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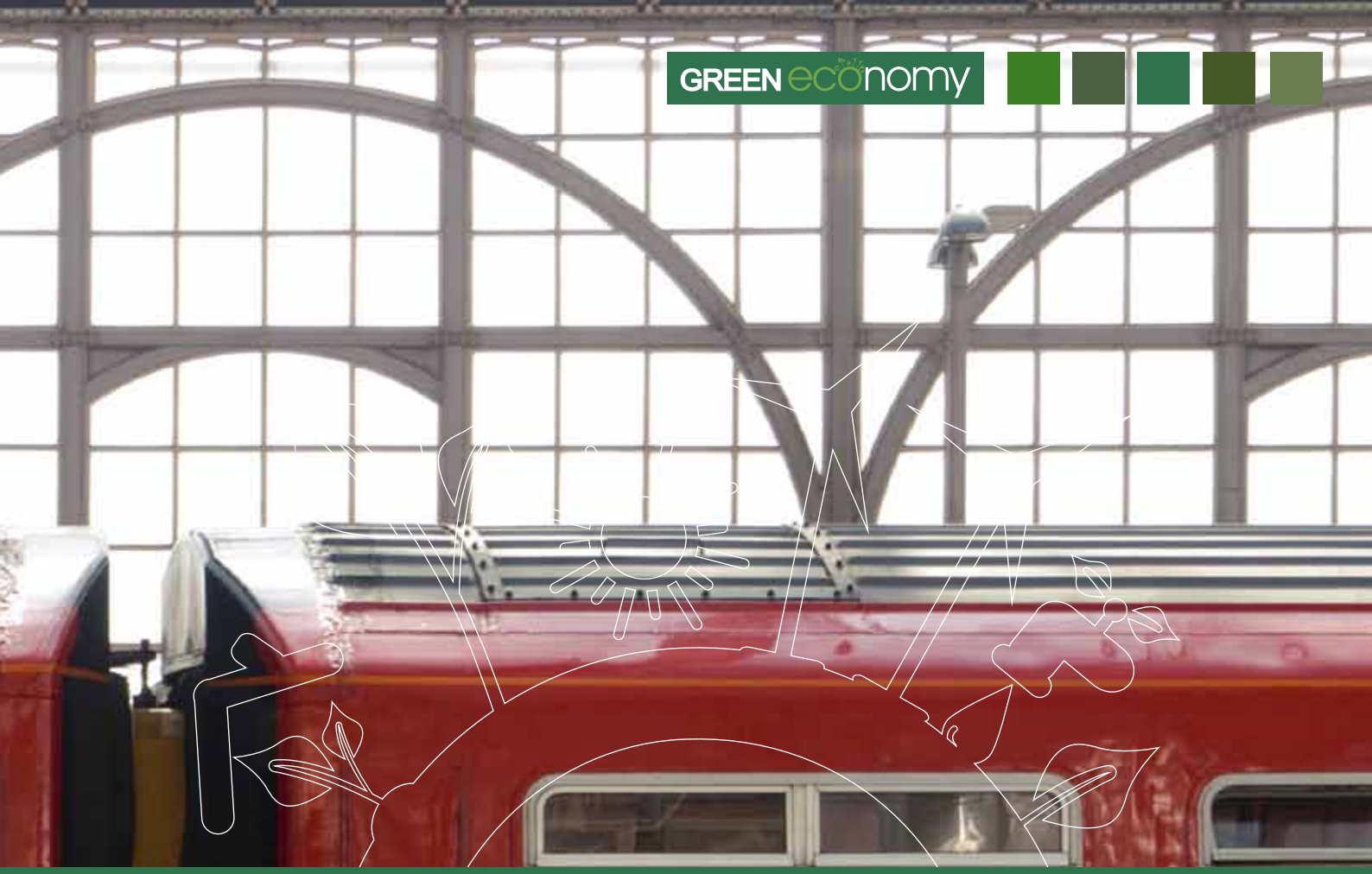
GREEN economy



# Transport

## Investing in energy and resource efficiency

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# Acknowledgements

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Fatma Ben Fadhl of UNEP managed the chapter, including the handling of peer reviews, interacting with the coordinating authors on revisions, conducting supplementary research and bringing the chapter to final production.

The chapter benefited from research conducted by the following experts: Dario Hidalgo, Aileen Carrigan, Prajna Rao, Madhav Pai, Clayton Lane (Embarq – the WRI Center for Sustainable Transport); Andrea M. Bassi, John P. Ansah and Zhuohua Tan (Millennium Institute); Yoshitsugu Hayashi (Nagoya University); Juan Carlos Dextre Quijandria, Felix Israel Cabrera Vega (Pontificia Universidad Catolica del Peru); Sanjivi Sundar, Chhavi Dhingra, Divya Sharma and Akshima Ghate (The Energy and Resources Institute); Anne Binsted, Kate Avery, Catherine Ferris, and Ellie Gould, (Transport Research Laboratory); Marianne Vanderschuren, Tanya Lane (University of Cape Town); and Ana Lucía Iturriza (ILO).

The coordinating authors would like to acknowledge the extensive work of the contributing authors, all of whom devoted a significant amount of time and effort in compiling the background papers. Much of their contributions were generously made in kind to make this work possible.

During the development of the chapter, the authors received advisory support from Rob De Jong and contributions from Elisa Dumitrescu, Kamala Ernest and Patricia Kim from the United Nations Environment Programme.

We would also like to thank the peer reviewers (in their personal capacity) of the chapter consisting of Brinda Wachs, and Romain Hubert (United Nations Economic Commission for Europe), ATM Nurul Amin (North South University, Bangladesh), Carmen Polo, Hernan Blanco, Arvid Strand (Oslo Transportøkonomisk institutt). A special thank also goes to Yuki Tanaka, Iwao Matsuoka (Institution for Transport Policy Studies), Lew Fulton and François Cuenot (International Energy Agency) for their role in facilitating access to data.

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## List of acronyms

ADB - Asian Development Bank
BAU - Business as Usual
Bn - Billion
BRT - Bus Rapid Transit
CDM - Clean Development Mechanism
CIF - Climate Investment Fund
COP15 - 15th Conference of the Parties to the United Nations Framework Convention on Climate Change
CTF - Clean Technology Fund
DfT - Department for Transport (UK)
ECMT - European Conference of Ministers of Transport
ETS - Emissions Trading Scheme
FHWA - Federal Highway Administration
FIA - Fédération Internationale de l'Automobile
GEF - Global Environment Facility
GFEI - Global Fuel Economy Initiative
ICC - International Chamber of Commerce
IEA - International Energy Agency
IET - International Emissions Trading
IMO - International Maritime Organization
IPR - Intellectual Property Rights
IQ - Intelligence Quotient
iRAP - International Road Assessment Programme
ITDP - Institute for Transportation and Development Policy
ITF - International Transport Forum
JI - Joint Implementation
LDVs - Light Duty Vehicles
M - Million
NAMA - Nationally Appropriate Mitigation Action
NAFTA - North American Free Trade Agreement
NMT - Non Motorised Transport
ODA - Official Development Assistance
OECD - Organisation for Economic Cooperation and Development
PKM - Passenger Kilometres
PPP - Public Private Partnership
R&D - Research and Development
SLoCaT - Partnership on Sustainable Low Carbon Transport
SMC - Social Marginal Cost
TfL - Transport for London (UK)
TKM - Tonne Kilometres
TNA - Technology Needs Assessment
TRL - Transport Research Laboratory (UK)
UNEP - United Nations Environment Programme
US$ - US Dollars
VKM - Vehicle Kilometres
VTPI - Victoria Transport Planning Institute
WB - World Bank
WHO - World Health Organization
WRI - World Resources Institute

# Key messages

***1. Present patterns of transportation – based mainly on petrol and diesel-fuelled motor vehicles – generate serious social, environmental and economic damage and are highly unsustainable.*** At present, transportation consumes more than half of global liquid fossil fuels; emits nearly a quarter of the world's energy-related $CO_2$; generates more than 80 per cent of the air pollution in cities in developing countries; results in more than 1.27 million fatal traffic accidents per year; and produces chronic traffic congestion in many of the world's urban areas. These costs to society, which can add up to more than 10 per cent of a country's GDP, are likely to grow, primarily because of the expected growth of the global vehicle fleet.

***2. "Business-as-usual" will significantly enlarge vehicle fleets and exacerbate their costs to society.*** If we continue on a "business-as-usual" path, the global vehicle fleet is set to increase from around 800 million to between 2 and 3 billion by 2050. Most of this growth will take place in developing countries. Aviation growth is expected to increase exponentially in the coming decades, fuelled largely by income growth in developing countries. Carbon emissions from shipping could also grow by up to 250 per cent.

***3. A three-pronged investment strategy is needed to transform this sector: promote access instead of mobility; shift to less harmful modes of transportation; and improve vehicles towards lower carbon intensity and pollution.*** A fundamental shift in investment patterns is needed, based on the principles of *avoiding* or reducing trips through integrating land-use and transport planning and enabling more localised production and consumption. *Shifting* to more environmentally efficient modes such as public and non-motorised transport (for passenger transport) and to rail and water transport (for freight) is recommended. Investment in public transport and infrastructure that promotes walking and cycling generates jobs, improves wellbeing and can add considerable value to regional and national economies. *Improving* vehicles and fuels is a priority to reduce urban air pollution and greenhouse gas emissions. Green transport policies will also reduce road accidents and alleviate poverty by improving access to markets and other essential facilities.

***4. Investment in public transportation and vehicle efficiency improvements generates exceptional economic returns.*** Several scenarios show that a green, low carbon, transport sector can reduce greenhouse gas emissions by 70 per cent without major additional investment. A reallocation of just 0.16 per cent of global GDP in support of public transport infrastructure and efficiency improvements to road vehicles would reduce the volume of road vehicles by between around one-third by 2050. It would diminish the use of oil-based fuel by up to one-third and promote strong and sustainable employment in the sector.

***5. Enabling conditions for "green" transportation have to be wide-ranging in order to be effective.*** Such investments, among other measures, should be enabled via:

- Policies, including *land-use planning* to promote compact or mass-transit corridor-based cities;[1] *regulation* of fuel and vehicles; and the provision of *information* to aid decisions by consumers and industry;
- Shifting *financing* priorities towards public transport and non-motorised transport, coupled with strong *economic incentives* such as taxes, charges and subsidy reform;
- Developing and widely applying green transport *technology*; and
- Setting up and building the capacity of *institutions* to foster greener transport, and to ensure close cooperation with other key sectors.

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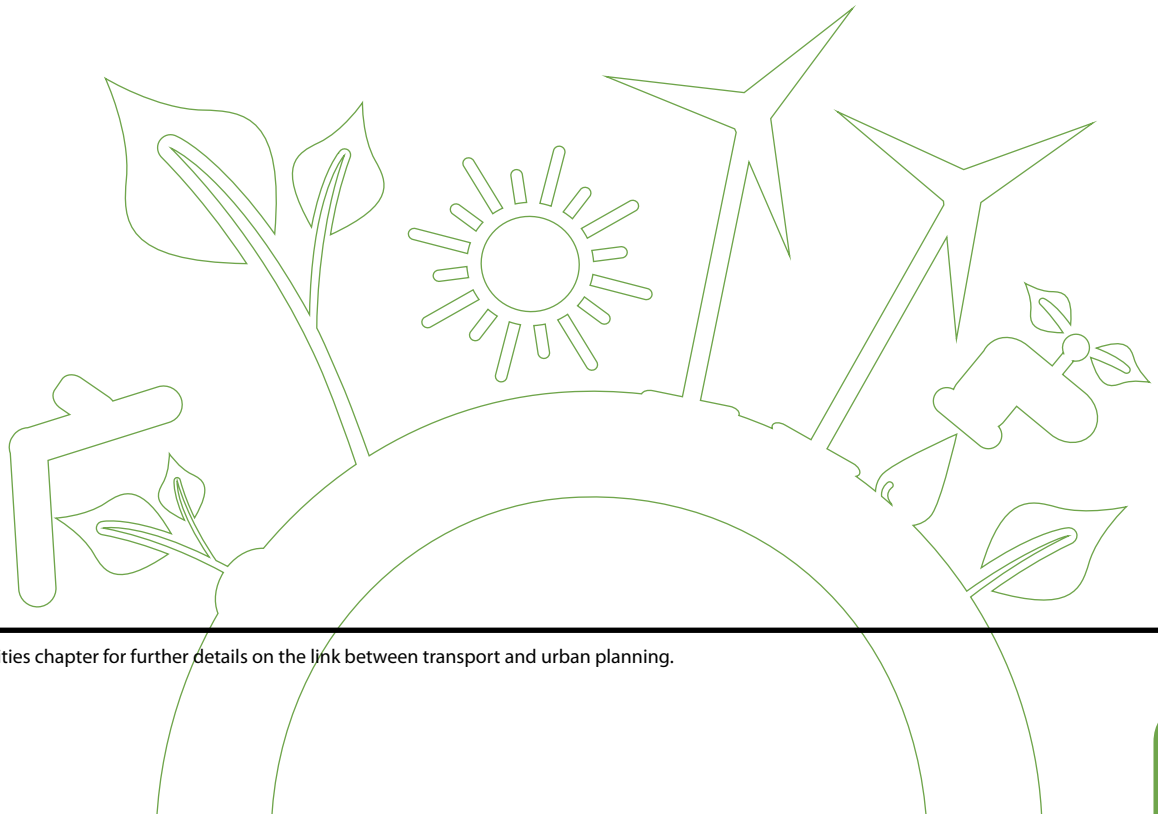


1. See Cities chapter for further details on the link between transport and urban planning.

# 1 Introduction

Transport is central to the lives of citizens across the world, yet the current patterns of transport, dictated mainly by fossil-fuel driven motor vehicles, generate a range of environmental, social and economic costs. It is estimated, for example, that transport is responsible for nearly a quarter of global energy-related $CO_2$.

There is a growing consensus on the need for more sustainable patterns of transport activity but investment patterns are still heavily skewed towards supporting the "motorisation" model of development. The recent economic recession has led to various stimulus packages that focus (with notable exceptions) on preserving current industries and forms of transport such as car manufacturing and road building.

This chapter examines the role of transport in a green economy and makes a case for ensuring future investment in the sector is increasingly green. It highlights a strategy of *avoiding* or reducing trips, *shifting* to more environmentally-friendly modes of transport and *improving* the efficiency of all modes of transport. It explores the challenges and opportunities posed by shifting to a greener transport system, and examines the various options for conditions that can enable actions and investments for the development of sustainable transport[2]. The analysis encompasses all modes of freight and passenger transport, with an emphasis on land transport, and it takes into account the varying circumstances of developed and developing countries, regional differences and rural-urban disparities.

Given the pivotal role of transport in the global economy, much of the analysis of the potential for greening the sector is interwoven with other chapters, notably cities, energy, manufacturing and tourism. The chapter was compiled through extensive collaboration with experts from around the world, whose background papers are available in the accompanying Full Technical Report.

2. Green transport is hereby defined as one that supports **environmental** sustainability through e.g. the protection of the global climate, ecosystems, public health and natural resources. It also supports the other pillars of sustainable development, namely **economic** (affordable, fair and efficient transport that supports a sustainable competitive economy as well as balanced regional development and the creation of decent jobs) and **social** (e.g. allowing the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promoting poverty reduction and equity within and between successive generations). This definition was developed through extensive discussions with transport experts including those at UN agencies, and was based on a review of existing and well-acknowledged definitions such as ECMT (2004).

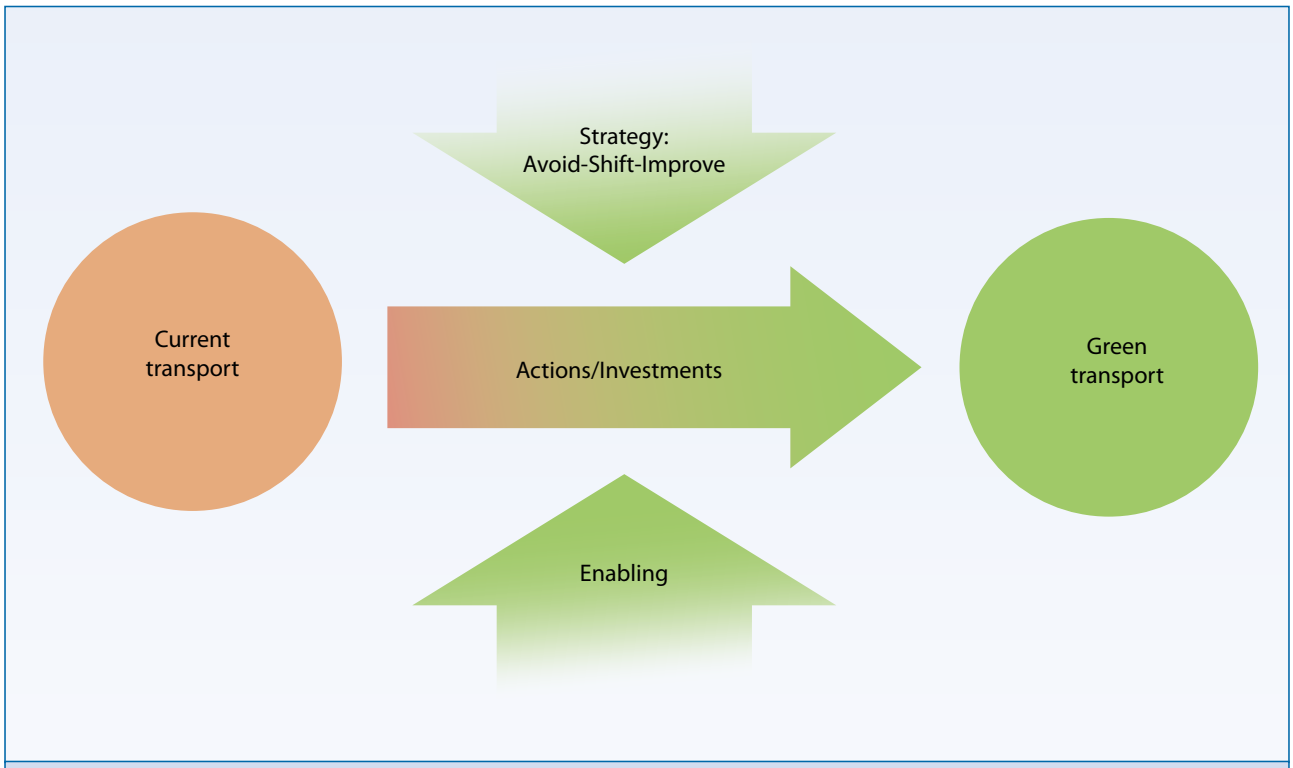



**Figure 1: Image of green transport as a goal, and actions and investments to achieve this goal**

# 2 Challenges and opportunities in the transport sector

## 2.1 Challenges

**Unsustainable trends**

The challenges for the transport sector in becoming "green" are made obvious by observing current trends, whereby:

- Overall demand for transport activity (for both passenger and freight) is growing rapidly, and it is predicted to roughly double between 2005 and 2050 (IEA 2009b);

- Transport activity is increasingly motorised (private cars for passenger transport and lorries for freight, almost all of which are propelled by internal combustion engines);

- The global vehicle fleet is set to multiply three or four-fold in the next few decades, with most of this growth set to occur in developing countries. In 2050, two-thirds of the global vehicle fleet is expected to be in non-OECD countries; and

- Technological improvements such as fuel-efficient vehicles and alternative power sources have not been rapid enough to offset the impacts of this growth.

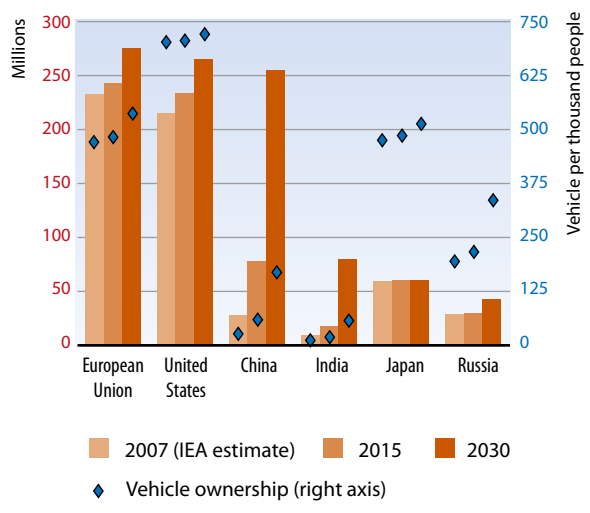



**Figure 2: Passenger light-duty vehicle fleet and ownership rates in key regions**

Source: IEA (2009a)

These trends translate directly into various costs for the environment, society and economy:

- Energy consumption and greenhouse gas emissions;

- Congestion (and associated losses in productivity of urban areas);

- Resource depletion and land grab;

- Degradation of human health (through air pollution, noise, vibration, etc);

- Reduction in human security (through traffic accidents);

- Reduction of accessibility and severance of communities; and

- Loss of biodiversity.

It should be acknowledged that such costs vary significantly between regions, and that priorities may differ between regions and by urban and/or non-urban area.

**Fuel and natural resources**

The transport sector's impact on natural resources is wide-ranging, including through manufacturing of vehicles and/or rolling stock (e.g. metals, plastic) and the construction of infrastructure[3] (e.g. concrete and steel). Fossil fuels, engine oil, rubber and other consumable material (including bio-fuels, which in certain circumstances may deplete farmland for food production) are consumed through the operation and maintenance of vehicles.

Transport consumes more than half of global liquid fossil fuels (IEA 2008) and it is expected to account for 97 per cent of the increase in the world's primary oil use between 2007 and 2030 (Figure 3).

**Greenhouse gases**

The transport sector's consumption of fossil fuels translates into around a quarter of global energy-

3. Infrastructure is not limited to roads, bridges and railways, but also supporting infrastructure such as parking facilities, fuelling stations etc.

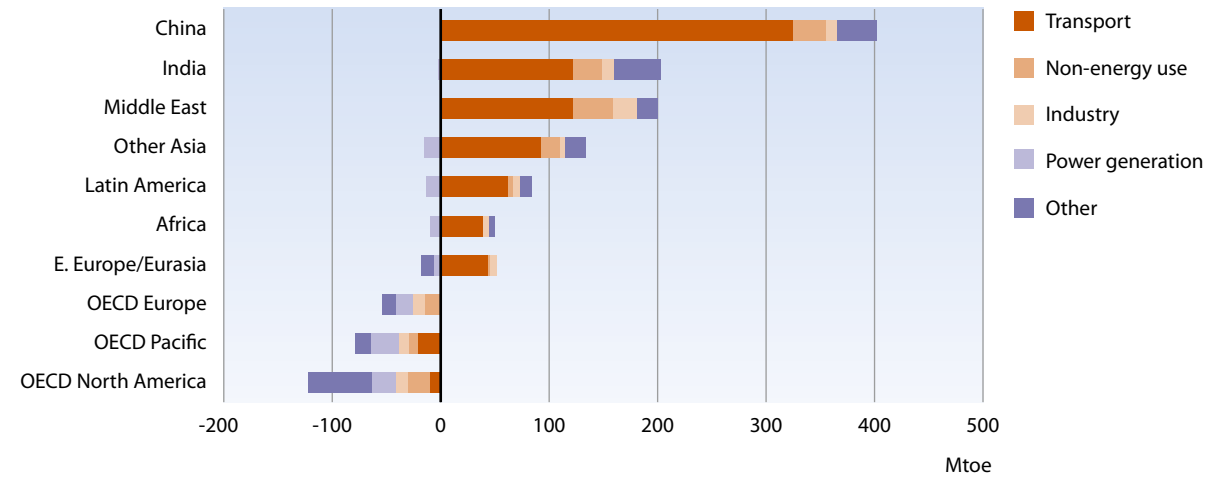



**Figure 3: Changes to energy consumption by sector and region between 2007 and 2030**
Source: IEA (2009a)

related carbon dioxide ($CO_2$) emissions[4], which is projected to increase by 1.7 per cent a year from 2004 to 2030.[5] Land transport accounts for roughly 73 per cent of the sector's total $CO_2$ emissions, followed by aviation (11 per cent) and shipping (9 per cent). Passenger transport accounts for the lion's share of overall emissions, with freight transport – predominantly road-based trucks – comprising 27 per cent of all transport energy use (and therefore emissions). More than 80 per cent of the predicted growth in transport emissions is expected to come from road transport in developing countries (IEA 2009b).

Moreover, it is estimated that around 15 per cent of the total $CO_2$ emissions generated from the car are a result of manufacturing and disposal when a full life-cycle analysis is conducted (King, in HM Treasury 2007).

**Pollution and health**

Transport-related pollution, noise and vibration can pose serious threats to human health and wellbeing.[6] Local air pollution is caused by exhaust emissions produced by traffic, mostly in the form of Sulphur Oxides ($SO_x$), Nitrogen Oxides ($NO_x$), Carbon Monoxide (CO), Hydro Carbon (HC), Volatile Organic Compounds (VOC), Toxic Metals (TM), Lead Particles[7] and Particulate Matter (PM) – including Black Carbon.[8] These emissions represent a large proportion of pollutants, especially in developing cities.

Such air pollutants are a cause of cardiovascular/ pulmonary and respiratory disease. For example,

4. OECD (2005) $CO_2$ Emissions from Combustion 1971-2003.

5. IEA (2006) World Energy Outlook 2006, Accessed from http://www.worldenergyoutlook.org/2006.asp

## Box 1: Externalities

Economic efficiency requires prices of goods or activities to match their social marginal cost including all external costs. Prices for transport services need to include costs imposed on society through congestion, accidents, infrastructure wear and tear, air pollution, noise and climate change so that choices made by the users of transport will take into account these costs (World Bank 2001, Button 1993, etc).

Congestion, accident and pollution externalities make up a significant and increasing cost to the economy, amounting in some cases to over 10 per cent of national or regional GDP. A recent study by Creutzig and He (2009) estimates that in Beijing, China, the social costs induced by motorised transportation are equivalent to between 7.5 per cent and 15 per cent of the city's GDP.

6. The UNECE's Transport, Health and Environment Pan-European Programme (THE PEP) has published guidelines for improved cooperation on sustainable transport among various sectors (see UNECE 2009). A system of monitoring and reporting is being instituted to assess the extent to which Member States are effectively implementing the mechanisms agreed, and to measure progress against the priority goals of the Amsterdam Declaration, in particular Amsterdam Goal 1: "To contribute to sustainable economic development and simulate job creation through investment in environment and health-friendly transport."

7. Although almost all countries have now banned leaded gasoline, there are still 7 countries in which action is still needed.

8. Black carbon is "the solid fraction of PM2.5 that strongly absorbs light and converts that energy to heat"(ICCT 2009). Black carbon not only affects public health, but also contributes to climate change. Actions are needed to both reduce $CO_2$ and black carbon. See http://www.theicct.org/pubs/BCsummary_dec09.pdf for further details.

| Region* | GNP, 1997 (USD billion) | Estimated annual crash costs | |
|---|---|---|---|
| | | As percentage of GNP | Costs (USD billion) |
| Africa | 370 | 1 | 3.7 |
| Asia | 2,454 | 1 | 24.5 |
| Latin America and Carribean | 1,890 | 1 | 18.9 |
| Middle East | 495 | 1.5 | 7.4 |
| Central and Eastern Europe | 659 | 1.5 | 9.9 |
| Subtotal | 5,615 | | 64.5 |
| Higly motorised countries | 22,665 | 2 | 453.3 |
| Total | | | 517.8 |

GNP: gross national product
* Data are displayed according to regional classification of the TRL Ltd, United Kingdom

**Table 1: Accident costs from various world regions**
Source: Jacobs et al. (2000)

exposure to lead can cause increased blood pressure, liver and kidney damage, impaired fertility, comas, convulsions, and even death. Children are particularly vulnerable; they can suffer from reductions in IQ and attention span, learning disabilities, hyperactivity, impaired growth and hearing loss (Rapuano et al. 1997). Hatfield et al. (2010) estimate that the removal of lead from vehicle fuels has resulted in more than 1 million avoided premature deaths per year with annual financial benefits over US$2.4 trillion.

Sánchez-Triana et al. (2007) note that for Colombia, the health cost of urban air pollution was roughly 0.8 per cent of the nation's GDP, amounting to 1,500 billion pesos (US$698 million).[9] Noise pollution generated by transport can be detrimental to health and well-being, particularly if it contributes to sleep disturbance, which can lead to increased blood pressure and heart attacks (WHO 2009b). Research by Lambert (2002) and Martínez (2005) indicate that the economic cost of noise can reach nearly 0.5 per cent of GDP in the European Union.

**Human security and accidents**

The latest report from the World Health Organization (WHO 2009a) confirms that road accidents remain a serious public health issue. Every year more than 1.27 million people die in road accidents, of which 91 per cent occur in low and middle income countries. About half of those who die in road accidents worldwide are pedestrians, cyclists and motorcyclists, for whom infrastructure provision is often neglected. In Europe, traffic accidents are a major cause of fatalities for young people, particularly men aged between 15 and 25 (WHO 2008).

It is estimated that the cost of traffic accidents amounts to US$518 billion, and represents between 1 per cent and

9. Calculated based on 2150 Colombian Pesos to US$ 1.

## Box 2: Maritime and aviation emissions

Road transport accounts for the majority of GHG emissions and their predicted growth, but those from maritime and aviation transport are increasing at a very rapid rate.

For maritime transport, developments in world trade are increasing while both the volume and distance of goods are being shipped at a pace that exceeds growth in world GDP. IMO (2009) predicts that by 2050, in the absence of additional policies, emissions from ships may grow between 150 per cent and 250 per cent (compared with 2007).

Despite a temporary slowdown in demand owing to the economic recession, the fundamental growth in the aviation sector remains strong. Aviation emissions are projected to increase exponentially in the next few decades, fuelled by income growth and reductions in the price of air travel.

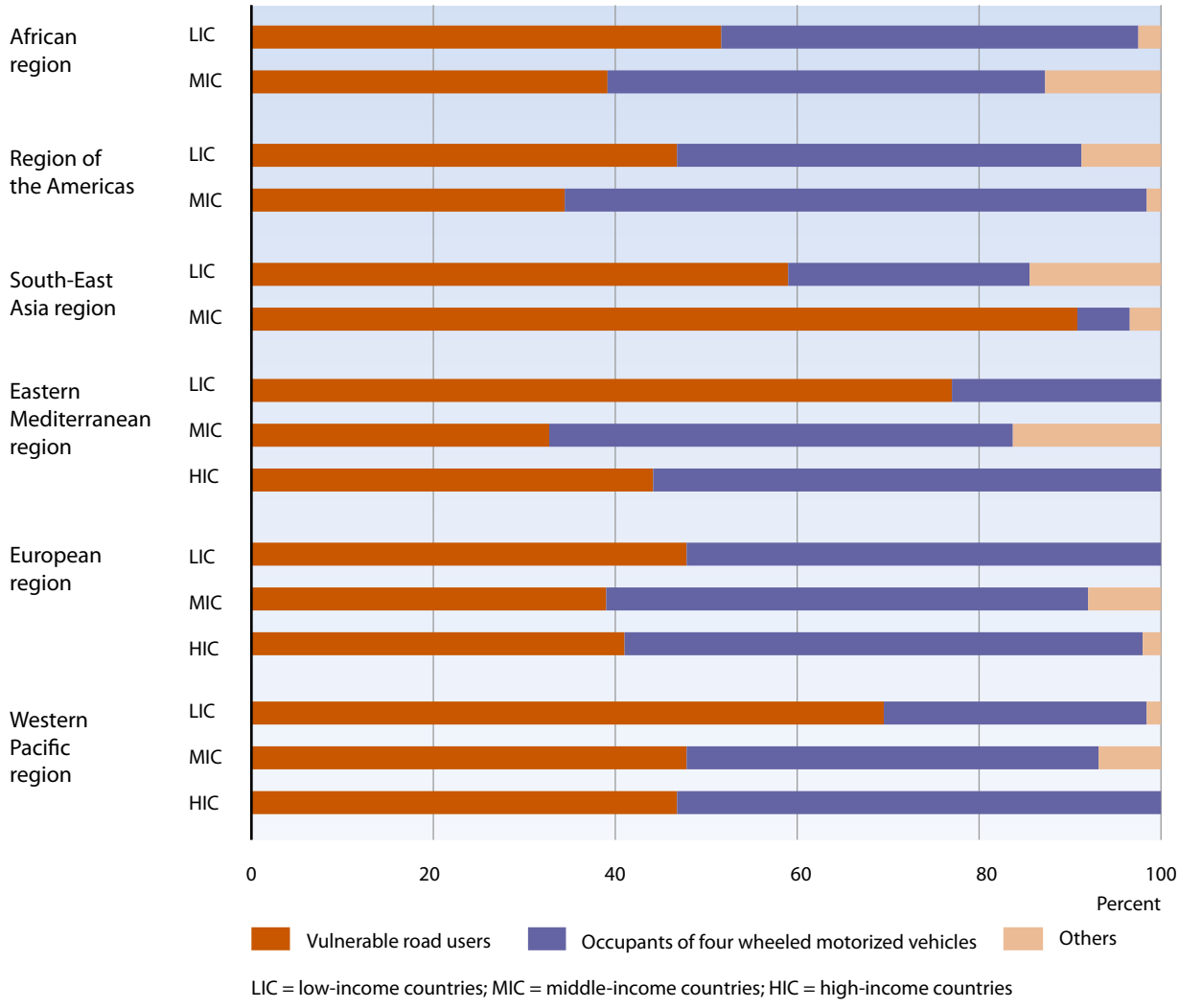



**Figure 4: Reported deaths by type of road user, region and income group**
Source: WHO (2009a)

## Box 3: Benefits of cleaner fuels in sub-Saharan Africa

A recent modelling study by ICF International for the World Bank and the African Refiners Association looked at the costs and benefits of investing in refineries in sub-Saharan Africa (SSA) to improve the quality of their produced fuels. It found that by reducing the sulphur content of fuels used for transport, a significant amount of health costs could be saved (US$640 million per year in West SSA, US$340 million per year in East SSA). These benefits were amplified by many-fold when coupled with policies to improve emission controls, particularly for motorcycles.

Source: ICF International, 2009.

1.5 per cent of GDP in low-and middle-income countries and 2 per cent of GDP in high-income countries, as shown in the table below (Jacobs et al. 2000). Reducing accidents requires a systematic approach incorporating elements of better infrastructure, vehicle inspection, and education to control speed and alcohol consumption, for example.

**Congestion**

Congestion is caused when the volume of traffic reaches the capacity of infrastructure. It is particularly common in urban areas, where it can severely limit the positive effects of agglomeration (see Cities Chapter). Travel times for public-transport users, as well as pedestrians and cyclists, frequently increase if dedicated infrastructure is not provided. Congestion also increases fuel consumption and the level of pollution, as fuel is still consumed whilst cars are stationary.

In the US it has been estimated that US$67.5 billion (0.7 per cent of GDP) was lost in productivity in the

| Strategy | Developed Countries | Developing Countries |
|---|---|---|
| **Avoid** | Reduce vehicle kilometres (VKM) through Transport Demand Management (TDM), land use planning, localised production, and shorter supply chains. | Avoid unnecessary generation of VKM through land-use and transport planning. |
| **Shift** | Shift from private vehicles to Non-Motorised Transport (NMT) and Public Transport (PT) and from aviation to rail/PT. Transfer freight from road to rail and water transport. | Enable conditions for the lowest-emitting modes (both freight and passenger).<br>Prevent shift from NMT and PT to private vehicles by ensuring that attractive alternatives to private vehicles exist. |
| **Improve** | Improve existing vehicles. Down-scale vehicle engine size. Increase penetration of electric vehicles and carbon-neutral liquid fuels. Electrify rail (for both freight and passengers). | Ensure future vehicles/fuels are cleaner, encouraging small efficient cars. Design innovations for traditional NMT such as cycle rickshaws. |

**Table 2: The avoid-shift-improve strategy**
Source: Dalkmann (2009)

year 2000, and 5.7 million gallons in fuel (FHWA, 2000). According to OECD (2009), congestion in Toronto, Canada costs the city around US$3.3 billion Canadian dollars a year in productivity (1.2 per cent of Toronto's GDP), while in the UK the estimated cost of time lost in traffic is £20 billion a year, or 1.2 per cent of GDP (The Telegraph Business Club et al. 2009). In developing countries, a lack of traffic data often makes it difficult to estimate the loss of productivity. Data are available for Lima, Peru: people living within the city are estimated to lose an average of four hours in daily travel, which leads to a loss of approximately US$6.2 billion, or around 10 per cent of GDP every year (UNESCAP et al. 2010). The traditional approach to tackling congestion—providing more road capacity—has often been counter-effective, as the extra capacity induces further demand for traffic activity (SACTRA 1997).

**Accessibility and severance**

Traffic-filled roads can become physical and psychological barriers that can sever communities and divide entire cities (see Cities Chapter). There are various ways in which accessibility and severance can be quantified and monetised. Although values are highly context-dependent and differ greatly by region, Sælensminde (2002) in VTPI (2007) notes an extra cost of US$0.54-US$0.62 per mile of vehicle activity shifted from non-motorised transport to the car. Transport systems dominated by motor vehicles have been shown to hinder access to jobs, markets, and essential facilities, particularly for the poorest and most vulnerable members of society.

**Land use and loss of biodiversity**

Roads, railways, airports, harbours and other transport infrastructure can have a severe impact on the natural environment, from the removal of vegetation during construction or the subsequent fragmentation of habitats (CEU 2002, and disturbance of animals, Kaczynska 2009). Fragmentation, without proper ecological infrastructure planning can severely disturb wildlife and reduce biodiversity.

## 2.2 Opportunities

**Leapfrogging towards green transport**

Responding to these challenges will require a "paradigm shift" in the way the transport sector develops in the coming decades. Action is required in all countries, but opportunities are greatest for developing countries, where future patterns of transport can be shaped by the investment and planning decisions made today. Investing in green transport will enable such countries to "leapfrog" towards a sustainable path, rather than reproducing the mistakes made by industrialised countries (Dalkmann 2009).

**Avoid-Shift-Improve strategy**

Making a decisive shift to green transport arguably requires a holistic strategy that combines the following three elements:[10]

1. *Avoiding* or reducing the number of journeys taken.

This can be achieved by integrating land-use and transport planning; designing denser, more compact settlements; harnessing telecommunication technologies such as teleconferencing and localising production and consumption[11]. Demand for freight transport can be reduced by localising production and consumption and by optimising logistics to reduce empty runs and ensure a high load factor.

2. *Shifting* to more environmentally efficient forms of transport

10. For further information see Dalkmann and Brannigan in GTZ (2007), and the Common Policy Framework on Transport and Climate Change, which represents an increasing level of consensus amongst transport experts and policy makers on this approach: http://www.sutp.org/slocat/bellagio-process/common-policy-framework-cpf-on-transport-and-climate-change-in-developing-countries/ The combination of the above three strategies will ensure transformation of both behaviour and technology.

11. Such technologies may not necessarily reduce the demand for travel activity by itself, and need to be combined with measures to reduce incentives to travel by private modes, such as road user charging, parking charges, vehicle tax and fuel tax.

This involves promoting public transport as well as walking and cycling, which usually requires substantial investment in infrastructure. For public transport to rival the private car it needs to be frequent, reliable, affordable and comfortable. Railways and waterways are generally greener methods of transporting freight, and shifting to them frees up road space.

3. *Improving* vehicle and fuel technology to reduce adverse environmental effects such as pollution and resource depletion.

Enhancing the fuel economy of conventional engines; reducing the weight of vehicles and developing alternatives such as electric and hybrid vehicles, biofuels, and hydrogen fuel technologies are all examples of this strategy.[12] Further efficiency gains can be achieved through an improvement in the occupancy rate of vehicles, or through better driving (eco-driving).

Given that transport systems vary greatly around the world, it is important that the above three strategies are applied in ways which fully consider the context and main problems facing each region. Many developing countries are heavily reliant upon non-motorised transport and therefore present opportunities for creating more sustainable transport systems than those in developed nations (see Table 2).

Enacting the "avoid, shift and improve" strategy requires adequate investment in the research, development, production and operation/management of:

- *Infrastructure* such as tracks for buses and rail, pavements and cycle routes and park-and-ride facilities;[13]
- *Greener vehicles and transport modes* (including bicycles, public transport vehicles and low emission vehicles, utilising technologies listed in section 5.3);
- *Cleaner fuels;*
- *Telecommunication technology* to substitute conventional transport, e.g. telework/ teleconferencing; and
- *Technologies* to enact green transport, e.g. GPS systems, Intelligent Transport Systems, green logistics etc.

The above would need to be supported by appropriate "enabling conditions", which are explored in Section 5.

12. It is important that the generation of electricity, production of hydrogen and biofuels are all conducted in a sustainable manner.

13. It is vital that such infrastructure promote connectivity between modes, so that journeys are made seamless.

# 3 Transport in a green economy

This section examines how a green transport sector can lead to green economic growth, create jobs and reduce poverty.

## 3.1 Supporting green growth

Investment in transport is often justified on the grounds that the movement of goods, services and workers is the vital fuel of the economic engine. Freight transport volumes have traditionally been thought to strongly correlate with economic growth on the supply side and passenger car use to be driven by economic growth on the demand side. There is evidence, however, to suggest that high levels of GDP can be accompanied by transportation systems that rely less on the private car, as may be seen in Figure 5.

This figure shows that cities and regions can significantly "decouple" car use – and the associated environmental pressures – from economic growth. In a green economy, mobility needs would be reduced through better city design and planning and impacts would be decoupled from growth through providing high quality, low carbon transport, especially through public transport, NMT infrastructure and cleaner, more efficient vehicles. For individuals, the lower levels of congestion and reduced travel time would leave more time for productive activities, especially if there is access to more frequent, reliable and affordable public transport services. By reducing fuel use and transport time, companies can be more competitive and profitable. McKinnon (2008) and UNEP (2008c) show that measures designed to improve the efficiency of freight transport reduce operational costs in addition to delivering carbon savings.

Of the various channels through which investment can flow into green transport, investment in infrastructure offers the greatest potential for economic growth, by encouraging government investment and stimulating new business opportunities. Investment in green transport technology is also likely to benefit the overall economy, particularly through its potential to stimulate government investment (see Table 3).

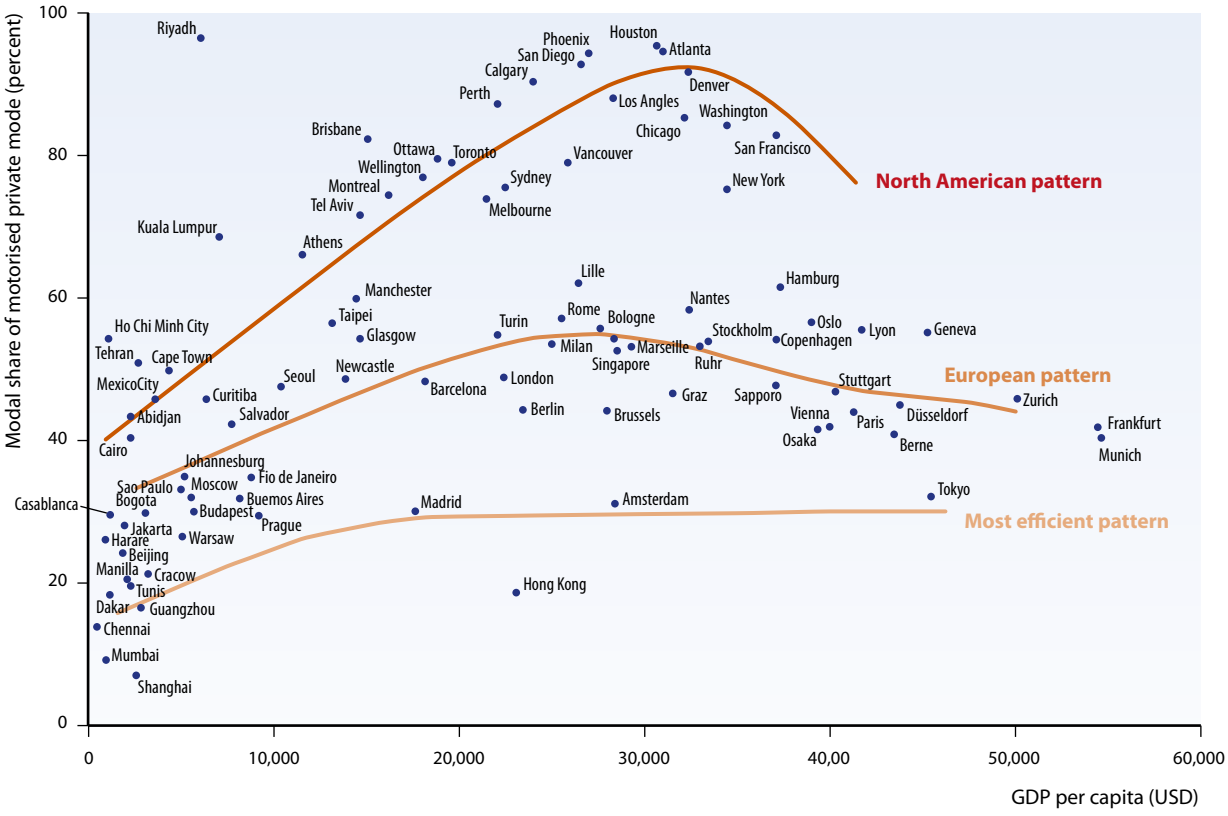



**Figure 5: Moving towards a green trajectory**
Source: UITP, 2006 (Courtesey of SYSTRA)

## 3.2 Creating jobs

Transport is fundamental to the functioning of economies and it is also a key sector in its own right in terms of generating employment, from manufacturing vehicles to refining fuels, managing transport services and developing and maintaining infrastructure.[14]

Under a green economy, transport-sector jobs would increasingly be those that are generated through investment in green transport infrastructure and vehicles, alternative fuels and telecommunication and other technologies (see section 2.2).

Empirical studies are scarce, but several studies suggest a strong link between green jobs and the transport sector. Based on US figures, EDRG (2009) in STPP (2004) suggest that one billion US dollars spent on public transport generates around 36,000 jobs (averaging between operations and capital projects[15]), which is 9 per cent and 19 per cent higher than the job-creation potential of road maintenance or new road projects respectively

14. Furthermore, by providing the physical link between jobs and workers, transport further contributes to employment.

15. The methodology employed by EDRG includes direct effects (public transportation manufacturing /construction and operations jobs), indirect effects (jobs at suppliers of parts and services) and induced jobs (jobs supported by workers re-spending their wages). See http://www.apta.com/gap/policyresearch/Documents/jobs_impact.pdf

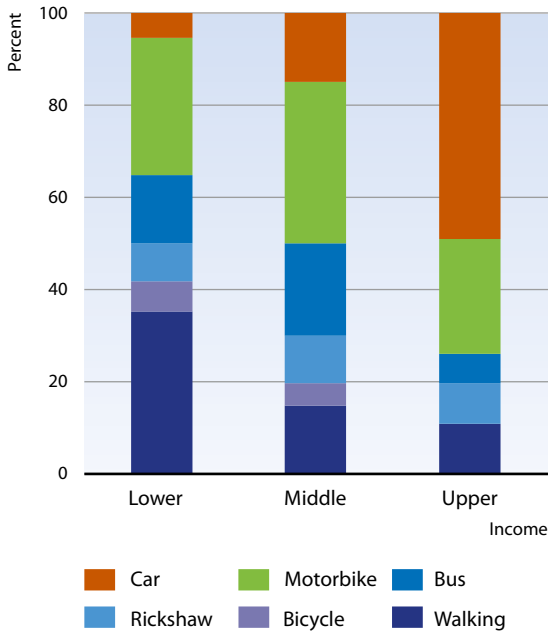



**Figure 6: Modal split by income group in Surabaya**
Source: GTZ (2002)

| Expense category | Value added 2006 dollars | Employment FTEs | Compensation 2006 dollars |
|---|---|---|---|
| Auto fuel | 1,139,110 | 12.8 | 516,438 |
| Other vehicle expenses | 1,088,845 | 13.7 | 600,082 |
| Household bundles | | | |
| *Including auto expenses* | 1,278,440 | 17.0 | 625,533 |
| *Redistributed auto expenses* | 1,292,362 | 17.3 | 627,465 |
| Public transit | 1,815,823 | 31.3 | 1,591,993 |

**Table 3: Economic impacts per US$1 million expenditures**
Source: Chmelynski (2008), in VTPI (2010)

### Box 4: Re-examining the employment-generating effects of aviation

It is often claimed that aviation is vital for the economy, because it generates jobs both directly and indirectly; the latter through the facilitation of tourism and business (OEF 2006). This is often given as a key reason to exempt aviation from fuel taxes and other levies, which not only distorts competition between modes, but leaves aviation externalities unchecked. Sewill (2005) et al. argue that the economic case for investing in aviation is often overstated, if not weak, owing to the large amounts of externalities the sector produces. He suggests that alternative forms of employment can be generated through taxing high-polluting industries such as aviation, and using the revenue to promote other sectors. As an example, the EU in its Emissions Trading Scheme is considering the use of revenue from aviation credits for climate mitigation actions in developing countries.

### Box 5: Green transport as a business

There are many revenue-generating opportunities for the private sector to support or complement sustainable transportation systems and operations. These may take the form of public-private partnerships, concession contracts between a public agency and private entity, or a for-profit business providing a service or product directly to users. Table 4 lists such businesses in the context of the Avoid-Shift and Improve strategy for sustainable transport.

| Avoid – Shift – Improve | Sustainable business | Emissions reduction potential | Examples |
|---|---|---|---|
| Avoid | **Telecommunication technology and services** | **Medium** – Provides alternatives to physical travel | Teleconferencing and teleworking by major companies in Europe, US etc. |
| Avoid and Shift | **Parking providers** | **High** – by providing formal parking space and replacing informal parking | Private parking operators in Tokyo |
| | **Shared vehicle systems** | **High** –by encouraging less private car usage | Car sharing integrated with rail and public transport in Switzerland<br>Bicycle sharing such as: JCDecaux/Cyclocity, Paris, Clear Channel/ SmartBike, Barcelona |
| Shift | **Public transport operations** (including fare collection, depot/fleet management, station management, security) | **High** – by increasing the quality of service and making transit systems more attractive | Bus Rapid Transit systems in Bogotá, Pereira, Curitiba, Ahmedabad, Guayaquil, Mexico, Leon, Guadalajara, Guatemala<br>Bus systems in Santiago, Sao Paulo (and most Brazilian cities)<br>Metro rail systems in Singapore etc. |
| | **Taxis and paratransit operations** | **Medium** – by providing door-to-door alternative to private cars (depends on fuel type and operational efficiency) | Auto-rickshaws in India, Pakistan |
| | **Non-motorised transport (NMT) services** | **High** – particularly when coupled with land use patterns that support shorter journeys achievable by NMT. | Bicycle rickshaws in India, New York City, San Francisco<br>Bike stations in Germany<br>Bike rentals in Amsterdam<br>Walking tours in Boston |
| | **Intelligent Transportation Systems** | **Medium** – optimising transportation system performance to minimising vehicle delays and making public transport attractive | Technology providers in Santiago, Guayaquil |
| | **Commercial enterprises in public spaces, advertising and street furniture** | **Medium** – improves the user experience of transit/non-motorised transport oriented cities | Barcelona, Buenos Aires, Guayaquil |
| Improve | **Low carbon vehicles** | **High** – by allowing better energy efficiency | Small, lightweight vehicles, ultra low emission engines, hybrid vehicles, plug-in hybrids linked with sustainable generation of electricity |
| | **Alternative fuels** | **High –** by allowing lower $CO_2$ per unit of energy | Second-generation biofuels, conforming to international sustainability criteria |
| | **Vehicle Maintenance** | **Medium** – proper vehicle maintenance can reduce emissions and GHG | Annual vehicle checks in e.g. Indonesia |

**Table 4: Green transport businesses in the avoid, shift, and improve groups**

## Box 6: The role of transport in reducing rural poverty

There is a large body of empirical evidence that shows a positive correlation between transport investment and economic outputs—for example Liu (2006). Binswanger et al. (1993) and AITD (2003) found that rural-road investment directly contributes to the growth of agricultural output, increased use of fertilisers, commercial bank expansion and overall improvements in the socio-economic conditions of rural villages in India. Khandker et al. (2009) in their research for the World Bank found that rural road investments in Bangladesh reduced poverty significantly through higher agricultural production, higher wages, lower input and transportation costs, and higher output prices. Rural roads were also found to lead to higher rates of school attendance for both girls and boys and to be pro-poor. However with rural road infrastructure investment also investments need to be made in infrastructure and facilities for public transport and NMT to those without access to private motor vehicles also increased mobility and to develop a multimodal transport infrastructure. This is especially the case when connecting urban centres with rural areas. Van de Walle (2002), in her work for the World Bank, argues that failing to consider the equity objective alongside the efficiency one can bias investment against poorer areas and poor people. This is particularly true in Asian transition economies, where roads are one of many constraints on development. Their economic, social and environmental benefits will be dependent on other factors such as whether affordable transport services follow the road investment.

(with the same amount of resources spent). Chmelynski (2008) suggests that in the US, each million-US-dollar block of consumer spending that is shifted from vehicle fuels to public transport generates 18.5 jobs.[16]

Furthermore, a study by Weisbrod and Reno (2009) of 13 public-transport investments in Europe suggests that a unit of investment in public transport would yield between 2 and 2.5 times this value to the regional economy.

UNEP (2008a) estimates that roughly 250,000 jobs in the car industry are targeted at relatively green cars and their components.[17]

## 3.3 Supporting equity and poverty reduction

Current transport systems, built primarily for private motor vehicles are, by nature, inequitable and impede efforts to reduce poverty by continuing the mobility divide. In many developing countries there is a vast gap between income groups in terms of access to paved roads, as well as affordable and safe transport.

Investment in green solutions such as public transport networks that are accessible, reliable and affordable can help alleviate poverty in a number of ways; providing people with the means to reach employment opportunities, education and healthcare. New jobs can be created in previously isolated areas, for example, by involving local workers and co-operatives in road maintenance.[18] Stimulating the local economy can also bring down costs and foreign exchange, while lower travel costs and reduced journey times can make essential goods and services cheaper. Safe and clean transport networks help protect the most vulnerable members of society from some of the adverse impacts of transport such as road-traffic accidents and air pollution.

16. Local employment potential depends heavily on the local context, for example how much of the good/service is provided domestically (versus imported). The figures are meant to be indicative.

17. Such figures depend heavily on the definition of green jobs, as well as the assumptions regarding the penetration rate of green vehicles. Further work is required to estimate a more accurate set of figures.

18. Such methods could be equally targeted at the construction and maintenance of infrastructure for public and non-motorised transport.

# 4 Quantifying the economic implications of green transport

To quantitatively assess the macroeconomic implications of investing in green transport at the global level, the study applied a modeling approach utilising the Millennium Institute's T21 model.[19] Within the multi-sector green investment scenario in which 2 per cent of the global GDP is allocated for investment in greening a large number of sectors, transport was assumed to receive 17 per cent of the total.

This section describes the differences between investing the assumed additional amount in green transport and in the business as usual scenario (BAU), including their macro-level implications up to the year 2050. Due to the scarcity of studies that employ the same modelling technique, the outcomes are to be interpreted as indicative of the direction of change that can be expected with green investment, and should be validated through further work. The figures should be assessed together with projections made by other models such as the IEA's Mobility Model, to which comparisons are made in this section.

## 4.1 Transport trends under business as usual

Under BAU without additional investment, the total *number of road vehicles*[20] increases rapidly. The stock of light-duty vehicles (LDVs) in particular would grow from the current 0.8 billion to 2.2 billion by 2050.[21] In line with the future growth in total vehicle stock, *travel volume* would increase for both passenger and freight transport. In the year 2050, passenger transport would reach 103 trillion passengers per kilometre (pkm) whereas freight transport would be approximately 38 trillion tonnes per kilometre (tkm). Compared with baseline figures from IEA, these figures are higher, especially for freight where IEA predicts only 13 trillion tkm in the same year.

In BAU, for passenger transport LDVs would continue to dominate all transport modes with an increasing share (47 per cent in 2010 rising to 62 per cent in 2050) of the passenger travel load over the period, while the share of buses would decline from 25 per cent to 15 per cent.[22] A steady share of the passenger travel load (6-7 per cent) is expected to be by rail, and around 10 per cent by aviation. For freight transport, the volume carried by rail would decline from 55 per cent in 2010 to 52 per cent in 2050, contrasted with an increase in road-based transport (trucks).[23]

With regards to *energy use* and *carbon emissions*, both are projected to increase by nearly 50 per cent by 2030 and more than 80 per cent by 2050 in the BAU case. The modes that will contribute most to emissions in 2050 are LDVs (56%), trucks (16%) and aviation (18%). By 2050 the $CO_2$ emissions of the transport sector would have increased to one fourth of the global energy related $CO_2$ emissions.

In the BAU case, *total employment* in the transport sector, which is 67.9 million in 2009, will continue to grow by 1.3 per cent per year on average through to 2050 and reach approximately 116 million.[24]

## 4.2 Investing in "Avoid Shift-Improve" policies

The transport sector will see massive investments in the coming decades, mainly through city planning, infrastructural works, public transport systems and procurement of transport vehicles. IEA (2010) predicts that

19. The information contained within this section draws from modeling work conducted by the Millennium Institute (MI). Whilst every effort has been taken to accurately integrate the modeling results throughout the entire report, there may be certain figures which are subject to further refinement or corrections, based on the larger modeling process and changes in other sectors. Note also that the modeling process has been limited by the relative lack of standardised evidence and data, for example assumptions on employment in the transport sector, harmonised information on transport activity by city, region and country, standardised figures on transport externalities, and the interrelationships between modes and sectors.

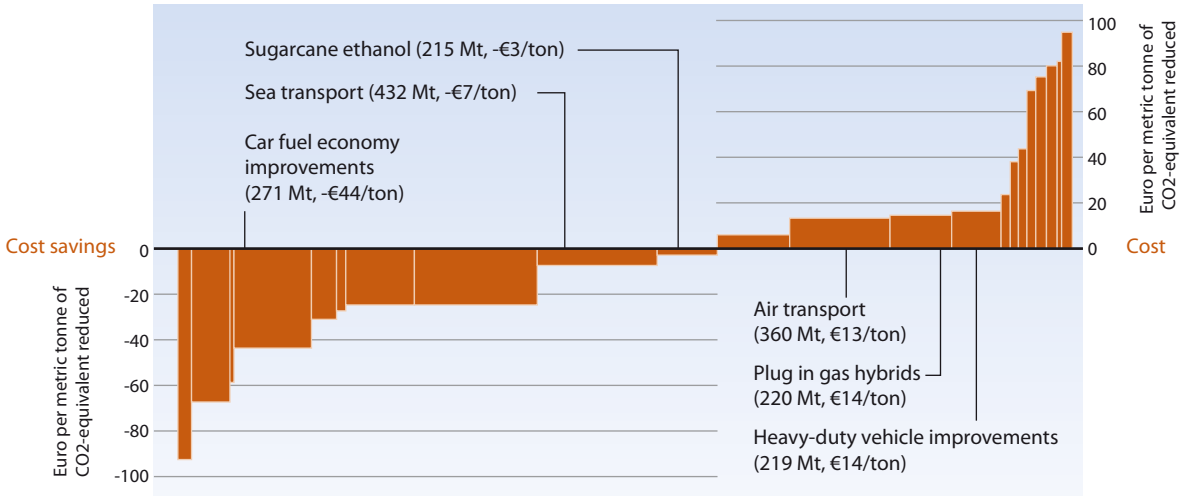
20. Includes both urban and non-urban, freight and passenger.

21. Others predict that this growth could even be higher. For example, IEA predicts the number of LDVs to reach 2.7 billion by 2050.

22. Of all passenger transport, IEA estimated, in terms of passenger-km per year (different from the measure in this model), 7 per cent to 6 per cent by rail, from 10 per cent in 2010 to 15 per cent in 2050 by air, and the remainder by road transport modes, in which 45-56 per cent of all passengers are carried by LDVs. Within road passenger transport, for which IEA reported total travel distance in km traveled by all road vehicles per year (same measure as in the model), LDVs account for 67-78 per cent of road passenger travel volume in 2010-2050.

23. IEA estimates the percentage of freight transport load, in terms of ton-km per year, that is carried by road vehicles increases from 55 per cent in 2000 to 59 per cent in 2050.

24. These figures exclude the large level of informal labour in the transport sector (for example, the maintenance of vehicles, operation of micro buses in developing countries), which were not able to be estimated due to data restrictions. Such forms of employment may also benefit from the shift in investments towards a green scenario.




Each rectangle representents an option for reducing emissions. The width measures the option's potential emissions reduction from business as usual, in millions of metric tonnes (Mt), in the year 2030.

**Figure 7: Global transport carbon abatement cost curve**

Source: ClimateWorks (2010)

by 2050 the world will spend another US$ 150 trillion on motor vehicles[25]. There will be an investment of another US$ 100 trillion in other types of transport vehicles (trucks, ships, aircraft etc) and US$ 150 trillion in fuels.

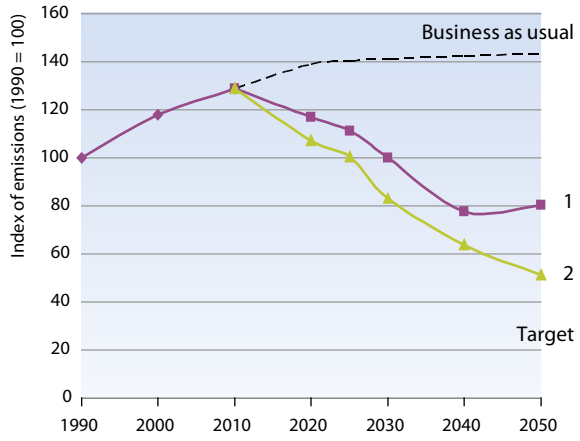
However, in a green economy these investments, if properly designed, do not have to result in increased emissions. Redirecting investment to green transport options can provide the same mobility needs but with significant reduced societal and environment impacts and in some cases even for less money. The global carbon abatement costs curve of McKinsey (2010) – presenting carbon benefits from investment in potential actions to reduce carbon emissions - shows that investing in green transport can be among the most cost efficient actions to reduce carbon emissions. For example, investing in improving the fuel efficiency of vehicles is claimed to be able to generate net savings of EURO 65 per ton carbon abated. The global transport carbon abatement cost curve of ClimateWorks (2010), see figure 7, shows a similar amount for initial improvements in fuel efficiency, but with declining net savings for additional efforts in the transport sector.

It is important to look not only at carbon abatement efficiency but to also look at other impacts on the various challenges identified in the first chapter of this report. Table 5 shows that while some transport interventions are cost effective ways to reduce carbon emissions, others are more effective in increasing accessibility or decreasing congestion.

25. Undiscounted dollars over the next 40 years worldwide.

| | INVESTMENTS | | BENEFITS | | | | |
|---|---|---|---|---|---|---|---|
| | Direct investment | Long term costs/ investment | Air quality | GHG emissions | Congestion | Transport accessibility | Road safety |
| Bus Rapid Transit (BRT) | ++ | + | ++ | ++ | ++++ | ++++ | ++ |
| Light Rail | +++ | ++ | ++ | ++ | ++++ | +++ | ++ |
| Rail | ++++ | ++ | + | ++ | +++ | ++ | + |
| Cleaner & more efficient vehicles | + | + | ++++ | +++ | +/- | +/- | +/- |
| NMT infrastructure | ++ | + | ++ | + | +++ | +++ | ++ |
| City planning/ design | +++ | +++ | +++ | ++ | ++++ | ++++ | ++ |

**Table 5: Costs and benefits of investing in green transport**




Each curve shows the additional effect of adding further instruments.

1. 'Improve' package: improved engine and vehicle design, electric cards, low-carbon fuels and technologies encouraging behavioural change. These measures lead to a 44% reduction in transport $CO_2$ emissions.

2. 'Avoid and shift' package: road pricing, car clubs, increasing population density in cities, travel planning. These measures lead to a 20% reduction in transport $CO_2$ emissions.

**Figure 8: Effect of a combination of Avoid, Shift and Improve measures to reduce $CO_2$ emissions from the transport sector in the EU**

Source: EEA (2010)

To achieve a green transport sector and meet targets set in terms of improved urban air quality, carbon emissions, and reduced road accidents, a mix of strategies is needed combining "Avoid, Shift and Improve" interventions. Modeling of the IEA (IEA, 2009b) and the European Environment Agency (EEA, 2010) come to the same findings. Figure 8 shows that a package of measures under the "Improve" strategy can reduce carbon emissions from IEA's BAU scenario by 44 per cent and an additional package of "Avoid and Shift" measures can reduce emissions by a further 20 per cent, achieving a total reduction of 64 per cent in 2050. The IEA's BLUE Map/Shift scenario predicts that a similar reduction (70 per cent) can be achieved by 2050 worldwide through combining investment in efficient vehicles with modal shifts. As with the EEA model, the majority of the emissions reductions will need to come from introducing efficient, low carbon fuels and vehicles.

In the context of climate-change mitigation, it is often claimed that actions in transport are costly due to the required new technologies. However, as demonstrated by several studies such as Cambridge Systematics (2009) in its "Moving Cooler" study and McKinsey's and ClimateWorks' cost abatement curves (see earlier), the cost of many transport interventions and especially a comprehensive set of policies based on the "Avoid, Shift, and Improve" strategy can often result in net savings to the economy as a whole. The savings in fuel costs brought about by a mixture of behavioural and technological changes far outstrip the implementation costs. A World Bank (2009) study on Mexico notes that projects targeted at improving the efficiency of bus networks, rail freight and vehicle-inspection schemes generated large net savings.

## 4.3 Investing in green transport

**Inputs and assumptions**

The green investment scenario (G2) assumes US$419 billion in constant US$ 2010 invested per year over the next 40 year period into:

- Expanding the *public transport infrastructure* (promoting modal share to bus and rail transport); and
- Increasing the *efficiency of road vehicles*.

With respect to *public transport infrastructure*, investments are made to reduce LDV (cars) and air travel and increase bus and rail travel volume, promoting a modal shift to less carbon intensive forms of transport. An annual investment of around US$24 billion is allocated to transport infrastructure over the 40 year period.

With respect to *energy efficiency improvement*, around US$ 384 Bn is assumed to be invested in more efficient vehicles on average each year between 2011 and 2050. Note that the investments assumed in the model for measures under the "Avoid/Shift" and the "Improve" strategies are in line with the EEA and IEA green transport investment scenarios discussed earlier.

Furthermore, to represent future *changes in travel needs* under the green scenarios, a 25 per cent avoidance of total transport volume is initially assumed, in accordance with IEA's outlook on total travel volume.[26] This reduction is assumed to happen at no cost as a result of changing needs and behaviour motivated by the various "enabling conditions" such as better city planning, more e-working, strict regulations, etc. Note that the above assumptions on investment and behavioural changes directly mirror the "Avoid, Shift and Improve" paradigm set out in Section 2.2. These are shown to impact on transport modal split,

26. Assumed to be primarily driven by transit oriented development, telework, shorter but more frequent trips, among others (as indicated in IEA's Transport, Energy and $CO_2$ study). On the other hand, the positive impact of the green scenarios on GDP are projected to push total travel volume higher, partially offsetting the impacts of this initial assumption.

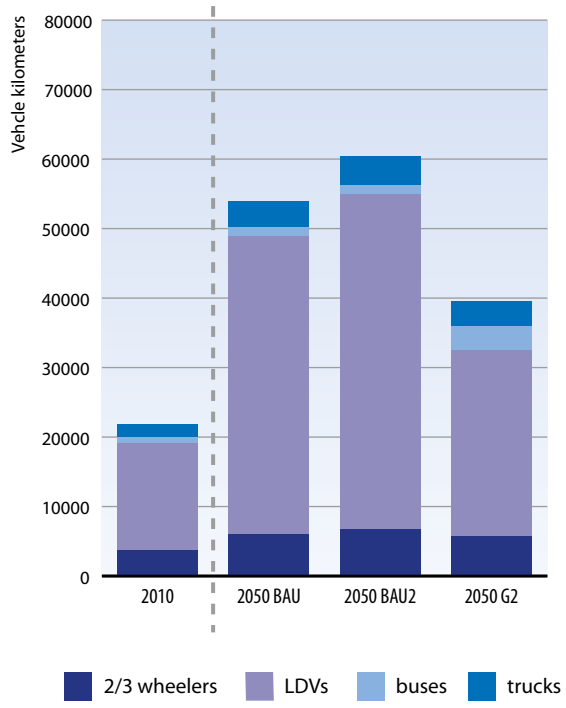



**Figure 9: Level of vehicle activity under BAU and the green scenarios**

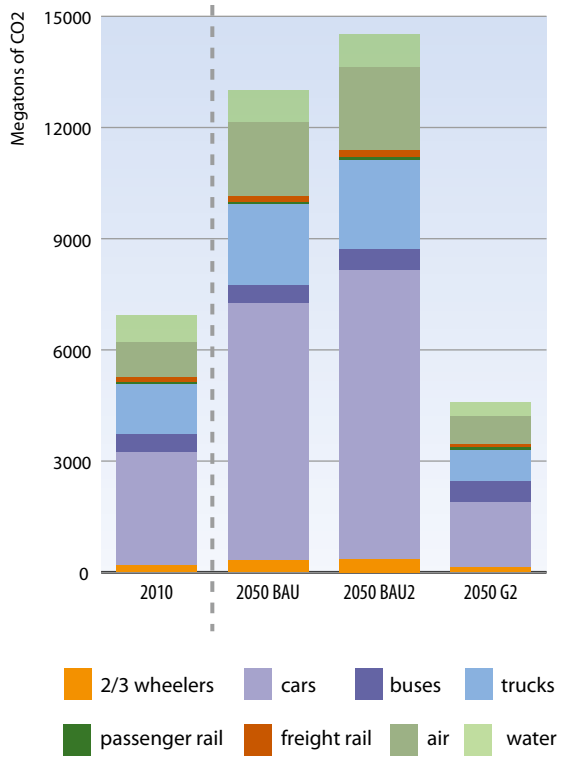



**Figure 10: Modeled changes to $CO_2$ emissions in the transport sector under the green and BAU scenarios**

energy consumption, energy-related emissions, and employment as discussed below.

The annual green investment in the transport sector would generally encourage the shift from (or retain the modal share of) private transport to public or non-motorised transport compared to the various BAU scenarios. The total travel volume of road vehicles will limit its increase from 21 trillion vkm in 2009 to 39 trillion vkm in 2050, 35 per cent below BAU2 (BAU with the same amount of additional investment as in G2). The figure below shows the level of road transport activity (in vehicle kilometres) under various BAU scenarios as well as the green investment scenario.

In terms of modal split, the green investment scenario assumes a fall in the share of passenger kilometres by car in 2050 from 62 per cent (BAU2) to 33 per cent[27]. For freight, rail retains a relatively large share of 52% of the transport volume (tkm).

The *total energy consumption* of the transport sector will be limited to 2.2 thousand Million tons of oil equivalent (Mtoe) in 2050 in green investment scenario. About 874 Mtoe are satisfied by biofuels,[28] limiting oil-based fuels to 1,251 Mtoe in 2050, 81 per cent lower than BAU2. Considerable energy savings come from the switch to public transport as the increase in emissions by buses and electrified rail are much smaller than the avoided emissions from LDVs.

**Results**

As a result of these investments, carbon emissions are reduced radically, by 8.4 Gt of $CO_2$, or 68 per cent relative to BAU2 in 2050. The green investment scenario corresponds roughly to the level of emissions modelled by IEA in their low carbon (BLUE Map) scenario, which combines incremental improvements in fuel efficiency of conventional engines, a 20-fold increase in biofuels and uptake of new vehicles such as hybrids and fuel cell vehicles. In the BLUE Map scenario, IEA estimates $20 trillion additional investments in vehicles (for more efficient vehicles including electric vehicles) but about a similar, US$ 20 trillion, savings in fuel costs due to increased fuel efficiency[29] (IEA 2009b). Therefore, a major global carbon reduction can be achieved without any cost (but would need investment policies that would promote investment in cleaner and more efficient vehicles).

27. This figure heavily depends on the assumptions that are used on the effectiveness of measures to avoid the need for travel, as well as to what extent the demand shifts towards public and non-motorised transport.

28. Care needs to be taken to ensure that the biofuels used comply strictly with sustainability criteria and do not lead to increases in food prices.

29. 2008 as a base year.

Total employment in the transport sector will remain substantial, with large growth in public transport modes such as passenger rail. Overall employment in the transport sector in 2050 is modeled to be higher in the green scenario compared to BAU2, by roughly 10 per cent. Jobs related to cars (including production and maintenance) will also grow, albeit less rapidly compared with BAU2 owing to the lower levels of car ownership under the green scenario.[30] As a result of the large reductions in carbon emissions, together with continued strong growth in transport employment, the carbon intensity of each transport job is reduced by around 70 per cent compared with BAU2, reflecting the decoupling of transport emissions from economic growth, and the "greening" of jobs in this sector.[31]

30. Note: Reliable job estimates on maintenance of cars could not be found and have not been included explicitly in the modelling. Concerning public transport, management and operation job numbers were calculated based on EU data (excluding France and Germany which have disproportionately high levels of employment in this subsector) to estimate employment at the world level.

31. The approach taken in this chapter to quantify the "greenness" of jobs may help inform existing and future definitions of "green jobs" – for example those from the International Labour Organisation (ILO). Further refinement and coordination of approaches in this aspect would prove beneficial in better quantifying and monitoring the transition towards a green economy.

# 5 Enabling conditions

Enabling conditions are background conditions in the investment and political environment that collectively allow the transition to a green economy. They will assist the implementation of the green investments identified for the transport sector, particularly if efforts are taken to ensure a harmonised and integrated approach that facilitates best available policies and technologies across the world. Below, we explore the key enabling conditions for green transport, namely:

- Designing appropriate regulation, planning and information provision;
- Setting the right financial conditions and economic incentives;
- Ensuring technology transfer and access; and
- Strengthening institutions and capacity.

Transport is a complex sector, which is shaped over a long period of time, and by various external sectors and factors (EEA 2008). Therefore, a combination of strategic approaches and policy instruments is required to "green" the transport sector. An inventory of policy instruments for environmentally sustainable transport and extensive discussion of their possible use in selected countries may be found in (OECD 2002)

## 5.1 Designing appropriate regulation, planning and information provision

A wide range of policies could support the Avoid, Shift and Improve strategies for green transport, namely:

- *Planning* – which can reduce the need or distance to travel by bringing closer together the people and the activities that they need to access. It can enable the implementation, and increase the attractiveness of new green transport infrastructure, including for public transport, cycling and walking;
- *Regulation* – which can be used to restrict the use of certain motorised vehicles but can also influence the types of vehicles used and the standards that they should adhere to (both in terms of vehicle performance and road regulations);
- *Information* – which can increase peoples' awareness of alternative means of transport, leading to a modal shift. Information can also be provided to improve driver behaviour and reduce fuel consumption; and
- *Economic Instruments* – which can provide incentives to change behaviour regarding choice of: vehicle type, fuel, type and timing of travel mode, etc.

Examples are provided in Table 6. Combining these individual policies is imperative to increasing their effectiveness. For example, restrictions on parking (or high fees) push users away from cars, whilst planning for public transport pulls them towards green transport.

Details of how these policies can enable green transport are provided in the sections below. Economic instruments are described separately in 5.2 (together with the related topic of financing).

**Planning**

Planning is essential in realising sustainable development. Good planning on all levels (urban, regional, and national) is a prerequisite for green transport, as land use often determines patterns of transport for many years (also see the Cities chapter).

Planners have investigated and postulated growth patterns for cities over the years. Six of the most common forms of city evolution or current growth patterns are outlined in Figure 11. The "compact city", which accommodates increases in population through densification of the city centre, and the "corridor city", which is synonymous with transit-oriented development are thought to be the most sustainable spatial approaches. The mid-sized city of Freiburg, Germany is a good example of the former, whereas Tokyo, Japan is a good example of the latter. Efforts have been made in many developing countries to build cities suited to public transport and non-motorised transport,[32] and Aguascalientes, Mexico is a good example (Embarq, no date). On the other hand, the "fringe city" based on suburban sprawl is synonymous with a heavily private car-dependent society; a result of a traditional, sectoral-based, planning approach.

**Regulatory instruments**

Owing to the inelastic nature of transport demand, economic signals such as the price of fuel are often insufficient on their own to trigger a large shift in

32. The potential for land use and urban planning to shape long-term transport patterns is higher in developing countries, where cities are still emerging and have not yet locked themselves into a car-dominated society. To incorporate the increasing population brought by the trend towards urbanisation, cities in developing countries can set clear physical boundaries to define the outer perimeter of the city, promote mixed land use, and (if needed) develop new land around public transport corridors.

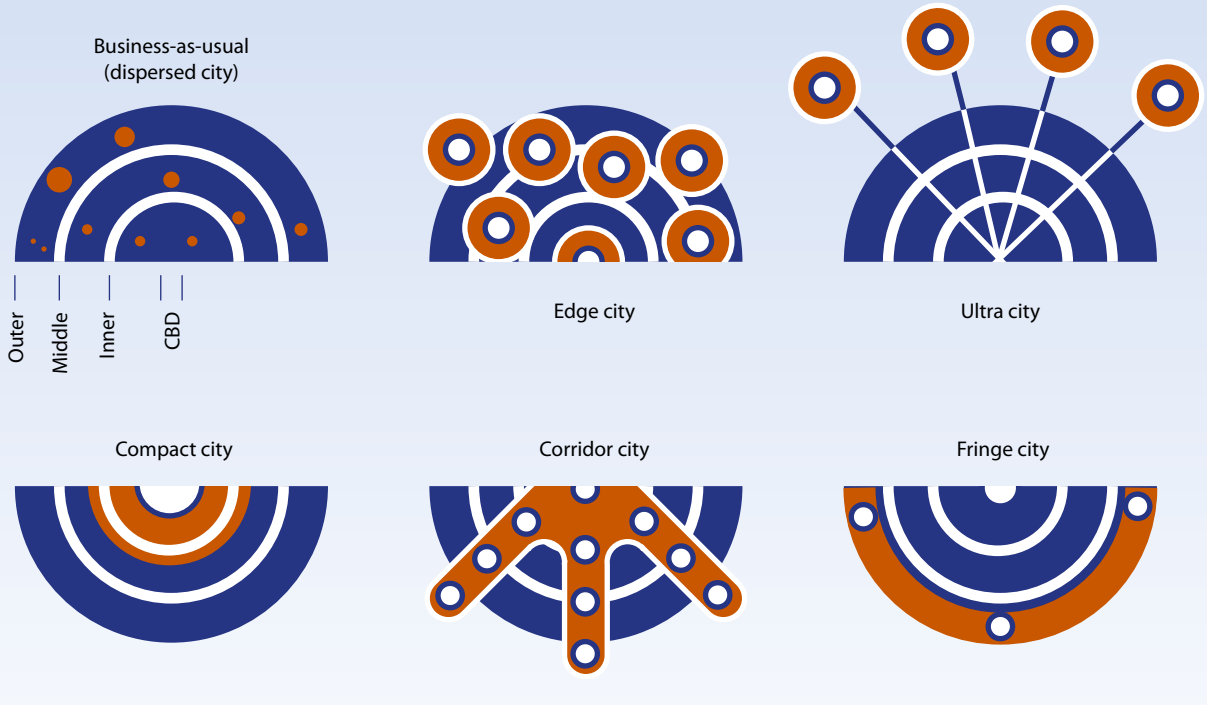



**Figure 11: Growth patterns for cities around the world**
Source: Vanderschuren (2003), after: Pressman (1985), Minnery (1992), Newton (1997)

behaviour for both consumers and industry. Regulatory instruments therefore play a large role in creating additional incentives to enable change. Timilsina and Dulal (2009) note that the main regulatory measures used to reduce environmental externalities in transport are those that relate to (1) fuel economy (2) vehicle emission levels (3) fuel quality (4) vehicle inspection regimes and (5) measures to discourage vehicle use or encourage high occupancy of vehicles. At present, many countries, and especially developing countries, lack comprehensive policies to regulate these five main areas. Practical applications of these regulatory measures are provided in the table below.

Regulation must be considered in conjunction with economic measures to ensure economic efficiency and avoid government failure. Regulation must also be feasible to enforce. Often a well intended scheme results in unforeseen consequences. For example, in Jakarta, a policy to mandate vehicle occupancy of three persons in one vehicle in the city centre has resulted in illegal "jockeys" receiving money from drivers to ride in their cars to help evade penalty fees.

**Information instruments**

Information instruments may induce further changes in behaviour through raising awareness of alternative modes or methods of travel. Public-awareness campaigns, mobility management, labelling of new cars, and driver education are representative examples.

By monitoring, accounting for and communicating the real financial, environmental and social implications of motorised transport, users may actively choose mobility patterns more in line with the Avoid-Shift-Improve approach. It is important to communicate the benefits of green transport in ways that directly relate to people's lives, such as improved health,[33] less financial expenditure, and reduced commuting time and stress.

Driver education and training can focus on "eco-driving" techniques, which can typically save between 5 and 10 per cent of fuel (ecodrive.org, 2010). Highlighting the reductions in fuel costs through eco-driving is likely to appeal particularly to operators of commercial vehicles.

## 5.2 Setting the right financial conditions and economic incentives

In order for investments in green transport to reach their full potential, a set of changes must be made to the current financing framework, coupled with the creation of market conditions that permit green transport to be economically feasible. These issues as well as the relationship of green transport with global trade will also be discussed below.

33. The World Health Organization has developed a methodology on evaluating the costs and benefits of human-powered mobility: Methodological guidance on the economic appraisal of health effects related to walking and cycling. http://www.euro.who.int/__data/assets/pdf_file/0007/87478/E90944sum.pdf.

| Type | Avoid | Shift | Improve |
|---|---|---|---|
| Planning | High density mixed land-use development. Parking standards. | Integrated public transport planning. Land use planning. | Planning of smart grids. Planning of decarbonised electricity sources. |
| Regulatory | Traffic restrictions and travel bans (e.g. in city centres). | Parking restrictions. Road space allocations. Restrictions on the type of vehicles. | Vehicle standards (on e.g. emissions). Speed limits. Regulation of production processes. |
| Information | Increase awareness of the real costs of travel by various modes. Mobility management and marketing. | Increase awareness of alternatives. Mobility management and marketing. Co-operative schemes. | Ecodriving<br>Public awareness campaigns.<br>Labelling of the environmental performance of vehicles. |
| Economic | National subsidies for low carbon transport city design and planning. | Public-private partnerships for public transport systems (esp. BRT and lightrail). Removal of fuel subsidies/ taxing of fuels. Allocating fixed percentage of road infrastructure for NMT. | Fiscal incentives for cleaner and more efficient vehicles. "Cash for clunkers" programs (buy-out of old/ polluting vehicles). Fiscal incentives for cleaner fuels. |

**Table 6: Overview of instruments to support avoid, shift, and improve strategies**

**Options for financing green transport**

Transport is a major attractor of public and private investment (Sakamoto, in Leather et al. 2009), characterised by:

- Strong prevalence of public-sector funding for transport infrastructure;
- Strong preference by international donors and national governments for the roads sector (particularly inter-city highways);
- High level of private and informal provision of transport services; and
- Limited recognition of, and funding for, green transport.

To enact green transport, it is clear that financing patterns must be reformed, so that:

- Adequate funding is provided for green transport in all aspects (e.g. technology, capacity-building, operation, infrastructure etc.) so that all extra costs associated with green transport can be recovered;
- Resources would be shifted from supporting non-sustainable forms of transport towards green transport, and additional resources are mobilised and scaled up wherever they are lacking

| Regulatory measure | Example application | Effects | Keys to success |
|---|---|---|---|
| Measures on fuel economy (regulating fuel consumption per kilometre of travel) | Corporate Average Fuel Economy (CAFE) standards in the US. | ■ 50 per cent increase in fuel economy between 1975 and 1995. (Greene, 1998)<br>■ Modelled net increase in jobs (140,000 by 1985). (Dacy et al. 1980)<br>■ Fuel saving of US$54 billion (in 1990 dollars). (Geller et al. 1992) | ■ Continuous improvement in the stringency of standards. |
| Measures on vehicle emission levels (regulating level of tailpipe emissions) | "EURO" standards in Europe, with gradually increasing level of strictness for CO, HC, HC+NOx, Nox and PM. | ■ Reduction of transport-related PM (-30%), acidifying substances (-34%) and ozone precursors (-48%) between 1990 and 2007. (EEA, 2010)<br>■ Adoption of identical or similar standards (with time lags) in various developing countries. | ■ Combination with other measures such as fuel economy standards, fuel quality standards and fuel taxation to further improve effectiveness. |
| Measures on fuel quality | Phasing out of lead, sulphur etc. from fuels, biofuel blending mandates in Brazil etc. | ■ Reduction in health problems associated with lead and sulphur intake.<br>■ Reduction in carbon intensity of fuels. | ■ Strong political will<br>■ Continuous pressure from civil society. |
| Measures for vehicle inspection | Vehicle inspection and maintenance system in e.g. Beijing. | ■ Reduction of local emissions by 28 to 40 per cent.(Kebin and Chang, 1999) | ■ Proper enforcement and, tackling of corruption. |
| Measures to discourage vehicle use/encourage high occupancy of vehicles | Car free zones in e.g. Germany, partial traffic bans in Mexico, speed restrictions. | ■ Increased quality of life and regeneration of economic activity in city centres.<br>■ Reduction of traffic congestion and air pollution. | ■ Prior communication of the benefits to local businesses and residents. |

**Table 7: Regulatory measures in practice**
Adapted from Timilsina and Dulal (2009)

| Funding stream | | Avoid | Shift | Improve |
|---|---|---|---|---|
| **Transport oriented funding streams** | | | | |
| **Public Sector Funding** | Fuel tax | +++ | ++ | +++ |
| | Vehicle taxes | ++ | ++ | ++ |
| | Parking charges | ++ | ++ | |
| | Road pricing | +++ | +++ | + |
| | Fare revenue* | | + | |
| | Public transport subsidies | | + | + |
| | Business taxes (e.g. Versement Transport in France) | | + | |
| | Land related taxes and charges | +++ | ++ | |
| | Grants, loans, tax transfers | ++ | ++ | ++ |
| Advertising | | | + | |
| Private sector investments | | + | + | +++ |
| **"Green" funding streams** | | | | |
| Environmental taxation and subsidies | | + | ++ | ++ |
| Clean Development Mechanism (CDM) | | P | P | P |
| Joint Implementation (JI) | | P | P | P |
| International Emissions Trading (IET) | | P | P | +/ P |
| Global Environmental Facility (GEF) | | P | + | + |
| Multilateral/ bilateral funds | | PPP | + / PPP | + / PP |
| Green Climate Fund, Fast Start Financing | | PP | PP | PP |

+++: High contribution; ++: Medium contribution ; +: Low contribution;
P: Low future potential, PP: Medium future potential, PPP: Large future potential

* Fare revenue in many cases also accrues to the private sector, if the transport operator is private.

* * Funding NAMAs could potentially be linked to the Avoid-Shift-Improve paradigm.

**Table 8: Options for financing green transport**
Modified from: Sakamoto, in Leather et al. (2009)

■ Public funding at all levels (international – including Official Development Assistance (ODA) and climate-related funds – national and local) is mobilised to support green transport;[34]

■ Private finance is leveraged, through the appropriate design of markets and the creation of consistent, long-term incentives to invest in green transport and through the application of public-private sector models to invest in and operate green transport systems (such as Bus Rapid Transit (BRT) systems); and

■ Financing flows from different sources are designed to complement each other, rather than work towards different goals.

A range of financing streams could contribute to providing support for green transport. These include not only funds and mechanisms devised specifically to support green options, but also existing sources. Table 8 outlines these options and assesses their relative support with regards to the Avoid, Shift and Improve strategies.

Typically, public-sector funding provides a major part of the overall financing volume for transport infrastructure investments, at an average of 52.9 per cent in developing countries (UNCTAD 2008). Here, efforts are required to screen transport investments according to sustainability criteria, so that resources will flow towards green transport (Sakamoto in Leather et al. 2009). The creation of a national green transport fund[35] (mirroring existing road funds found, for example, in Japan, fed by fuel and vehicle taxes) may be another option to guarantee adequate resources for green transport and help recoup any additional costs associated with green modes.

As transport investments are costly, increasingly public-private partnerships have become common. Such partnerships are also increasingly common in developing countries, for example in the operation of BRT systems.

34. Decision-making tools (e.g. project appraisal) should be reformed to ensure consistency with supporting green transport. Independent environmental analyses for transportation projects may be used to screen potential projects before they occur. They should also fully incorporate the potential synergies and trade-offs between projects for different modes/ sectors. Promoting transversal programmes without a sectoral focus may also be a way of integrating land use, transport and social services spontaneously.

35. Alternatively, such a fund could be set up under a wider "national green investment fund" which mobilises resources in all green sectors including transport.

Private-sector funding can be mobilised through, for example, Build-Operate-Transfer schemes, which have successfully channelled private resources into large infrastructure projects in many developing countries.[36]

Furthermore, there are a number of climate-oriented financing instruments with increased levels of funding available for green transport. For example, the Global Environment Facility (GEF) has released US$2.675 billion for transport projects over the last 20 years (GEF, 2009).[37] The Climate Investment Fund (CIF) and its Clean Technology Fund (CTF) have started to address transport as a key sector.

The financing framework (or the combination of the above options) for green transport would need to consider the following issues (Sakamoto in Leather J. et al. (2009):

- Its ability to generate the level of funding required to shift the emphasis towards sustainable transport;
- The ongoing stability of funding – enabling the sustainable transport strategy to be continuously implemented and long-term goals to be pursued;
- Efficiency – ensuring that resources are allocated to their best use, and reducing transaction costs throughout the system;

36. For practical guidance on utilising private finance for transport, see for example World Bank/ICA/PPIAF (2009).

37. US$201.5 million of direct finance matched by US$2.47 billion in co-financing as of May 2009.

## Box 7: "Share the road"

UNEP's "Share the Road" campaign promotes non-motorised transport (NMT) by advocating increased investment by donors and governments in NMT infrastructure within road projects (e.g. at least 10 per cent of the overall budget). The emphasis is on a paradigm shift towards roads that benefit all users and thus re-thinking how space and resources are shared between pedestrians, cyclists, users of public transport and motorists. Increased investment in NMT infrastructure can substantially benefit the environment (air quality, GHG emissions), development (accessibility, affordability), and safety (protected facilities for vulnerable users), and it is a prerequisite for building resource-efficient, liveable cities. Share the Road is working with partners with a view to making safe, low carbon and accessible mobility a reality for all users (UNEP and FIA Foundation, forthcoming at www.unep.org/transport/sharetheroad).

## Box 8: The future role of climate finance in enacting green transport

In the context of the ongoing negotiations on climate change, the design of financial instruments need to take into account the failure of existing instruments (such as the Clean Development Mechanism, CDM[38]) to be fully applied to the transport sector. Under a Post-2012 framework, mitigation actions in transport in developing countries are likely to fall under the umbrella of Nationally Appropriate Mitigation Actions (NAMAs), which could be financed through:

- A transport window under a Mitigation Fund such as the future Green Climate Fund;
- An up-scaled, programmatic CDM;
- A transport-specific instrument (see Bridging the Gap, 2010 for a proposal for a sectoral approach in transport.); and
- Other potential funds specific to capacity-building or technology.

NAMAs supported by developed countries are likely to be supported by fund-type instruments, whereas actions taken to acquire credits would be enacted through a crediting scheme such as an up-scaled CDM.[39]

38. Of the 2,400 registered CDM projects (as of October 2010) only three are transport projects, and only 32 out of the 5,529 CDM projects in the pipeline relate to the transport sector. Transport therefore only constitutes less than 0.l per cent of expected CERs. Source: UNEP-Risoe Centre.

39. The framework surrounding NAMAs is continuing to evolve, with the Conference of Parties (COP) to the United Nations Framework Convention on Climate Change agreeing at its 16th session in Cancun Mexico that developed countries shall provide support for preparation and implementation of developing country NAMAs, and that a registry will be set up to match finance, technology and capacity building support to NAMAs seeking international support. NAMAs are principally driven by the developing countries themselves.As noted in Binsted et al. (2010), many developing countries (26 of the 43 countries that submitted NAMAs to the UNFCCC by September 2010) have proposed NAMAs in the transport sector. See: http://www.transport2012.org/bridging/ressources/files/1/913,828,NAMA_submissions_Summary_030810.pdf

■ Equity – both horizontally (i.e. fair treatment of all transport users) and vertically (i.e. across income groups, ensuring support to those who are most deprived);

■ Practicality – both in terms of political acceptability and technical feasibility, taking into account local conditions and priorities; and

■ Measurability and transparency – to ensure that the effects of the new funding arrangements on carbon emissions can be monitored and evaluated against various criteria including cost effectiveness.

**Pricing practices and their reform (energy costs, taxation, subsidies)**

The market for transport is currently distorted in many ways. Firstly, the various impacts of motorised transport (observed in Section 2) are in most cases not accounted for in transport costs. Secondly, roads, fuels and sometimes vehicles are subsidised in many countries. This results in unsustainable transport patterns and is major barrier to the introduction of green transport models. These subsidies can be significant, in the European Union they are estimated to amount to 4 per cent of GDP (however, total taxes related to transport are about the same size). The overall externalities of transport are large, possibly as much as 7 per cent of GDP in the EU (OECD 2007).

As regards transport taxes, Hayashi and Kato (2000) point out that such instruments can be applied at three different levels, namely car *purchase*, car *ownership* and car *use* (e.g. fuel/mileage tax, road user charging and parking charges). The distinction between car ownership and use is important. Many developed countries, especially in Europe, combine high levels of car ownership with limited vehicle use. For example, the city of Vienna has one of the highest car ownership rates among European cities while the use of public transport is also among the highest. Taxing car use rather than ownership, together with providing high quality public and non-motorised transport alternatives, seem to be able to limit car use in many European cities.

Changes in pricing are essential in promoting green transport. Revenues from a full-cost-priced transport system[40] can be used to invest in green transport. London's Congestion Charge scheme, for example, directs part of its revenue towards improving the quality of the city's bus services (see Box 10). Pricing private modes of transport correctly will also ensure a level playing field for public transport.

The relationship between levels of trade and environmental sustainability is complex and their impacts should be assessed from a holistic perspective. In some cases, importing goods from other countries may actually be less carbon intensive—for example if organically grown imports replace food crops grown in greenhouses. In other cases, there could be a renewed case for local production and consumption of seasonal products.

A related issue is the trading of transport vehicles themselves. On the one hand, the global market may allow the rapid diffusion of the most recent technology,

40. Especially in developing countries where coverage of all transport costs is difficult due to existing structures, one may begin by initially pricing for the variable (operational and maintenance costs), and/or subsidising certain elements of transport from other transport revenues in the form of cross-subsidies, for example using fuel tax revenue to cover rail transport infrastructure..

## Box 9: Fuel subsidies – transitional arrangements

The implementation of policies and shifts in financing priorities will inevitably lead to some groups in society to be worse off, at least in the short term. The elimination of fuel subsidies may impact disproportionately on poorer households, with little access to alternative sources of energy. UNEP (2008b) argues that targeted subsidies towards the lower income groups may offset such impacts. Lessons can be learnt from the recent reduction of fuel subsidies in Indonesia, which has been coupled with cash compensations and increases in other types of social benefits for vulnerable groups, such as staple food prices and education (Bank of Indonesia 2008).

## Box 10: Congestion charging

Congestion charging, a fee charged to motorist to enter a zone prone to heavy congestion, may be an important element of more comprehensive energy price rationalisation in the longer term, particularly in developed countries. Congestion charging in London is thought to have reduced the vehicle volumes by around 15 per cent in 2003-2004 (Green Fiscal Commission 2009). The Eddington Review (2006), for example, emphasised the importance of controlling spiralling future congestion costs in the UK. This may facilitate a restructuring – and in some cases perhaps lowering – of fuel excises to focus them on the objectives they are best served to address, such as climate change mitigation.

| | | Level of importance/significance* | | |
|---|---|---|---|---|
| Green Transport Goals | Technologies | 2010 | 2020 | 2030 |
| ■ Improvement in energy efficiency<br>■ Reduction in air pollution and greenhouse gases<br>■ Increased use of renewable resources<br>■ Reduced use of non-renewable resources | ■ Improved internal combustion engines (ICEs) | +++ | ++ | + |
| | ■ Vehicle technology improvements (e.g. material substitution, aerodynamics) | ++ | +++ | +++ |
| | ■ Retrofitting technologies | +++ | +++ | + |
| | ■ Hybrid and Plug-in hybrid electric vehicles | +++ | +++ | ++ |
| | ■ Battery electric vehicles | ++ | +++ | ++ |
| | ■ Solar electric vehicles | + | + | + |
| | ■ Fuel cell vehicles | + | + | +++ |
| | ■ Flex-fuel vehicles | ++ | +++ | +++ |
| | ■ Alternative fuel technologies – Biofuels, CNG, LNG, LPG[1] and hydrogen | + | +++ | +++ |
| | ■ Non motorised transport vehicles | +++ | +++ | +++ |
| | ■ Public transport systems | +++ | +++ | +++ |
| | ■ Intelligent transport systems | ++ | +++ | +++ |
| | ■ Use of Information technologies for traffic management (smart infrastructure) | ++ | +++ | +++ |
| | ■ e/tele-technologies for travel demand reduction | ++ | +++ | +++ |
| | ■ Integrated ticketing | +++ | +++ | +++ |
| | ■ Eco-driving and speed control | ++ | +++ | +++ |
| ■ Waste minimisation<br>■ Reduction in land pollution | ■ Material substitution, use of composite materials | ++ | +++ | +++ |
| | ■ Recycling technologies | ++ | +++ | +++ |
| ■ Reduced noise pollution | ■ Electric vehicles, hybrids | ++ | +++ | +++ |
| | ■ Silencers, etc. | + | ++ | ++ |
| ■ Safety | ■ Vehicle safety technologies such as tyre-pressure monitoring, Adaptive cruise control/collision mitigation, Emergency brake assist/collision mitigation, etc. | ++ | +++ | +++ |

+++ : Central, ++: Highly Relevant, + : Relevant
1 Compressed natural gas (CNG); Liquefied natural gas (LNG); Liquefied petroleum gas (LPG)

**Table 9: Various technologies to support green transport goals**
Authors' assessment based on IEA (2009), Petersen et al. (2009) and others

including green vehicles. On the other hand, Davis and Kahn (2009) point out that free-trade agreements (such as NAFTA) have enabled used cars (often not meeting environmental standards) to flow from rich countries to developing countries and adversely affecting the environment. In this context, it is vital that environmental standards are harmonised to mitigate the creation of "pollution havens".[41]

## 5.3 Ensuring technology transfer and access

A wide range of technologies are relevant to green transport, as shown in Table 9. Conventional technologies involve the use of fossil fuels for vehicle propulsion, which are the main cause of air pollution and GHG emissions. Advanced transportation technologies aim at energy efficiency, switching from fossil fuels to renewable and clean technologies, improvements in public transport and non-motorised transport systems and infrastructure and travel demand management in order to reduce the negative externalities caused by conventional technologies.

In order to meet the sustainable transport development challenge for future, it is important to continue to develop new technologies. According to ICC (2007), technology developments in the transport sector should focus on:

1. Promoting use of existing efficient technologies;
2. Retiring existing inefficient technologies; and
3. Supporting R&D for advanced technology developments.

At the same time, there is the need for commercialisation and widespread dissemination of existing efficient technologies. For example, applying already existing

41. UNEP is currently working, with partners in the Partnership for Clean Fuels and Vehicles (PCFV - see www.unep.org/PCFV) to regulate the export of used vehicles to developing and transitional countries.

efficiency measures at a global scale (weight saving measures, stop-and-start technology, low resistance measures, hybridisation of vehicles etc) can already double the fuel economy of the global vehicle fleet. This is without introduction of state-of-the-art technologies such as electric and hydrogen vehicles (see Box 11).

**Technology transfer/access needs**

Technologies developed for developed nations often cannot simply be "transferred" to developing countries. According to UNEP (2009), effective technology transfer in the transport sector requires:

- Accelerated deployment and diffusion of technologies;
- Learning from the technology progress within countries already practicing technology transfer; and
- Supporting mechanisms through appropriate financial mechanisms, knowledge networks and capacity building.

Technological, financial, institutional, information and social barriers can prevent the effective transfer of technology. UNEP (2009) highlights economic and market barriers as one of the main obstacles for the transfer of technology. Furthermore, technology and knowledge transfer in transport should take place between developing countries, for example to share experiences in applying low cost transport solutions such as BRT systems.

To facilitate an increased level of technology transfer, a detailed inventory of relevant technologies should be developed at national and regional levels. This may be linked to a Technology Needs Assessment, currently undertaken by many developing countries, which could also identify key actions for support from the international community.

## Box 11: The global fuel economy initiative

Improving the efficiency of conventional engines is shown (at least in the short term) as one of the most cost-effective means to reduce environmental impacts (McKinsey and Company 2009). In this context, UNEP works with the International Energy Agency (IEA), the International Transport Forum (ITF) and the FIA Foundation in the Global Fuel Economy Initiative (GFEI)[42] to promote vehicle efficiency worldwide. The GFEI is promoting at least a doubling of global vehicle fuel efficiency by 2050, and through this will make a major contribution to a future climate regime and meeting of climate targets. By providing the space for discussion and consensus on automotive fuel economy, the GFEI serves as a bridge between the car industry, governments, international organisations and NGO groups worldwide in addition to providing support for the development of national clean and efficient vehicle policies.

42. See http://www.globalfueleconomy.org/

# 6 Conclusions

This report highlighted that the current patterns of transport activity, based primarily on private motorised vehicles, generates many social, environmental and economic costs, represented for example by:

- Consumption of more than half of global liquid fossil fuels;

- Emission of nearly a quarter of the world's energy-related $CO_2$;

- The source of typically more than 80 per cent of developing cities' local air pollutants;

- More than 1.27 million fatal traffic accidents per year, mostly in developing countries; and

- Chronic traffic congestion amounting to time loss and productivity loss.

Such costs, which can add up to nearly or over 10 per cent of a region or country's GDP, were shown to grow further under the current trends of ever-increasing motorisation. This trend is unsustainable.

There is a need for a fundamental shift in investment patterns, based on the principles of:

- **Avoiding** or reducing trips through integration of land use and transportation planning, and localised production and consumption;

- **Shifting** to more environmentally efficient modes such as public transport and non-motorised transport and to rail and water transport (for freight); and

- **Improving** fuels and vehicles through introduction of cleaner more efficient fuels and vehicles.

Models and scenarios show that a global paradigm shift is possible; investing in green transport measures could reduce emissions of the global transport sector by as much as 70 per cent. However this is only achievable with integrated policies that combine measures from all three components of the Avoid, Shift and Improve strategy.

Quantitative analysis using an integrated macro-economic model suggests that a small reallocation of investments (approximately 0.16 to 0.34 per cent of global GDP) in support of public transport infrastructure and efficiency improvement of road vehicles would (in the year 2050, and compared to BAU) avoid travel volume of road vehicles by 27 per cent and 35 per cent, shift the share of private-car transport to other modes (by nearly 30 per centage points), reduce oil-based fuel usage by between 16 per cent and 31 per cent, reduce carbon emissions by 5 to 8.1 Gigatonnes (38 to 63 per cent compared with BAU), and retain strong and growing employment. Most of the green transport measures would actually be cost-efficient—for example major carbon reductions can be achieved with little or no extra investment.

Moving towards a green transport sector as part of an overall green economy strategy would also result in:

- **Green growth**, by supporting cities with less congestion, air pollution and other costs;

- **The creation of jobs**, particularly through the development for public transport infrastructure and operations; and

- **The alleviation of poverty** by increasing affordability of transport and improving accessibility to markets and other essential facilities.

Furthermore, it was highlighted that, among others, such investment should be enabled via:

- **Policies**, including **land-use planning** to promote compact or mass transit corridor-based cities and conservation-based transportation infrastructure, **regulation** of, for example, fuel and vehicle standards, and the provision of **information** and awareness raising (e.g. on the health and safety benefits of active travel such as cycling and walking) to promote behavioural change in the form of modal choice;

- A shift in **financing** priorities towards public and non-motorised transport, coupled with strong **economic incentives** (via taxes and charges) to promote sustainable consumption patterns and behaviour and to ensure green modes are commercially feasible and economically attractive; and

- Development and application of green transport **technology.**

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