Public Transport Infrastructure including Mode Integration

Introduction

This record of evidence forms part of the work undertaken by UKERC's Technology and Policy Assessment team relating to its project on policy strategy for carbon emissions reduction in the passenger transport sector. The material was produced alongside the project's main report and since it supports that report, it was judged appropriate to make this material available to a wider audience. The main report itself '*What Policies are Effective at Reducing Carbon Emissions from Surface Passenger Transport*?', and the supporting evidence can be found at:

http://www.ukerc.ac.uk/ResearchProgrammes/TechnologyandPolicyAssessment/TPAProjects.aspx

Explanation of Content

Evidence on this policy measure has been collected by the TPA team on the basis that it has, or may have, the potential to result in carbon dioxide emissions reductions in the passenger transport sector. This evidence document begins with a summarised description of the policy measure. The evidence itself follows the summary and is presented in table form.

Each piece of evidence has been assigned a separate row and tabulated using four columns:

- Year of publication, arranged chronologically, beginning with the most recent year
- Name of author, including where applicable additional cited authors (and year); and a Reference ID number.
- Type of evidence:
  - Evidence containing quantitative information is denoted by the letter 'Q'
  - Qualitative evidence is denoted by the letter 'C' for 'comment'
- The evidence itself

The evidence was originally gathered and assessed using several sub-headings. The purpose of this was primarily internal i.e. to facilitate the handling of evidence and the production of the main report. These sub-headings have been retained here as follows:

- Policy Measures and Carbon Savings
- Other potential CO_2 Impacts i.e. outside of the immediate policy influence
- Other Benefits e.g. air quality improvement or traffic congestion reduction
- Policy Costs and/or Revenues i.e. to local or national government
- Business and Consumer Costs
- Unintended Consequences e.g. rebound effect
- Reasons/Arguments for Carbon Savings Achievement or Failure
- Policy Suitability for the UK

A list of references follows the evidence tables. Note that the Reference ID numbers are allocated by Reference Manager, the referencing software used by the TPA team.

Any charts, figures and tables referenced in the evidence are not reproduced here but can be found in the original publication or evidence material.

Where no relevant evidence was found for a particular sub-heading, this has been noted.

Policy Description

The evidence recorded here covers measures for the promotion and enhancement of bus, light rail (e.g. trams and streetcars), and rail infrastructure and services. This includes optimisation of public transport (PT) services by increasing and/or regularisation of service frequencies, and making PT more comfortable through fleet renewal, quality of information, better or more bus stops and stations etc. Measures for the promotion of bus public transport include traffic priority measures such as bus lanes and guided busways and/or priority traffic lights, which have so far primarily been used to alleviate congestion in urban centres.

The evidence recorded here also covers mode integration measures that facilitate the interface and integration of different travel modes e.g. bicycle parking at railway stations or multimodal ticketing on public transport.

Evidence Tables

Carbon Savings and Policy Measures

Year	Author	Type	Evidence
			General
2006	Noland (ref 11450)	Q	Table 3 shows fuel savings (useable as a proxy for CO2) for various policies. % reductions are relatively small for all the public transport policies.
2005	Wolfram et al. (ref 11380)	C	Public transport priority measures seem to have very limited direct potential for the reduction of air pollutant and noise emissions. However, they can be an important measure in an integrated transport strategy to make public transport more attractive and encourage modal shift.
2005	Annema (ref 11287) citing Transecon, 2003	Q	In 13 case studies mostly of metro but also of tram and bicycle schemes in European cities, only three produced reductions, which for Co2 were very small (2-5%). "…the metro results in higher car speed, making car travel more attractive. So why is there a decrease in car use in the Helsinki and Vienna case? It is not quite clear but one explanation could be that the cities in these cases took additional car restricting measures next to the metro investment project" (citing Transecon, 2003).
2005	Annema (ref 11287) citing Van Essen et al., 2003	C	Shifts to public transport can show very low CO2 emissions effects when assessed on a marginal basis (citing data from 2003 Van Essen et al. study). "The figures given…are presented as marginal emission factors: the emission factors of a hypothetical extra passenger in a given situation. Using marginal emission factors is considered to be fair, especially for evaluating modal shift impacts toward public transport off-peak. This is because during off-peak many seats in public transport are empty; these could be filled if a modal shift took place without much extra energy consumption (no extra buses or trains are required)."
2003	Brand and Preston (ref 2270)	C	There is little difference in energy use at point of use (in terms of MJ per passenger-km travelled) between car, bus and light rail once full account is taken of the actual levels of utilisation.
1998	Lundqvist	Q	A transport strategy to improve the public transport network

Year	Author	Type	Evidence
	(ref 11235)		could yield a 39 kiloton CO2-reduction (3.3 %).
			Bus
2008	Hensher (ref 11464)	C	Doubling bus frequencies does little to reduce CO2 – see Table 6.
2007	Shaheen (ref 11192) citing Vincent and Jerram, 2001	Q	A Bus Rapid Transit (BRT) system employing 40 foot compressed natural gas (CNG) buses provided the greatest decrease in CO2 emissions when compared to light rail and 60 foot hybrid diesel BRT buses. The 40 foot CNG buses in a BRT system exceed light rail CO2 reductions by approx 300% (citing Vincent and Jerram, 2001).
2007 2002	Shaheen & Lipman (ref 11192); Lehtonen & Kulmala (ref 11581)		Modelling of bus signal priority in Helsinki, Finland in 1999 indicates that a 5% reduction in annual fuel consumption is achievable.
2005	Dierkers et al. (ref 11455)	Q	With each 1.0 percent growth in transit service levels (e.g., increased vehicle coverage and expanded operating hours) it is estimated average ridership increases by 0.5 percent. Dierkers (2005) shows a sample calculation assuming transit frequency improvements in conjunction with additional transit service improvement measures resulting in a 10 percent increase in transit ridership. The emission savings calculation is based on a regional impact where 500,000 trips per day are originated. The VMT savings calculation for the transit service improvement case is: VMT Savings = (5,000,000 × 5.0 × 0.95) – (5,000,000 × 5.0 × 0.945) = 125,000 miles per day.
2005	Dierkers et al. (ref 11455)	Q	In examining Bus Rapid Transit, Dierkers (2005) provides a quantification for a 1-2% reduction in VMT based on implementation in a single 'corridor' as opposed to regionally.
2001	IEA (ref 11354)	Q	The EC's Auto-Oil II modelling program for Athens assessed the effect of a package of measures to improve public transport, primarily by increasing average bus speeds by 15%. The measures included adding new bus lanes and giving buses priority at intersections. As a result, CO2 emissions declined for the city's transportation system, but by only a net 0.3%, mainly because of a projected increase in overall traffic congestion due to loss of lanes for private vehicles.
2001 1996	IEA (ref 11354) Michaelis (ref 11593)	Q	A modeling exercise undertaken by NOVEM, the Dutch Environment Agency, found that a scenario to improve public transport cut CO2 emissions by a small percentage, 0.5%, for the Dutch transportation system between 1990 and 2010.
2001	IEA (ref 11354)	C	Such models as above may exclude potential long-term effects on land use. A pro-transit strategy, therefore, might yield much greater-than estimated reductions in CO2 emissions in the long term. Some studies have estimated a

Year	Author	Type	Evidence
			long-run land-use multiplier of five to ten times the amount of the short-run reductions.
			Light Rail
2008	VTPI/ TDM (ref 11487) citing Puchalsky, 2005	C	Although Light Rail Transit generally serves a relatively small portion of total regional travel, it tends to be concentrated in dense urban areas where vehicle traffic costs are high. As a result, total benefits per trip tend to be large. Air pollution emissions are significantly lower per passenger-mile than automobile travel, conventional transit bus and Bus Rapid Transit (citing Puchalsky, 2005).
2005	Dierkers et al. (ref 11455)	Q	Dierkers (2005) shows a sample calculation for light railway transit (LRT) policy effects. The VMT savings is 2% or 47,500 miles per day.
			Mode Integration
2007	Shaheen (ref 11192)	Q	Another strategy to reduce CO2 emissions is smart cards. Smart cards contain electronic chips. They are used for a variety of applications, such as travel and parking payments. Stockholm is integrating smart cards for use on transit, taxis, and carpools throughout the city. This approach is estimated to reduce CO2 emissions by 1,500 tons per year by the 2030 to 2050 timeframe.

Other CO2 Impacts

Year	Author	Type	Evidence
1981	Pikarsky (ref 11071) citing Pushkarev 1981	C	Development near railway stations tends to be more dense than elsewhere, leading to energy reduction in provision of services, including heating, in multi dwelling buildings (citing Pushkarev, 1981).

Other Benefits

Year	Author	Type	Evidence
			General
2005	Dierkers et al. (ref 11455)	C	The benefits of public transit typically include: • reduced exposure to traffic congestion • lower costs relative to automobile ownership • less land allocated for roadway and parking infrastructure • greater mobility choice • decreased fuel consumption • improved public health and safety • increased property values near high quality transit enhanced environmental protection through reduction in air pollution emissions, preservation of land resources, and reduction of water pollution caused by runoff of impervious surfaces
			Bus
2005	Dierkers et al. (ref	C	The benefits attributable to Bus Rapid Transit may include: • lower economic and environmental costs associated

Year	Author	Type	Evidence
	11455)		with BRT than with automobile infrastructure facilities • lower capital cost than rail projects • reduced commute times • increased transit ridership • expanded transit accessibility in suburban regions that lack the density to make rail transportation an effective option • implementation that can be quick and incremental • fuller use of existing infrastructure through the use of pre-existing running ways • adequate capacity for high volume transportation corridors • enhanced system flexibility allows for a variety of service options in a range of urban and suburban environments • easily integrated into transit and pedestrian oriented developments • promotes development and redevelopment in station areas
2003	Brand and Preston (ref 2270)	Q	Guideways can decrease bus journey times, but only if junction design and priorities with other traffic modes are properly designed. Some UK schemes (Leeds, Edinburgh) have shown no benefit overall in parts. Urban bus lanes show some improvements in overall travel time for buses (0·5–5 min), but sometimes at the cost of delays for general road traffic sharing the same corridor. Guided busways and buses with off-board fare collection have the greatest in-vehicle time savings. IVT savings are generally lower and spread more widely for buses on bus priority schemes (–10% to +30%), but much higher at peak times. Savings range between 0 and 5 minutes regardless of the length of the scheme.
			Light Rail
2003	Brand and Preston (ref 2270)	C	LRT policy can provide many co-benefits such as: • reducing the need for new highway and parking facility investments • preserving livable neighborhood characteristics • reducing exposure to traffic congestion • lower costs relative to automobile ownership • greater mobility choice • decreasing fuel consumption • improving public health and safety LRT can also provide additional benefits to transit systems that can result in improved performance and ridership levels through: • serving as a catalyst for economic development along transit corridors • increased property values along corridors and around stations

Year	Author	Type	Evidence
			• flexibility to service a variety of environments • increased capacity per vehicle over many rapid transit and urban bus systems • lower per-passenger operating costs compared to bus rapid transit • improved safety over urban bus service due to fixed guide-way and reserved lanes • provision of higher quality of service and comfort levels • greater ability to attract riders who have the option to drive
2003	Brand and Preston (ref 2270)	C	Brand and Preston, 2003 suggests the following benefits: • Regeneration – although evidence on this is unclear • In vehicle time savings: light rail (between 10% and 55% of IVT) and suburban rail (21–31% of IVT) schemes appear to improve IVT compared with bus alternatives serving the same corridor. Savings compared with car travel at peak times are lower but still positive • Safety – light rail systems are safer than non-segregated buses, or cars in terms of the number and severity of accidents per passenger-km. (Suburban) rail has a higher proportion of serious accidents per vehicle-km than does bus, indicating that accidents happen less frequently but have more severe consequences. • Reduced local noise pollution depending on technology used (unclear) • Reduced local air pollution depending on technology used (unclear) • Reduced community severance for metro systems, but poor access • Duel mode rail can improve inter-modal interchange
			Rail
1981	Pikarsky (ref 11071) citing Pushkarev, 1981	C	The construction of a new transit, line attracts development because of increased accessibility (citing Pushkarev, 1981).
			Mode Integration
2008	VTPI/TDM (ref 11487)	C	VTPI/TDM (2008) summarises the benefits of bicycle mode integration in Table 3 ‘Benefit Summary’.

Policy Costs and/or Revenues

Year	Author	Type	Evidence
			General
2003	Brand and Preston (ref 2270)	C	Under similar conditions, infrastructure costs for busways, guided buses and light rail are comparable.
			Bus

Year	Author	Type	Evidence
2003	Brand and Preston (ref 2270)	Q	• Bus lanes using existing roads are the cheapest option of all guided bus and light rail schemes, with infrastructure costs of £0.01–1.29m/km for a two way lane, average £0.49 m/km. Vehicles cost £0.11–0.19m (high value for articulated buses, more for alternative fuel buses (15% for CNG/ethanol, 85% for battery electric). • Busways have infrastructure costs of £2.8-11m/km for a two-way lane, average £6.1 £m/km, or more if bridges and tunnels needed. Vehicle costs are as for bus lanes. • Guided buses have infrastructure costs of £2.5-5.8m/km for a two way lane, average £3.7 m/km. Guided light transit schemes have lower costs of £2.2m/km. Vehicles cost £0.12–0.2m (high value for articulated buses, more for alternative fuel buses (15% for CNG/ethanol, 85% for battery electric). • Vehicle costs in all cases are £1.5-1.6k per potential passenger
			Light Rail
2008	VTPI/ TDM (ref 11487) citing APTA, various years	C	Rail Transit systems tend to be expensive to develop and operate. According to American Public Transportation Association data, Light Rail Transit has higher operating costs per passenger-mile than other forms of transit. However, this reflects the fact that LRT systems are located in dense urban areas where any transportation service is costly to provide, and because many LRT systems are relatively new and still building ridership (citing APTA, various years) .
2003	Brand and Preston (ref 2270)	Q	Light rail schemes have infrastructure costs of £3.3-10.5m/km for a two way line, average £6.6 m/km. For schemes with bridges and tunnels this can be up to £60m/km. Vehicles cost £0·8-2.0m, or £4.0-5.7k per potential passenger. Duel mode light rail schemes have lower infrastructure costs, and they also use suburban heavy rail lines, but higher vehicle costs.
			Rail
2008	VTPI/ TDM (ref 11487) citing Litman, 2005a and Litman 2005b	C	When all costs (including roadway, parking, vehicle, and external) are considered, Rail Transit is often more cost effective per passenger-trip than accommodating additional automobile travel or attracting more bus transit users on congested urban corridors. Claims that rail transit projects cost more than alternatives often consider only a portion of total costs (citing Litman, 2005a and Litman, 2005b).
2003	Brand and Preston (ref 2270)	Q	Suburban rail schemes have infrastructure costs of £4-15m/km for a two way line. Vehicles cost £1.8-3.0m, or £4.0-7.2/km per potential passenger.
			Rail
2002	BTRE (ref 11429)	Q	Research by the US Department of Transportation (DOT) indicates that new urban rail systems have generally cost more than anticipated to build, cost more than anticipated to operate, and carried far fewer riders than planned (citing

Year	Author	Type	Evidence
			Cox and Love, 1993). The same DOT study estimated the cost of each new rider attracted to a rail system ranged from US$4,800 to US$17,700 annually.

Business and Consumer Costs

Year	Author	Type	Evidence
			General
2008	VTPI/ TDM (ref 11487) citing Litman, 2004	Q	Residents of cities with high-quality Rail Transit systems pay approx $100 p.a. per capita in additional transit subsidies, and save approx $500 p.a. per capita in direct consumer transportation (automobile and transit) expenditures, indicating a high return on investment (citing Litman, 2004).
2003	Brand and Preston (ref 2270)	Q	On a cost per vehicle-km basis, urban bus operations are four times less expensive than light rail, followed by suburban rail (seven times) and metro (14 times). However, there is little difference on a cost per passenger-km basis, except for metro systems, which are twice as expensive to run as bus-based systems. As a result, rail revenues are higher. Fares are higher for metro, then light rail, then buses. Suburban rail revenues per passenger can be substantially higher (but note the much lower fare per km, as trip lengths are longer).
			Bus
2008	Hensher (ref 11464)	Q	Doubling bus frequencies does little to reduce CO2 suggests Hensher (2008), but given that buses share roads with cars, it adds to the money cost of road use (attributable to increased payment of public transport fares) but results in an improvement in time costs (due to modal substitution) of -5.35%. This is a potential winner for bus operators (58.5% growth in fare revenue) but has to be contrasted with the cost of extra vehicles and other inputs (labour, fuel, maintenance, etc.).
2003	Brand and preston (ref 2270)	Q	On a cost per vehicle-km basis, urban bus operations are about four times less expensive than light rail, followed by suburban rail (seven times) and metro (14 times). However, there is little difference on a cost per passenger-km basis, except for metro systems, which are twice as expensive to run as bus-based systems.
			Mode Integration
2008	VTPI/TDM (ref 11487)	Q	Bicycle mode integration costs include expenses to purchase, install and maintain bike racks and lockers; liability, accident risk and delays from bike racks on buses; and increased stress to drivers. Most transit agencies that carry bikes on racks or in vehicles experience minimal problems once the programs are established, as indicated by the large number of transit agencies that have expanded this service. Bicycle racks suitable for buses typically cost $500-1,000

Year	Author	Type	Evidence
			(U.S. dollars) for a high-quality model that can carry two bicycles. Bike racks on buses can create operational problems (such as extending bus size, and making it more difficult to wash buses). Simple bicycle storage racks typically cost $50-100 per bike. Covered bike racks and lockers cost $300-1,000 per bicycle, depending on design, materials and location. Bike storage may take up valuable space around transit stations.
2008	VTPI/TDM (ref 11487) citing Replogle & Parcells, 1992	Q	VTPI/TDM (2008) in Table 1 'Park-and-Ride and Bike-and-Ride Facility Comparison' (citing Replogle & Parcells, 1992) compares typical costs for automobile and bicycle parking.

Unintended Consequences

Year	Author	Type	Evidence
			General
2005	Wolfram et al. (ref 11380); and citing Lautso et al., 2004	C	If the travel time or travel cost budgets people are willing to spend are not used up entirely, people will not enjoy the savings but will travel more in order to extend their range of activities and contacts. Thus, the trip lengths for both car and PT may increase result in possible city sprawl including workplaces and inhabitants moving to outer areas. The PROPOLIS project tested three policies to take into account an increase in the quality of public transport services leading to positive environmental results, although determining – in the long term – an increase of the urban sprawl phenomenon (citing Lautso et al. 2004).
2004	Stopher (ref 517)	Q	Stopher (2004) imagines an example metropolitan region: Now, assume there is a policy that says the market share for public transport is to be increased to double within 20 years, meaning that public transport must carry 16% instead of 8%. If public transport maintained the 8% share, the number of trips carried in 20 years would be 1.9 million, or an increase over the base year of over 600,000 daily trips. To increase public transport's share to 16% would entail carrying 3.8 million trips per day, or an increase of 2.5 million over the base year. Thus public transport would have to carry three times the ridership that it does at present. This presents some real problems. Hence there is serious doubt as to whether it is feasible to increase public transport ridership by a significant amount from present levels, given the volume of passengers that would have to be carried, the downward trend in public transport market share, and the increasing dispersion of jobs and residences, producing a pattern of demand that is very difficult for public transport to serve.
2003	Brand and	C	Land take, which is important in urban centres, is greatest in

Year	Author	Type	Evidence
	Preston (ref 2270)		terms of track width for bus ways, then bus lanes, then trams and guided buses. Suburban railways are in the middle of this range, and metros take the least.
			Rail
2002	Glaister (ref 3521)	C	Spending on railways is less socially equitable than spending on buses or roads, as poorer groups have poor access to railways.

Reasons/Arguments for Carbon Reduction Achievement and/or Failure

Year	Author	Type	Evidence
			General
2008	Moriarty (ref 11470)	Q	An OECD fully public transport system in 2030 might at best be 7.5 times as CO2-e efficient as a present fully car-based one. If anticipated personal mobility levels were maintained by a shift to public transport in countries like the US or Australia, a three-fold reduction in CO2-e by 2030 would still be required to meet the 22.0- to 23.6-fold reductions suggested above. (To the extent that some travel is already by public transport, the reductions needed will be even larger).
2008	DfT (ref 11491)	C	Improvements which encourage greater use of rail or bus capacity at off-peak times will improve the overall efficiency of these modes as well as reducing emissions from road transport if a mode switch has occurred.
2007	ECMT (ref 11272)	C	"The less energy intensive transport modes tend to have small market shares and even a small change in share represents a large increase in the transport activity for these modes".
2007	DfT (ref 11493)	Q	Public transport modes have much smaller shares of total passenger mileage than that of private cars as shown by the Table 'Passenger kilometres travelled by mode in the UK' in DfT (2007).
2007	DfT (ref 11493)	Q	Between mid-80's and early 2000's passenger kilometres grew by 41%, and public transport passenger km grew by 12% (all of which was accounted for by the growth in rail travel).
2007	DEFRA (ref 11506)	Q	CO2 emissions intensities by travel mode (gCO2 / passenger km) adapted from DEFRA (2007): Rail – 60.2 Passenger Cars (Petrol) - 130.9 Passenger Cars (Diesel) - 124.2 Bus/Coach - 89.1
2007	Anable & Bristow (ref 12297)	C	The Public Service Agreements with respect to public transport relate purely to increases in patronage. This can be achieved with no environmental benefit as it is easier to increase the number of trips made by existing users and attract trips from walk or cycle than to achieve modal shift from the car.
2007	Hass-Klau (ref 11607)	Q	The relationship between good public transport provision and longer term lifestyle changes was investigated by Hass-Klau et al. (2007) who used census data to explore changes

Year	Author	Type	Evidence
			over time in car ownership in public transport corridors in 17 areas in five countries (Germany, UK, France, US and Canada). The study concluded that in the majority of cases car ownership is lower and grows less in areas close to public transport, even when socio-demographic factors are controlled for. The average case showed a relative reduction of car ownership of about 37 cars per 1000 population, or about 9% less car ownership in these areas. The strongest car reducing effect was seen around underground stations followed by light rail or tram.
2003	Van Essen (ref 11652)	C	The potential for emissions savings is largest if car drivers can be persuaded to switch modes and spare capacity is filled with little extra energy consumption, since marginal public transport emissions can increase very little whilst car journeys are removed.
2003	Goodwin & ECMT (ref 11497)	C	Policies that seek to minimise travel demand through planning can be undermined if transport services are not appropriate.
2002	BTRE (ref 11429)	C	The load factor for public transport is critical in determining whether fuel usage per passenger–kilometre is higher with private transport than public. While a train may generate less GHG emissions than urban cars per passenger kilometre, it is often only during peak hour that trains are at capacity. As with buses, there will be times when their operations produce higher emissions per passenger kilometre than cars.
			Bus
2006	Marshall (ref 417)	Q	Marshall (2000) examined a park and ride in Bristol – see Table 6 - and concluded that the scheme has been successful in encouraging a switch from car to public transport to some extent. However, there is also some evidence of trip generation
2000	Parkhurst (ref 11590)	Q	In relation to bus-based Park and Ride, an important study in several UK market towns demonstrated a clear pattern that approximately 65% of the users were indeed people who would have otherwise driven by car all the way into the town centre, but 35% were people who would have otherwise travelled by bus all the way from their home to the centre.
			Light Rail
2003	Brand and Preston (ref 2270) citing Hass-Klau et al., 2000	Q	Light rail schemes usually (but not always) carry more passengers than bus based systems, with capacities from 1000-21,000 passengers/hour. They can also vary their capacity, through changing the length of unit. The inflexibility of routes for light rail allows a more long-term approach to car restraint than bus-based systems (citing Hass-Klau et al, 2000).
2003	Brand and Preston (ref 2270)	Q	The main advantage of light rail systems appears to be achievement of a higher and longer sustained modal shift away from car travel, with apparent journey-time (and occasionally accident) benefits for general traffic users. In the UK, between 18% and 25% of light rail users were former car drivers. According to one source, decongestion benefits of ‘major rail-based urban public transport’ per car-

Year	Author	Type	Evidence
			kilometre removed from the road network range from 13 to 53 pence per PCU-km (in 2000 prices; PCU ¼ passenger car unit)'.
1981	Pikarsky (ref 11071) citing CBO, 1977	C	A previous study (citing CBO, 1977) notes that light rail systems cause circuity – non-productive mileage, as they are not as direct as driving. Therefore if trips involve driving to a rail stop, they may not save energy, especially as the cars driven tend to have only one or two passengers. The previous study concludes that 'rail transit offers little aid to the nation's efforts to save fuel' and that they should not, therefore, receive federal funding. Pikarksy (1981) cites rebuttals to this previous study, which dispute the boundaries used for the energy use calculation (e.g. cars often have non-productive mileage e.g. dropping off children at school), and energy use data used, and which point out if electricity is used in rail, then non-oil energy sources can be used.
1981	Pikarsky (ref 11071)	C	Suitability for light rail is very location dependent, and so average data is not very helpful.
			Rail
2007	ECMT (ref 11272)	C	"There is under-utilised capacity on much of the European rail network, but outside Central and Eastern Europe this tends to be on peripheral parts of the system where demand is declining…To an extent the ability of rail to substitute for road is limited by its much more limited territorial coverage (rail infrastructure is much more expensive to build, maintain and operate than roads)".
2007	ECMT (ref 11272)	C	"Potential for modal shift is also limited by whether the alternative can supply the same level of service as passengers and freight currently receive. Time is very important in passenger markets and most freight markets (journey time, punctuality and reliability) and comfort levels are important in the passenger market. Behavioural barriers are quite significant in the passenger market. These factors are summarised in the tendency for cross-modal elasticities to be quite low"
2004	Begg (ref 3472)	C	In the UK, rail investment has not delivered the required growth in passengers so has not achieved modal shift. "Despite being the main beneficiary of the 10-Year Plan (total rail investment was to be about three times as high as strategic roads) it is unlikely that the railway industry will assist in managing road traffic levels by delivering the predicted 50% growth in passenger numbers and 80% freight growth.".
1981	Pikarsky (ref 11071) citing CBO, 1977	C	Rail systems cause circuity – non-productive mileage, as they are not as direct as driving. Therefore if trips involve driving to a rail stop, they may not save energy, especially as the cars driven tend to have only one or two passengers. The study describes that rail transit has a disadvantage when the energy saved or lost per passenger-mile of travel induced by new programs was considered (citing CBO, 1977).
1981	Pikarsky	C	Several studies show that many new rail-transit-system

Year	Author	Type	Evidence
1977	(ref 11071) and citing Pushkarev, 1981; CBO (ref 11653)		passengers formerly used bus (36% for Philadelphia's Lindenwold line, 54% for San Francisco's BART line, and 72% for Chicago's Dan Ryan line) or were making a new trip because of the system (13%, 11%, and 16% for the three systems). This modal shift, resulted in a net energy loss per passenger-mile of travel when compared with the modal energy previously used. The study concludes that 'rail transit offers little aid to the nation's efforts to save fuel' and that they should not, therefore, receive federal funding. Pikarsky (1981) cites rebuttals to this previous study, which dispute the boundaries used for the energy use calculation (e.g. cars often have non-productive mileage e.g. dropping off children at school), and energy use data used, and which point out if electricity is used in rail, then non-oil energy sources can be used. One of these studies (citing Pikarsky, 1981) states that in the US at this time, [given] the occupancy rates and energy use of rail systems, rail systems could achieve lower energy use than cars or buses.
			Mode Integration
2008	VTPI/TDM (ref 11487) and citing Bracher, 2000	Q	Bicycling integrates well with Public Transit (bus, train, ferry, and air transport). Transit is most effective for moderate- and long-distance trips on busy corridors, while cycling is effective for shorter-distance trips with multiple stops. Combining transit and cycling can provide a high level of mobility comparable to automobile travel. A transit stop normally draws riders within a 10-minute (a half-mile) walking distance. At a modest riding speed a cyclists can travel three or four times that distance in the same time, increasing the transit catchment area about ten-fold. Bicycle access tends to be particularly important in suburban areas where densities are moderate and destinations are dispersed (citing Bracher, 2000).

Policy suitability for UK

Year	Author	Type	Evidence
			Bus
2003	Brand and Preston (ref 2270)	C	Many of the examples of bus infrastructure schemes given in Brand and Preston (2003) are in the UK, and have been developed recently. Land use needs could restrict use in some historic urban centres. Efficient busways require large stations and sometimes multiple lanes. This raises the question whether this increased land take would be technically and politically feasible in some of the historic cities in the UK.
			Light Rail
2003	Brand and Preston (ref 2270)	C	Several of the light rail schemes discussed in Brand and Preston (2003) are in the UK.

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