport system, light-rail systems can attract motorists out of their cars and reduce vehicles in city-centres, particularly in conjunction with park-and-ride, so reducing demand for city-centre parking, freeing up space for other development. While buses must continue to provide much of our public transport provision in a zero-carbon future, conversion of heavily trafficked bus corridors to light-rail will replace many of the buses with fewer trams, providing the same passenger-carrying capacity.

In the largest cities, underground, metro and heavy-rail suburban services tend to be the mainstay of public transport and opportunities to increase their coverage need to be seized. But such cities can still use light-rail solutions to supplement other facilities. Light-rail/tram is most appropriate in urban or inter-urban systems in cities where full metro systems are inappropriate. Light-rail vehicles are more versatile than heavy-rail trains and have street-running capability as they can negotiate the sharper curves and steeper gradients of the urban environment and can stop much faster, so operating in line-of-sight mode without major signaling.

They offer some of the readiest alternatives to car use - Manchester Metrolink registered a modal switch approaching 32%. Light-rail can move large passenger flows more cost-effectively than buses at a fraction of the cost of a full urban railway. While buses must continue to provide much of our public transport provision in a zero-carbon future, conversion of heavily trafficked bus corridors to light-rail will replace many of the buses with fewer trams, providing the same passenger-carrying capacity.

There is emerging evidence that, during the Covid-19 epidemic which severely reduced connectivity by public transport, UK light-rail systems were able to carry more socially distanced passengers by their layout; all stops are generally open-air and vehicles have positive air conditioning.

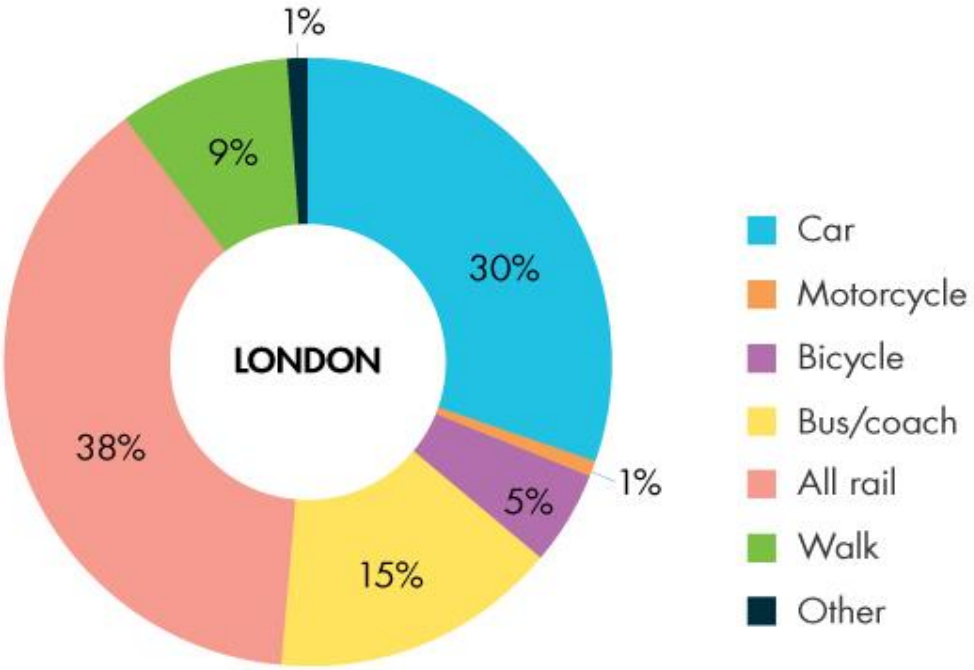
Exact definitions of what is a "conurbation" or an "urban area" are elusive, but most UK cities are significantly short of dense networks of rail-based public passenger transport of any kind.

The Office for National Statistics uses the term "built-up area" and a list of those with populations over 100,000 in the UK is included in Appendix 1. Some are arguably not really conurbations in the city public transport sense at all, but in the rest of the world city public transport systems frequently extend to adjacent towns and cities, though less often in the UK. But the list is the best we have.

In the UK, only six of the larger conurbations (Edinburgh, Greater London (Croydon-based), Greater Manchester, Nottingham, Sheffield and the West Midlands) and one smaller conurbation (Blackpool) have modern light-rail systems. Metro systems in the conventional sense are harder to specify. The capital has the London Underground system and there are "light metros" in Glasgow, London Docklands and Tyne & Wear. In the metropolitan areas, heavy rail suburban rail passenger services are mostly electrified and organised as discrete systems on metro lines, though they are part of the Network Rail system. Indeed, if there is an obvious division, it is between light-rail/light-metro systems and heavy-rail metro/suburban rail systems. As with "light-rail", we do not intend to enter sterile debates here about where metro systems end and suburban heavy-rail begins because both need investment if our cities are to get the sustainable rail-based transport they urgently need.

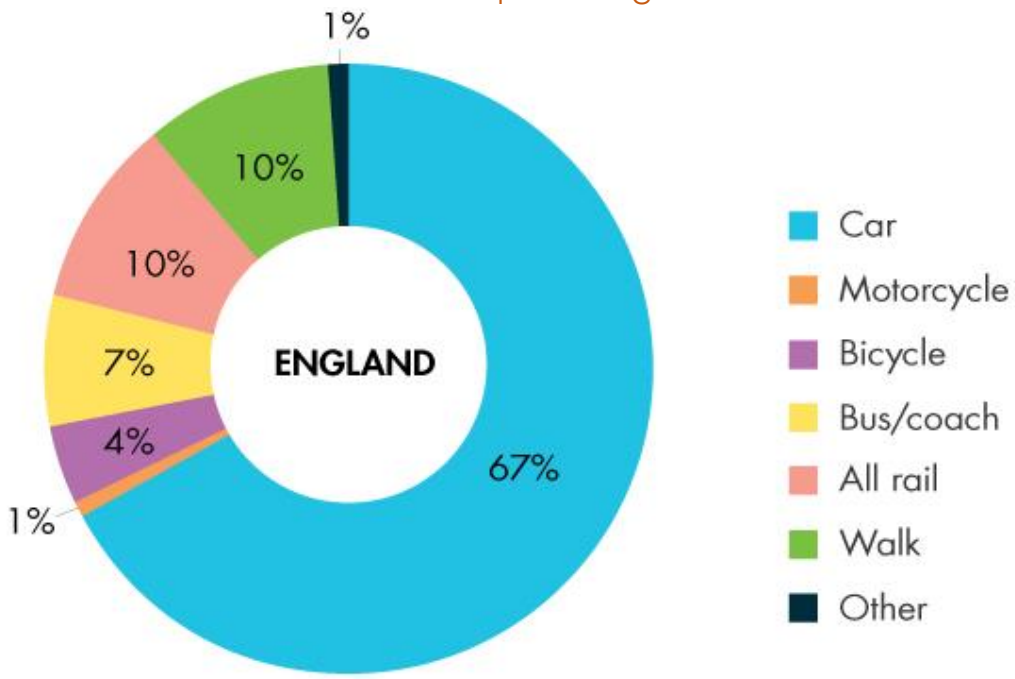
The shortage of rail-based commuting opportunities is evident even in the city with the densest network – London.

Commuters usual mode of transport – London



Source: CBRE/Department for Transport

Commuters' usual mode of transport – England



Source: CBRE/Department for Transport

Of course this is trips, rather than passenger-km, but there is a degree of comparability between car and rail.

Overall, the lack of rail-based transportation in many of the conurbations, including some of the larger ones, is striking and it compares unfavourably with most advanced nations. No UK city could be said to have a fully comprehensive network of light-rail lines to complement what metro/heavy rail they have. A handful of other lines are in the pipeline and several of our conurbations have had major proposals (some of them of long-standing) to work towards comprehensive systems. But all are aware the national approval process is complex and can appear deliberately designed to frustrate public transport. And there is always the threat of Whitehall's financial axe falling on proposals which are at an advanced stage or even where construction is underway. The sector has not forgotten the events of 2004 when new light-rail lines in Greater Manchester, Leeds, Portsmouth and Liverpool were axed by the Government at an advanced stage.

In the Smart Growth UK response to the 2019 Government consultation on light-rail, we urged adoption of a "pipeline" for light-rail investment. This would have a number of advantages. It would give light-rail promoters the certainty that funding would become available, it would eliminate the stop-go which has been such a destructive feature of national investment in rail projects generally and it would enable a real start to be made on an objective long overdue; decarbonising city transport.

The biggest hits will be achieved in the biggest cities and, happily, it is here where the big investments in rail-based transit can be most easily justified in financial terms. But

we also need to go beyond that and look at smaller cities and large towns and ask what opportunities exist there.

Light-rail and light-metro: As mentioned above, only six UK conurbations with populations above 250,000 have light-rail systems and three have light-metro systems. No less than 24 with populations above a quarter of a million have neither. All have some heavy-rail suburban systems (a few of them organised on metro lines) but in many cases this is fairly vestigial and provides little of their day-to-day passenger movement. Essentially, even in these very big cities, it is mostly cars and buses.

So, as a primary package of investment, we recommend creating a high-standard light-rail/tram line in all these 24 areas to give them all a flying start towards developing comprehensive systems. For most, that would involve a line running through the city-centre with termini at either end in the suburbs, plus a depot and associated infrastructure. This is the most costly and challenging part of any light-rail system and provides a basis for later routes which can use the depot and city-centre capacity and so can be built very much more cheaply and drive up ridership. This is the experience of hundreds of modern light-rail projects across the world.

The emergence of ultra-light-trams could enable much smaller towns to have a starter line at around £9-15m per track mile using on-board power, certainly in built up areas. The WebTag accountancy period also needs to be amended to allow costs to be spread over the inter-generational life. As some European systems have now celebrated their 125th year of operations, this shows that urban trams can be very significantly cheaper than other modes over their working lives.

The cost of building an initial large conurbation light-rail line can vary significantly but we suggest a ball-park figure of £400m for the first line in each city. Some would be rather more and some less, but that should get one high-quality line with articulated vehicles, a city centre route, a depot etc.. Doing that in all 24 250,000+ conurbations would thus cost a little over £9bn. Extending that to a handful of smaller cities, plus allowing for contingencies, suggests an initial pot of £10bn for this work. In addition we recommend a £5bn pot for developing innovative light-rail/tram/ultra-light-rail projects.

Heavy-rail and heavy-metro: Building new urban railways and metro systems, often involving extensive tunnelling is expensive, but often these are the best solutions to city transport systems, particularly when long-distance commuting is involved. In some cities, even the largest, not all the heavy-rail network is even electrified, so such systems would benefit from the electrification we recommend in the next section.

The need for such work is hard to gauge and considerable sums would be involved. To meet a need for urgent work in this area we suggest a pot of £5bn, though plainly greater sums will be needed for the longer-term.

Lighter-rail-based-systems: Light-rail technology has moved forward at a surprising rate and now offers a range of solutions for both large cities and smaller urban areas. Where once conventional wisdom said light-rail wouldn't work in any UK city with populations below 250,000, cities with much smaller populations (down to 150,000 or lower) are now looking at light-rail as an attractive low-carbon solution. In some cases it will be possible to power these vehicles with alternatives to overhead wires – batteries, hydrogen etc. – at least over relatively short distances.

Once such technologies become established and, more importantly in the UK, accepted, the possibilities become huge. There are nearly 50 UK conurbations with populations between 100,000 and 250,000 and only one currently has a light-rail system.

Estimates of the cost depend on the type of system chosen and the characteristics of the location. But some estimates suggest that, in the right situations, such schemes can cost less than £10m per km, including the cost of vehicles and infrastructure.

To get such systems up and running, as stated above, we suggest the pot of £5bn for innovative light-rail and tram schemes should include help to make such technology mainstream in smaller cities and larger towns - and even in larger cities and smaller towns - where opportunities or need arise.

The bus alternative?: For nearly a hundred years now, many municipalities have believed that buses can provide most of the public transport needed, even in the bigger cities. To this end, hundreds of tramways were replaced with buses from the inter-war period onwards. At first this involved replacement with electrically powered trolleybuses but these too fell out of fashion and the last UK system was abandoned in 1972.

Bus services will always provide much of our public transport. They are much cheaper to install than rail-based and can serve places where population density (and ridership) is lower than is practicable to serve by tram, even though modern technologies are reducing that gap. But the other oft-cited "advantage" – that buses can go wherever they like and are not restricted to their rails or overhead wires like trams or trolleybuses is scarcely an advantage at all. A basic requirement of public transport is that it operates along fixed routes with predictable stopping places.

Buses will always provide the backbone of our public transport in much of the country. But in cities, and in very large towns, they have a number of disadvantages compared to trams:

- they offer a much bumpier ride;
- they have been shown to be much poorer at encouraging people to leave their cars;
- many are still diesel powered and emit greenhouse gases and other pollutants;
- they emit high levels of harmful NEE particulates from tyres, brakes and road surface wear (see Box on the "Oslo Effect");

- they have lower passenger capacities than the largest light-rail vehicles;
- bus services are easier to abolish than light-rail.

In recent decades, bus enthusiasts have tried to overcome some of these disadvantages with "guided-bus" systems which involve creating dedicated road space with guidance systems with specially adapted buses alone able to use them. They have generally proved expensive to build, poorer at attracting passengers out of cars and expensive to maintain. Their vehicles have all the disadvantages of buses: higher-energy use, air pollution and particulates and rough riding. We recommend that municipalities operating such systems should have access to the funding pots we recommend to convert them to light-rail.

Why rail-based? The "Oslo Effect" (NEE)

Air pollution in cities is a killer, estimated to cause tens of thousands of premature deaths every year (see Section 5.3 below). Much of this is the result of harmful particulate matter (PM) emitted by road vehicles. Attention has mostly focused on internal combustion (IC) powered vehicles' exhaust emissions which include both particles less than 10µm diameter (PM_{10}) and less than 2.5µm ($PM_{2.5}$). Advocates of a switch to electric vehicles (EVs) suggest it would result in reduced particulate emissions but this is not necessarily the case. IC exhausts are mostly $PM_{2.5}$s which have been viewed as the most dangerous, but PM_{10}s also have an effect on mortality. All vehicles, however, also emit PMs from tyre wear, brake wear, road surface wear and resuspension of road dust. Unlike exhaust emissions, such particulates are mostly inorganic PM_{10}s but these too have an effect on mortality and they also result in secondary inorganic aerosols. But studies are showing a switch to EVs would not significantly reduce PM emissions, thanks to non-exhaust emissions[7]. This has been dubbed the "Oslo Effect" after the city where it was first identified. As EVs tend to be heavier than equivalent IC vehicles, EVs' PM_{10} emissions have been found to be equivalent to ICs and $PM_{2.5}$s only 1-3% lower; non-exhaust emissions now account for over 90% of PM_{10}s and 85% of $PM_{2.5}$s from traffic. Meanwhile a recent DEFRA report[8] showed that tyre particles are also a major source of the microplastics contaminating our oceans etc.. So a switch to EVs is unlikely to yield much benefit on air pollution. Of course there are greenhouse gas benefits to moving people from cars to buses, however powered, but to secure the air pollution benefits of this switch to public transport, it will be necessary to switch to rail-based solutions which largely eliminate PM emissions.

We recommend that:-

- **a £10bn fund be made available for creating initial light-rail lines in major cities as the first stage of a rolling programme;**
- **a £5bn fund be made available for developing heavy-rail passenger and metro services in cities;**
- **a £5bn fund be made available for innovative light-rail/tram/ultra-light-rail projects;**
- **funds be made available within these programmes to municipal operators of guided-bus systems to enable their conversion to light-rail;**
- **funds be made available for three feasibility studies and Webtag/Stag business cases annually for new systems**
- **a hydrogen/biomethane tram be imported as a demonstrator.**

4.3 Electrifying the railways

A surprisingly small percentage of the UK railway network is electrified. Presently some 13,045 single-track km of Network Rail are electrified out of 31,046, just 42%. There is no electrified mileage in Northern Ireland. In recent years the Government has given little support to continuing electrification of the network in Britain and large parts of the plans to electrify the Midland and Western mainlines were ditched in 2017. The lack of electrified lines contrasts badly with Europe.

In February 2018, the then rail minister Jo Johnson called on the rail industry to remove diesel-only trains from the network by 2040, although electro-diesel bi-mode trains would be permitted beyond that date. However, the report of the Rail Industry Decarbonisation Taskforce[9] the following year concluded that bi-mode trains could not be part of any permanent solution if net-zero were to be achieved. The Taskforce recommended that the Government should have a clear policy of expecting the rail industry to pursue a suitable mix of zero-carbon traction technologies. That, effectively, put the pressure on to electrify the UK's railways.

Electrified railways have a number of advantages:-

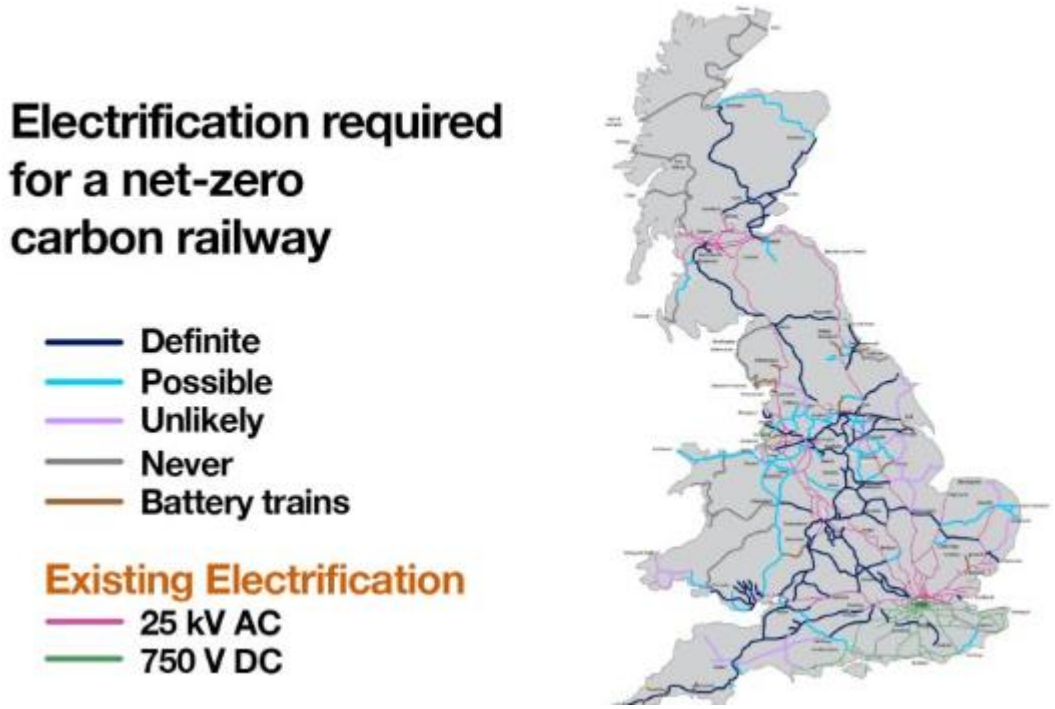
- They can accelerate and run faster than diesels, improving line capacity;
- They emit no significant air pollution
- Their energy can come from non-fossil sources;
- They don't carry heavy diesel engines around, so reducing energy consumption;
- They are quieter than diesels.

Decarbonising rail transport will mean electrifying most of the current Network Rail mileage. There are alternatives to diesel for some lightly used passenger lines including battery power, hydrogen and some alternative liquid fuels such as biofuels. However, these are not an option for freight or high-speed passenger lines. As *Decarbonising Transport* concluded: "The challenge for rail freight is that current alternatives to overhead electrification, such as hydrogen or battery, do not have sufficient power to pull heavy freight trains". Freight trains currently account for 29% of GB rail traction emissions and only about 13% of rail freight is hauled by electric locomotives.

The Rail Industry Decarbonising Taskforce recommended a future of electrification, together with some hydrogen and battery trains on lightly used lines where investment in electrification might not be justified, despite their disadvantages. It recommended that at least 4,250 route km of Network Rail be electrified, although it has not yet actually specified which. A draft of the final strategy, reportedly[10] shown to the Rail Industry Association in May, will recommend that 80% of the Network Rail system be electrified by 2050.

An analysis of the Taskforce report by *Rail Engineer* magazine[11] attempted to fill this gap by assessing non-electrified mileage against a number of factors and categorised them as "definite", "possible", "unlikely but possible" and "never". It concluded that

4,327km would require electrification under the definite scenario (close to the Taskforce recommendation), 5,993km if the "possible" lines were included and 7,029km if the "unlikely" lines were also added (which would leave just 1,401km of Network Rail unelectrified). To electrify the basic 4,327km by 2050 would necessitate 144 route km being electrified each year, only around 50% more than the extremely low figure of recent years.



Source: *Rail Engineer*, March 2020

From the point of view of this analysis, rail electrification certainly meets two of the prime objectives – reducing greenhouse gas emissions and freeing up rail capacity and the more of the network that is electrified, the greater the benefits would be.

But we are also concerned here with stimulating the economy in the short and medium-terms. And here rail electrification offers very real opportunities. In the very short-term the electrification of schemes brought to a halt in 2017, could be unpaused as is now the case with the trans-Pennine link.

Recent policy with regard to rail electrification has been extremely unsatisfactory for a whole number of reasons. It has seen the halting of the Midland Mainline (MML) electrification from Kettering to Sheffield, the Great Western electrification from Cardiff to Swansea and the branch from Oxenholme to Windermere. Currently just 24 route km of line, from Bolton to Wigan and Huddersfield to Dewsbury, are scheduled for electrification.

The stop-start MML electrification from Bedford north to Nottingham, Derby and Sheffield was originally approved in 2012, paused and then restarted in 2015 with a target of completing it throughout by 2023 and then truncated north of Kettering in

2017 on the belief that bi-mode trains could do the job as well. (In 2019 the electrification scheme was extended slightly to Market Harborough.) Presently the section between Clay Cross and Sheffield is due to be electrified by 2033 as part of HS2 which would leave a non-electrified gap of just 70 miles between Market Harborough and Clay Cross.

The electrification of the Great Western was also truncated in 2017. The scheme originally approved involved electrifying from London to Bristol, Swansea, Newbury and Oxford. In 2017, at the same time as the MML electrification was truncated, so were the sections of the GW electrification from Cardiff to Swansea, Didcot to Oxford and Chippenham to Bath and Bristol. The DfT argued that the new bi-mode trains could do the job; these were subsequently shown to be unable to match the 125mph top speed of the HSTs they were replacing when running with a high passenger load on diesel power, even on level track. Electrification of the Oxenholme-Windermere branch was also axed at the same time.

Plans to electrify the Trans-Pennine route between York and Manchester were first approved in 2011 as part of a £38bn upgrade of railways in the north of England. The electrification scheme was originally expected to be completed by 2019. In 2015 it was delayed indefinitely for further work, then unpaused the same year with a start date put back to 2022. Then, in 2017, the transport secretary said it would be "too difficult" to proceed with electrification from Leeds to Manchester throughout and, once again, bi-mode trains were suggested as a solution. In 2019, plans were put forward to quadruple and electrify only the eight miles between Huddersfield and Dewsbury. The stop-start-stop-start plans for the electrification saw the red light clear to green once again in July 2020, with approval for electrification between Leeds, Huddersfield and Manchester[12].

The cancellations of electrification of the MML, Great Western to Swansea and Oxenholme-Windermere were the subject of a National Audit Office report[13] which found that bi-mode trains for the MML with the required speed and acceleration did not exist when the transport secretary took his decision. The NAO concluded it was too early to tell whether the benefits of electrification could be delivered by other means.

Whatever the merits of the decisions to axe the various schemes, it is clear that, if the Government is at all serious about its commitment to decarbonise transport, these lines and very much more would need to be electrified. And what is also clear is that work could restart very rapidly, enabling stimulus benefits to roll quickly and allowing the beginning of a "pipeline" of electrification to secure wiring of the bulk of the network in a timely fashion. But what we have seen in the past decade is schemes being approved, paused, restarted, cancelled and, in a few cases, revived. No industrial investment of any kind can proceed under those circumstances and plainly central government policy which does not involve such destructive stop-start must be a central feature of any national transport policy.

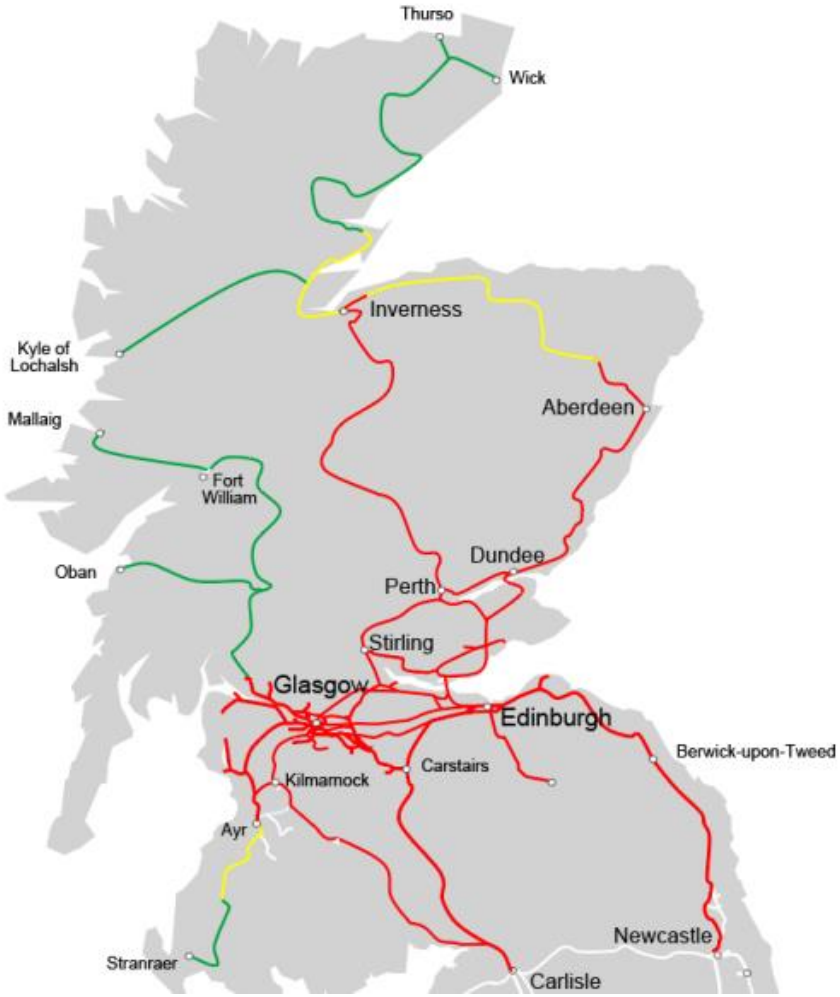
Rising costs were cited as the reason for the 2017 cancellations, with that on the Great Western rising to £2.3m per single track km. Work by the Railway Industry Association

suggested these cost rises were an aberration and that electrification should cost between £1m and £1.5m per single track km. The *Rail Engineer* article says that, on the assumption that each route km involves around 2.5 single-track kilometres of electrification, the cost of electrifying the 4,327 route km of its "definite" schemes would cost about £14bn. And delivering that by dedicated planning/design/construction teams as part of a rolling programme could reduce that still further.

Such extensive electrification would produce huge benefits in terms of greenhouse gas reductions and increased rail network capacity, as well as spin-offs for regional regeneration. There is little reason why this first phase of electrifying Network Rail should not be complete by 2030 or soon afterwards and the programme should continue thereafter for much of the rest of the network. The 80% by 2050 strategy falls far short of what's needed for decarbonisation, and should be completed in the 2030s.

Scotland: The Scottish Government has, however, recently moved ahead in meeting the need for rail electrification. Its *Rail Services Decarbonisation Action Plan*[14] sets out plans to decarbonise passenger rail services by 2035, involving electrification of major routes and using alternative technologies elsewhere.

Transport Scotland's Plans for a Decarbonized Rail Network in 2035



Source: *Transport Scotland*

The *Plan* envisages a combination of electrification, battery and hydrogen power and modal shift. Central to this is extensive rail electrification. Full electrification is proposed on all major routes, alternative traction as a temporary measure on the Inverurie-Tain and Ayr-Girvan lines and alternative traction on Wick/Thurso-Tain, Kyle of Lochalsh-Dingwall, Mallaig/Oban-Glasgow and Stranraer to Girvan lines. To achieve the 2030 target would mean, on average, 130 single-track km being electrified each year. Transport Scotland says that a commitment to a long-term programme, rather than an intermittent schedule with inherent peaks and troughs, would create opportunities for the rail supply industry to implement innovative and appropriate technologies and secure greater efficiencies.

Northern Ireland: None of Northern Ireland Railways' 354km network is presently electrified. The Northern Ireland Executive is believed to have carried out a scoping exercise for electrification in 2013-4 but no action was taken and the subsequent suspension of Stormont put such ideas on ice. Capacity enhancements including double tracking the cross-harbour Durgan Bridge and third tracks between Lagan Junction and Lanyon Place and between Great Victoria Street and Adelaide. There has also been discussion within both jurisdictions of electrifying the Belfast-Dublin-Cork route.

We recommend that:-

- **a £15bn stimulus programme be initiated for rail electrification**;
- **the Government commit to a rolling programme of electrification to secure an initial 4,500 route km of electrification by 2030 and to complete electrification of most of the network in the 2030s.**

4.4 Growing rail capacity

In its publicity, HS2 Ltd says: "In many places the rail network is over-crowded and unreliable with rail journeys slow and uncomfortable"[15]. This is perfectly true. It might have added that freight services are also limited by capacity problems. We have spent around a century under-investing in our rail networks and our urban transit and nearly as long casually destroying our railways to invest in unsustainable transport modes.

"Commuter and inter-city lines serving London, Birmingham and Manchester are under particular pressure," says the website. "Therefore, there are suggestions to upgrade existing routes, like the Grand Central [*sic*] route between the Midlands and London."

The closed Great Central route has long exercised a fascination on those who advocate new rail capacity between London and the Midlands and there are indeed serious capacity problems on the three main lines from London to the Midlands and North. But although relief is needed and HS2 would undoubtedly provide some, we are far from convinced that it provides an optimal solution nor that it represents value for money. It is over-specified and over-engineered, its business case is poor, its carbon-reduction case non-existent and it is poorly integrated with the national rail network. At best it needs a complete redesign; at worst it needs to be scrapped and alternatives

considered. It would do nothing for rail capacity before its scheduled opening dates in the 2030s and relief is needed before that. The climate emergency will not wait for Whitehall to build an overblown political vanity project.

Above all, perhaps, it would do nothing for rail capacity outside the north-south corridor from London to Birmingham and the northern cities; indeed, in some cases, it could actually reduce it. But although capacity problems are chronic on "commuter and inter-city lines serving London Birmingham and Manchester", there are serious problems elsewhere. HS2 would do nothing for rail capacity in the south and west of England, East Anglia, Wales or Northern Ireland and surprisingly little for east-west movement even within its own corridor.

A national review of capacity problems throughout Network Rail is urgently needed. Despite claims that all alternatives to HS2 have been examined and dismissed, it is clear that no fully independent study giving equal weight to alternatives has yet been carried out and neither was it provided by the Department for Transport's *Oakervee Review*[16]. This was simply limited to "whether and how we proceed" with HS2. Although the *Review* failed to produce a united view and generated a critical minority report from its vice-chair Lord Berkeley, none of this was reflected in its final report which effectively said the DfT, which had commissioned the report, was pursuing the correct policy.

In his *Dissenting Report*[17] to the *Oakervee Review*, vice-chair Lord Berkeley did set out a range of capacity improvements which could achieve the same capacity increments as HS2 at much lower cost. His recommendations are set out in Appendix 2.

Much of the package of improvements proposed by Lord Berkeley would fall into the recommendations of our other sections: Section 4.2 (urban rail), Section 4.3 (electrification), Section 4.5 (freight) and Section 4.6 (railway reopening), although many would have multiple benefits. It did, however, also propose many straightforward capacity improvements. On the other hand, Lord Berkeley's recommendations offered no capacity improvement in the south or west of England, East Anglia, Wales or Northern Ireland – also weaknesses of HS2.

Lord Berkeley has, however, now also recommended a £1.2bn Great South West Plan to increase the capacity of the rail network in south-west England, using Network Rail's new "rail method of measurement" to improve cost certainty.

The recommended schemes in the south-west are:-

- reinstatement of double track between Exeter, Yeovil and Salisbury (£382.3m);
- reopening the railway between Okehampton, Tavistock and Bere Alston and upgrading existing sections to create an alternative to the storm-damage-prone Exeter – Plymouth main line (£426.5m);
- upgrading the Exeter – Barnstable line (£17.25m);
- reopening the Bodmin – Padstow line (£31.8m);
- reopening the Lostwithiel – Fowey freight line to passenger trains (£5.25m);
- reopening the direct link between Newquay and St Austell (£181.5m);

- upgrading the Taunton – Minehead West Somerset Railway heritage line (£11.8m).

The estimated cost of all the HS2-alternative improvements recommended by Lord Berkeley would be £58.5bn and those in the south-west £1.2bn. Without detailed costings, it is unclear what percentage of that would fall into other rail sections of the report, or how many would overlap, but it would certainly be substantial. Against this, we also need to add the cost of capacity improvements in the other parts of the UK we specified above.

It is also worth noting at this point that, although significant parts of the network are facing capacity problems, other parts are underused, for a variety of reasons. In some cases passenger usage may be light because of low population density, but this is not the case in much of the UK. Low frequency services, low quality trains, poor integration with other public transport, failure to promote services and competition from heavily invested road transport may all play a part. And that is also true of rail freight.

We are probably talking about a package of £50bn to get a major programme of capacity improvements at least underway over the next decade or so across the whole UK. Some of those proposed by Lord Berkeley are "shovel-ready" or almost so and include programmes curtailed while actually being implemented like the MML electrification. We should begin with a smaller, but still substantial, package agreed by rail experts spread across the rest of this decade, with huge benefits to sustainable transport and ensure it is the beginning of a rolling programme to eliminate serious capacity restrictions across Network Rail.

We recommend:-

- **that a fully independent study be set up to recommend priorities for investment in capacity on Network Rail;**
- **that a new additional £25bn fund be created to begin to accelerate rail capacity improvements across the UK.**

4.5 Helping rail freight

Although rail freight volumes have appeared fairly stable in recent years, this disguises huge changes in the sector. Even in recent decades tonnages were dominated by coal moving from pit to power station, but this traffic has almost ceased and been replaced by other traffics. In 2013-14, rail freight exceeded 22bn net tonne km, but by 2016-17 this had fallen to 17.2bn net tonne km and it continued to fall as coal traffic disappeared.

But given the huge loss of coal traffic, the fact that overall tonnages have fallen much less is testament to the underlying growth of other traffics. Currently rail freight contributes an estimated £870m to the economy, the economy moves goods worth £30bn and, as each train takes an average 60 HGVs off the road, it contributes hugely to our response to climate change.

But changing traffic patterns mean rail freight is using different parts of the network so, while capacity has been freed up in some areas, it has created fresh capacity problems elsewhere. Much of this is traffic to the ports, so currently only about one in four sea containers arriving at a UK port continues its journey by rail and there is plainly scope for growth here. An enormous amount of freight now lends itself to intermodal transport, and there is big potential for substantial growth in other traffics.

Two things militate against such growth, however. One is the continuing bias in favour of road freight in national policy, the other is limitations imposed by the current rail network.

National transport policy continues to build high-capacity roads despite the obvious fact there is no alternative to high-carbon fuels for HGVs. In April 2020, for instance, the Department for Transport signed off on its £27.4bn *Roads Investment Strategy 2*[18]. National planning policy encourages growth in HGV-dependent distribution infrastructure near motorway and trunk road junctions, even on greenfield sites.

In its "Vision of the network in 2050", the *RIS2* document says: "The SRN [strategic road network] supports the freight and logistics industry and continues to carry more freight and more business than any other part of the transport system. It works well to connect together people who are keen to do business and ready to compete in the global economy." Given the lack of alternative to diesel power for this traffic and this clear determination to ensure other modes do not make serious inroads into it, here is a clear admission that continuation of current national freight policy will continue to cause unacceptable levels of greenhouse gas emissions.

The other big problem is capacity constraints on the existing network, including the failure to electrify the network. On many parts of the network, freight trains are competing for pathways with passenger services, many of which will need room for much higher speeds than goods trains. But beyond the route capacity problems explored in the previous section, there is a further problem for rail freight, namely the extremely restrictive loading gauge on Britain's traditional rail network. Currently, on a substantial part of the network, it is not possible to carry a 9ft 6in "hi-cube" ISO container on a standard wagon and only wagons with restricted capacity can be used. Gauge clearance to W10 gauge to eliminate this problem is urgently required on a number of routes, including some ports.

With a high proportion of even container traffic using roads, there is clear potential for a big shift of road freight to rail. Ports are an obvious early target, given their high volumes and average haul distances.

The port of Felixstowe, for instance, is the busiest container port in Britain. But while traffic from Felixstowe to the Midlands and north of England was a factor in justifying the £1.5bn upgrade of the A14 between Cambridge and Huntingdon, it's a very different story with the railway line from Felixstowe. The line through Ipswich, Peterborough,

Leicester and Nuneaton which connects the port to the Midlands still has severe capacity constraints; part is single-track and signalling and junction improvements are needed. As a result only 19 of the 36 scheduled freight trains leaving Felixstowe each day use this line while 17 head down the Great Eastern route to London before making their way round suburban lines in north-east London and many of them then continue north up the West Coast Main Line. All these routes are heavily congested and would benefit greatly if these trains could be rerouted along the direct line. Upgrading and electrifying the route could have been done for a fraction of the cost of the A14 upgrades.

This is just the sort of challenge that any rail-based stimulus package should urgently address. Improved rail links to other ports are also needed. One possibility canvassed would be to reopen the Didcot-Newbury-Winchester line closed in the 1960s as a way of improving links between Southampton and the Midlands. The Rail Freight Group is also urging a North Pennine upgrade.

In 2009, a Strategic Freight Network (SFN) was established and included a £250m fund to be invested during Network Rail's Control Period 4 – 2009-14. A cross-industry steering group was established to oversee development and a number of projects saw investment. The SFN continued in Control Period 5 – 2014-19. What's needed is something to build on that initiative, with a national programme of freight route improvements and a serious budget.

Rail freight terminals are another issue and new rail freight terminals are needed in neglected regions and undersupplied areas. The industry complains these often face opposition through the planning process; at the same time it's clear that some, at least, of this opposition is due to promoters using a small rail element in proposed strategic rail freight interchanges to try to still opposition to greenfield and green belt developments. There is a danger that being used to facilitate what's been described as "truck-dependent-sprawl" could undermine public support for rail freight. An expansion of rail freight facilities, including intermodal interchanges, is something that needs to be supported for very good environmental reasons but these must be planned in ways which secure significant modal shift to rail and meet high planning standards.

The three issues of electrification, route capacity and terminals require investment throughout the UK. Transform Scotland, for instance, set out proposals for a low-carbon freight network in Scotland in its response to consultations on the *National Planning Framework 4*[19]. This is set out in Appendix 2.

We recommend:-

- **that a new £15bn fund be created to accelerate action on rail freight capacity issues;**
- **that consideration be given to reopening lines to form part of a freight network.**

4.6 Reopening railways

Smart Growth UK's recent report *Defending Our Lines – Safeguarding Railways for Reopening*[20] was published in April 2020. It examined how so much of our rail network was closed in the 20th century, the obstacles to their reopening and the potential that reopening many of them would offer to serve a variety of purposes.

The lines we recommended for reopening (for passenger use) include urban, suburban, inter-urban and rural services. Reopening the urban and suburban would be a mixture of light and heavy-rail. Outside the cities, the routes recommended for reopening include a number of main lines whose closures were bitterly fought at the time and which, with the passing of the decades, appear ever more destructive and inexplicable.

There are various reasons for reopening lines and these include both traffic potential and social need. Reopened railways offer new opportunities in urban transport, in increasing capacity of the existing rail network, in bringing sustainable transport to rural and remote areas and, even though not the focus of the study, creating new rail freight links.

The report examined reopening of existing freight-only lines, mothballed but still extant lines and, most numerous, lines which were closed and demolished. It looked at the way the formations of demolished lines get nibbled away at by a variety of processes including building development and road building and put forward suggestions for safeguarding them against future development. Deciding which closed lines should be considered for safeguarding involves balancing a number of criteria including traffic potential, improved rail capacity, intactness of the formation, social need etc. and decision making is inevitably complex. With this in mind, the report put forward, for discussion purposes, lists of such lines which might be considered under three priorities for reopening and it recommended national conversations to take this forward.

Inevitably, given the thousands of miles of route involved, any such programme will be expensive and multi-decadal and will need very substantial capital investment. The funding we propose here can only be enough to make a substantial start on this need. The rewards, in terms of greenhouse gas emissions, improved rail capacity and regional regeneration, would be huge.

We recommend:-

- **a £10bn fund be made available to begin the process of reopening vitally needed railway lines;**
- **that a programme and ongoing budget be put in place to restore passenger services to freight-only or mothballed railway lines where the potential exists;**
- **that national planning policy throughout the United Kingdom should make clear that the formations of abandoned railways should either be formally**

safeguarded or safeguarded through the planning system wherever they have potential for reopening;

- **that the UK government, the devolved administrations and regional and local authorities agree a comprehensive map of railways with potential for reopening, promote protection of their alignments and work to prevent obstruction of them by development or other obstacles.**

5. Decarbonizing urban roads

5.1 The challenge of restraining urban traffic

The biggest challenge we face in decarbonizing our transport system is our gross over-reliance on road transport and our neglect of other modes. The DfT's *Decarbonising Transport: Setting the Challenge* document talks of making "public transport and active travel the natural first choice for daily activities" and "investment in… development of sustainable supply chains". These are certainly vital components of any route to zero carbon, but there is little sign the Department has any real plans to ensure these ambitions succeed.

Even with the *most* optimistic projection of the take-up of electric vehicles over the next 12 years, Transport for Quality of Life (TfQL) estimates that carbon emissions from the strategic road network alone would be 381MtCO_2.[21] But just achieving a Paris-compliant carbon budget for the transport sector up to 2032 would mean limiting that to about 214MtCO_2. But instead of ways to limit transport emissions, the DfT is planning to increase them, notably by its Roads Investment Strategy 2. TfQL estimated the likely carbon impact of the £27.4bn programme thanks to the materials involved, land clearance, higher traffic speeds and induced traffic and estimates RIS2 will lead to an additional 20MtCO_2 between 2020 and 2032. This would exceed any reduction in emissions from electric vehicles even were these to become reality.

"Emissions could be higher than this if planning policy becomes more permissive, allowing more out-of-town, car-dependent development," says the report. Planning policy in England becomes ever more permissive, so the 20MtCO_2 is probably an under-estimate if RIS2 goes ahead.

The challenges posed by road transport are different in urban areas and outside them. They are different also for passenger traffic and for freight. Radical action is needed for both and we will consider them separately, although the two plainly interact and some commonality of approach may be emerging.

On the roads of our towns and cities, decarbonisation will need a mixture of investment and disinvestment, as we have seen. Overall, there are big gains to be had from public

investment in more sustainable policies, including financial savings resulting from a drop in road accidents and the health benefits of cleaner air.

5.2 Why restrain traffic?

The obvious answer is to reduce greenhouse gas emissions, but another reason became all too clear during the health crisis of 2020. This brought about a huge reduction in vehicular traffic with most people locked-down in their homes. Nowhere was this experienced more dramatically than in the cities, where decades of worsening air quality were suddenly put into reverse.

When people did go out for essential work, shopping or exercise etc., they were faced with the difficulty of trying to remain 2m apart on the narrow footways, which is all the majority of city streets have. For most people, this involved walking in roads which had apparently become much less hazardous thanks to the drop in traffic. Hazards were not necessarily lowered, however, as some motorists took advantage of empty roads to exceed speed limits.

Towns and cities in many overseas countries quickly tried to make things easier for pedestrians by coning-off lanes adjacent to footways to allow space for pedestrians or cyclists. UK cities were some of the last to follow suit amid restrictive legislation and lack of clear government guidance. It took the Department for Transport until 9 May to announce[22] a package of measures to work with local highway authorities. Plans included pop-up cycle lanes, wider footways, junction improvements and bus and cycle only corridors. New statutory guidance was announced. There was no new money however; the funding came out of a pot for buses and cycling announced earlier in the year[23]. In some places, when cities did begin narrowing roads, opposition from motorists saw a few schemes removed.

But although people missed the freedom to drive, they also enjoyed the clean air, noise reduction and ease of crossing roads. They enjoyed greater freedom to walk or cycle. They enjoyed street space that was reused for outdoor dining or play areas etc.. Smart Growth practitioners internationally believe that city traffic should be restrained and the majority of journeys within cities made on foot, by bike or on public transport.

5.3 Health effects of traffic

Air pollution isn't just about greenhouse gases; it is a killer and the most vulnerable are the young and the old, people with underlying health conditions, pedestrians and cyclists. According to the pedestrian charity Living Streets, around 40,000 premature deaths a year in the UK are caused by air pollution and toxic air is now believed to be killing more people across Europe than smoking. Much of this is caused by road vehicles. Around 80% of the oxides of nitrogen found by roadsides comes from traffic and those who believe they are safer inside cars are mistaken.

A recent report by the Centre for Cities[24] estimated that $PM_{2.5}$s are the cause of more than one in 19 deaths in the UK's largest cities and towns and that rises to one in 16 in the heavily trafficked cities in the south including London. It found that 11% of UK roads are breaching legal limits for nitrogen dioxide and 95% of the monitored roads breaching these limits are in the largest urban areas.

The report notes there are many sources of air pollution but road transport is the main source of nitrogen dioxide emissions (42% in cities) and a significant percentage of $PM_{2.5}$s, while the main source of these, domestic wood and coal burning, is being addressed by Government action.

"While road transport's contribution is much higher in city centres, in suburbs more than half of $PM_{2.5}$ emissions come from domestic and commercial combustion," says the report. "Such a difference can be explained in part by higher congestion rates and traffic flows in city centres, and residential wood burning in less central areas. This shows that in tackling air pollution, different approaches will be required even within a city."

Nor would electric vehicles solve the particulate problem. As we have seen, pneumatic-tyred vehicles emit $PM_{2.5}$s from tyre fragments, the binders in road surfaces and their braking systems. Although the latter might be reduced somewhat by regenerative braking in electric vehicles, the contribution of road vehicles to $PM_{2.5}$ levels in cities as a percentage will rise as other sources are tackled.

"The Royal College of Physicians has estimated[25] that air pollution is responsible for more than 20,000 hospital admissions a year due to respiratory or cardiovascular diseases," says the Centre for Cities report. "There is no comprehensive local data on the various health impacts of air pollution. However, research conducted by King's College London and UK100[26] has estimated the following effects on nine UK cities:-

- living near a busy road in London may contribute to 230 hospital admissions for strokes every year;
- living near a busy road may stunt lung growth in children by 12.5% in London and 14.1 per cent in Oxford;
- in Birmingham, the risk of outside-hospital cardiac arrest is 2.3% higher on high pollution days;
- higher air pollution days are responsible for 43 more people going to hospital for respiratory disease in Southampton, 68 in Bristol, 98 in Liverpool.

"Public Health England estimates[27] that there could be around 2.5 million new cases of coronary heart disease, stroke, lung cancer and other health conditions by 2035 if pollution levels remain the same," it says.

The health and social effects of the noise from traffic are harder to gauge but are nonetheless severe in cities. Noise causes annoyance and fatigue, says Environmental Protection UK. It interferes with communication and sleep, reduces efficiency and damages hearing.

"Physiological effects of exposure to noise include constriction of blood vessels, tightening of muscles, increased heart rate and blood pressure and changes in stomach and abdomen movement," says EPUK. "The effects of exposure to noise are personal as hearing sensitivity varies. Exposure to constant or very loud noise – either occupational or leisure – can cause temporary or permanent damage to hearing. There is an increasing body of research linking prolonged exposure to transport noise to health impacts. A major impact of noise is sleep disturbance – and disrupted sleep has been linked to effects on cardiac health. A number of reports have made direct links between transport noise and cardiac health."

The most dramatic and immediate health effect of traffic is, of course, road accidents. In 2018, 1,784 people were killed on the roads of Great Britain, an average of almost five a day and a level which has been broadly unchanged since 2010. In 2018, Britain saw 25,511 serious accidents and 160,597 casualties of all severities. Of these, 36% of the fatalities and 63% of all casualties occurred on urban roads.

5.4 Restraining traffic in cities

If we are serious about eliminating greenhouse gas emissions from vehicles and addressing their other health effects, we need to restrict traffic radically. Where that can be started with the least hardship and disruption is in our cities. To put it simply, the vast majority of car journeys in our cities are, or should be, unnecessary. We need to make sure they can be, and are, made by sustainable modes of transport.

The only way to achieve this is to ensure public transport and active travel opportunities exist at scale. In some places, such as most of Greater London and parts of our other cities, dense networks of public transport exist and could easily be enhanced. At the opposite end of the spectrum, some cities and many towns are seriously deficient. While facilities for active travel have improved in recent years, most road space is still given over to cars and lorries.

The empty roads and car parks of the health emergency demonstrated all too clearly how much of the land in our towns and cities is devoted to vehicular transport. If we can restrain traffic in the future on a serious scale, then a significant part of that area could be made available for more useful and less damaging purposes including:-

- public transport;
- cycling;
- walking;
- open space;
- play areas.

Surface-level and multi-storey car parks also offer opportunities to free up space for building homes, employment space, open space etc..

There are many modern techniques for restraining urban traffic and those available expand all the time; they are well understood and practicable. This is a once-in-a-generation opportunity to tackle the biggest cause of greenhouse gas emissions, air pollution, noise, accidents, physical separation and wasteful use of land in our urban areas. City centres can get along fine without free movement of cars and with restrictions on goods vehicles. Urban areas in general can manage with their traffic significantly restrained. We must not squander this opportunity.

5.5 Public transport

Decarbonizing road passenger transport will require substantial investment in urban public transport. The investment we need in rail-based public transport is explored in the sections on rail investment above, but this must also include substantial capital investment in bus services, such as new interchange facilities and revenue support where necessary. A multi-billion pound package plus a commitment to onging revenue support where necessary is needed.

5.6 Active travel

While some of the space freed up by restraining traffic must be made available to the buses and trams that replace it, a great deal of space would also become available for walking and cycling. It is now perfectly clear that cheap solutions to "separate" cyclists from traffic using paint alone are inadequate, as the accident record shows.

Across the world, many municipalities saw both a need and an opportunity to use the road space freed up by traffic reductions during the coronavirus emergency to increase space for pedestrians and cyclists, both to allow them to keep a safe distance apart, to protect them from increased vehicle speeds and, in some cases, to accommodate increased walking and cycling. Some of the new cycle lanes and wider footways installed during the health emergency may prove temporary, however. A permanent revolution is needed here, and neither the cost, nor the disruption involved in installing active travel facilities need be high.

Cyclists must be separated from vehicular traffic by at least a kerb, as pedestrians generally are. This is more expensive than white paint, but not intolerably so. But we also need to separate pedestrians and cyclists by kerbs. Large concentrations of cyclists, or the aggressive use of a bike practised by a small minority, can be very intimidating to pedestrians, particularly the old, young and infirm.

As with traffic restraint, the measures needed to improve travel for pedestrians and cyclists are well known to traffic engineers and transport planners and the right solution will always depend on local circumstances. But a huge expansion in these facilities is long overdue as active travel reclaims large parts of our urban areas.

5.7 Traffic restraint

There are many ways of restraining traffic, from simple physical barriers and reduced road capacity to road pricing, complex congestion charging schemes and workplace parking levies. This is not the place to explore the multiplicity of options on offer which are well known to traffic engineers and transport planners and which are being added to all the time. Every town and city has its own individual needs and what would work in one would not necessarily be appropriate in another. But we need to remember that, unlike many of the measures we advocate here, traffic restraint can be revenue-positive thanks to the income stream from pricing or levies.

But we need to be sure how the sort of road pricing scheme that can cover most or all of a large town or city can work, and how it can be framed to secure public acceptance. A number of reasons to install road pricing have been advanced in the past, including a number of implemented schemes including reducing congestion or improving air quality. Yet it appears none has so far been implemented with the main objective of reducing carbon emissions[28] despite the fact that carbon reductions in road pricing schemes are significant. Both London and Stockholm report carbon savings of 14-16% while traffic reduction varies from 9% in Gothenburg to 47% in Milan city centre.

TfQL argues that any road pricing scheme will only succeed and cut carbon emissions if it secures public support and is correctly framed and designed. The report argues that road pricing used to raise funds for road maintenance or construction are self-defeating as any improvements in road capacity will simply lead to more driving. Even fiscally neutral schemes have the perverse incentive of encouraging driving in some places. It argues that an urban scheme should have the explicit objective of reducing carbon emissions. “If road pricing is framed as a way of tackling climate change, cleaning up toxic air and making towns and cities healthier and more liveable, many more people will care strongly about it, and that will create the space for politicians to act,” it says and cites the support London’s Ultra-Low Emission Zone and Milan’s Ecopass scheme received.

It urges using the revenues from road pricing to improve public transport rather than using it to raise tax or for mega-transport-projects and it will have much more chance of implementation when framed as an Eco Levy than as a congestion charge or a way of funding infrastructure. And it suggests some design pointers for an effective Eco Levy:

- upfront investment in public transport in the months before the Levy is introduced;
- revenue should be invested in “quick wins” that improve alternatives to driving like more bus services, cheaper fares, free travel, segregated cycle lanes and street improvements;
- the scheme should be simple and easy to understand, operating 24 hours a day, 365 days a year, distance-based and encompass the whole built-up area;
- the scheme should be flexible with exemptions and adjustments to secure wide buy-in. But blanket exemptions for residents would undermine its purpose,

although they might be allowed a degree of free movement or free trips on public transport;
- monitoring of impacts on traffic, carbon emissions, air quality, public transport and people's perceptions should be monitored and communicated so residents can see the benefits;
- the Government should support the first councils to implement Eco Levies or a leading city could implement then sell its expertise to other towns and cities.

An Eco Levy could thus form a central part of large towns' and cities' approach to reducing transport carbon, along with much better public transport and active travel. What is needed is a comprehensive national package to support public transport, active travel and traffic restraint in urban areas. We recommend £10bn be dedicated to this as an initial investment to get the programme underway.

We recommend that:-

- **a £10bn fund be made available to expand traffic restraint, bus services and active travel;**
- **large areas of space in urban areas devoted to vehicular movement and parking be rededicated to public transport, active travel and other purposes;**
- **large towns and cities consider implementing Eco Levies to reduce greenhouse gas emissions from road transport.**

6. Roads outside the cities

6.1 Passenger travel

While urban passenger movements are easier to move from private car to public transport and active travel, a high percentage of the carbon emissions from cars is made on journeys into towns, on inter-urban journeys or on rural trips. Exacerbated by the dispersed settlement pattern which has been our default for the past 100 years, these are all very prevalent and hard to move to more sustainable modes.

The simplistic response in *Decarbonising Transport: Setting the Challenge* is that these journeys will, in future, be made by electric cars and so carbon emissions will be eliminated. Sadly this is not the case. Cars are a huge source of carbon emissions from sources other than their tail pipes. There is a high level of carbon emissions in their manufacture and further emissions in their scrappage and the recycling of their components. The concrete, blacktop and other materials involved in our grossly over-expanded road system and the plant that maintains it generate massive carbon emissions too. Electric vehicles still cause extensive air pollution from particles emitted from tyre and brake wear and road surface erosion. And that's before all the other environmental impacts of the road system are taken account of, like the soil sealing

involved in our huge road network which prevents the soil carrying out its vital functions (including carbon sequestration), the light and noise pollution and the impacts on biodiversity.

Some measures to reduce traffic outside towns are fairly obvious:-

- an end to major road building;
- a huge increase in public transport facilities;
- increased facilities for active travel;
- reforming planning to restrict car-dependent sprawl (see Section 3.2).

It is clear that, while these are essential and would reduce the growth of vehicular traffic, and possibly even reduce it somewhat, they would not on their own bring about the very substantial reductions in traffic that the climate emergency demands.

There will always be some journeys, in country areas and especially in remoter areas, and for emergency services, where use of a car will remain necessary. In these cases a switch to electric vehicles will be needed.

There is a clear contrast between urban traffic restraint, which is well understood and implemented widely with a large and growing range of available techniques, with restricting traffic outside towns. Here, a lack of political support has hindered development of mature techniques.

Any programme to reduce car traffic outside towns would involve action in five areas:-

- much wider provision of sustainable alternatives to driving;
- fiscal measures;
- electronic measures to charge for mileage;
- planning measures to reduce the need to drive;
- reduction in road capacity or physical methods of traffic restraint.

None of these currently enjoys political support, but the gathering climate emergency means that politicians will, in a rapidly approaching future, need to follow the science on this one. A clear programme to examine what kinds of extra-urban journey can only be made by car and which can be limited is now urgent.

As well as advocating an Eco Levy on urban roads, Transport for Quality of Life also advocates its use on the Strategic Road Network (SRN). A national road pricing scheme on all roads would have many difficulties so, given the urgency of climate change, a simpler scheme that could be introduced on trunk roads throughout the UK would be quicker. “Road pricing on the SRN would have more impact, and be more acceptable to the public if, at the same time, train fares were reduced and simplified,” says TfQL. “Indicatively, we estimate that even a modest 6p per km charge for cars to use the SRN might reduce car mileage on motorways and trunk roads by around a quarter, while at the same time raising enough revenue to halve all rail fares.”

There would be pitfalls aplenty of course. Some traffic would divert to local authority roads so they should be allowed to opt in parts of their network, meaning gradually more of the network would be included. Then there's the shift to electric vehicles which do not pay fuel duty, potentially making vehicle usage much cheaper and increasing congestion, accidents, etc., as well as keeping up a high level of carbon emissions given that emissions from the vehicles' manufacture and scrappage is similar to the significant proportion of life-time carbon emissions. Eventually the Eco Levy would need extending to all areas to eliminate these impacts and to replace fuel duty. The latter has been frozen for some years, increasing greenhouse gas emissions and reducing tax receipts.

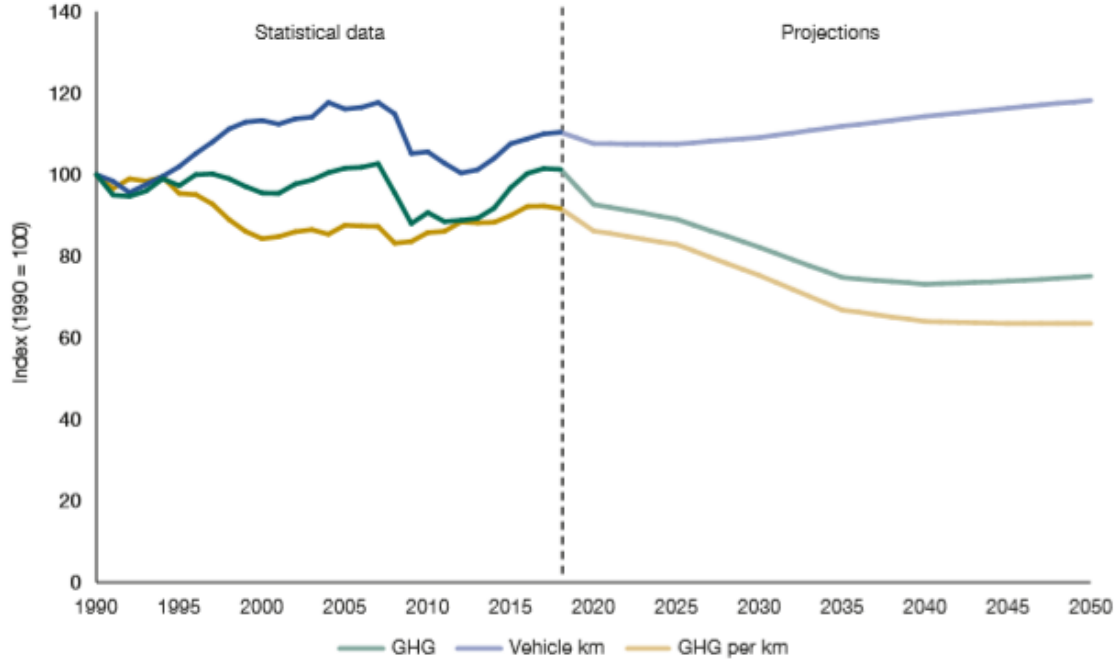
We recommend that:-

- **an expert commission be set up to determine which extra-urban car journeys are impossible to replace and which could be dramatically reduced;**
- **the commission examine the most suitable techniques for achieving the reductions required;**
- **the Government and devolved administrations should consider an Eco Levy on the Strategic.Road Network to reduce greenhouse gas emissions and to start replacing fuel duty.**

6.2 Freight

Freight transport is probably the biggest challenges to those who believe it possible to decarbonize existing transport systems without radical change. *Decarbonising Transport* illustrates just how seriously adrift present Government thinking is.

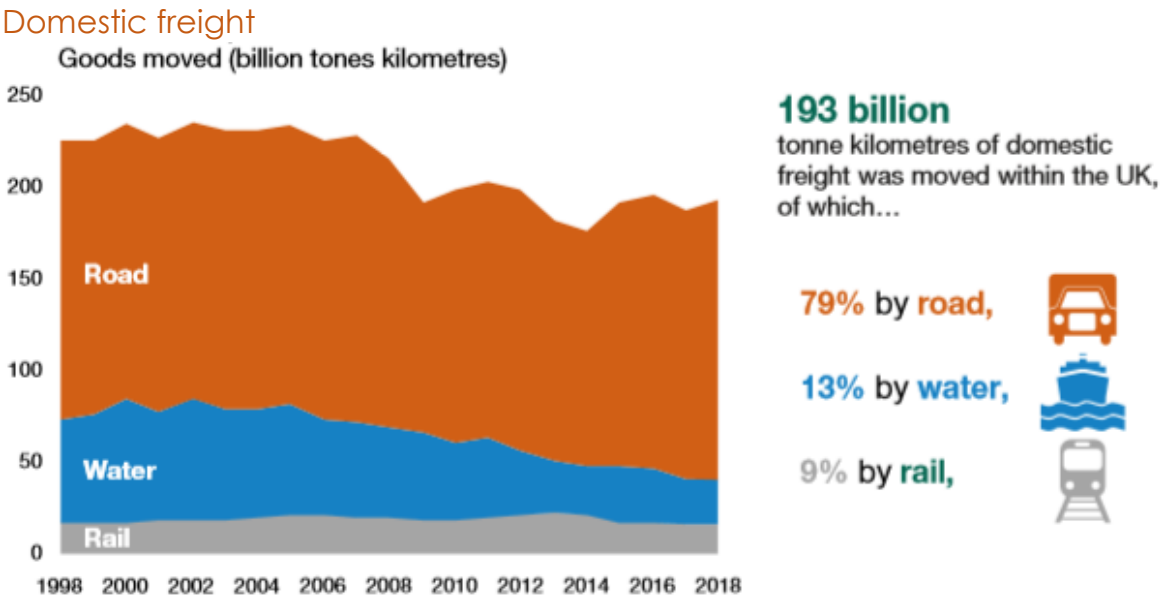
DfT projection of change in HGV GHG emissions under current policy



Source: Department for Transport

Freight movement is a major hole in Government GHG policy. The DfT admits that HGVs account for 17% of UK domestic transport emissions and HGV traffic went up by 10%, from 15.5bn miles to 17.1bn miles, in just six years to 2018. The DfT believes HGV emissions might fall by 26% from 2018 to 2050 due to various unspecified "efficiency savings" though these, it accepts, would be offset by an expected 7% *increase* in HGV vehicle-km over the same period. At the heart of this failure, of course, is the realisation that there is no alternative to diesel power for heavy goods vehicles.

Given that this is almost certainly true, we plainly need to plan for a substantial and progressive reduction in HGV vehicle-km in the years to come. Presently, domestic freight movement is heavily dominated by road and, in recent decades, a distribution industry fatally dependent on HGV networks and distribution depots beside major trunk roads has come to dominate.



Source: Transport Statistics Great Britain 2019

Over recent decades, the UK freight industry and its customers have become increasingly dominated by huge road-based distribution depots and techniques like just-in-time. The end result is a freight system heavily dependent on high-carbon transport and a lack of low-carbon alternatives. *Decarbonising Transport* shows just how adrift current policy is.

"The regulation for HDV [heavy-duty vehicle] vehicle manufacturers making new vehicles requires reductions of 15% for 2025 and 30% for 2030 against a 2019 baseline and includes incentives for sales of zero and low emission HDVs," it says. "As committed to in the *Road to Zero* strategy, now that the UK has left the EU it will pursue a future approach that is at least as ambitious as the current arrangements for vehicle emissions regulation."

So, in the unlikely event of vehicle design aspirations going according to plan, HGV emissions would drop by 30% by 2030, less the expected growth in vehicle-km. But

diesel engines are a very mature technology; these reductions are just aspirational and, even were they achieved, they would be unlikely to continue. So any reduction in overall GHG emissions from HGVs in the foreseeable future if current national freight policy continues are unlikely, indeed *increases* are likely. Plainly a more radical alternative policy is needed.

Two things are needed:-

- A big shift in freight movement from unsustainable modes (roads and air) to sustainable modes;
- Radical changes in our distribution systems.

Achieving the first of these would necessitate a massive transfer of freight movement to rail and water. This would mean substantial investment in the rail network, as advocated above and taking opportunities for moving goods by water too. The second would need a radical changes in both the way current distribution systems work and in customer expectations. Such changes will take decades and we need to start now.

Tackling HGV mileage will require political support and again it becomes ever more necessary with every hotter year that passes. Electric vehicles may reduce emissions from cars and light goods vehicles to some extent, however inadequate, but the DfT expectation that mileage of diesel-powered HGVs will actually increase is reckless and irresponsible in the extreme.

Reducing HGV mileage will again necessitate a mixture of fiscal, charging, physical restrictions and provision of alternatives. As a first step, planning policy needs to put a stop to new distribution depots. After decades of increasing reliance on distribution and consumption based on ever higher availability of HGVs, the climate emergency now necessitates we find ways of distributing goods in ways which progressively reduce HGV mileage.

We recommend that:-

- **an expert commission be set up to determine ways in which HGV journeys could be dramatically reduced;**
- **the commission examine the most suitable techniques for achieving the reductions required.**

7. Water transport

The DfT estimates that GHG emissions from UK domestic shipping are dropping sharply and more slowly from international shipping. It estimates that, in 2018, domestic shipping accounted for 5.9MtCO_2e and international for 7.9MtCO_2e. It says shipping "is considered one of the most carbon-efficient modes of transport".

This is, however, somewhat disingenuous. Currently the International Maritime Organisation estimates that international shipping accounts for about 2.2% of global CO_2 emissions. In 2018, IMO adopted an initial strategy to reduce GHG emissions from ships, with the objective of ending their growth in the near future and reducing them by at least 50% by 2050 compared to 2008 "whilst pursuing efforts towards phasing them out"[29]. But states that drew up the commitment made no progress on the measures needed to achieve this.[30] And the focus on decarbonisation is significant too; it is estimated that much of the adverse effects on climate from international shipping are caused by the oxides of nitrogen emitted in the deep ocean where they are not mitigated by terrestrial ozone. The Global Maritime Forum estimates that around $1-1.4tn needs to be invested between 2030 and 2050 to reduce emissions by only 50%[31].

The Government responded to the IMO proposal with its Maritime 2050 Strategy[32] in 2019 and has a *Clean Maritime Plan*[33] as part of its Clean Air Strategy. It is plainly needed; the Clean Maritime Plan estimates that continuation of current policies would see total GHG emissions from UK domestic and international shipping rise by around 80% between 2016 and 2050.

The shipping figures include both passenger and freight movement. But they refer solely to shipping; inland waterway transport in the UK is extremely limited given the historical nature of most of its waterways. Nevertheless, it is worth taking opportunities that do arise to increase its use.

But, as can be seen from the foregoing, while the view that shipping is one of the most carbon-efficient modes of transport may be true, it needs to be treated with substantial scepticism.

8. Restraining aviation

While there is some justification for considering shipping, at least potentially, carbon-efficient, that could never be said of aviation.

Without question, aviation presents the biggest challenge to those who believe it possible to decarbonize existing transport systems. *Decarbonising Transport* says UK domestic aviation emitted 1.5MtCO_2e in 2018 and international flights 37MtCO_2e. The document admits that: "its proportional contribution is expected to increase significantly as other sectors decarbonise more quickly".

The DfT is working on an aviation strategy and has been pushing to expand the sector aggressively with several airport expansion plans. Currently domestic flight emissions are included in the UK carbon budgets and international aviation and shipping are accounted for in "headroom" in those budgets "meaning that the UK can remain on the

right trajectory for net-zero global greenhouse gas emissions across the whole economy".

But here *Decarbonising Transport* begins to reveal the massive obstacle that aviation represents in decarbonizing transport. It says the Government's preferred approach to emissions from international flights, given their global nature and lack of agreement on whose emissions belong to which country, is international action. This is mostly lacking.

Instead the DfT says Britain has joined 81 other states in the 2016 Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) which commits members for a "medium-term goal of carbon neutral growth" (and note this is "growth", not reduction) through "more efficient aircraft technologies as incentivised by the CO_2 standard, operational improvements such as more efficient flight procedures, the development and use of sustainable alternative fuels and market-based measures like COSRIA". COSRIA requires aeroplane operators to offset the growth in international emissions above average 2019 and 2020 levels (this was before the COVID-19 emergency). Up to 2.5Gt of CO_2 is expected to be offset by 2035, though there is no indication at all how this "offsetting" might work.

The DfT imagines that, despite demand for passenger km by plane increasing by a projected 73% between 2018 and 2050, larger and more efficient planes and "sustainable aviation fuels" would enable emissions to remain "broadly flat". But flat here means high, and completely incompatible with carbon reduction, let alone elimination.

"As a responsible national government, we need a contingency measure in case international progress does not go far enough or fast enough," concludes *Decarbonising Transport*. Given that the only serious way to reduce aircraft GHG emissions is to fly less and to eliminate them is abandoning flying, some "contingency" is plainly needed, i.e. a completely different policy.

A whole strategy for reducing both domestic and international flying is needed. A first step should be formally abandoning plans for expanding airports or granting licences for new routes. Then we will need both fiscal and regulatory measures to progressively reduce flying. The alternative is to continue the massive carbon emissions involved in taking aircraft aloft. "headroom" provided by other modes can only work to the point their emissions are reduced to zero; after that, flying has to go.

We recommend that:-

- **all plans to expand airports are now abandoned;**
- **a graduated programme of fiscal and other restraint measures is progressively introduced to reduce flying.**

9. Conclusions and recommendations

It is extremely heartening to read in the Setting the Challenge chapter of *Decarbonising Transport* that: "whilst it is technically possible to deliver net-zero based on 'current consumer behaviours and known technologies', the target will only be credible if policy measures ramp up significantly and urgently. We agree and do not underestimate the challenge of delivering what will be fundamental changes to the way people and goods move around".

We too strongly agree. This document has attempted to set out some of those challenges and the political choices and changes in individual and business behaviour that will be required. These are fundamental and, in many cases, will face huge opposition. A lead needs to come from central government and it needs to take some decisions which represent a fundamental change of direction. Both England and the devolved administrations need to end most, if not all, of their trunk road building programmes and local authorities need to follow suit. The HS2 project needs to be paused urgently for a fundamental review. The capital spending plans aimed at these projects need to be urgently repurposed for rail investment and active travel. Investment in rail electrification and freight measures is available and can start quickly.

Beyond that, a huge amount of research into sustainable transport is needed. Our research has shown there is no agreed programme of the rail capacity improvements that are needed throughout the UK, rather than the narrow north-south HS2 corridor in England which is currently sucking up most of the investment planning, together with piecemeal improvements elsewhere. There is no universal national programme to bring comprehensive active travel to our towns and cities. While there are many well developed techniques for restraining traffic in towns and cities, and comprehensive programmes are needed, there is no clear route to reducing inter-urban road transport. There is no clear route to making freight movement more sustainable and less dependent on HGV mileage. There is little thought to reducing domestic air travel beyond the wholly inadequate HS2 proposals. There is no serious programme for reducing international flying. Our planning policies, in England especially, are not geared to making our transport more sustainable, but would lead to much more land-hungry car-dependent sprawl.

The ambition "to support industry and put the regulatory mechanisms in place to set the UK up to become a world-leader in low-carbon transport technology" is entirely admirable. But we now need to move beyond verbal ambition and to start making the painful decisions that are vital to achieve this ambition. Much of this will be unpopular, but only central government and the devolved administrations are in a position to lead on this. But lead they must. Climate change is upon us; the old ambition of "net-zero by 2050" is no longer a route to sustainability but to climate disaster. The chance to pursue that has now passed us by; the route to decarbonized transport must now be a radically different one.

We recommend that:-

- **national and local planning policy in England and the devolved administrations incorporate Smart Growth type policies designed to reduce the amount of passenger and freight movement by high-carbon modes;**
- **national research be instituted to plan ways of moving freight which progressively reduces and eliminates HGV mileage;**
- **a £10bn fund be made available for creating initial light-rail lines in major cities as the first stage of a rolling programme;**
- **a £5bn fund be made available for developing heavy-rail passenger and metro services in cities;**
- **a £5bn fund be made available for innovative light-rail/tram/ultra-light-rail projects;**
- **funds be made available within these programmes to municipal operators of guided-bus systems to enable their conversion to light-rail;**
- **funds be made available for three feasibility studies and Webtag/Stag business cases annually for new systems;**
- **a hydrogen/biomethane tram be imported as a demonstrator;**
- **a £15bn stimulus programme be initiated for rail electrification**;
- **the Government commit to a rolling programme of electrification to secure an initial 4,500 route km of electrification by 2030 and to complete electrification of most of the network in the 2030s;**
- **a fully independent study be set up to recommend priorities for investment in capacity on Network Rail;**
- **a new additional £25bn fund be created to begin to accelerate rail capacity improvements across the UK;**
- **a new £15bn fund be created to accelerate action on rail freight capacity issues;**
- **consideration be given to reopening lines to form part of a freight network.**
- **a £10bn fund be made available to begin the process of reopening vitally needed railway lines;**
- **a programme and ongoing budget be put in place to restore passenger services to freight-only or mothballed railway lines where the potential exists;**
- **national planning policy throughout the United Kingdom should make clear that the formations of abandoned railways should either be formally safeguarded or safeguarded through the planning system wherever they have potential for reopening;**
- **the UK government, the devolved administrations and regional and local authorities agree a comprehensive map of railways with potential for reopening, promote protection of their alignments and work to prevent obstruction of them by development or other obstacles;**
- **a £10bn fund be made available to expand traffic restraint, bus services and active travel;**

- **large areas of space in urban areas devoted to vehicular movement and parking be rededicated to public transport, active travel and other purposes;**
- **large towns and cities consider implementing Eco Levies to reduce greenhouse gas emissions from road transport;**
- **an expert commission be set up to determine which extra-urban car journeys are impossible to replace and which could be dramatically reduced;**
- **the commission examine the most suitable techniques for achieving the reductions required;**
- **the Government and devolved administrations should consider an Eco Levy on the Strategic.Road Network to reduce greenhouse gas emissions and to start replacing fuel duty;**
- **an expert commission be set up to determine ways in which HGV journeys could be dramatically reduced;**
- **the commission examine the most suitable techniques for achieving the reductions required;**
- **all plans to expand airports are now abandoned;**
- **a graduated programme of fiscal and other restraint measures is progressively introduced to reduce flying.**

Appendix 1

UK "built-up areas" with populations above 100,000

(based on ONS definitions and using the 2011 Census)

Built-up areas with populations above one million

1. Greater London
2. Greater Manchester
3. West Midlands
4. West Yorkshire
5. Greater Glasgow

Built-up areas with populations from 500,000 to one million

6. Liverpool
7. South Hampshire
8. Tyneside
9. Nottingham
10. Sheffield
11. Bristol
12. Belfast
13. Leicester

Built-up areas with populations from 300,000 to 500,000

14. Edinburgh
15. Brighton and Hove
16. Bournemouth and Poole
17. Cardiff
18. Teesside
19. Stoke-on-Trent
20. Coventry
21. Sunderland
22. Birkenhead
23. Reading
24. Kingston upon Hull
25. Preston
26. Newport
27. Swansea

Built-up areas with populations from 250,000 to 300,000

28. Southend-on-Sea
29. Derby
30. Plymouth
31. Luton
32. Farnborough and Aldershot

Built-up areas with populations from 200,000 to 250,000

33. Medway
34. Blackpool
35. Milton Keynes
36. Barnsley and Dearne Valley
37. Northampton
38. Norwich
39. Aberdeen

Built-up areas with populations from 150,000 to 200,000

40. Swindon
41. Crawley
42. Ipswich
43. Wigan
44. Mansfield
45. Oxford
46. Warrington
47. Slough
48. Peterborough
49. Cambridge
50. Doncaster
51. Dundee
52. York
53. Gloucester

Built-up areas with populations from 100,000 to 150,000

54. Burnley

55. Telford
56. Blackburn
57. Basildon
58. Grimsby
59. Hastings
60. High Wycombe
61. Thanet
62. Accrington and Rossendale
63. Burton-upon-Trent
64. Colchester
65. Eastbourne
66. Exeter
67. Cheltenham
68. Paignton and Torquay
69. Lincoln
70. Chesterfield
71. Chelmsford
72. Basingstoke
73. Maidstone
74. Bedford
75. Worcester

Appendix 2

Capacity improvements recommended by Lord Berkeley

1. HS2 Recovery or replacement works

Station developments	London (Euston) redeveloped within its existing footprint	• Capacity • Performance • Additional platforms for Chiltern Line train service • Over-site development compatible with London Mayor and LB Camden policy • Makes use of and recovers monies already spent on HS2 Phase 1 project
Station developments	Birmingham "Curzon St" station completed as a regional commuter hub interchange with	• Capacity • Performance

	travellator to Birmingham New St station	• Alternative routes • OHL Electrification • Station development completed to meet City of Birmingham planning and regeneration ambitions • Makes use of and recovers monies already spent on HS2 Phase 1 project
Route development new works	London (Euston) additional platforms connection to Chiltern Lines at Old Oak Common via tunnel from Queens Park (not Park Village East) creating new route to the West Midlands via Chiltern Lines	• Capacity; frees up capacity on the West Coast mainline • Basis of alternative route from London to the West Midlands • OHL Electrification • Makes use of and recovers monies already spent on HS2 Phase 1 project • Removes the problem caused to Crossrail 1 at Old Oak Common by overcrowding at interchange
Electrification	Chiltern Lines OHL Electrification • Capacity; additional commuter route from London to the West Midlands, applying RIA methodology from Old Oak Common, Aynho Junction, Banbury, Leamington Spa to Birmingham Curzon and New St.	• Capacity; additional commuter route from London to the West Midlands, freeing up capacity on the West Coast Mainline • OHL Electrification, making use of the methodology advocated by the Railway Industry Association (RIA) to reduce the cost of OHLE • Additional infrastructure required at intermediate stations
Redevelopment or reinstatement of existing lines	Doubling and electrifying the line between Leamington Spa and Coventry	• Capacity; provides additional access to Coventry away from WCML south of Rugby • Performance • Additional infrastructure needed at Intermediate Stations • OHL Electrification
Redevelopment or reinstatement of existing lines	Reinstatement of the railway along the former Great Central Railway route from Banbury to Rugby providing access to the	• Capacity; increases rail freight capacity from southern ports

	WCML and Trent Valley 4-track section	• Capacity; provides alternative north-south access routes
West Coast Mainline interventions	Grade segregated junctions at Hanslope and Ledburn	• Capacity by enabling 125 mph trains to get to and from the fast lines • Improved journey times on WCML inter-city and commuting services
West Coast Mainline interventions	Incorporation of under-used DC lines into WCML proper, including reassessment of Bakerloo line	• Capacity for London commuting services • Better use of underused assets
West Coast Mainline interventions	Review of Cheddington, Tring and Apsley Station	• Capacity improvement on slow lines • Performance
WCML train fleet	Ensure all trains using the fast lines are capable of 125 mph line speed during the passenger day	• Traffic management of fast lines during the passenger day to ensure 125 mph running • Introduction of 125 mph commuter trains - "The Flying Cobblers"
Midland Mainline Electrification	OHL Electrification extended from Kettering to Leicester, Derby and Nottingham to Sheffield and Leeds in conjunction with XC electrification	• Provides electrified high-speed route to the East Midlands and South Yorkshire • Capacity • Performance • Additional infrastructure required at stations • Extension of existing Network Rail electrification programme.
ECML route upgrade	Interventions and new works; enhanced running speeds, 4-tracking congested sections and removal of operating obstructions	• Enhance running speeds; 140 miles per hour running along the entire route to Newcastle-upon-Tyne • Four-tracking congested sections; Between 21 miles 18 chains and 23 miles 68 chains; Welwyn Viaduct, Welwyn South Tunnel, Welwyn North Tunnel and Robbery Lane Viaduct and between 58 miles 20 chains and 75 miles 02 chains; Huntingdon to Fletton Jn

		• New Junctions and New Flyover and Chord at Newark, removing at grade crossing

2. Midlands Connect area schemes

Four-tracking	Rugby, Coventry to Birmingham (New Street) or Birmingham (Curzon)	• Capacity • Performance • Additional infrastructure needed at Intermediate Stations • OHL Electrification
Reinstatement	"The Whitacre Link"; Whitacre Junction to Hampton in Arden	• Capacity • Alternative routes • Direct access to Birmingham Airport and NEC from the East Midlands, North East and East of England and the West Midlands • Direct route from Leicester to Coventry using existing Nuneaton Station • Triangular junction at each end of route to form "figure of eight" layout between Birmingham and Coventry • OHL Electrification
Reinstatement	Sutton Park Line; passenger services allowing direct access to Birmingham Curzon Commuter Station Hub	• Capacity • Alternative routes to Birmingham City Centre • Direct access to Birmingham Airport and NEC • OHL Electrification
Diversions and interventions	Lichfield, Sutton Coldfield, Walsall, Bromsgrove and Redditch commuter services to Birmingham Curzon Commuter Station Hub	• Capacity; frees up Birmingham (New Station) for long distance services • Alternative routes to Birmingham City Centre • OHL Electrification

Reinstatement and extensions	Walsall to Lichfield via Rycroft Junction and extension of Cross-City services to Burton-on-Trent	• Capacity; increases Birmingham "Travel to Work" area • Performance • Additional infrastructure needed at Intermediate Stations • OHL Electrification
Metro extensions	Birmingham City Centre to South West Birmingham via A38	• Capacity; increases Birmingham "Travel to Work" area • Avoids disruption to Camp Hill and West Suburban Lines

3. Northern Powerhouse area

Transpennine Route Upgrade	York-Leeds-Manchester	• Capacity • Performance • Suite of interventions – needs change to ensure whole-route electrification • Additional infrastructure needed east of Leeds • Needs freight to be accommodated (proven possible with additional running lines on former four-track sections)
Electrification	Birmingham – Doncaster/South Kirby Jct, ('XCE')	• Carbon • Performance
Electrification	MML to Derby (plus Erewash) (connects with above)	• Carbon • Performance
Grade separation	Marshgate, Doncaster	• Performance and Capacity NB: Not easy given adjacent rail routes, roads, canals and rivers and may take a more expensive "Doncaster Avoider" as researched by Virgin in an early 2000s franchise bid
New build	Leeds - 'Northwest Viaduct' from Holbeck (High Level) Jct to new three 260m-long platform	• Capacity and new services • Resilience

	station in Wellington Street car park. Connection from viaduct down to Armley Jct. Most built off-line.	• Performance (of main station)
LSI (Line Speed increases) and Loops	Hope Valley (is current, delayed a further two years, scheme actually ambitious enough?)	• Performance • Capacity • Line speed
Reopening	Matlock-Buxton	• Strategic capacity • Strategic connectivity • Intercity journey time • Freight re-routing (de-congesting Dore-Ambergate on MML) • Funding support from private sector from aggregates companies at Buxton

4. North East of England and East Scotland

New passenger service	Ashington – Blyth - Newcastle	• Job opportunities and connectivity from deprived area. A lot of work already done in background. • Environmentally beneficial • Possible tram-train
Extra tracks and avoiding line	Main line Newcastle – Morpeth	• Speed and capacity for inter-city fast trains • Segregate and expand stopping services • Permit new stations in deprived area
New line	Berwick - Dunbar	• Avoiding geological threats to line along cliffs • Increased speed on better alignment • Resilience
Extra tracks	Dunbar-Edinburgh	• Increased local services • Increased speed and frequency of inter city trains • Will avoid flyovers at Drem, Portobello
Electrification and widening	Borders line to Tweedbank	• Environmental • Extend loops as in the original plans

		• Permit part-route services and allow faster whole route services
Electrification and platform extensions	Edinburgh – Fife network and on to Perth and Dundee	• Environmental • Capacity
Electrification	Edinburgh suburban line	• Strategic and resilience (offers emergency routes from East and West to Edinburgh Waverley)
Widening	Saughton – Newbridge Jn.	• Growth on west side of Edinburgh • Capacity and performance • Avoids a flyover at Newbridge Jn
Widening	Saughton - Dalmeny	• Capacity for commuters • Segregation of fast and slow • Tidal flow
New line	Through Fife	• Essentially a cut-off. Is an old Network Rail scheme. • Speed and capacity to avoid very twisty line in area of high commuting • Avoid a further road bridge at Queensferry
Bi-directional	East Coast where not four-tracked	• Resilience • Tidal flow at peak times

5. North West of England and west Scotland

Replace loops by two pairs of dynamic loops	Preston - Carlisle	• Capacity (frequency and train lengths) • Economy (removal of existing loops)
Electrification	Newcastle - Carlisle	• Resilience (diversions if either East or West Coast closed) • Environmental • Enhance commuter services at each end
Alignment and station rebuild	Carlisle Citadel	• Speed for both passenger and freight • Economy through modern track facilities • Capacity of the route • Release of land for house building
Reopening lines	Carlisle goods lines	• Capacity (frequency and train lengths)

		• Safeguarding of station infrastructure
Dynamic loops	Lockerbie	• Speed • Capacity (train lengths)
Realignment and new loops	Abington	• Speed for intercity trains • Capacity (frequency and train lengths)
Widening	Carstairs	• Speed to both Edinburgh and Glasgow • Capacity Note: A scheme already in CP6, which gives four-tracking and bi-directional working. These could be enhanced.
Widening	Uddingston Jn. – Rutherglen East Jn.	• Capacity • Performance, both commuting and inter-city
Grade separation	Newton	• Capacity • Performance, both commuting and inter-city
Electrification	Gretna – Ayr/Barrhead	• Resilience • Connectivity (Ayrshire to/from the south) • Commuting at Carlisle and Glasgow ends

Appendix 3

National low-carbon freight network recommended by Transform Scotland

The modernisation of strategic Anglo-Scottish corridors is fundamental to unlocking the potential for rail freight to better serve domestic and export markets. Amongst the core upgrades needed are lengthened overtaking loops on the East Coast and West Coast Main Lines to accommodate 775-metre freight trains – the equivalent of more than 40 lorry loads in a single movement. But rail freight cannot prosper simply by concentrating on the Anglo-Scottish lines. Development of a national low-carbon freight network will depend on three factors:

1. Electrification: Early electrification of the routes from Central Scotland to Aberdeen and Inverness – speeding up transits, improving route capacity and further cutting

carbon emissions compared to road haulage. To support electrification there must also be investment in ensuring that the electricity supply will be able to meet the demand placed on it. The energy density provided should ensure that freight trains are able to run; this is especially important on Anglo-Scottish routes (East and West Coast Main Lines) in conjunction with the start of HS2 services.

2. Route Capacity Enhancement: Enhancement of route and train capacity and capability (including loading gauge) to secure cost-effective rail freight operations connecting Central Scotland with key ports and terminals across the country.

The Scottish rail network as a whole remains a patchwork of different clearances involving complex permutations of wagon and container types. This imposes particular constraints on rail conveyance of wider refrigerated containers for chilled / frozen food on the routes from Aberdeen / Inverness to the Central Belt.

An early focus for investment should be the longoverdue enhancement of the largely single-track Highland Main Line from Perth to Inverness, with longer crossing loops and more double track allowing rail freight to increase the capacity of each container train from 20 to 28 containers. This will make rail freight more economical to run and will make rail freight more attractive to customers and help to reduce the carbon emissions of the transport sector.

3. Terminals: Realising the above potential depends in part on the creation of new rail freight terminals to serve currently neglected regions and undersupplied areas. Amongst the priorities should be:-

● Speyside – re-opened terminals at Keith and/or Elgin are needed to allow rail freight to help cut down on the 50,000 long-distance whisky lorry trips on the A9 annually.

● Direct rail access to key whisky industry sites, such as Cameron Bridge in Fife (the largest grain distillery in Europe) and Cambus / Blackgrange near Alloa (the largest bonded warehouse site in Europe).

What part or parts of the development requires planning permission or other consent? The electrification and improvements along existing lines do not require planning permissions or other consent and are within the scope of Network Rail. We propose that where those terminal sites cited above lie outwith the current operational railway that these should be considered part of the National Development and hence exempt from normal planning procedures.

When would the development be complete or operational? To be completed within the next 15 years (2035), in line with Transport Scotland ambitions for complete decarbonisation of the Scottish rail network.

Is the development already formally recognised – for example identified in a development plan, has planning permission, in receipt of funding etc.? Much of the above falls within the existing policy ambitions of Transport Scotland & the Scottish Ministers. The Scottish network would also form part of Network Rail's Strategic Freight Network.

Climate Change

A low-carbon economy is central to the Scottish Government's aims having, in April 2019, declared a Climate Emergency. But there is a relatively low level of awareness of the important contribution rail freight can make – in both the short and long term – to delivering policy objectives, for example through cutting CO2 emissions by up to 76 per cent compared to road haulage, even where road collection and delivery legs are

required at either end of the rail trunk haul. Switching freight from road to rail can offer a 'quick win', as it involves doing the same for less carbon, rather than having to doing things completely differently (as is often the climate change prescription in other sectors). The carbon emissions of rail freight can be reduced still further by a programme of electrification. Reducing the emissions of the transport sector is key to tackling the climate emergency as it is currently the sector with the most emissions. Encouraging modal shift from road to rail will be following the wider European policy direction as set out in the European Green Deal.

People

The transfer of freight from road to rail will benefit public health and quality of life across the country by cutting air and noise pollution, by reducing road congestion which cause delays to other business etc, road traffic crashes and community severance where high numbers of HGVs make it difficult to cross roads.

Inclusive Growth

Rail freight has long played a central role in Scotland's exporting economy, particularly in the movement south of spirits – for domestic, mainland European and Deep Sea markets – from hub container railheads at Coatbridge, Grangemouth and Mossend. Following the end of the Rosyth-Zeebrugge freight ferry service, two container trains daily link Mossend with the fast-expanding Teesport, providing vital links to mainland Europe. Rail has the potential to create jobs and growth in all regions of Scotland.

The retail transport sector has successfully moved into using rail to convey supermarket supplies in containers from the West Midlands of England to the Central Belt, and from the latter to Aberdeen and Inverness. And traditional bulk commodities by rail continue to efficiently service the Scottish economy – and keep heavy lorries off the roads, with big safety benefits – through trainloads of alumina, cement, china clay, coal, oil and steel.

Rail provides timetabled reliability, avoiding 100% dependence on road haulage and its vulnerability to road congestion, lorry driver shortages and future energy constraints. But the much bigger role which freight trains could play in a sustainable low-carbon economy is fundamentally dependent on the quantity and quality of available infrastructure.

Place

By encouraging the use of rail freight, more HGVs can be removed from the roads meaning that more historic and special places can be enjoyed as they were intended. Strong planning policies encouraging new development to have access to rail could unlock the potential of vacant and derelict land near rail as it would encourage it to be reused.

References

[1] Department for Transport: *Decarbonising Transport – Setting the Challenge* [London, Department for Transport, March 2020] https://www.gov.uk/government/publications/creating-the-transport-decarbonisation-plan

[2] Ibid.
[3] *Investment Strategy for Northern Ireland 2011-21* [Belfast: Northern Ireland Executive, 2011] https://sibni.org/app/uploads/2015/05/investment_strategy_for_northern_ireland_2011_-_2021.pdf
[4] Alberto Carrillo Pineda, Pedro Faria: *Towards a Science-Based Approach to Climate Neutrality in the Corporate Sector* [Science Based Targets initiaitve, September 2019] https://sciencebasedtargets.org/wp-content/uploads/2019/10/Towards-a-science-based-approach-to-climate-neutrality-in-the-corporate-sector-Draft-for-comments.pdf
[5] Andie Stephens: *Net Zero: An Ambition in Need of a Definition* [London: the Carbon Trust, November 2019] https://www.carbontrust.com/news-and-events/insights/net-zero-an-ambition-in-need-of-a-definition
[6] Air Quality Expert Group: *Non-Exhaust Emissions from Road Traffic* [London: Department for Environment, Food and Rural Affairs, 2019] https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1907101151_20190709_Non_Exhaust_Emissions_typeset_Final.pdf
[7] Victor R.J.H. Timmers, Peter A.J. Achten: *Non-Exhaust PM Emissions from Electric Vehicles* [*Atmospheric Environment*, 134 (2016) 10-17] http://www.soliftec.com/NonExhaust%20PMs.pdf
[8] Florence N. F. Parker-Jurd, Imogen E. Napper, Geoffrey D. Abbott, Simon Hann, Stephanie L. Wright, Richard C. Thompson: *Investigating the Sources and Pathways of Synthetic Fibre and Vehicle Tyre Wear Contamination into the Marine Environment* [London: Department for Environment, Food & Rural Affairs, May 2020] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=20110&FromSearch=Y&Publisher=1&SearchText=ME5435&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description
[9] *Rail Industry Decarbonisation Taskforce - Final Report for the Minister for Rail* [London: Rail Industry Decarbonisation Taskforce with the support of RSSB, July 2019] https://www.rssb.co.uk/-/media/Project/RSSB/Platform/Documents/Public/Public-content/Research-and-Technology/rail-industry-decarbonisation-taskforce-final-report-for-the-minister-for-rail-july-2019-final.pdf?la=en
[10] Ben Jones: *Network Rail Wants 80% of British Network Electrified by 2050* [Horncastle: *Railway Magazine*, June 2020]
[11] David Shirres: *Getting Electrification Done: the Net-Zero Imperative* [Coalville: *Rail Engineer*, 13 March 2020] https://www.railengineer.co.uk/2020/03/13/getting-electrification-done-the-net-zero-imperative/
[12] *£589 Million to Kick Start Rail Upgrades Across the North* [London: Department for Transport press release, July 2020] https://www.gov.uk/government/news/589-million-to-kickstart-rail-upgrades-across-the-north
[13] National Audit Office*: Investigation into the Department for Transport's Decision to Cancel Three Rail Electrification Projects HC 835* [London: National Audit Office, March 2018] https://www.nao.org.uk/report/investigation-into-the-department-for-transports-decision-to-cancel-three-rail-electrification-projects/
[14] *Rail Services Decarbonisation Action Plan* [Edinburgh: Transport Scotland, July 2020] https://www.transport.gov.scot/publication/rail-services-decarbonisation-action-plan/
[15] [HS2 Ltd website, accessed April 2020] https://www.hs2.org.uk/why/how-hs2-helping-reduce-overcrowding/
[16] Douglas Oakervee: *Oakervee Review of HS2* [London: Department for Transport, February 2020] https://www.gov.uk/government/publications/oakervee-review-of-hs2
[17] Tony Berkeley: *A Review of High Speed 2 – Dissenting Report by Lord Tony Berkeley* [Unpublished, January 2020]
[18] Department for Transport: *Road Investment Strategy 2: 2020-2025* [London: Department for Transport, April 2020] https://www.gov.uk/government/publications/road-investment-strategy-2-ris2-2020-to-2025
[19] Transform Scotland: *National Developments – Response Form* [Edinburgh: Transform Scotland, may 2020] http://transformscotland.org.uk/wp/wp-content/uploads/2020/05/NPF4-National-low-carbon-freight-network-final.pdf
[20] Smart Growth UK: *Defending Our Lines – Safeguarding Railways for Reopening* [Haltwhistle, Smart Growth UK, April 2020] http://www.smartgrowthuk.org/resources/downloads/Rail_Safeguarding_Report_2020.pdf
[21] Lynn Sloman and Lisa Hopkinson: *The Carbon Impact of the National Roads Programme* [Machynlleth: Transport for Quality of Life, July 2020] https://www.transportforqualityoflife.com/u/files/The%20carbon%20impact%20of%20the%20national%20roads%20programme%20FINAL.pdf
[22] *£2 billion Package to Create New Era for Cycling and Walking* [London: Department for Transport, 9 May 2020] https://www.gov.uk/government/news/2-billion-package-to-create-new-era-for-cycling-and-walking

[23] Darren Shirley: *Recovering Public Transport Post-Covid Lockdown* [London: Campaign for Better Transport, 11 May 2020] https://bettertransport.org.uk/blog/better-transport/recovering-public-transport-post-covid-lockdown

[24] Centre for Cities: *Cities Outlook 2020* [London, Centre for Cities, January 2020] https://www.centreforcities.org/wp-content/uploads/2020/01/Cities-Outlook-2020.pdf

[25] Royal College of Physicians: *Reducing Air Pollution in the UK* [London: RCP, 2018]

[26] M. Williams et al: *Personalising the Health Impacts of Air Pollution – Summary for Decision* [London: King's College, 2019]

[27] Public Health England: *Estimation of Costs to the NHS and Social Care Due to the Health Impacts of Air Pollution* [London: Public Health England, 2018]

[28] Lynn Sloman and Lisa Hopkinson: *An Eco Levy for Driving: Cut Carbon, Clean up Toxic Air and Make our Towns and Cities Liveable* [Machynlleth: Transport for Quality of Life, November 2019]

[29] *IMO Gives Strong Signal to the Shipping Industry to Start Decarbonizing* [Nicosia: Helennic Shipping News Wordlwide, April 2018] https://www.hellenicshippingnews.com/imo-gives-strong-signal-to-the-shipping-industry-to-start-decarbonizing/

[30] *After UN Deal on Shipping Emissions, It's Now up to Europe 'to Get Things Moving'* [Brussels: Transport & Environment, May 2018] https://www.transportenvironment.org/news/after-un-deal-shipping-emissions-it's-now-europe-'-get-things-moving'

[31] *The Scale of Investment Needed to Decarbonize International Shipping* [Copenhagen: International Maritime Forum, January 2020] https://www.globalmaritimeforum.org/news/the-scale-of-investment-needed-to-decarbonize-international-shipping

[32] *Maritime 2050* [London: Department for Transport, 2019] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/872194/Maritime_2050_Report.pdf

[33] *Clean Maritime Plan* [London: Department for Transport, 2019] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/815664/clean-maritime-plan.pdf