

C. Mass Transit

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1. Introduction

Mass transit is a key ingredient in a sustainable, low-carbon transport future, whether in urban or rural settings, in developing or developed countries. It covers three modes of public transport: trains, light rail (or trams) and buses. Train systems include long haul trains (running at either normal or high speed), Metro (subway or elevated urban trains) and conventional suburban trains. There is also rail freight, which is discussed in the Freight section of this guide. Buses include bus rapid transit (or BRT) with dedicated road lanes and other distinctive features, and conventional bus services that share lanes with other traffic.

Figure 3.9 Light-rail, trains and buses are all key parts of the global transport future



Picture Credit: Claire Pendrous.

A good mass transit system provides services that are frequent, fast, punctual, safe, comfortable, clean and affordable. It provides transport at the times and in the locations that people require. The system is accompanied by good walking and cycling access to and from transit stations. Town planning measures complement good transit by encouraging higher urban densities and mixed land use, particularly near stops and stations. In this way, homes, workplaces, shops, schools, health centres, services and recreation facilities are closer to transit, and more people can use it as they go about their daily lives.

Middle Eastern cities are building \$80 billion of new high quality transit including the new Dubai Metro and a service to do the Haj. China and India are now prioritising mass transit as the solution to their traffic problems with 82 Metros being built in China and 14 in India. Most other cities and localities around the world recognise – or are quickly coming to recognise – the economic, social and environmental necessity of good transit systems in the twenty-first century. On the other hand, many localities in the developing world

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do not yet have a basic organised bus service, that is, a coordinated, quality service that systematically covers the locality.¹

2. Benefits of mass transit

Economic benefits

Mass transit can move large numbers of people at less cost to the individual and society. It is much cheaper to transport a large number in one vehicle than to move one person in each of a large number of vehicles. (While cars can potentially transport four or five people, in fact they only transport 1.52 on average, based on the 84 city survey described in Chapter 2.) Thus, it is not surprising that cities and countries that have high rates of mass transit use spend much less on transport overall than do localities where larger proportions of the population use private vehicles.²

Mass transit also makes it easier for people who can't afford private vehicles, or can't drive them, to get to workplaces, shopping areas and educational institutions. This means that more people are able to be economically active as workers, buyers and sellers, and as well-educated workers of the future.

Public transit and denser cities reinforce one another through a 'virtuous circle'. Transit moves large numbers of people in a smaller space, thus saving space and allowing greater urban density. Vuchic first set out the passenger capacity in the different modes. He suggested that a train service could carry up to 50,000 people per hour in a space that could only convey 2,500 car travellers per hour. In the same time and space light rail and BRT could both convey 10-20,000, while conventional buses could convey 5,000.³ Since then, there have been data claims of over 40,000 passengers per hour on the Bogota BRT and over 80,000 per hour on the Hong Kong Metro and Mumbai rail system (which carries 10 million passengers a day). Such huge numbers are related to the density of these cities as only mass transit can adequately service places where space is at such a premium. In car-based cities densities are much lower. It is argued that viable transit requires densities over thirty-five people or jobs per hectare.⁴ Moreover, the provision of transit, given its benefits, can further increase densities in its corridor.⁵ Finally, a denser city's infrastructure costs less per resident.⁶

Social benefits

Mass transit's greater affordability,^{***} and its accessibility for people too young or unable to drive, makes it a form of transport that more people can use to meet their needs: to get to health and other services, to make vital social connections and, as just noted, to work, shop and learn. Thus it is a factor leading to greater equality and social inclusion.⁷

Clean, efficient mass transit makes for healthier communities, because it is responsible for less pollution and fewer traffic accidents, and it encourages walking and cycling.

And communities with fewer private vehicles, an effective mass transit system and good walking and cycling routes are pleasant places to live in, with less congestion and noise, and greater levels of social interaction – all factors that have been shown to boost health and happiness.

*** Public transit in fact is often expensive and unaffordable for people on low incomes, but it is cheaper than car ownership, and the challenge for governments – discussed later in this section – is to make it as affordable as possible.

Environmental benefits

As well as using less energy and emitting less greenhouse gas than private vehicles do, mass transit has many other environmental benefits. As just noted, much larger numbers of people can be transported within a given space and period of time than private vehicles can transport, and this contributes to higher densities.

In denser urban areas, less energy and other resources are required per urban resident for the provision not only of roads, but also of all the other services these residents need – footpaths, bicycle paths, electricity, gas, telecommunication lines, water, sewerage, stormwater drainage, and so on. And in denser urban areas people travel shorter distances for work, shopping, leisure and social purposes, and this leads to further energy savings.

And despite being denser, if cities have clean, efficient mass transit they will have less of the crowding, noise and pollution that cars, motor-bikes, motor-scooters and other private vehicles generate. Pollutants like particulates from diesel are major causes of asthma and other respiratory diseases. A well-designed mass transit city will also have good networks of safe walkways and cycleways to enable residents to walk or cycle for short trips, or to walk or cycle to transit stations for longer ones. These non-motorised means of travel are of course completely non-polluting and, to the extent that they replace trips using other transport modes, they help to reduce overall pollution and greenhouse gas emission levels.

3. Greenhouse gas emissions reduction potential

Details of the variations in mass transit CO₂ equivalent emissions are given in Chapter 2 to show how they vary across different cities. The summarised energy efficiency data by mode in 84 cities are provided in the table 2.8.

In some cities exceptionally low energy usage can be found, such as 0.05 MJ/pass-km in Chinese light-rail, due mainly to high loadings. When estimating greenhouse gas reduction potential from mass transit it is also necessary to consider the ‘transit leverage’ factor, the tendency for every kilometre travelled on transit to replace between 5 and 7 kilometres of total travel, which is described in Chapter 2.

4. Implementing a good transit system

Complementary and integrated modes

Good public transit is designed as a whole system. For example, trains or BRT will move larger numbers of people longer distances, and then bus services, with shorter trips and fewer passengers, will radiate out from transit stations. BRT and Light-rail may exist as an in-between mode in terms of its passenger capacity and route lengths, and local buses can complete an urban transit network, linking fast cross-city services to corridor services and local routes. As part of this integration of transit modes, timetables, ticketing and information provision will be integrated, so that a person can use two or three modes to travel from departure point to destination easily, without long delays, and on one ticket (see the section *Influencing travel choices*). New technologies also assist with network planning, organisational management and integrated ticketing.

The following are some salient features of the different transport modes:

- **Train systems:** These can carry 50,000 (perhaps even 80,000) passengers per hour in one direction on one line, and are suited to major arterial urban routes, as well as regional and long distance travel. Costs vary enormously depending on whether it is a Metro system (with a subway or overhead line), a fast rail system, or a conventional speed system at ground level (which is the least expensive). But even normal speed trains can be faster than alternative modes. Bangkok has a new train system travelling through and above its crowded streets at speeds reaching 60 kilometres per hour, averaging 25-45 kph compared with the Bangkok traffic speed of 14 kph and bus speed of 9 kph.⁹ Rail lines can be built down the middle of freeways, as in Perth and Oregon.

Figure 3.10 Tainan High Speed Rail Station, Taiwan



Picture Credit: Kok Leng Yeo.

- **Light rail systems:** These can carry 10-20,000 people per hour down one corridor, and thus they are suited to routes that have fewer travellers than train systems can carry, but more than bus systems usually can. They normally take up the equivalent of one traffic lane, a lane which, as previously noted, can only carry 2,500 car travellers an hour. Light rail is attractive to cities wanting to regenerate corridors or to provide a higher capacity system where there is space in the roadway. The latest models no longer require overhead wires, as batteries can be recharged at stops.
- **Bus systems:** These include conventional buses, which must share lanes with other traffic, and normally only take a maximum of 5,000 passengers per hour on one route. Conventional buses are a critical part of any city's transport system as they offer flexibility and linkage to the faster, higher capacity mass transit systems. New technology buses can provide a safer and more comfortable service and with GPS installed can enable passengers at bus stops to know exactly when they are arriving.
- **BRT systems:** Bus Rapid Transit (BRT) has increasingly been used to provide a faster, higher capacity bus service.⁹ BRTs require dedicated lanes, off-road stops, rapid boarding and alighting, level boarding, pre-board fare collection or checking, frequent service, large capacity, clear signage and real-time information displays, clean engine technologies, signal priority, intelligent control systems and excellent customer service. In one dedicated BRT lane 10-20,000 passengers can be carried – with some carrying over 40,000 – but at higher levels there is a risk of buses 'bunching' at stops. This problem can be reduced with multiple doors on the bus and well-designed stations, as occurs in Curitiba. Cities like Curitiba, Bogotá and Ottawa have examined moving to rail to solve this problem. There can also be problems with noise and emissions. BRTs can be cheaper if they take over a road lane, although this can be a difficult political issue in cities. Other cities with BRTs include

Bogotá, Mexico City, Jakarta, Beijing, Kunming, Chengdu, Guangzhou, Istanbul, Ahmedabad (India), Paris, Los Angeles, Pittsburgh, Miami, Boston and Brisbane.

Advantaging transit

To attract passengers, transit needs to be faster than cars on the same routes. This is why it helps if trains travel at high speeds and have grade-separated intersections with roads. BRT and light rail need dedicated lanes and priority traffic signals to achieve this required speed advantage (Figure 3.11). Moreover, there is little point in having fast travel speeds if passengers have to wait a long time for the transport to arrive. This means frequent services and integrated timetables for the different modes so that, for example, a person switching from a train to a bus has minimal waiting time. Mass transit will also have a speed advantage over private vehicles if city governments refrain from building more and faster roads. While this may increase traffic congestion in the short term, the intention is that such congestion will encourage private vehicle users to switch to the faster transit services. And making private vehicle travel more expensive – through, for example, petrol taxes, registration charges or congestion taxes – achieves two things: it recovers some of the environmental and social costs of private transport, and it is another measure to encourage people to switch from private vehicles to transit.

5. Town planning and transit oriented developments (TODs)

Transit oriented developments are areas of new development around BRT and train stations that feature higher density residential complexes and a mix of other land uses, for example, shops, workplaces, educational institutions, health facilities and other services, as well as good walking and cycling paths. TODs can reduce car use by around fifty percent, save money on infrastructure, and encourage community interaction.¹⁰

TODs can occur where there are ‘greenfield’ (new) sites ‘brownfield’ (old industrial) sites or ‘greyfield’ sites (redeveloped old housing areas). TODs should include a range of housing types, including affordable

Figure 3.11 Luas Light Rail Train in Dublin



Picture Credit: C. G. P. Grey, Wikimedia Commons, http://commons.wikimedia.org/wiki/File:Ireland_-_Dublin_-_Tram.jpg viewed 22 March 2011.

Figure 3.12 Bus Rapid Transit can, as this Bangkok street scene demonstrates, move passengers to their destination much faster than ordinary buses – and private vehicles



Picture Credit: Karl Fjellstrom, itdp-china.org.

housing for those on low-incomes. The increased value of TOD properties can be used to help fund the mass transit system, a process known as ‘value capture’ that is discussed below (and TODs are described in more detail in another section of this chapter).

Not every area can be a TOD, however. In other parts of cities the challenge is to make changes within an already established infrastructure of buildings, roads and other features. Over time, with new developments and altered building uses, higher densities and more mixed land use can be permitted and encouraged. Existing thoroughfares can be used for walking and cycling paths and dedicated transit lanes. Traffic can be restricted and calmed through a variety of measures. And available land and buildings can be used for parks and other community facilities. All of these measures complement good transit systems and make them more viable.

Raising the status of mass transit

Mass transit sometimes has an image problem. It can be seen as a second-rate form of transport, used only by those who can’t afford their own vehicles. However, this image is changing rapidly, as modern mass transit is attractive, clean, comfortable, safe, fast and frequent. The stations as well as the transit vehicles need to be of a high standard (Figure 3.13 & 3.14). Climate control can make a big difference, as can proximity of stations to shops and other attractions. Sophisticated marketing can also lift patronage. Such measures will counteract the growth in many developing world cities of very car-dependent greenfield housing estates and gated communities.

Modern transit services in all parts of the world amply demonstrate that people at all levels of society will choose mass transit if the quality is good. In fact, rail-based cities in the 84 global cities sample are 40% wealthier than non-rail-based cities.¹¹ There has been a big growth of new transit systems in developed countries, including the United States and Australia, with railways being built, for example, in over 100 US cities. Many parts of developing world have an advantage in that cities are already dense enough to make transit very viable, and transit does have to compete with such a high level of private vehicle use.

Figure 3.13 Modern Metro station in Shanghai



Picture Credit: Karl Fjellstrom, itdp-china.org.

Good quality bus systems also raise the status of mass transit, providing high quality services and infrastructure. The newer systems include well segregated bus lanes, accessible and enclosed stations with prepayment and level boarding, lower emission buses, integrated information systems for centralised control and user information, and a distinctive image.

6. Intercity, regional and rural transit services

Modern mass transit is just as important for towns, villages and rural areas as it is for cities, and it is also vital for intercity transport. The absence of sufficient transit services outside and between cities has two major adverse effects.

Firstly, it means continued high levels of use of less sustainable modes of transport, including trucks, cars, motor-bikes and air travel. Although air pollution, such as particulates from diesel, may not have as severe

Figure 3.14 Modern BRT station in Guadalajara, México



Picture Credit: CTS Mexico.

an effect in the countryside as it does in the city, greenhouses gases are just as bad wherever they are emitted. And petroleum, a limited resource, is still being depleted. Moreover, traffic accidents in rural parts of the developing world are a significant cause of death and injury.

Secondly, it puts a real brake on national development, and on the ability of ordinary people, especially for the poor, to carry out normal daily activities. Most people cannot afford their own vehicle. Therefore they must rely on walking, on the existing less than adequate public transit services, on animal transport, or on various kinds of three- and four-wheeled vehicles adapted to carry passengers, vehicles that may not be available and affordable when they are needed. This means that it's much harder and takes much longer for children to get to school, for the sick to get to health services, and for people to get to jobs. An estimated 75% of maternal deaths could be prevented through quicker access to childbirth services, facilitated by transport, and girls' enrolment in school can more than triple with the completion of a rural road (which is, of course, a precondition for a bus service).¹² Hours and even days can be wasted walking or waiting for infrequent transport services.

Thus there is a need for good train services between cities or towns, and for more bus services to radiate out from train stations and population centres into outer urban localities, villages and rural areas. If developing countries can afford rapid trains these will be more competitive with cars and air transport, but the cost, of course, is more.

7. Selecting and implementing the right transit modes

In choosing the most appropriate transit modes for particular localities, planners and communities need to consider a range of factors. These include cost, population density, and whether there is space to build railway lines or dedicated lanes for BRT or light rail. These factors should be considered very carefully from the outset, because experience indicates that once cities or localities select a particular transit mode they tend to stick with that and not adopt other modes later.¹³

Mass transit systems represent a large public investment. If you are making this investment for your locality, you need to ensure that the public – who will ultimately be paying the cost – are aware of the full range of benefits mass transit provides, because greenhouse gas reduction may not be high on their list of priorities. There are many other benefits to tell them about: faster, safer, more comfortable travel; less traffic pollution, congestion and noise; fewer people killed or injured in traffic accidents; cheaper transport for the nation and for individuals, especially people on low incomes; a more pleasant city in which to live and move around; healthier and more connected residents; and a more efficient transport system to service a twenty-first century economy.

Given the systemic and technological complexity of modern integrated transit systems, developing the necessary capacity to plan, construct and operate such systems can be a major challenge. One solution is to form a partnership with a locality that already has such technologies and systems in place. For example, the city of Kunming in China is twinned with the Swiss city of Zurich and, as one part of this, the Swiss partners have helped to build the capacity of their Kunming counterparts in the transport area. This has seen the development of a transport master plan, and the design and implementation of a BRT system.¹⁴

8. Costs of transit systems and sources of finance

Comparing the costs of various modes of mass transit is fraught with difficulty as so many local factors can make costs vary hugely for each mode. The costs of going above ground or underground are always

higher than on-ground though this may just not be possible in some dense cities. The main consideration is the capacity of the system to attract patronage and the mode that is best able to do that needs to then be assessed against the costs of the cars that will be cramming the city if the system is not built. High capacity systems like fast rail (regional, Metro and suburban) are most expensive to build, but will take the highest proportion of car travel out of the urban system, and this can be demonstrated to provide higher benefits than costs.¹⁵ And transport that is more costly to build may also be cheaper to run.¹⁶ When assessing the benefits and costs of mass transit, many factors need to be taken into account, including predicted travel time savings, reductions in fuel, pollution and accidents, and space saved when the city builds up around the transit infrastructure (known as ‘agglomeration economies’).¹⁷

A rapid train system costs about the same per kilometre as a freeway, whether the train or freeway are at ground level, underground or above ground. Perth’s new southern train system costs much less than a normal freeway to build (\$A17 million per km) and frequently carries the equivalent of eight lanes of traffic.¹⁸

Transit systems can be financed and managed through public-private-partnerships, with private partners building the system, operating it, or both. When the transit system in Buenos Aires switched to private operators, patronage doubled over a five year period and the budget burden of the system was reduced by nearly US\$1 billion per year.

Systems can also be financed through land development, as mentioned in the TOD section. Real estate above and around transit stations can be sold by government or private developers to help finance the transit system. Such property will sell for a higher price because of its closeness both to good transit and to the many facilities clustered around transit stations. It will tend to keep its value in bad times and appreciate faster in good times. Hong Kong and Tokyo financed their rail systems in this way, and many US cities are using Tax Increment Financing based on land development to fund new rail projects. In relation to Hong Kong, see *Rail and Property Development in Hong Kong: Experiences and Extensions*.¹⁹

Public funds may also be available through the World Bank, regional development banks or bilateral development cooperation arrangements. In addition, climate change funding mechanisms may fund transit projects, specifically, the Clean Development Mechanism (CDM) and the Global Environment Facility (GEF). These are described in more detail in Chapter 4.

Transit operating costs can of course be at least partially covered by passenger fares. Almost all modern public transit systems are subsidised by government, and each city or locality must decide the amount of subsidy it can afford to provide. Making transit affordable for all socio-economic groups should be a high priority, and one option is to offer concessional fares for specific groups, such as older people, children and those out of work or unable to work. In this way public support is being targeted at those who might not otherwise be able to afford the transit.

9. Conclusion

Mass transit is critical to the proper functioning of any city, town or rural area. A range of transit modes offer different capacity opportunities, and therefore the potential for high or low impact on car use. Higher capacity systems cost more to put in, but offer much more potential reduction in total transport costs and greenhouse gas emissions. The social, economic and environmental costs of *not* having an efficient mass transit system never go away, so it is really a case of stemming these costs earlier or later.

Endnotes

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15. Wright & Fjellstrom.
16. See, for example Agence Française de Développement (AFD) and the French Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM), *Who pays what for good transport? Handbook of good practices*, CODAU, 2009, http://www.codatu.org/english/studies/handbook_good_practices.pdf, viewed 23 Feb 2011. Figure (p 13) and Figure 3 (p 14) show how trains, though more expensive to build, are cheaper to run, especially if they have high carrying capacities. It should also be noted that there are much cheaper rail options than MRT if countries cannot afford this.
17. See Australian Government, Department of Infrastructure and Transport (Infrastructure Australia website), www.infrastructure.gov.au, viewed 23 Feb 2011.
18. Newman, Beatley & Boyer.
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