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Reducing Emissions from Private Cars: Incentive measures for behavioural change*

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Executive Summary

To avoid duplication of effort, this report is focused on explaining the inadequate utilization of accumulated knowledge and on reporting insights received from experiences in reducing car use and emissions reduction – both of which are directed to reduce health-affecting (lead, fine particulate matter, SO_X, NO_2, ozone) and greenhouse gas-emitting emissions such as CO_2. It is primarily intended for decision makers in national governments, automobile manufacturers, fuel industry executives and city officials. Its contents are based on a review of the accessed literature, compiled information and analysis of the cases prepared on selected practices concerning car use reduction and emission controls having a global and regional scope.

Clearly, serious concerns about human health, productivity loss and climate change have arisen from the use of unsustainable transport modes, The analysis of the ongoing efforts suggests it is not that "little is happening" on emissions reduction: it is rather that these efforts are often piecemeal, partial, one-shot attempts or mere show pieces. Successful outcomes often do not have lasting effects, because they have not led to changes in attitudes or in the behavioural norms of citizens, governments and businesses. In some instances, changes have not been lasting or permanent because the outcomes were not institutionalized or sufficiently funded for up-scaling. Good practices in developing countries are often created by Official Development Assistance (ODA) support, but their up-scaling and institutionalization require financing by governments, the private sector or foreign direct investment. Often this is not available because of investors' concerns about cost recovery, which, in turn, are a casualty of the combined influence of citizens' unwillingness to pay (e.g., for transit service) and politicians' unwillingness to charge for fear of losing votes. Breaking this vicious cycle requires the proactive role of local political leaders to educate citizens about the benefits from investing in physical infrastructure such as walkways and public transit.

This report is intended to motivate concerted efforts by governments, industries and citizens to reduce emissions from the private car sector. It is based on an analysis of numerous initiatives and actions that seek to reduce car use and emissions reduction. One conclusion of the report is the need to use comprehensive incentive measures to encourage behavioural change. Indeed, in the absence of the simultaneous use of regulatory, economic and persuasive measures, any outcome is likely to be insufficient.

The content of the report has been largely defined by a "what-why-how" approach to problem solving in that it: first, defines the problem (i.e., *what* is the nature & magnitude of the problem of automobile emissions); then explores and explains the reasons or causes (i.e., *why* the emissions tend to persist or even to increase); and finally suggests solutions (i.e., *how* to design public policy, planning and management tools to reduce emissions).

There are several reasons for non-optimal outcomes of ongoing policies, programmes and actions. Among these is the tendency not to sustain them for long

enough periods, often due to the cessation of ongoing financial support. Another is the failure to consider a city or country's political economy or stage of development before launching a programme.

In the cities of developing countries, the lack of alternative modes of transportation is a major cause of growing reliance on automobiles by middle class urban residents. Absence of some simple and basic amenities, such as walkways, safe bikeways or convenient access to public or mass transit (such as BRT or subways) renders urban residents helpless in meeting their commuting needs.

This report's contents suggest that to alter the less than optimal outcomes associated with ongoing efforts, public policy and action programmes need to be founded on a sound understanding that (i) behavioural change is central to sustainable transport mode choice by citizens; (ii) financial support is essential to accomplish goals (i.e., from creating pedestrian and bicycle ways to building mass transit systems); and (iii) incentive measures can be used to influence positive changes in individual behaviour.

The health and productivity consequences of emissions from the use of automobiles have long been known. As a result, some citizens have been making individual efforts to reduce dependence on their automobiles. Some have even voluntarily discontinued using them. Since the 1970s, public policy on this issue has also started to emerge. This was spurred by the formation of the Organization of the Petroleum Exporting Countries (OPEC). Other factors have been the contribution of CO_2 emissions to global warming, which has created a new momentum for promoting environmentally sustainable transport (EST). This is evident in the EST initiative by the Organisation for Economic Development and Cooperation (OECD) and the follow-up actions by similar international agencies, national governments and city authorities. In Asia since 2003, the United Nations Centre for Regional Development (UNCRD), in collaboration with the Government of Japan, has launched EST programmes in earnest for the countries in this region.

In the OECD strategy, adopted policy instruments include: regulatory (e.g., concerning emissions of CO_2 and local pollutants); fiscal (e.g., fuel taxes and road pricing, other disincentives and also incentives); and hybrid regulatory/fiscal instruments (e.g., tradable entitlements to emit CO_2 from vehicles). These instruments are used for (a) technological breakthroughs, (b) mobility management, and (c) awareness raising and education, since information and education are seen to be key to raising public awareness. Regulations are widely used for setting emission standards and limiting values. Use of economic instruments includes fuel and road pricing and providing fiscal incentives. Land use planning is used to reduce commuting distance, promote access to public transit and avoid suburbanization.

Lessons learned from OECD countries' experience in EST implementation include some of the following: (a) to ensure acceptability of goals, targets and strategies, phasing in the implementation over a period of time is effective; and (b) to be effective, careful monitoring of the effects of instruments and their appropriate adjustment are required; (c) "business-as-usual" in transport policy is no longer a

viable option; and (d) EST can be defined, is attainable, induces structural changes, provides new opportunities and can be achieved in several ways.

In preparing this report, the most time-consuming work involved compiling specific transport policies, programmes or projects having a bearing on reduction of emissions from automobiles and undertaken by cities in different regions. Initially, the search generated information on 79 cases that focused on reducing emissions. Of these 79, ten cases concerned cleaner fuel; six, greener cars; ten, emission control technologies; nine, road/congestion pricing; 17, public/mass transit; six, bicycles; three, car-free days; four, car-sharing; one, walking; one, car ownership restrictions; four, travel awareness initiatives; one, reducing parking spaces; two, urban planning/land-use; one, transportation planning; two, area licensing systems; and one on restoring waterways. Three are miscellaneous.

The cities of these cases are: Dhaka, Beijing, Hong Kong, Shanghai, Bangalore, New Delhi, Jakarta, Teheran, Fukuoka, Sapporo, Seoul, Kuala Lumpur, Kathmandu, Singapore, Bangkok, Adelaide, Strasbourg, Dortmund, London, Calgary, Ann Arbor, Los Angeles, Buenos Aires, Curitiba, Bogota, Quito, Mexico City and Dar es Salam. A few country-wide cases are from Taiwan, Vietnam, China, Germany, Austria, and the Netherlands.

Because of inadequate information, 25 cases were omitted. To draw lessons from the data, 54 cases were finally prepared and analysed (Appendix A) in order to examine (i) the issue addressed; (ii) how the problem was formulated; (iii) the components of policy and/or incentive measures used; (iv) how these measures were implemented; and (v) the challenges faced and the ways they were (or were not) overcome. A mere glance at the list that follows should shed some light on the variety of initiatives and actions in place worldwide to reduce vehicular emissions, either directly by vehicle and fuel technology and/or indirectly by car use reduction.

Given the number and length of the prepared cases (Appendix A), an overview of their contents has been prepared by categorizing the cases according to the type of strategies adopted (Chapter 4). A selection is listed below:

Total Transport Demand Reducing Strategies

Urban planning cases

- *Vancouver's urban planning and densification strategy for reducing car use*
- *Curitiba's urban planning practice that integrates transport planning*

Transport planning cases

- *Singapore's integration of transport and land use planning*
- *Beijing's integrated road transport system development*

Car use reduction cases

- *Singapore's adding of quantity measures to initial reliance on incentive measures alone*

- *Beijing's substitution of private travel by financing investment for public transit to create disincentives for car use*
- *London's congestion charges*
- *Korea's congestion pricing*
- *France's bonus rebates for buyers of new vehicles with low CO_2 emissions*
- *Singapore's area licensing system*
- *Sapporo's travel feedback programme*
- *Seoul's car-free days*
- *Fukuoka's multi-stakeholder initiative in car sharing for reducing CO_2 emissions*
- *European countries' popularization of pedestrian malls for restoring city's early image without cars*

Public transit cases

- *Bangalore's overcoming of perennial losses in running its bus service by a combination of fleet modernization, augmentation of service, revenue mobilization, fare policy and cost minimization measures*
- *Ann Arbor's bus pass programme to reduce car use*
- *Bangkok's van transit service to promote ride sharing for reducing traffic congestion*
- *Beijing's institutional, technological and financing innovations to overcome the barriers to create its MRTS*
- *Jakarta's bold start with BRT in reducing car use*
- *Bogota's BRT operation funded entirely by fare collection*
- *Dar es Salam's transition to a BRT system*

Emissions-free travel mode cases

- *Marikina city's bikeway programme*
- *Bangkok's walking street programmes*
- *Africa-wide initiative for "cycling out of poverty"*

Emissions Reduction

Cleaner fuel cases

- *Mexico's adoption of common sense economic strategy by increasing gasoline price and making CNG the least expensive fuel*
- *Vietnam's success in switching from leaded to unleaded gasoline*
- *Quito's electric trolleybus system based on financing and cost recovery*
- *China's tradition of learning from others as reflected in adoption of Shanghai's alternative fuel vehicles*
- *Delhi's CNG programme following a Supreme Court mandate*
- *Thailand's switch from leaded to unleaded gasoline*
- Calgary's making its wind-powered commuter train a reality by incorporating private companies
- *China's incorporation of fuel-cell initiative in its high-technology development programme*

Greener vehicle cases

- *Hybrid cars*
  a *Kenworth hybrid truck*
  b *Honda*

c Toyota
d Japan's hybrid technology cars

- *Tata's Nano Car: concern on trade-off between "peoples' car" image vis-à-vis energy efficiency*
- *Suffolk's "hybrid only" parking for promoting green vehicles*
- *Beijing's programme to transform vehicles for alternative fuel use*
- *Thailand's change from two-stroke to four-stroke motorbikes*
- *Kathmandu's electric three-wheelers to replace diesel vehicles.*

Emission control and fuel economy improvement cases

- *EU's switch from largely voluntary commitments to a comprehensive set of measures for CO_2 emissions from cars*
- *China's regulatory system for fuel economy improvements including incentives to lighter vehicle manufacturers*
- *Mexico City's air quality improvement programme using vehicle inspection and maintenance*
- *Japan's use of green purchasing law for vehicle emission controls*
- *Beijing's combining of standards, regulations, technology and fiscal incentive measures for vehicle emission controls*
- *Shanghai's use of vehicle emission control programme involving implementation of EU-1 standards*
- *U.S. fuel economy improvement system's novelty*
- *Japan's following America's lead in allowing manufacturers to accumulate credits from fuel economy improvements*

All 54 cases presented in this report have direct and indirect effects on emissions reduction. They are grouped into two broad categories according to the thematic nature of the strategies used: (a) strategies for reduction of total transport demand and (b) strategies for reduction of emissions.

The strategies being used to reduce total transport demand fall into five major groups:

- urban planning;
- transport planning;
- car use reduction;
- public transit; and
- free/low emissions travel modes.

Strategies for reduction of emissions directly by technological means include:

- vehicle emissions controls and
- cleaner fuel and greener vehicles.

The prepared cases were then analysed to determine the dominant policy instruments, tools and measures widely used, as well as the partial use or absence of these measures. The analysis is grouped into three major categories: (i) regulatory/command and control (CAC), (ii) economic/financial and/or (iii) persuasive/information measures.

Cases with predominance of regulatory measures

- Singapore's restriction on car purchase (Case A7): quantity measures, i.e., regulatory instruments (RIs) are added to initial reliance on taxation measures, i.e., economic instruments (EIs);

- China's fuel economy improvement (Case A19): mandatory (RI) with economic incentives (EIs) for lighter vehicle manufacturers;

- Japan's vehicle emission controls (Case A32): greener vehicle purchase requirements as per Green Purchasing Law (RI);

- European Union's vehicle emissions control technology (Case A15): switch from largely voluntary commitments to a comprehensive set of measures to reduce CO2 emissions from cars using a dominance of RIs;

- Beijing's vehicle emissions control programme (Case A36): combines RIs, technology and fiscal incentives (EIs), but standard regulations used prominently;

- Shanghai's vehicle emissions control programme (Case A37): involves implementation of emissions limits equivalent to EU-II standards;

- "Hybrid only parking" in Suffolk, New York (Case A45): hybrid vehicle parking only (RI) – an indirect incentive to the manufacturers via green purchase incentives to the buyers; and

- Kawasaki's (Japan) traffic signal control for reducing vehicle CO2 emissions (Case A33): traffic signal control (RI) is basically the only tool used for the stated purpose.

Cases with predominance of economic/financial measures

- London's congestion charge (Case A32): Although road pricing to address congestion was pioneered by Singapore, London's Mayor Ken Livingstone's determined implementation of congestion charges has not only been accepted by London residents, but has drawn global attention as an option to reduce car use in the central city;

- Congestion pricing in South Korea (Case A3): Although Seoul experienced some positive results with the use of a set of EIs to reduce car use, South Korea is experiencing some difficulty extending this policy country-wide because of the public perception that the congestion charge is "double taxation". This vindicates the need for the other two sets of policy instruments – regulatory and persuasive/information instruments;

- Singapore's area licensing system (Case A8): ALS is essentially a "cordon pricing" system designating the central business district as a restricted zone for the purpose of using road pricing to reduce congestion;

- France's bonus rebate to purchasers of cars with low CO_2 emissions (Case A16): Consumer-directed incentive measures for buyers of new vehicles

having low CO_2 emissions and penalties for buyers of high emission vehicles. This is a use of EI that indirectly works as an incentive for green vehicle technology innovations;

- Mexico City's policy of making the compressed natural gas (CNG) price the least expensive fuel for vehicles (Case A29): World Bank funding allowed Mexico to undertake retrofitting of vehicles to run on CNG. This, combined with a policy of high gasoline prices and low CNG prices, is working well. A similar policy is working effectively in Dhaka, Bangladesh; and

- Seoul car-free days (Case A21): Unlike other cases of car-free days relying primarily on persuasive or regulatory measures, Seoul has introduced a strong dose of economic/financial incentives to reduce car use. Both private and public sectors have joined hands in providing these incentives.

Cases with predominance of persuasive measures

- Fokuoka's car sharing (Case A21): For reducing CO_2 emissions, Fukuoka has launched a multi-stakeholder initiative in which a Car Sharing Network (CSN) and an Integrated Circuit (IC) card system are used. Although the working mechanism was based on persuasive measures (PIs), market creation and deriving economic benefits have become this initiative's obvious "co-benefits";

- Sapporo's travel feedback programme (TFP): This programme in Sapporo demonstrates the power of persuasive measures. After trying several travel demand management measures without success to substantially reduce traffic, TFP was launched in Sapporo. It involved regular meetings with local communities based on their personal/family tracking of vehicle use and feedback in classroom lectures concerning the levels of CO_2 emissions as recorded in diaries. The TFP model resulted in significant behavioural change with possible long-term effects, given the availability of alternative models of transport (Case 4); and

- Bangkok's walking street programmes: To combat the city's image of traffic congestion and its lack of safe walkways, the promotion of a pedestrian-friendly environment for Bangkok started in Silom Road. Starting the programme in a heavily congested street, such as Silom, has been commended, and the programme was extended to several other cities in Thailand. The principal implementation instrument has been "community education" (PIs). Unfortunately, this measure was not effective enough to sustain the programme, and it has been discontinued. This case (22) reveals that a well-designed traffic policy is essential before restricting any street to pedestrians only.

The cases were analysed to determine whether any particular set or all three sets of policy measures (regulatory, economic or persuasive) were used to influence behaviour during the implementation of emissions reduction policies. The underlying hypothesis was that in the absence of using all three sets of measures

simultaneously as a policy package, the outcome would be non-optimal at best. The findings of the report were that, in many instances, the start of the programme involved either command and control instruments/regulatory instruments (CAC/RIs) or market-based incentives/economic instruments (MBIs/EIs). In some other instances, only suasive/persuasive/Information Instruments (SIs/PIs/IIs) were used. In still others, CAC/RIs was added to the initial use of MBIs/RIs alone – as it was in the European Union's (EU's) goal of reducing CO_2 emissions to fulfil the requirement to have greenhouse gas emission reduction targets as per the Kyoto protocol (Case A15). Similarly, in the case of Singapore's car purchase reduction policy, the programme began by using economic instruments (EIs). Later, quantitative measures (VQS) were added after experiencing limited success with EIs alone (Case A7). Only in a few instances were all three sets used (e.g., in switching from leaded to unleaded gas in Thailand (Case A27) and Vietnam (Case A30).

It should be noted that typical incentive measures – regulatory, economic or persuasive – are not the only means of influencing human behaviour. Cases in urban planning, transport planning or investment in physical infrastructure are good examples of how these measures can also be used effectively to reduce car use. Vancouver's planning and densification strategy (Case A1); Curitiba's integration of urban planning and transport planning (Case A9); and pedestrian malls in several European countries (Case A52) all demonstrate how classical methods of urban planning are being used to reduce dependence on private cars. Beijing's investment in public transit (Case A12); Bogota's funding of a BRT operation (Case A43); Jakarta's bold start of bus rapid transit (BRT) (Case A42); and a Global Environment Facility (GEF) grant for a bikeway programme in a Philippine city (Case A4) are some examples of how investment in public/mass transit, walkway/bikeways can change citizens' travel habits.

Lessons learned

In varying degrees, all three sets of measures – regulatory, economic and persuasive – having the potential to influence travel behaviour are in use, but they are rarely used simultaneously or in a concerted manner. As a result, policy measures fail to comprehensively address all three elements of human motivations: fear, economic interest and a moral/ethical sense (Figure 3.5). Consequently, the scope for influencing behavioural change has not been fully realized. The effectiveness of coordinated measures has been vindicated by cases in which there has been a successful switch from leaded to unleaded gasoline, namely in Thailand and Vietnam (Cases A27 and A30), where all three measures are used systematically and comprehensively.

A new generation of tools to change travel behaviour are also in use to reduce CO_2 emissions. These are the basic but effective measures of education, awareness and training that are keys to making considerable progress in emissions reduction. While these measures are widely used, the role of the physical infrastructure in influencing travel behaviour is less well-known. Local inhabitants frequently turn to car purchases and their use to offset the disadvantages of travelling by bus. Yet case studies of bus service in Curitiba and Jakarta demonstrate how investments in bus

service can positively influence travel behaviour (Cases A9 and A43). Similarly, the cases involving walking and bicycle way use (Case A4) show that investment, even in low-cost physical infrastructure, can facilitate citizens' switch to highly desirable transport modes.

Arguably, the role of urban planning in influencing travel behaviour is the least understood and discussed of all the measures proposed. Unfortunately, urban planning does not assume a central role in public policy (in contrast to the role of economics). This has been the case since the 1980s when free market/price, signal-based individual, household and industry decision making became the dominant factors influencing human behaviour. Since then, the "planning" paradigm has been largely neglected as an economic, physical or spatial solution for controlling car use emissions.

As a result, development controls, land use planning and zoning have lost political, hence, policy support, the consequences of which are suburbanization, urban blight and the growth of Extended Metropolitan Regions (EMRs) around major cities. These developments contravene the principles of urbanization, urban growth and the city as agglomerations of livable, high-density economic activities and compact living. This, coupled with an absence of mass transit, has made the automobile an essential means of transport in developing country cities in contrast with its earlier use as a luxury or a status symbol. Five cases presented in this report: (i) urban planning and densification for reducing car use, Vancouver, Canada, 2007; (ii) Curitiba, Brazil: a model in urban planning, with particular reference to the city's transportation system; (iii) restoring Cheonggyecheon stream in Seoul; (iv) the Marikina bikeways network (an encouraging local government programme in a Philippine city); and (v) a pedestrian mall in Singapore, are all positive examples, because each makes substantial use of urban planning paradigms to reduce automobile use, and hence, CO_2 emissions.

The review of the cases clearly suggests that in recent years cross-country and cross-city learning has been taking place in EST promotion worldwide. There have been significant gains in terms of knowledge sharing on environmental management in different cities. For example, in the case of the Bangkok pedestrian street, the showcasing of a possible car-free street created a momentum for similar streets in other cities – in spite of the closure of the model street itself. Embodying models and measures is critical for overcoming the psycho-social and cultural inertia dictating the seeming "implausibility" of addressing the environmental dilemma in many cities. It is always safe to learn from already tried models. Most explicitly, this is seen in cases from China.

From a conceptual perspective, the most crucial lesson from the cases analysed is that they reveal the importance of combining environmental management measures. From an enforcement perspective, the key lesson is the importance of bringing together different critical actors (local and national government, private sector, community groups and the media) to work synergistically for a successful outcome. In all cases, while the role of the government has been key to initiating work and building or providing infrastructure, the necessary variable in making programmes

feasible has been the space created for a public dialogue or cultural consensus. This seems to have facilitated interaction among relevant public agencies, private sector groups, NGOs and donors to establish a network necessary for implementation of a policy or programme.

Key Lessons Learned to Influence Changes in Policy Direction

The research for this study in general and investigation of numerous global initiatives and practices in particular offer some helpful directions for improving public policy and actions to reduce vehicular emissions. These include the following:

- ***Instead of piecemeal or partial use, public policy and action programmes need to be implemented simultaneously and comprehensively:*** Policy instruments and environmental management measures are often used without taking note of the objectives they are intended to accomplish. For example, regulatory, economic and persuasive instruments or measures are by definition meant to make use of citizens' fears of legal action, their economic interests and their moral/ethical sense. The outcome from their using these instruments will be non-optimal at best if all three sets of instruments are not used simultaneously and in a concerted manner. Several cases in this report demonstrate the validity of this point.

- ***The physical infrastructure is an important influence on the choice of free/low emissions transportation modes:*** Several cases reveal that citizens have moved from car use to bus rapid transit (BRT) once the infrastructure for the latter has been put in place. Construction of bikeways, pedestrian ways and pedestrian malls have influenced citizens to walk and bike and to leave their cars where these facilities are available.

- ***There is a need to expand public infrastructure and public transit to reduce substitution of "'public goods" with "private goods":*** Widespread substitution of public goods or public utilities by individually owned private goods (which cost much more on a per capita basis) are eating at the vitality of developing countries. In these countries, citizens often resort to corrupt practices in order to have the resources to substitute for traditional public utilities, such as electricity, by using individually owned electricity generating machines (generator or IPS – instant power supply/systems) because of a lack of a regular electricity supply. In the present context, the prime example is citizens' spending considerable amounts of money to own private cars in the absence of adequate public transport.

- ***Ways and means must be found to overcome the financial constraints to fund the substantial investments necessary for public infrastructure:*** Investment in the public infrastructure for BRT, LRT and subways, for example, will demonstrably serve the purpose of developing a green economy. For this to happen, cost recovery needs to be built-into the

financing mechanism. A few success stories presented in this report demonstrate that this is possible.

- ***There is a need to discard policies that work at cross-purposes:*** Cities with air quality management programmes also appear to have thriving car-purchase lending programmes. Similarly, senior civil and military bureaucrats and international elites posted in developing countries are entitled to have cars even if the streets are already virtually impassable for reasons of congestion or because emissions have risen to a level that they cause a high incidence of respiratory diseases.

- ***Stakeholders' participation must be made a reality:*** Pronouncements concerning stakeholder participation are widespread, but are often made without implementing policies that make this participation operative. Stakeholder participation can reduce costs and facilitate the enforcement of regulations.

- ***Forces that reverse positive change must be counteracted:*** Progress in technological innovations for clean fuel and clean vehicles has been associated with the rise in oil prices, but this progress brought about by innovation is often stalled when oil prices collapse. This has been a recurring pattern since the oil embargo of 1973. Recent developments indicate that this self-defeating pattern is continuing.

- ***Policies of keeping fuel prices low and cars affordable must be discarded:*** Although this study reports positively about making compressed natural gas (CNG) the least expensive fuel, one distortion of this policy results from car users no longer feeling that the fuel cost is a burden of any significance. The rapid increase in car use in a city such as Dhaka (capital of a low-income country) is at least partly explainable by the low price of CNG. Other factors contributing to increased car use include the importation of low-priced, reconditioned cars and the absence or inadequacy of a public transport system. The situation may get worse if Tata's "people's car" makes its way to the market of low-income cities.

- ***Urban sprawl and suburbanization must be contained:*** One widespread response to high urban land prices is an increase in the horizontal spread of cities to suburban areas (urban sprawl) and expansion of vertical (high-rise) buildings in cities. Whereas the former has increased the per capita burning of fossil fuels used to commute to city centres, the latter has made central city streets and lanes often impassable because of traffic congestion. Development controls and zoning can contain urban sprawl to an extent, but these tools have often been violated in the name of freedom of choice, democratic rights, free market norms, sheer muscle power and political patronage.

- ***Democracy and free market economy norms should not be allowed to be used as a licence to violate development controls and zoning laws:*** To overcome the problems alluded to in the paragraph above, urban

planning, compact city and smart growth paradigms need to be employed. Acceptance of the free market economy, democratic policies and human freedoms have not decreased, but rather increased the need for urban planning. Millions of individuals' free choice of residential and business locations can never produce socially and environmentally desirable outcomes. Developing countries in particular are ignoring urban planning at their own peril.

- ***Technology is no panacea, but public policy support for innovations can lead to more fuel efficiency and the development of green vehicles:*** Numerous innovations are taking place in this regard. Incentive measures need to be carefully designed to promote cost-reducing innovations for public transit systems instead of focusing on improving the environment for individually owned vehicles.

- ***International support (public and private) needs to be mobilized:*** It goes without saying that the task at hand is complex and huge. None of the above action agenda can adequately progress unless there is genuine international cooperation to share knowledge and provide access to financial resources and technology.

Abbreviations

AATA	Ann Arbor Transportation Authority
ADB	Asian Development Bank
ADME	Agence de l'Environment et de la Maitrise de l'Energie
AFV	Alternative Fuel Vehicles
AI	Aspiration Index
ALS	Area Licensing Scheme
APEIS	Asia Pacific Environmental Innovations Strategy Project
BAQ	Better Air Quality
BMA	Bangkok Metropolitan Administration
BMR	Bangkok Metropolitan Region
BMTC	Bangalore Metropolitan Transport Corporation
BRT	Bus Rapid Transit
BTS	Bangalore Transport Service
CAC	Command and Control
CAFE	Corporate Average Fuel Economy
CBD	Central Business District
CIDA	Canadian International Development Agency
CME	Coco Methyl Ester
CNG	Compressed Natural Gas
COE	Certificate of Entitlement
CRS	Country Response Sheet
CSN	Car Sharing Network
DANIDA	The Danish International Development Agency
DPI	Domestic Private Investment
EC	European Commission
ECMT	The European Conference of Ministers of Transport
EMM	Environmental Management Measures
EI	Economic Instruments
EMR	Extended Metropolitan Region
EPA	Environmental Protection Agency
ERP	Electronic Road Pricing
EPPO	Energy Policy and Planning Office of Thailand
ERP	Electronic Road Pricing
EST	Environmental Sustainable Transport

EU	European Union
EV	Electric Vehicle
FDI	Foreign Direct Investment
FY	Fiscal Year
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gas(es)
GNI	Gross National Income
GPS	Global Positioning System
GVWR	Gross Vehicle Weight Rating
IC	Integrated Circuit
ICEV	Internal Combustion Engine Vehicles
IDCT	The District Institute of Culture and Tourism
IDU	Institute of Urban development
IGES	institute for Global Environmental Strategies
IKEA	An American Home and Office Depot
II	Information Instruments
I/M	Inspection and Maintenance
IPCC	Intergovernmental Panel on Climate Change
IPPUC	The Institute of Research and Urban Planning
IQ	Intelligence Quotient
IT	Innovative Transport
ITDP	Institute for Transport and Development Policy
JPOI	Johannesburg Plan of Implementation
LDF	Local Development Framework
LEV	Low Emission Vehicles
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LRT	Light Rail Transit
MBI	Market-based Incentives
MDG	Millennium Development Goals
MDI	Motor Development International
µg	Micro-gram
MRT	Metro Rail Transit
MRTS	Mass Rapid Transport System
NEV	Net Economic Value

NGV	Natural Gas Vehicles
NHTSA	National Highway Traffic Safety Administration
NMHC	Non-methane Hydrocarbons
NMT	Non-motorized Transport
NPP	National Physical Plan
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PM	Particulate Matter
PI	Persuasive Instruments
RIs	Regulatory Instruments
RISPO	Research on Innovative and Strategic Policy Options
SEPA	State Environmental Policy Act
SI	Suasive Instruments
SMG	Seoul Metropolitan Government
TCF	Transport Congestion Fee
TCRP	Transit Cooperative Research Programme
TDM	Transport Demand Management
TFP	Travel Feedback Programme
TSC	Transport Smart Card
UK	United Kingdom
UN	United Nations
UNCRD	The United Nations Centre for Regional Development
UNFCCC	United Nations Framework Convention on Climate Change
UOST	Operating Unit of the Trolley bus
UPM	Universiti Putra Malaysia
US	United States
US$	United States Dollar
USAID	United States Agency for International Development
VQS	Vehicle Quota System
WHO	World Health Organization

1. Introduction

For a considerable time, the concerns surrounding emissions from automobiles have been primarily focused on air pollutants – lead, particulate matter (PM), sulphur dioxides (SO_2), nitrogen oxides (NOx), carbon monoxides (CO) – because of their effects on human health. The lead content in air has a harmful impact on children's intelligence quotients (IQs); PM, SO_2 and NOx can cause respiratory diseases; ozone can cause lung function decrement; and CO inhibits the capacity of the blood to carry oxygen to body organs and tissues.

Most developed countries have now largely contained some of these emissions, as a result of technological changes in vehicle parts and fuel content. However, this is not yet the case in developing countries, although improvements in some are taking place through technology transfer and local effort. No country or city, however, has yet been able to overcome the other persistent transport problem, traffic congestion, despite the harmful impact this has on stress and productivity.

Where it has been financially affordable, the policy response to this distress has often involved large investments in roads, expressways and toll ways. Instead of easing the problem, these mega-projects appear to have facilitated car[1] use, resulting in more cars on the roads. Therefore, it is not surprising that global vehicle numbers are predicted to increase ten-fold from 2008 to 2050 (de Jong 2008). Meanwhile, the mounting evidence concerning climate change and the contribution of greenhouse gases to worsening this development has increasingly alarmed the global community.

As a consequence, along with energy, the transport sector in general, and cars in particular, have been the subject of unprecedented scrutiny. The transport sector has an overwhelming dependence on fossil fuels – oil alone accounts for 81 per cent of its energy use – and of the total CO_2 emissions from an average car, 76 per cent are from fuel usage (Chapman 2007, p. 355). The automobile's greenhouse gas burden is also evident from the fact that it is the second largest contributor to global warming emissions from the transport sector (after road freight). This extent of CO_2 emissions from automobiles has transformed transport in general, and cars in particular, from a local to a global issue. A growing body of opinion believes that "we need to do everything we can to get people out of cars" (de Jong 2008). The question, however, is how that is to be accomplished. A number of public policy ideas, initiatives and actions (in nearly every major city) are in place to reduce automobile use and

[1] Private cars or simply the word "car" in this report is defined to include individually or privately owned vehicles used by individuals, households, offices and businesses for the purpose of commuting to work, schools, shopping, long drives, sightseeing, etc. In many instances only one seat of a common five-seat car is utilized. With chauffer use, as it is the case in many instances in developing countries, it commonly involves utilization of two seats. For many users in these countries, a car is unaffordable. Many could not buy a car without support from the government, a private sector employer or through a bank's lending policy. Some individuals spend their lifetime savings to buy a car. In other instances, a car is purchased by selling land. A car's total cost is even higher than its high private cost because of associated social and environmental costs. Yet use of this small, emissions-generating vehicle continues to be widespread in cities worldwide because a car provides privacy and convenience. It once also saved commuting time. The notion of car as a prestige symbol is no longer a major factor, but its role in increasing congestion and emissions is now widely understood.

emissions. Many of these are well-documented by international agencies such as the Organisation for Economic Development and Cooperation (OECD), the World Bank, the Asian Development Bank (ADB), the Institute for Global Environmental Strategies (IGES), UNCRD and in numerous academic works.

This report has as an objective to assist government officials, business executives, urban residents and environmental activists in their respective efforts to reduce emissions from private cars. Its methodology is to explore ways of achieving behavioural change to sustain the ongoing positive changes that will have lasting effects.

One way to influence human behaviour is to use incentives. In this report, ‘‘incentive measures” are used, not in the limited sense of economic incentives alone (e.g., subsidies or pollution charges), but in the broader sense of measures that will influence citizen, industry and government decision making. These incentives utilize at least three sets of policy measures: regulatory, economic and persuasive.

The means of reducing the impact of automotive use – cleaner fuels, greener vehicles, public transit, walking and cycling – all require behavioural change. At the same time, technology and investment in infrastructure can also be effective tools to achieve these changes. For example, if technological innovations make cleaner fuel less expensive, it will be easier for individuals to switch to using them. Similarly, investment in public transit, good pedestrian walkways and bicycle ways also has the potential to influence many urban residents to move from cars to these highly desirable transportation modes.

The importance of behavioural change in limiting harmful emissions has been increasingly realized[2], but its future role as a means of influencing technological change and necessary investment has not yet been widely recognized or practised. The results of efforts to alter human behaviour – based on an analysis of selected global practices being pursued largely through a two-pronged strategy (i.e., by using cleaner fuels, greener vehicles and reducing car use) – is the subject matter of this report.

Having set the context, the contents of this report are structured as follows: Section 2 defines the problem and highlights automobile use as major contributor to CO_2 emissions. Section 3 then explores the policy failures that influence a continued increase in automobile use. Section 4 provides an overview of the cases in the Appendix that review and analyse the numerous ongoing public policies and actions aimed at reducing CO_2 emissions. Section 5 briefly pulls together the major ingredients for improving infrastructure design and the actions taken to motivate and sustain changes. Some concluding observations are found in Section 6.

[2] In this report ‘‘regulatory”, “economic”’ and “persuasive” measures are respectively used for referring to (a) command and control (CAC) or regulatory instruments (RIs), (b) market-based incentives (MBIs) or economic instruments (EIs) and (c) education & awareness campaign or information instruments (IIs)/suasive instruments (SIs)/persuasive instruments (PIs). Section 3.4 provides more elaboration on these points. Amin, et al (2006) contains details.

2. Increase in Private Car Use: Domestic and Global Environmental and Economic Challenges

As noted, until recently concerns about the growing use of light duty vehicles, principally private cars, have been related to traffic congestion and emissions that affect human health. In recent years, alarm about climate change and the automobile's contribution to CO_2 emissions has added a new dimension to these concerns.

With every nation viewing economic growth as the means to achieve its respective development goals, the transport sector continues to be a driving force for growth, along with industries that produce greenhouse gases. In this environment, the absence of appropriate public policy, emissions policies for the transport sector will continue to adversely affect the local environment, human health and climate change.

The adverse effects of emissions produced by the transport sector can be minimized by the implementation of concerted local, national and international efforts. These efforts, if implemented wisely, can also reduce dependence on fossil fuels.

Although the focus in this report is on reducing CO_2 emissions from the transport sector, simultaneous action to reduce other sectors' share of greenhouse gas emissions must also be in place. Otherwise, any gains achieved by a reduction in car use will be easily offset by inaction in other sectors.

While developed countries still account for the largest share of transport emissions, the transport sector's emissions from developing countries, particularly in Asia, have been growing rapidly. Transport-related CO_2 emissions are expected to rise 57 per cent over the 25 years to 2030 (ADB, 2009). The ADB report notes that increases from developing countries are expected to contribute to 80 per cent of this growth as car (and light truck) ownership become more widespread.

2.1 Private car's predominance in road transport

The private car continues to be the predominant transport mode globally, particularly in developed countries. Along with economic growth and development, car dependence is on the rise – at a faster pace – in developing countries as well. The growth of car ownership is likely to follow the growth of per capita income, particularly in the rapidly growing developing countries. Globally, light duty vehicle numbers are predicted to increase ten-fold from 2008-2050 (de Jong, 2008). Along with aviation, "motor cars are increasingly the favoured modes for passenger transport but are also significantly the most damaging" (Chapman 2007, p. 357).

The factors influencing private car ownership include:

- personal or a company purchases;
- replacement of an existing vehicle or purchase of an additional vehicle;

- age, family status and employment status;
- residential location in relation to the workplace, to other destinations and to alternative means of transport;
- driver's licence status – newly licensed drivers, established drivers, or relinquishing a driver's licence;
- personal or household income (gross, net or disposable income);
- the net cost of purchase, annual costs of ownership and running costs in comparison with other goods and services, and to alternative forms of transport;
- whether the car is the 1st , 2nd or 3rd vehicle and its intended use; and
- discretionary factors relating to the size, technical specifications and features of the vehicle.

The Aspiration Index (AI), based on ‘‘current ownership" levels and ‘‘future intention" to buy a private car, shows that the AI for private car ownership is high in China, Indonesia, India, Thailand, Korea, Hong Kong and the Philippines, as illustrated in Table 2.1 (AC Nielson, 2005).

Table 2.1: Car ownership aspiration index in selected countries

High (AI>60%)	Medium (AI: 30-60%)	Low (AI<30%)
China	Malaysia	US
Indonesia	Singapore	Sweden
India	Taiwan	Germany
Thailand	Spain	Norway
Korea	Australia	Austria
Hong Kong	France	Netherlands
Philippines	Italy	Finland
	UK	Denmark
	Belgium	Japan
	Portugal	
	New Zealand	

Source: AC Nielsen (2005), Aspiration index. http://kr.en.nielsen.com/pubs/2005_q1_ap_car.shtml

New road construction and private car ownership

A key factor influencing the increase in private cars is the construction of new roads. Indeed, the expansion of roads, express and toll ways appears to facilitate car ownership aspirations – the classical dictum of "supply creates its own demand". For example, the chart above shows that in Thailand the Aspiration Index for private car ownership is high. To deal with severe traffic congestion in Bangkok during the late 1980s to 1990s, 175.9 km of expressways were constructed (ETA, 2005). This development seems to have facilitated increased car use. Table 2.2 shows that more investment in highway construction in China has been accompanied by an increase in highway and expressway mileage.

Table 2.2 Relationship between transport infrastructure investment and car use

Year	Highway Investment (Billion USD)	Highway mileage (10,000 km)	Expressway mileage (km)
1998	1,072	127.9	8,733
1999	1,140	135.2	11,605
2000	1,261	140.3	16,314
2001	1,393	169.8	19,437
2002	1,529	176.5	25,130
2003	1,726	181.0	29,745
2004	2,032	187.1	34,288
2005	2,326	193.1	41,005

Sources: China Statistical Yearbook 2006
China Statistical Yearbook on Transportation and Communication 2006

Oil price declines and/or the extremely low price of an alternative fuel, e.g., the CNG price in Dhaka, are other factors that do not help to achieve car or CO_2 reduction targets. Bangkok's car ownership level stands at 399 per 1000 population compared with Singapore's 152 per thousand, although Singapore is a more economically developed country. This is in sharp contrast with the observed positive relationship between motorization and the "level of economic development" (Table 2.3).

The Singapore case demonstrates that public policy can make a difference. Singapore's low level of private car ownership was made possible because of the government's determined intervention. Initially, the government used economic incentive measures, but later it added quantitative restrictions because the results from tax measures did not produce the required outcome (Case A7). Promoting public/mass transit also contributes to a reduction in the purchase/use of light duty vehicles, because would-be car buyers have access to an alternative travel mode.

Other factors contributing to emissions from passenger vehicles

Levels of car ownership, along with other pertinent factors (e.g., fuel types and vehicle technology), are factors contributing to the greenhouse gas emissions release that stems from the transportation sector. Private cars are still the major contributors to these emissions in terms of vehicle-kilometres and passenger-kilometres travelled in rapidly growing developing country cities (Tables 2.3–2.4). Controlling the private car population through stringent car ownership restriction policies, as in Singapore, contributes significantly to reducing emissions. However, it is important to note that car ownership is not the only factor contributing to these emissions. Fuel types, technology and emission standards adopted are also essential contributing factors.

Table 2.3: Trends in motorization

By income level/region	Motor vehicles per 1,000 people		Passenger cars per 1,000 people	
	1990	2003[a]	1990	2003[a]
World	118	141	91	100
By Income				
Low	5	8	3	6
Lower middle	22	39	10	29
Low & middle	25	47	16	35
Middle	37	69	24	51
Upper middle	121	187	91	143
High	499	623	390	433
By Region				
East Asia & Pacific	9	20	4	14
Europe & Central Asia	97	170	79	142
Latin America & Carib.	100	153	72	108
Middle East & N. Africa	36	..	24	..
South Asia	4	10	2	6
Sub-Saharan Africa	21	..	15	..
Europe EMU	429	570	379	502

a. Data are for 2003 or most recent year available.
Source: World Bank's World Development Indicators (WDI) (2006).
http://devdata.worldbank.org/wdi2006/contents/Table3_12.htm

Table 2.4: Automobile sector growth in different countries

Country	Population	Per Capita GDP (PPP)	GDP Growth Rate (%)	Total automotive sales 2006	Total automotive production 2006	Market growth 2006 vs 2005 (%)
China	1,321,851,888	US$7,700	10.7	7,182,720 (3,854,510)*	7,335,965 (3,979,481)*	+22.4
India	1,129,866,154	US$3,800	9.2	1,749,985 (1,026,574)*	1,958,671 (1,186,063)*	+21.6
Thailand	65,068,149	US$9,200	4.8	682,055 (191,522)*	N/A	-3.0
Japan	127,433,494	US$33,100	2.2	5,739,513 (4,641,735)*	11,484,223 (9,756,515)*	-1.9
Malaysia	24,821,286	US$12,900	5.9	490,766 (439,792)*	503,048 (416,840)*	-10.9
Indonesia	234,693,997	US$3,900	5.5	318,980 (209,086)*	N/A	-40.3
Philippines	91,077,287	US$5,000	5.4	99,538 (40,555)*	N/A	+2.6
Vietnam	85,262,356	US$3,100	8.2	41,112 (23,033)*	N/A	+16.6
Singapore	4,553,009	US$31,400	7.9	115,087 (103,318)*	N/A	-5.8
Hong Kong	6,980,412	US$37,300	6.8	30,065 (22,682)*	N/A	-2.2
Taiwan	22,858,872	US$29,500	4.6	306,433 (255,930) *	303,237 (252,660)*	-31.4
Australia	20,434,176	US$33,300	2.7	962,521 (761,675)*	N/A	-2.6

*passenger cars
Source: Segment Y Automobile Intelligence web-site, http://www.segmentY.com/countries.html or http://www.segmentY.com/[countryname].htm

2.2 Urban air pollution: impact on health and productivity

Productivity loss, human health effects and economic damage from traffic congestion and air pollution are well documented (see Gorman 2002) and have received wide media coverage. As a result, public policies to address these problems are in place in most countries, but no city has been able to satisfactorily contain them. Some data regarding this issue are presented in Tables 2.5-2.8.

Table 2.5: Air pollution scenario in different Asian cities

Country	City	Population thousands 2005	Particulate matter $\mu g/m^3$ 2002	Sulphur dioxide $\mu g/m^3$ 1995-2001	Nitrogen dioxide $\mu g/m^3$ 1995-2005
China	Anshan	1459	92	115	88
	Beijing	10849	99	90	122
	Changchun	3092	82	21	64
	Chengdu	3478	95	77	74
	Chongquing	4975	137	340	70
	Dalian	2709	55	61	100
	Guangzhu	976	70	57	136
	Guiyanj	2467	78	424	53
	Harbin	2898	85	23	30
	Jinan	2654	104	132	45
	Kunming	1748	78	19	33
	Anzhou	1788	101	102	104
	Shanghai	12665	81	53	73
	Wuhan	6003	88	40	43
India	Ahmedabad	5171	98	30	21
	Bangalore	6532	53	--	--
	Calcutta	14299	145	49	34
	Chennai	6915	44	15	17
	Delhi	15334	177	24	41
	Hyderabad	6145	48	12	17
	Kanpur	3040	128	15	14
	Lucknow	2589	129	26	25
	Mumbai	18336	74	33	39
	Nagpur	2359	65	6	13
	Pune	4485	55	--	--
Indonesia	Jakarta	13194	115	--	--
Iran	Tehran	7352	68	209	
Japan	Osaka	2626	37	19	63
	Tokyo	35327	42	18	68
	Yokohama	3366	32	100	13
Malaysia	Kuala Lumpur	1392	28	24	--
Philippines	Manila	10432	42	33	--
Singapore	Singapore	4372	48	20	30
Thailand	Bangkok	6604	83	11	23

Source: World Bank World Development Indicators (WDI), 2006.

Table 2.6: Health effects associated with common vehicular pollutants

Pollutants	Health effect
Lead	Ingestion of lead aerosols has been linked to cardiovascular disease, brain and kidney failure. Chronic effects include behavioural and development problems among children, elevated blood pressure, problems with metabolizing Vitamin D and anemia. Exposure to lead has also been associated with decreased sperm count in men, and increased likelihood of spontaneous abortion among pregnant women.
Particulate matter	Causes cardiopulmonary diseases, cardiovascular diseases, respiratory diseases, lung cancer and other cancers.
VOC	Toxic and precursor of ozone formation. It is also known to cause harmful effects on the immune system, the neural network and haemoglobin.
NO_2	NO_2 has been shown to have toxic effects on human health, including altered lung function, respiratory illness and lung tissue damage.
CO	CO causes oxygen deprivation (hypoxia) displacing oxygen in bonding with haemoglobin. This can cause cardiovascular and coronary problems, increase risk of stroke and impair learning ability, dexterity and sleep.
Ozone (O_3)	Ozone is dangerous to human health: it interferes with respiratory functions, leads to reduced lung capacity and increases the intensity of lung infections.
SO_X	So_x is associated with various bronchial conditions, which can be acute even at relatively low levels of exposure for children and asthma patients.

Source: Adopted from Gwilliam, Kojima and Johnson (2004, p.152) and Gorham (2002, pp 76 – 86).

Table 2.7: Relative problems of health-affecting pollutants in world mega-cities

Name of cities	Suspended particulate			Sulphur dioxide		
	Serious problem	Moderate to heavy pollution	Low pollution	Serious problem	Moderate to heavy pollution	Low pollution
Bangkok	√	–	–	–	–	√
Beijing	√	–	–	–	–	–
Bombay	√	–	–	–	–	√
Cairo	√	–	–	–	–	–
Calcutta	√	–	–	–	–	√
Delhi	√	–	–	–	–	√
Jakarta	√	–	–	–	–	√
Karachi	√	–	–	–	–	√
Manila	√	–	–	√	–	√
Mexico	√	–	–	√	–	–
Seoul	√	–	–	–	–	–
Shanghai	–	√	–	–	√	–
Buenos Aires	–	√	–	–	–	–
Los Angeles	–	√	–	–	–	√
Moscow	–	√	–	–	–	–
Rio de Janeiro	–	√	–	–	√	–
Sao Paulo	–	√	–	–	–	√
London	–	–	√	–	–	√
New York	–	–	√	–	–	√
Tokyo	–	–	√	–	–	√

Source: Based on data contained in Gorham (2002, pp.82 – 86).

The economic damage caused by deteriorating air quality has yet to be comprehensively documented. Table 2.8 presents available evidence showing that the damage is less than two per cent of gross national income. The concern is that in the absence of progress in mitigating the problem, the damage will rise.

Table 2.8: Air pollution related economic damage

Region	Carbon dioxide damage % of GNI 2004	Particulate emission damage % of GNI 2004
China	1.4	1.5
India	1.3	0.8
Indonesia	0.7	0.9
Iran	1.7	0.9
Japan	0.2	0.6
Malaysia	0.9	0.1
Philippines	0.6	0.3
Singapore	0.4	0.9
Thailand	1.0	0.6
East Asia & Pacific	1.2	1.2
Middle East & N Africa	1.2	0.9
South Asia	1.2	0.8
World	0.4	Wo0.5

Source: Based on World Bank (2006), World Development Indicators.

Table 2.9: Motor vehicle, passenger car and PM_{10} concentration in different regions

Region	Motor vehicles Per 1000 people		Passenger cars Per 1000 people		Particulate matter concentration Urban population weighted PM_{10} ($\mu g/m^3$)	
	1990	2003	1990	2003	1990	2002
World	118	141	91	100	77	60
East Asia & pacific	9	20	4	14	112	80
Middle East & N Africa	36	--	24	--	126	89
South Asia	4	10	2	6	131	99
Europe & Central Asia	97	170	79	142	39	35
Latin America & Carib.	100	153	72	108	60	43
Sub-Saharan Africa	21	--	15	--	114	73
Europe EMU	429	570	379	502	33	27

Source: World Bank World Development Indicators, 2006.

Despite the increase in vehicular emissions such as CO_2, the global increase in the number of motor vehicles has thus far made no significant contribution to the increase in PM_{10} air pollution. Although it is believed that the transportation sector contributes to PM_{10}, the record shows that an increase in the number of motor vehicles does not necessarily increase PM_{10} pollution. Table 2.9 illustrates this.

It is important to note that success in reducing air pollution from vehicular sources may be offset by an increase in the production and sale of more fossil fuel-based motor vehicles. As shown in Table 2.9, passenger car sector growth-related indicators render that scenario a distinct possibility.

2.3 Global CO_2 emissions by region

Carbon dioxide, particularly from transport and industry, is a major greenhouse gas that contributes to global warming and thereby climate change. Due to human activities such as the combustion of fossil fuels, deforestation, and the increased release of CO_2 from the oceans (due to the increase in the earth's temperature), the concentration of atmospheric carbon dioxide has increased by about 35 per cent since the era of industrialization began.

The world's total annual CO_2 emissions from various sources are about 24-27 billion metric tons equivalent (UNSD 2008 and WRI 2008). Table 2.10 shows the annual CO_2 emissions by region.

Table 2.10: Annual CO_2 emissions for different regions

Country	**1980** (Million Metric Tons)	**1990** (Million Metric Tons)	**2000** (Million Metric Tons)	**2006** (Million Metric Tons)
North America	5488.11	5806.56	6820.19	6954.03 (24%)
Central & South America	627.76	716.95	992.81	1138.49 (4%)
Europe	4707.50	4568.17	4500.07	4720.85 (16%)
Eurasia	3092.69	3834.05	2355.98	2600.65 (9%)
Middle East	490.76	730.05	1093.74	1505.30 (5%)
Africa	537.76	728.00	892.07	1056.55 (4%)
Asia & Oceania	3558.55	5299.37	7365.81	11219.56 (38%)
World Total	**18503.12**	**21683.16**	**24010.66**	**29195.42**

Source: Energy Information Administration (2006). World carbon dioxide emissions from the use of fossil fuels, International Energy Annual 2006.

Table 2.10 shows that CO_2 emissions are the highest in Asia, which accounts for 38 per cent of the world's total. Asia's huge population, rapid industrialization, increasing urbanization and growing motorization are some obvious reasons for these figures.

Developed and developing country differences on CO_2 emissions

One positive development is that there appears to be a slight decrease in high-income countries' share of total CO_2 emissions (see Table 2.11). This trend is clouded by the propensity of among low- and middle-income countries to show an increase in these emissions. The achievements in some countries may have been made possible in part by the requirements of the 1997 Kyoto Protocol. The increase of CO_2 emissions in certain countries may be largely attributable to higher rates of growth in these countries and increasing reliance on private cars for urban mobility.

Table 2.11: CO_2 emissions by level of income

Countries	Share in CO_2 emission (%)		
	2002	2001	2000
High income	48.9	49.8	50.0
Middle income	41.3	40.5	40.5
Low income	9.8	9.7	9.6
Total	100.0	100.0	100.0

Source: http://earthtrends.wri.org/searchable_db/index.php?theme=3&variable_ID=466&action=select_countries (online database).

2.4 Transport as a key source of CO_2 emissions

Data from the 1990s show three main sectors – industry, transportation and commercial and residential – respectively contributed 47 per cent, 22 per cent and 31 per cent of the world's total CO_2 emissions (Halman and Steinberg, 1998). According to IEA data (IEA 2000 cited in Chapman, 2007 p. 355), the sectoral (categorized differently) origin of CO_2 emissions is of the following order: energy production (41 per cent), manufacturing and construction (19 per cent), transport (26 per cent), residential (8 per cent) and commercial and others (6 per cent). Later data from the U.S. government's Environmental Protection Agency (EPA) reported that "Transportation sources accounted for approximately 29 per cent of total U.S. greenhouse gas (GHG) emissions in 2006. Transportation is the fastest-growing source of U.S. GHGs, accounting for 47 per cent of the net increase in total U.S. emissions since 1990. Transportation is also the largest end-use source of CO_2, which is the most prevalent greenhouse gas."
(http://www.epa.gov/otaq/climate/index.htm).

Table 2.12: Global CO_2 emissions by sector

Producing sector	Sectoral share (%)
Power Generation	44.4
Industrial sector	
Steel	6.0
Cement	3.0
Paper & pulp	0.8
Non-ferrous metals	0.5
Other industries	10.9
Sub-total	21.2
Domestic	
Household	9.5
Commercial, others	3.4
Sub-total	12.9
Transport	
Automobile	18.5
Others	2.9
Sub-total	21.5

Source: Based on IEA, World Energy Outlook, International Energy Agency, Paris, 2005.

Evidence that the transport sector is one of the largest contributors of CO_2 emissions is also seen in Table 2.12. Consequently, the reduction of emissions from this sector will likely have multiple impacts on air quality, health and global warming. Increasing concern about transport CO_2 emissions has stimulated local efforts to control them. These have ranged from encouraging more pedestrian walkways and non-motorized travel to discouraging motor travel through the use of congestion fees, higher taxes on automobile purchases, etc. (see Chapter 4 and the Appendix citing cases).

Freight, aviation and shipping

Although road transport is the largest producer of CO_2 in the transport sector, the automobile is not the only source of these emissions. Buses, taxis and inter-city coaches all play a significant role. Freight, for example, typically accounts for just under half of road transport total emissions (Chapman, 2007 p. 356). In addition, the contribution of aviation to climate change is well-documented. Emissions generated by aviation are directly released into the upper atmosphere, creating pollution that travels far from its source. Major quantities of climate changing pollutants are generated by aviation, which, except for a slowdown during the economic crisis of 2007 – 2009, has been rapidly expanding (Somerville, 2003). Increasing numbers of aircraft also lead to delays in landing that reduce fuel efficiency, thereby increasing greenhouse gas emissions.

Shipping is a transport mode able to move a bulk quantity of goods and is the dominant transport mode for overseas freight. Shipping is often recognized as a

sustainable, energy efficient and relatively environmentally friendly form of transport (The UK Department for Transport (DfT 2004). Technological advances to improve the fuel efficiency of shipping derive from the design of better ship engines, slowing speeds and more efficient ship hulls, which can cut emissions as much as 50 per cent (International Maritime Organization (IMO 2000). The use of cleaner fuel for ships can also reduce the emissions generated by 90 per cent (Chapman 2007, p. 361). In addition, ships can also use fuel cells as a hybrid energy source. All of these possibilities, individually or in tandem, are expected to further reduce emissions from shipping.

Road freight, which has been continuously expanding, is also a considerable burden on the environment. Data show that CO_2 emissions from freight relative to gross domestic product are dominated by trucks, particularly in countries where trucks are more viable options than other freight modes (Schipper and Fulton, 2003). Reversing the growth of road freight to more sustainable levels is expected to reduce global CO_2 emissions.

Implications of oil as the predominant fuel

The transport sector's CO_2 emission levels are elevated because oil is still its predominant fuel. Oil accounts for 97 per cent of the transport sector's fuel use, while natural gas accounts for two per cent, electricity one per cent, and renewable sources of energy less than 0.5 per cent (IEA, 2002). Moreover, the production and distribution of fuel for the transport sector also contributes significantly to CO_2 emissions, one of the reasons the transport sector has been identified as a key sector in the Kyoto Protocol. Kyoto's objective was to reduce worldwide greenhouse gas emissions by 5.2 per cent from 1990 levels by 2012 (Chapman, 2007). This commitment was also restated at the 2008 Bali conference of the United Nations Framework Convention on Climate Change (UNFCCC). Containing transport sector emissions is obviously key to attaining this goal.

2.5 Mechanism of CO_2 emissions

Vehicles that produce energy by the combustion of hydrogen and carbon present in fossil fuels produce water vapour, H_2O and CO_2, which increases global temperatures by trapping energy from sunlight. The greater the energy production and use in the transportation sector, the more it generates CO_2. The Intergovernmental Panel on Climate Change (IPCC) (2007) reports that "road transport currently accounts for 74 per cent of the total transport CO_2 emissions" (IPCC 2007, p. 325). Twenty-three per cent of world energy-related CO_2 emissions originate from the transport sector. The growth rate of these emissions is highest among the end-user sectors. Such high CO_2 emissions and their links with GHG, temperature rise and climate change require de-carbonization of the transport energy system through the use of alternative fuels, such as electricity, hydrogen and biomass (IPCC 2007, p. 325). Despite some improvements in this direction, the trend in fossil fuel CO_2 emissions continues to rise (Table 2.13) from the combined effect of population growth and more dependence on private cars.

Table 2.13: Trends in fossil-fuel CO_2 emissions in top 20 emitting countries

Country	Per capita emission rate (metric tonnes)	
	1990	2006
China	0.58	1.27
United States of America	5.24	5.32**
Russian Federation	3.65*	2.87**
India	0.23	0.37
Japan	2.61	2.80
Germany	3.56	2.67
United Kingdom	2.69	2.47**
Canada	4.43	4.55
Republic of Korea (South Korea)	1.45	2.56**
Italy (Including San Marino)	2.04	2.19
Islamic Republic of Iran	1.14	1.81
Mexico	1.26	1.13
South Africa	2.49	2.38**
France (Including Monaco)	1.91	1.71
Saudi Arabia	3.66	4.36
Australia	4.68	4.90
Brazil	0.39	0.51
Spain	1.49	2.16
Indonesia	0.23	0.41
Ukraine	3.20*	1.86

* Russia and Ukraine figures are for 1992. No more recent data are available for these countries. .

** Data from the USA, Russia, UK, South Korea and South Africa are from 2005.

Source: Based on data from the Carbon Dioxide Information Analysis Center (http://cdiac.ornl.gov/trends/emis/tre_usa.html)

CO_2 emissions and the fossil fuel relationship

The increase in CO_2 emissions largely corresponds with an increased use of fossil fuels (IEA 2005). Transport's share of CO_2 emissions stemming from fuel combustion is shown in Table 2.14.

A breakdown of different transport modes shows road transport as the highest contributor, accounting for 65 per cent of CO_2 emissions. Rail, domestic aviation and waterways account for 23 per cent, international aviation 5 per cent and international shipping for 7 per cent (Chapman, 2007, p. 355).

TABLE 2.14: Transport sector's share (%) of CO_2 emissions from fuel combustion

Sector	World	OECD
Road	18	23
Aviation	3	3
Navigation	2	2
Other Transport	1	1
Energy Industries	45	43
Manufacturing Industries and construction	18	14
Residential	8	8
Other Sectors	5	6
Total	**100**	**100**

Source: IEA (2005) CO_2 emissions from fuel combustion.

To summarize: the industry and transport sectors are the two major contributors of CO_2 emissions. Within the road transport sub-sector, the automobile is the largest source of these emissions. Therefore, any attempt to reduce global CO_2 emissions requires giving explicit attention to the transport sector. A wide array of transport-related policies and strategies to reduce GHG are being employed. These include restraining vehicle usage, managing traffic congestion and reducing energy use, GHGs and air pollution. Based on these strategies, IPCC (2007, p. 336) suggests four sets of measures to reduce emissions associated with vehicles:

- reducing the loads on the vehicle;
- increasing the efficiency of converting fuel energy for work purposes;
- changing to less carbon-intensive fuels; and
- reducing emissions of non-CO_2 GHGs from vehicle exhaust.

The commonly applied policies and measures for the transport sector, as noted by IPCC (2007, pp. 366 – 375), are the following:

- land use and transport planning;
- taxation and pricing, regulatory and operational instruments;
- fuel economy;
- transport demand management;
- non-climate-degrading policies to reduce GHG emissions; and
- realizing co-benefits and ancillary benefits.

Although the these policies and measures have, at present, shown limited results, they are increasingly considered to be key to global efforts directed at reducing the transport sector's CO_2 emissions.

3. Increase in Private Vehicle Use as Policy Failure

Many factors contribute to the increased use of private cars. While most of these are policy amenable factors, in most instances known solutions or policy measures have not been fully grasped or adequately used. Some of the common reasons for this are as follows:

- **Non-use or inadequate use of urban planning paradigms** to contain problems such as urban sprawl that increase car dependence, particularly in the absence of public or mass transit;
- **Lack of a comprehensive strategy to encourage the development of a green transport sector**, e.g., an environmentally sustainable transport (EST) strategy launched by OECD countries or the one initiated by the UNCRD in Asian countries;
- **Inadequate understanding of circumstances** and motivations that increase car ownership;
- **Lack of understanding of the policy tools that can be used to influence behavioural change**, e.g., the role of (a) taxation or subsidies and (b) other regulatory, economic or persuasive measures appealing to economic interests and moral/ethical considerations;
- **Failure to realize the full potential of technological changes or innovations leading to cleaner fuels and greener vehicles**;
- **Lack of appreciation of the role of and need for public investment in infrastructure,** e.g., pedestrian and bicycle ways, light rail, good bus service and other forms of mass transit;
- **Inability to attract domestic private investment (DPI) and foreign direct investment (FDI)** to meet the capital cost of a green transport infrastructure, often because of reluctance to allow cost recovery and perceived public (voter) opposition;
- **Failure to fully grasp the value of involving stakeholders** in the effective implementation of a policy, enforcement of a regulation or dissemination of information that could make them more receptive to environmentally friendly public policies and programmes.

In light of the above, public policies and actions to reduce private car use or otherwise reduce emissions remain inadequate. The following sections of this chapter elaborate on the above points based on materials reviewed and the cases prepared for this report.

3.1 Neglect of urban planning

Neglect of urban planning has given rise to a host of urban environmental problems, including urban sprawl that, in turn, is increasing motorized travel, particularly by private cars in the absence of good public transit systems, as is the case in developing countries. Transport, a key to urban mobility, is obviously a major component of an urban system. Urban mobility and urban development are inter-related. If there is a strong city plan, urban mobility becomes a sub-component of urban development. However, in cases where strong city planning is absent, overall

urban development is dictated by other sub-components, such as housing development. In the latter case, urban sprawl often predominates.

Two inter-related phenomena – (i) the erroneous notion that scope of planning is limited to countries having a free market economy and (ii) that planning education and educated professionals have only a limited influence on urban public policy – are impeding the use of land use planning, development controls and urban containment strategies. As a result, suburbanization, urban sprawl and extended metropolitan regions (EMR) are widespread features of contemporary cities. In populous developing countries, such as Mexico for example, this development has taken the form of mega-cities.

Urban containment

Urban containment policies limit sprawl by restricting out-of-town development (Gabrielsons *et al* 1997). Specifically, they work by restricting development outside of a designated zone and provide accessibility to all destinations in an urban area to residents in and outside of the area. Shopping, jobs and schools are closer to home and more easily serviced by private and public transportation.

Urban containment reduces emissions by encouraging compact development. Cultural institutions and public parks are well coordinated to correspond with traffic patterns, making them more relevant to the residents of a compact urban environment. Commonly used strategies for urban containment include: regulatory (e.g., growth boundaries, green belts) and economic instruments (development taxes, property taxes and gasoline taxes). However, regulatory instruments are more commonly used than economic ones. In developing countries, effective implementation of urban containment strategies is still very limited. As a result, cities are expanding horizontally in all directions, particularly along road corridors.

Land use planning tools and choice of travel modes

Unsuitable use of land is normally caused by inconsistent land use planning and implementation. Moreover, the absence of a land use plan – not uncommon in cities of developing countries – can make a bad situation even worse.

The pace of urbanization often exceeds a city authority's capability to establish an effective and responsive land use plan, and where such a plan is in effect, insufficient implementation may create spatial incompatibilities and associated undesirable impacts, such as energy-intensive urban forms (Permana, Perera and Kumar, 2008).

In residential areas, multi-family dwellings tend to have a lower energy use per unit area than single-family dwellings. In the former, if elevators are required, the energy savings may be offset somewhat, but this does not cancel the considerable energy savings resulting from less travel associated with living in a compact city and environment.

The travel necessities of citizens are influenced by the distance between the origin and the destination needed to accomplish their tasks. It is also the case that the need for and availability of travel generates additional trips for various purposes.

The general features of urban mobility include work trips, shopping trips, social or recreation trips, business trips and school trips (Meyer and Miller, 2001). Although the nature of these trips varies from city to city, most classifications include the following (Hanson, 1995):

- **work trips** made to a person's place of employment, e.g., public or private institutions, manufacturing plants, retail stores or shopping malls;
- **shopping trips** to any retail outlet, regardless of the size of the store and whether or not a purchase was actually made;
- **social trips** made for social activities, e.g., to go to parties or visit friends;
- **recreation trips** made to go to entertainment, cultural or other recreational facilities;
- **school trips** made by students at any level to a learning institution;
- **business trips** usually defined to include trips made from a place of employment to another destination in the city; and
- **home trips** include any trip ending at home.

For moderate and longer travel distances, motorized transport is generally required. This means that citizens' choice of a motorized or non-motorized transport mode is affected by land use. If there is "no origin-destination separation" or if a trip is "within walking distance separation", motorized transport is not required. Consequently, no energy (non-human) is required for transportation purposes, no emissions are released and better urban air quality is achieved.

Origin and destination governs individual travel pattern

Origin and destination affect transport mode choices and also govern individual travel patterns. The movements of urban citizens can be analysed by identifying existing urban forms with respect to the origin-destination hypothesis. Permana (2005) identifies four general types of the forms that affect the physical mobility of citizens and lead to motorized transport demand and, in some cases, transport energy wastefulness:

- star-type polycentric with origin-destination (O-D) separation (Figure 3.1);
- concentric with origin-destination separation (Figure 3.2);
- polycentric multi-linkage with partial origin-destination separation (Figure 3.3); and
- full origin-destination separation (Figure 3.4).

Figures 3.1 – 3.4 use schematic diagrams to illustrate different types of origin-destination patterns. Each urban form creates different traffic loads at its links on condition that equal traffic volumes exist in each of the forms. Figure 3.1 is characterized by separation of origin and destination, those with a single linkage of

origin-destination and also those with single destinations. This pattern influences the mobility of the individual citizens as reflected in the following:

In Figure 3.2, the central business district (CBD) is the place for working and shopping. Traffic is therefore generated to provide the linkages between origin and destination. In fact, the pattern depicted in Figure 3.1 has similarities to that in Figure 3.2. In these models, concentric residential areas will grow peripherally – each connecting with the other to form a concentric pattern. This has been the case in some developing country cities, where a concentric pattern of the urban form spreads over the city beyond walking distances. As a result, the motorized travel dependence of the citizens is considerable. The situation is also worsened if there is an absence of a pedestrian-friendly environment.

Figure 3.3 illustrates a general pattern in a polycentric form with development of independent sub-centres. The sub-centres are linked to one another, which causes a proportional distribution of traffic load. Lesser traffic loads to the CBD occurs in this model, because in the independent sub-centres, motorized transport is not required because of the proximity between origin and destination. The principle of neighbourhood development becomes operational in sub-centres (William, et al., 2000) if it is complemented by public facilities (Friedman, 1996). This can be reinforced by supporting the growth of independent sub-centres as satellite cities or towns.

The nature of the urban form does not in itself ensure or reduce energy conservation; however, the emergence of a particular urban form can significantly contribute to reducing car use and emissions. For example, changes in the relative location of residences and workplaces make it possible for transport energy consumption to be reduced through reductions in average journey-to-work trip lengths and mode switching from car to public transit (Anderson et al., 1996).

Travel patterns are greatly affected by travel behaviour. Dieleman et al. (2002) clarify that personal and household characteristics such as income, family composition and participation in the workforce have an impact on mobility behaviour and modal choice. Another factor is the location of residences, whether in the city centre or suburbs, as well as the compactness of the residential environment. Still another concerns the purpose of the trips undertaken. These factors, along with the length of the trips and the choice of travel modes, will be impacted by urban planning paradigms. However, these paradigms alone, without efforts to influence users' behaviour, will not yield the desired outcome.

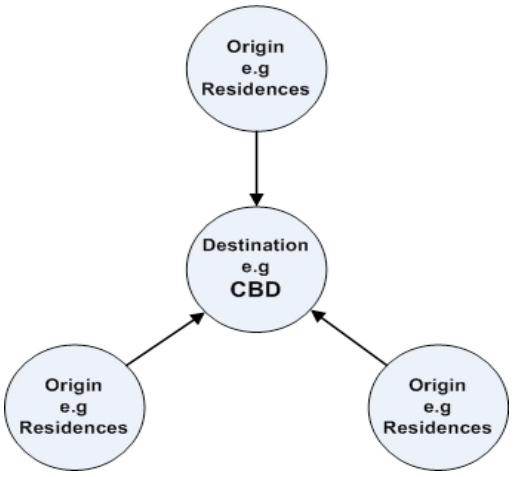

Fig 3.1 Star-type (polycentric) with O-D Separation

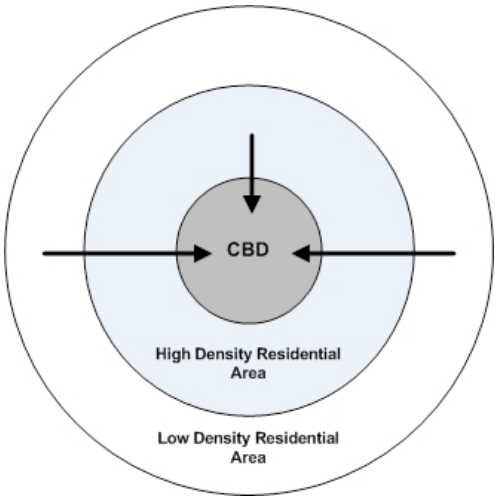

Fig 3.2 Concentric Pattern with O-D Separation

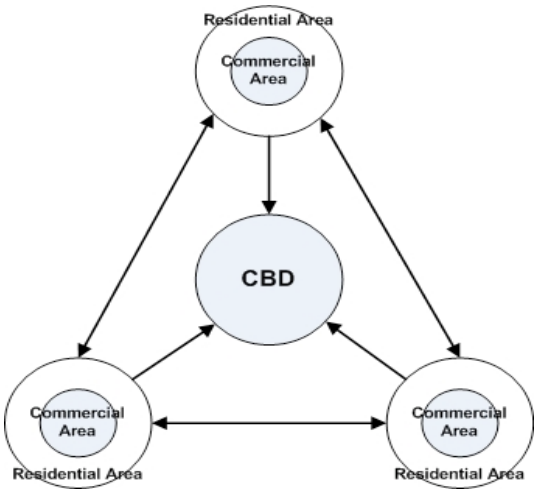

Fig 3.3 Polycentric Multi-linkages with Partial O-D Separation

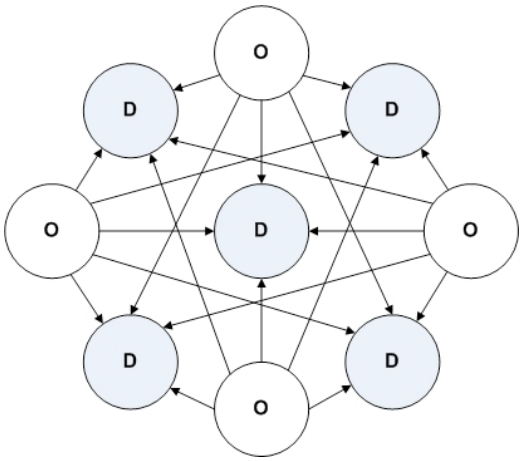

Fig 3.4 Full O-D Separation Polycentric Pattern

Source: Permana, A. S. (2005). Impacts of Existing Land Use Pattern on Urban Physical Mobility and Air Quality in Bandung City, Indonesia.

In short, a tendency towards motorized travel occurs if the distance between origin and destination is longer than walking distance. Moreover, the absence of an adequate public transport system will increase the propensity of users to travel in private vehicles. However, a well-planned urban form, in the absence of sufficient public transport, will still increase dependence on private cars. The absence of either will be detrimental to the search for an environmentally sustainable transportation system.

3.2 Failure to adopt comprehensive and environmentally sustainable transportation strategies

Following the lead of the OECD countries, the United Nations Center for Regional Development (UNCRD) has been promoting environmentally sustainable strategies in Asian countries through inter-governmental policy dialogues, expert group meetings, discussions with mayors and regional forums. UNCRD has identified 12 thematic areas for promoting EST in Asia. These are the following:

- disseminating information on the link between vehicular emissions and public health;
- propagating the importance of and supporting the integration of land use and transport planning;
- promoting an environmental and people-friendly urban transport infrastructure;
- advocating public transport planning and transport demand management (TDM);
- promoting non-motorized transport, particularly walking and bicycling;
- promoting social equity and gender equality in transportation systems;
- ensuring road safety;
- monitoring and assessment of roadside air quality;
- adoption of vehicle noise standards;
- use of cleaner fuels;
- improving vehicle emission controls, standards, Inspection and maintenance (I&M); and
- launching awareness campaigns to enhance public knowledge and participation.

These activities form a comprehensive strategy for promoting environmentally sustainable transport. Behavioural and technological changes are not explicitly included, but are implied in the awareness campaign that disseminates information about the links between vehicle emissions and public health, as well as in the encouragement to use cleaner fuels. Economic incentives, regulatory measures or financing of investments to support a green transport infrastructure are also absent; however, these themes appear in country or city presentations and deliberations that follow in UNCRD-organized regional dialogues and forums.

Although this EST initiative and follow-up activities have generated considerable interest among countries, cities and expert members, the national governments of Asia's developing countries are still far behind their developed counterparts in Asia, e.g., Japan, the Republic of Korea and Singapore. Therefore, while the message of EST is spreading, the Incorporation of EST strategies by national and city governments in Asia's developing countries is still very limited. These strategies –

including financial support for public/mass transit, technical assistance for urban planning, integration of land use planning and transportation and development controls – can make a considerable difference in EST adoption by developing country and city governments.

Integration of transport planning into land use planning

Integration of transport planning into land use planning is central to developing environmentally sustainable transport systems. In most cases, this integration is absent; as a result, public transit systems, when not completely lacking, are often not compatible with land use. This, along with other factors mentioned previously, leads to the extensive use of private cars and creates car-dependent citizens. When these two key paradigms are integrated and provided that public transport is of high quality (see following section), citizens can expect to enjoy the benefits of a seamless transit system starting from their homes, as well as efficient intermodal transfers.

Absence of adequate public transport

Public transportation can play a major role in reducing energy use, air pollution and global warming and can compensate in part for inefficient land development patterns (Nash, 2006), but for public transport to have a greater share of the urban transport system, the service must be reliable, adequate and comfortable.

As the need for passenger transport continues to grow, the increased use of private cars and a reduced number of passengers per car will negate the improvements gained from improvements in vehicle efficiency. This is another challenge for cities with insufficient public transport. One key obstacle to achieving a mode shift from private to public transport is the poor availability, slowness and unreliability of many public transport services. The quality of the urban transport infrastructure (i.e., roads, trains, buses, public spaces, bus stops, terminals and footpaths, etc.) is an important problem in this regard. Poor quality has a tendency to discourage users who have an alternative option (mostly a private car). Indeed, it may be easier to deter people from using public transport if it is low quality than to attract them back when the quality improves. This is because non-users are often not aware of quality improvement initiatives and are therefore less likely to be influenced. Insufficient attention given to raising awareness about improvements could restrict the use of public transport to only those users who do not have a choice due to factors such as age or economic status.

Providing good public transport service and adequate transit system facilities is a public service task of government. A clean, comfortable and efficient public transport system is a precondition to reducing the use of private cars and to developing a transit-oriented population. To achieve this, the transit authority needs to equip itself with adequate regulatory instruments and should be supported by a clearly spelled-out urban land use plan which guides the development of a public transit system. Unfortunately, as noted, public transit, in most developing countries is “overcrowded, uncomfortable, undependable, slow-moving, uncoordinated, inefficient and

dangerous" (Kashirsagar, Bhushan and Prakash, 2008). Inadequate investment, poor maintenance and low fares are some of the reasons for this.

Several cities, however, have pioneered change by introducing decent public transit service. Bogota's BRT operation, largely funded by fare collection (Case 43); Jakarta's bold start with BRT (Case 42); Bangkok's ''sky train"; Beijing's & Shanghai's MRTS (Case 40 and 41); and electric trolley bus service in Quito, Ecuador (Case 26) are good examples of these changes, which are likely to inspire similar undertakings in the near future. (See also Chapter 4 for a summary of these cases). Table 3.1 provides a quick summary:

Table 3.1 Strategies for influencing urban mobility and reducing dependence on private cars

Strategy for influencing EST	Key elements/ objectives in the strategy	Adopting city/country and the appeal of the experience
Urban planning (including land use planning)	Densification to reduce car use	Case 1: Vancouver adopted urban planning and a densification strategy for reducing car use
	Integration of land use planning and transport planning into urban planning	Case 9: Curitiba introduced an urban planning practice that integrates transport planning
Transport planning	Integration of all elements of transportation towards an environmentally sound transportation system	Case 50: Singapore stands out among Asian countries in its integration of transport and land use planning and Case 51: Beijing's integrated road transport system development
Infrastructure	Restoring a stream to improve the transportation system	Case 23: Restoring the Cheonggyecheon stream in Seoul
	Development of bikeways to create a pedestrian-friendly environment	Case 4: An model bikeway programme in a Philippine city
	Development of a pedestrian mall	Case 52: Several European cities popularize pedestrian malls to enhance the city's image and reduce automobile traffic

Public mass transit	More efficient mass rapid transit system, e.g., bus rapid transport, rail transport or subway	Case 10: Curitiba's busways are a model of bus rapid transit Case 13: Bangalore overcame perennial losses in running its bus service by a combination of fleet modernization, augmentation of service, revenue mobilization, fare policy and cost minimization measures Case 26: The electric trolleybus system in Quito, Ecuador was made a reality by giving attention to financing and cost recovery Case 39: Bangkok's van transit service. Its ride sharing contributes to reducing traffic congestion Case 40: Institutional, technological and financing innovations allowed Beijing to overcome the barriers to create its MRTS Case 42: Rail-based Mass Rapid Transport System in Shanghai, China Case 42: Jakarta makes a bold start with BRT in reducing car use and Case 43: Bogota's BRT operation funded entirely by fare collection
	Bus pass program	Case 39: Ann Arbor, Michigan, USA bus pass programme reduces car use by ten per cent
Greener car technology	Wind powered commuting rail	Case 25: Calgary makes its wind-powered commuter train a reality by incorporating private companies
	Hybrid technology	Case 45: Hybrid technology car
	Tata Nano Car	Case 44: Tata's Nano Car: concern about the trade-off between "people's car" Image vis-à-vis energy efficiency)
	Electric car in developing countries	Case 49: Kathmandu introduces electric three-wheelers to replace diesel vehicles
	The use of four-stroke motorcycles	Case 47: Switch from two-stroke to four-stroke motorcycles introduced in Thailand
Cleaner fuel technology	Alternative fuels (renewable fuel)	Case 5: Hydrogen fuel – an outcome of automaker's investment for sustainable mobility Case 6: China incorporated a fuel cell initiative in its high technology development programme Case 11: China maintained its tradition of learning from others as reflected in its adoption of Shanghai's alternative fuel vehicles and Case 49: Beijing's programme to transform vehicles for alternative fuel use
	The use of CNG (cleaner fuel)	Case 14: Delhi CNG programme follows a Supreme Court mandate
	Biofuel	Case 28: Bio-fuel in Thailand obtained momentum from E85 adoption
	Fuel economy	Case 17: Novelty in U.S. fuel economy improvement system and Case 18: Japan followed American lead in allowing manufacturers to accumulate credits from fuel economy improvements

These initiatives in public transit were launched to reduce the dependence of citizens on the use of private vehicles. The operation of these systems is gradually contributing to an increase in the share of public transport in the urban transport systems in terms of passenger-kilometres travelled. To benefit more from public transit, these programmes need to be complemented by constructing pedestrian and bicycle-friendly environments. In that regard, facilities that provide more modal complementarity are helping to discourage citizens from using private vehicles, as has been observed in some European countries and Japan.

Absence of pedestrian-friendly environment

A sufficient pedestrian-friendly environment can encourage people to walk or bike and reduce the use of private cars. Governments that provide a pedestrian-friendly environment as part of their public service function tend to do so in certain public areas where pedestrians are encouraged to come or are expected to be present. A central business district is one favourable location for creating this kind of environment. In many cases, pedestrian streets, broad sidewalks, streets, stores and housing have been organized to create a vibrant atmosphere that stimulates transit use, economic investment and that provides a sense of place.

Unfortunately, pedestrian-friendly environments are still rare in developing countries. An unfortunate development in these countries has been the disappearance of areas that have traditionally been characterized by walkways or open space. Nonetheless, the worldwide interest in improving the pedestrian environment is growing as a means of encouraging non-motorized travel, reducing vehicle-miles and controlling pollution emissions. Increasingly, emphasis is being placed on the role of the importance of physical activity associated with walking and biking in improving public health (Parks and Schofer, 2006).

Jian et al. (2005) note that the pedestrian movement is exerting an important influence on the design of transportation facilities – walkways, traffic intersections, markets and other public buildings. The authors argue that the random flow of pedestrians is an essential ingredient in city planning. Studies indicate that the flow of large pedestrian crowds associated with special events are limited when compared with that of pedestrian flow in a normal walking environment. In large crowds, there is a potential for injury and even loss of life resulting from the dynamics of the crowd's behaviour (Lee and Hughes, 2006). The complexity of pedestrian behaviour derives from the presence of collective behavioural patterns evolving from the interactions among a large number of individuals. This suggests the need to consider two different approaches: pedestrians as a flow and pedestrians as a set of individuals or agents (Antonini et al, 2006).

The concept of a pedestrian-friendly environment is being increasingly integrated into the ‘‘smart growth” concept. Smart growth (Irwina and Bockstael, 2004) attempts to optimize the trilateral components of development: social, economic and environmental. To qualify as a smart growth city requires that a balance be struck between the needs of pedestrians and those of motorists. The balance does not

necessarily mean that the needs of both are quantitatively equal; it focuses rather on maintaining an appropriate proportion of both in a total transportation plan.

Until recently, the needs of motorists have been considered at the expense of pedestrians, particularly in developing countries. An example, as noted, is the absence of walkways and a pedestrian-friendly environment that increases the share of motorized travel with all of its associated consequences: traffic congestion, air pollution and greenhouse gas emissions.

Cycling and walking: their advantages and disadvantages

Along with walking, cycling (and, for that matter, all non-motorized transport) have an important role to play in reducing car use. Cycling and walking provide access to public transport for long trips and provide alternatives to the use of the private car for short local trips. It should be noted, however, that safety (actual and perceived) can be a major barrier to walking and the use of bicycles. Indeed, non-motorized users are amongst the highest casualty groups in accidents involving motorized transport, particularly in developing countries. But studies show that as more people use cycles, the safer the environment is for each cyclist. According to Jacobsen's Growth Rule, if the number of cyclers doubles, the risk per cyclist falls by 34 per cent. If the number cycling halves, the risk per cyclist increases by 52 per cent (Jacobsen, 2003).

There are some other concerns associated with the promotion of cycling and walking. The policy on wearing cycle helmets varies across Europe, but where it is compulsory there are concerns that it can discourage potential cyclists. Security is also an issue, particularly apprehensions concerning bicycle theft and vandalism, and for pedestrians' walking alone at night. However, these concerns are more than offset by the advantages walking and cycling provide.

Networks, rather than individual routes for cyclists, lead to greater ridership, whereas high-quality footpaths, crossings, cycle parking and other amenities increase the attractiveness of cycling and walking. Planting trees along walking and cycling routes is essential to reduce the discomforts associated with hot and humid weather. This is a factor affecting modal choice in cities of the tropics.

Journey distance and purpose can also create barriers for the use of non-motorized modes. UK travel survey data show that for shopping trips 51 trips per person per year are undertaken by walking, compared to 82 by private car as drivers (42 as passengers) (Department for Transport, 2006). However, the average length of walking trips is one kilometre, compared to 8.4 kilometres for a car with a driver (10.9 kilometres as passenger). Consequently, it is mainly shorter shopping trips that are likely to be undertaken on foot.

3.3 Influencing behaviour: partial and piecemeal use of incentive measures

The policy initiatives presently used to influence environmentally friendly behaviour are often used in isolation rather than as a coherent package. This is the case with regulatory instruments (RIs), economic instruments (EIs) and persuasive instruments (PIs). If used in isolation, these measures only appeal to one set of human motivations: economic interests (in the case of tax and subsidy, for example); fear of change (RIs) and PIs (moral and ethical motivations). Because these initiatives are often used individually, in a piecemeal way, rather than simultaneously, they frequently fall short of attaining their objectives (see Figure 3.9).

The cases reviewed in the preparation of this report show that in most instances RIs, EIs and PIs are used in isolation (see Table 4.1) and without full comprehension or appreciation of their potential when used jointly and simultaneously.

Figure 3.5 Three elements as the basis of environmental management instruments (EMM).

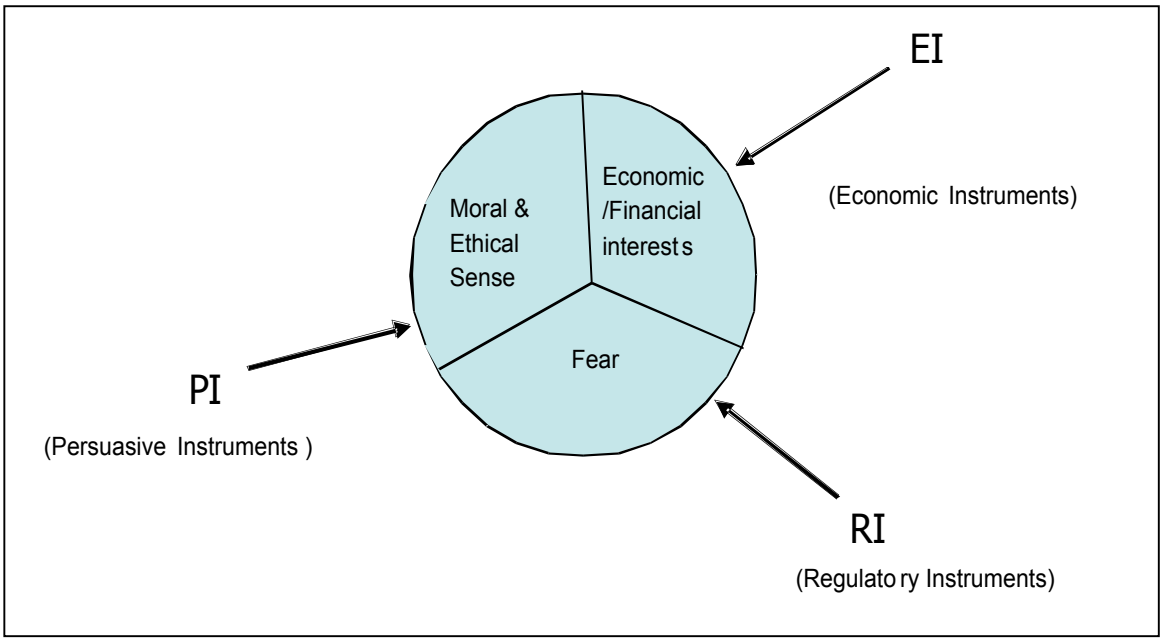

Figure **3.5 Three elements as the basis of environmental management instruments (EMM).**

Source: Amin, *et al* (2006).

The case for simultaneous use of environmental management measures (EMM)

Given the emphasis in this report on the simultaneous use of RIs, EIs and PIs, it is important they be considered together as constituent elements of one framework. Setting aside for the moment the problems in applying these three sets of instruments, it is clear that, on the conceptual side, two drawbacks are depriving societies of the potential gains from their use. The first is that policy makers have not always recognized that the aim of these measures is to influence human behaviour. As a result, they are not explicitly targeted to effect necessary behavioural change. The second is that using one set of measures and setting aside the other two is a partial approach that only addresses one of the basic motivations affecting behaviour. In the absence of a simultaneous use of these instruments, this approach will inevitably only be a partial one.

In short, it is necessary to understand that citizens' motives are complex and interdependent. Therefore, a policy strategy to effect behavioural change needs to target each of the basic elements motivating human behaviour. This means that, for policies to be comprehensive, the use of regulatory, economic and persuasive measures needs to be effected simultaneously as part of a policy package.

One way to begin this process is to include all three sets of instruments as integral parts of an EMM framework. Considering these elements together as EMM – instead of referring to them separately as three individual categories of policy measures – will reduce the chance of using them in isolation and will encourage a holistic approach to changing behaviour.

Of the 54 cases prepared for this report (see Annex and case summaries in Chapter 4), in most instances only one of the three sets of the policy instruments were used. As shown in Table 3.2, which is based on the cases reviewed, the use of regulatory measures is dominant, followed by the cases in which only economic instruments were used. Persuasive measures are used in only three cases. Only in two cases were all three sets – RIs, EIs and PIs – used. These are to the cases involving the switch from leaded to unleaded gas in Thailand (Case A27) and Vietnam (Case A30). As a result, in both instances the policy goal of phasing out leaded gasoline was achieved as planned (see Amin, et al 2006).

Table 3.2 Use of environmental management measures (EMM) to influence travel behaviour in reviewed cases

EMM	Key elements	Adopting city/country and appeal of the experience
Regulatory Measures	Vehicle Quota System controls the right of vehicle ownership through regulation (predominantly) and economic instruments (supporting instruments)	Case A7: Singapore added quantity measures to Initial reliance on Incentive measures alone
	Mandatory fuel economy	Case A19: China's regulatory system for fuel economy improvements includes incentives to lighter vehicle manufacturers:
	Greener vehicles purchase	Case A32: Japan's vehicle emission controls make use of its new green purchasing
	Vehicles emission controls	Case A31: Vehicle emissions control technology – European Union (EU) member countries Case A36: Beijing combines standards, regulations, technology and fiscal incentive measures for emission controls Case A37: Shanghai's vehicle emission control programme involves implementation of EU-1 standards
	Hybrid only parking	Case A46: ''Hybrid only"' parking in Suffolk, New York to promote the use of green vehicles
	Traffic signal controls	Case A34: Traffic signal controls to reduce vehicle CO_2 emissions – Kawasaki City, Japan
Economic and Financial Measures	Congestion charges	Case A2: Congestion charges make a difference in London and Case 3: Traffic congestion pricing, Seoul, Korea, November 1996
	Area licensing schemes	Case A8: Singapore's area licensing system since 1975
	Rebate/penalty according to low/high emissions of new car purchases	Case A16: Bonus rebates in France for buyers of new vehicles with low CO_2 emissions
	Increasing gasoline prices	Case A29: Mexico's common sense economic strategy: increases the gasoline price and makes CNG the least expensive fuel
Suasive Measures	Car-free days and walking streets (pedestrian streets) programme	Case A20: Car-free days: Seoul provides incentives with the public and private sector joining hands Case A22: Bangkok launches walking street programmes

	Car sharing	Case A21: Fukuoka Launches a multi-stakeholder initiative in car sharing to reduce CO_2 emissions
	Travel feedback programme	Case A24: Sapporo's travel feedback programme
Combination	Combination of three sets of regulatory, economic and persuasive measures for changing leaded to unleaded gasoline	Case A30: Vietnam's success in switching from leaded to unleaded gasoline with simultaneous use of all three elements of EMM
	Voluntary commitments to comprehensive measures	Case A15: EU's change from largely voluntary commitments to a comprehensive set of measures to reduce CO_2 emissions from private cars

Even in more sophisticated policy environments (i.e., the EU countries and Singapore), the policy goals were not attained by using only one set of instruments, e.g., the use of taxation measures alone for reducing car purchases in Singapore (Case A7) and the use of only regulatory measures to reduce CO_2 emissions in EU countries (Case A15). In both of these cases, the initial policy measures were later revised by adding regulatory measures in the case of Singapore and economic measures in the case of the EU.

The cases studied illustrate, as noted previously, that policy measures need to be targeted at changing behaviour and that using one set of measures while ignoring the others is only a partial solution in that it only addresses one set of human motivations. This is not always borne in mind by policy makers.

To avoid misleading impressions, it must be said that cases such as road pricing (Case A2), quantity measures for reducing car purchases (Case A7), bonus rebates to buyers of new vehicles with low CO_2 emissions (Case A16), multi-stakeholder initiatives in car sharing for to reduce CO_2 emissions (Case A21) – all show positive results. The point is that measures targeted at behavioural change are necessary to sustain the positive changes and to encourage replication.

To sustain behavioural change, an education and awareness campaign, including information dissemination – which has been given the name persuasive instruments (PIs) – are key policy tools. While there is no substitute to creating environmentally aware, concerned and committed citizens, it must be recognized that there is no easy way to do this. Indeed, it may require years to establish these attitudes. Gradual and step-by-step use of PIs or information instruments (IIs) may well be the most effective way to proceed.

Education and systematic awareness campaigns are two conventional means of creating environmentally aware citizens. An effective public awareness campaign requires that some conditions be met. Establishing clear objectives and themes, specific messages for specific target audiences, partnership with other stakeholders

and effective media strategies are required. Mainstreaming the awareness campaign into a compatible existing long-term programme will ensure the continuous implementation of the campaign. Moreover, the campaign should involve various stakeholders having different levels of participation to encourage their participation in the programme.

3.4 Inadequate understanding of human attitudes and behaviour

Strategies to motivate behavioural change have to take into account the motivations for citizens to use private cars. The demand for private car use is inelastic *(*Gardner and Abraham, 2007*)*.

To design policies that will encourage citizens to switch from private cars, the following points need to be considered:

- This inelastic demand, at least in part, is created by the automobile industry through the extensive use of advertising. Considerable sums of money are spent to induce automobile purchases;
- Policymakers do not use sufficient policy measures to counteract this inelastic demand;
- Policymakers can counteract the inelastic demand by two sets of policy measures: regulatory and persuasive measures;
- Preferences for public transport rather than automobile use increase as public transport journey time decreases (Van Vugt, et al., 1996 cited in Gardner and Abraham 2007);
- Despite measures to create disincentives for automobile use, studies in different regions have found that the subsidy for the use of automobiles is around US$4,000 per vehicle per year for roads, parking, health costs, pollution costs and so on (Newman and Kenworthy, (1996). A study carried out in 2000 estimates automobile subsidy costs in the U.S. as US$5,000 per vehicle per year (Duany, Plater-zyberk and Speck 2000);
- Other experimental research has shown that introducing financial disincentives can reduce private car use (Jacobson, Fuji and Garling, 2002 cited in Gardner and Abraham, 2007); and
- Other than incentives, travel mode choices correlate with the experience of driving and perceived stress, excitement, uncertainty, safety, enjoyment and autonomy (studies are cited on this by Gardner and Abraham, 2007).

Factors in travel mode choices favouring private cars journeys

Some of the following factors influence a preference for using light duty vehicles (specifically, private cars):

- Private car driving is frequently idealized whereas public transport is considered to be problematical;
- The potential health benefits in terms of physical exertion in using other than private cars for functional journeys have been neglected; and

- The costs of a single automobile journey are systematically underestimated because they are conceived of primarily in terms of fuel costs.

Motives in sustaining automobile use

Once the choice is made to use private cars, certain other factors tend to sustain the use of them. These are as follows:

- It (the private car) minimizes journey time;
- It minimizes physical and psychological effort;
- It creates a personal space; and
- It is considered to minimize financial expenditures (Gardner and Abraham, 2007).

In view of all of these elements involved in choice, it is unrealistic to pursue public policies that will lead to a radical change in car use. That said, there is still a wide scope to reduce car dependence if modal complementarity is promoted.

3.5 Non-utilization of the full potential of change and innovation in fuel and vehicle technologies

Although it is unrealistic to expect that technology alone can solve the problem of greenhouse gas emissions from the transport sector, it would be unfortunate if known technological solutions were not fully utilized. The danger associated with too much optimism centering on technological solutions is two-fold: one, essential behavioural change may be bypassed; two, incentive measures required for promoting R&D may be ignored or overused.

The latter can occur as a result of activities by industry lobbyists. Nevertheless, a number of technical solutions are becoming feasible to make vehicles greener, fuel cleaner and emissions control technology more effective. For example, of the five approaches to reducing CO_2 emissions in motor vehicles listed by Difiglio (2007), four involve technology. Similarly, Chapman observes that “technological change will play an increasing role in the reduction of greenhouse gas emissions from transport” (Chapman, 2007, p.359).

Greener vehicles

Fuel cell cars, electric and/or hybrid cars and cars with good mileage per gallon are now available (though some are only available in limited quantities). These technologies, however, are still expensive. Given the substantial positive attributes of these technologies, government support to improve their viability would be helpful. This support can take the form of government subsidies for green and environmentally friendly vehicles. If that support is forthcoming and with advances in research and development, along with economies of scale, the price of green and environmentally friendly vehicles will gradually decrease and will approach that of conventional cars.

Cleaner fuel

The use of unleaded gasoline, compressed natural gas and liquefied petroleum gas would also benefit from government subsidy. This has already occurred in some cases. The objective should be to price these fuels as low as, or lower than, conventional fuels. To gradually lower the government subsidy, a campaign the build awareness about the positive impact of using cleaner, low-emission and carbon-neutral fuels should be undertaken. This will be useful in attracting more citizens to use them. One problem in this regard could arise from a wrong price signal, e.g., a fall in the price of oil, which can impede the shift to alternative fuels.

Technology used and age of fleet

Because the performance of automobile engines deteriorates as a function of age, old or obsolete automobile engine technologies generate higher emissions than newer ones. The newer vehicle technology is characterized by greater mileage per gallon with less or, in some cases, no emissions. These are characteristics of hybrid vehicles and those powered by fuel cells. In addition, the use of catalytic converters, long required in several developed countries, also lowers emissions and contributes to better air quality.

Improved vehicle technology is one key to reducing air pollution caused by the transportation sector. Some governments, such as those in France and the U.S., have recognized the positive impact of better engine technologies by offering rebates to customers who turn in older, polluting cars for newer, cleaner models.

Poor maintenance of vehicles

Poor maintenance of new vehicles will lead to degradation of the vehicle's performance, marked by greater fuel consumption and higher emissions. Periodic maintenance to sustain the vehicle's performance is essential.

Use of improper fuel

Fuel is inherently a mobile source of pollution. The fuel type of vehicles, including their price, is specified by the regulatory authorities. Use of the wrong fuels will generate emissions of certain kinds of pollutants. Therefore, the role of regulatory authorities in regulating the type and price of fuel is of importance in reducing air pollution from mobile sources.

Vehicle emission controls

When vehicle engines are running, vehicles emit a range of air pollutants – hydrocarbons, carbon monoxide and oxides of nitrogen during the combustion process are emitted from the tail pipe into the atmosphere. Hydrocarbons are emitted as a result of the vaporization of gasoline from the automobile’s crankcase. All of these pollutants need to be controlled to render air quality cleaner.

Vehicle controls can be carried out using several strategies – imposing vehicular emission standards, periodic vehicle inspections, installing catalytic converters, setting fuel quality standards, chassis dynamometre smoke tests and on-the-road emissions tests.

However, emissions control strategies will not be successful without sufficient awareness by, and cooperation from, the public, who need to make judgements concerning which strategy will be most appropriate to meet their obligations. Moreover, citizen awareness has to be supplemented by forceful implementation of control measures; weak implementation can serve as an excuse for drivers to escape their obligations.

3.6 The role of and need for investment in a green transport infrastructure

Construction of urban environmental infrastructures or urban green infrastructures – whether involving water supply, drainage and sewage or transportation systems – requires very large investments. Because of the capital cost barrier associated with their construction, developing country cities often cannot benefit from the built-in advantages these infrastructures provide, even though their unit costs diminish as their size increases.

In developing countries, few serious attempts have been made to understand or realize the advantages green infrastructures – the virtual circle of green jobs, more public transit, fewer cars – can provide if capital could be mobilized from global capital markets for the construction of urban environmental infrastructures, including mass transit, walkways and bicycle ways.

Some cases (e.g., Beijing's financing of investment for public transit that has created disincentives for car use (Case 41) do show an understanding of these issues, but most developing countries have yet to succeed in attracting the foreign direct investment necessary for green projects.

3.7 Inability to attract necessary investment: need for cost recovery

Even if large investments in green technology and infrastructure are understood to be beneficial, the potential for these investments remains largely unrealized, because of a reluctance to allow for cost recovery. As noted previously, the latter is the result of a two-fold problem: citizens' unwillingness to pay and politicians' unwillingness to charge for fear of losing votes (Rammont and Amin, 2009).

This situation can be overcome if politicians' take a proactive role, informing citizens about the gains associated with green investments having cost recovery provisions. The common concern is that the poor will be disadvantaged by cost recovery, e.g., higher bus fares, for example. But this can be effectively addressed by employing cross-subsidization or by a discriminatory pricing policy that protects the interests of poor and low-income public transport users.

In developing countries, the problems of poor public services in general and public transit in particular persist, because the solutions mentioned above are not employed to break the vicious circle of not providing for public transport – and by a failure to replace this with a virtuous circle centered on improving transport facilities and infrastructure. To make matters worse, the need for a public transport service is often superseded by a costly (for most citizens) focus on the private good – individually owned private cars. The widespread problem of limited public goods and services in general and public transport in particular have led to private means of meeting basic needs at a much higher cost (e.g., individual deep tube wells replacing public water supply, private cars as an alternative to bus service, privately owned electricity generators instead of public power supply), which, in turn, can encourage corruption, since large sums of money are involved.

3.8 Involving stakeholders for better enforcement of public policy

The stakeholder concept has its roots in business management. Its significance lies in the fact that "any stakeholder group or individual can affect or is affected by the achievement of a firm's objectives" (Freeman 1984 cited in Kitnuntaviwat 2009). The value of this concept is increasingly appreciated and used in environmental management, because the involvement of stakeholders has the potential to overcome the problems inherent in regulatory enforcement, public policy implementation and reducing costs.

This is possible because stakeholder participation makes all concerned receptive to change and willing to cooperate. The three most important stakeholders – citizens, government and industry in synergistic roles – can make a considerable difference in improving urban air quality and reversing climate change. Yet the practice of involving stakeholders is still seriously limited – often it does not go beyond tokenism.

Despite the increasing role of the private sector, including NGOs and others, government still has the primary responsibility to formulate and implement policies, particularly those concerning environmental protection and management in general and urban planning and transportation systems in particular.

In addition to government, the automobile and fuel industries are also keys to innovation and to applying green vehicle, clean fuel and emission control technologies. The time has come to include industry as a partner in reducing emissions and even in efforts to reduce automobile use. This is because industries' profit-making strategies are undergoing change; auto companies increasingly realize that cleaner vehicle and fuel technology innovations are now better guarantors to ensure profits than the production of vehicles that consume inordinate amounts of carbon fuels. This is an important reason to include industry in efforts to address climate change. Concerted actions undertaken by citizens, government and industry will have multiplier effects on emissions and automobile use reduction and will aid in the struggle against global warming.

4. Lessons from Global Experiences in Reducing Emissions from Private Cars

Numerous public policy and action programmes for reducing emissions from private automobiles are in place globally. These fall principally into two categories:

1. reducing total transport demand; and
2. reducing emissions

To reduce the use of private cars, efforts mainly involve urban planning, transportation planning and switching to low-emission travel (for passengers) such as public/mass transit and emission-free travel (i.e., walking and cycling).

Emissions reductions based on technological innovations are taking place in the form of cleaner fuels, greener vehicles and technical devices to reduce emissions.

The Appendix provides a summary of 54 cases prepared for this report recounting global experiences leading to emissions reductions for light duty vehicles (private car) use. This chapter contains an overview of the efforts undertaken.

4.1 Reducing total transport demand

Urban planning

- ***Vancouver adopts urban planning and densification strategy for reducing car use:*** In 2007, Mayor Sam Sullivan called on the municipalities of his cities, as well as senior levels of government, to open the debate on increasing urban density as a way to reduce dependence on private car use and thereby to limit global climate change. Addressing Vancouver's private citizens, business people and those in the development, housing, social services and environmental communities, he said: "We should be talking about how *better urban planning and densification* (emphasis added) of our cities can significantly reduce our impact on the environment." The discussions that followed led to adoption of subsequent policy measures, based on feedbacks from citizens and businesses, on very specific plans that are enforceable and effective. Of the various reasons for ineffective urban planning in developing countries, one is the near absence of practices such as those undertaken in Vancouver (*Case A1*).

- ***Curitiba employs urban planning practices that integrate transport planning:*** After a failed first plan for an urban transportation system planning due to funding constraints for the large infrastructure required, the creation of the Institute of Research and Urban Planning (IPPUC), along with strong government leadership (the sustained commitment of mayors despite successive changes in administration), led to successful integration of urban and transportation planning. The master plan minimized urban sprawl by introducing zoning laws and land use plans, created a transit-oriented city, reduced traffic and involved transportation stakeholders to ensure effective

planning. Some key planning strategies included restructuring the city's radial configuration into a linear model of expansion and creating an urban planning agency responsible for developing, supervising and updating the master plan. Key transportation strategies included building an extensive BRT network, determining bus fares based on cross-subsidization and integrating public transit with biking and walking. The successful integration was founded on the mutually reinforcing use of the urban planning paradigm's tools, such as zoning laws and maximum accessibility *(Case A9)*.

- Several European countries popularize pedestrian malls to enhance a city's image: Another popular programme in developed countries has been the development of pedestrian malls that have been implemented in cities such as Bonn, Cologne, Hamburg and Munich (Germany), Copenhagen (Denmark), Norwich (UK) and Singapore. These programmes are implemented through urban planning and development control instruments, but also involve economic instruments and community education. The significant advantages of pedestrian malls are in preserving central city functions, facilitating access for shoppers, reducing noise and air-pollution and improving the city's appearance. Pedestrian malls are creating a more pedestrian-friendly environment that encourages people to walk or bike instead of using motor vehicles for short distance travel within a particular area of a city (Case A52).

Transport planning

- ***Singapore stands out among Asian countries in integration of transport and land use planning:*** The effectiveness of Singapore's land transport policies lies in the effective implementation and workability of the policies. The land transport policies of Singapore aim to deliver an effective land transport network that is integrated, efficient, cost-effective and has a sustainable plan. The focus is to encourage commuters to choose the most appropriate mode of transport. To achieve these objectives, necessary investments have been made in road infrastructure, public transport and traffic management schemes. Road user charges and fiscal measures on car ownership have also been implemented, allowing financial support and cost recovery to be built into the system. Consequently, the reputation of Singapore as a country which relies on command and control (CAC) measures is somewhat misleading. On a closer look, it becomes clear that Singapore uses all three major sets of policy instruments: regulatory instruments, such as a vehicle quota system; economic instruments, such as electronic road pricing; and education of vehicle owners, drivers and commuters (*Case A50*).

- ***Beijing's integrated road transport system development:*** The development of the transport system in Beijing focused on reducing continuously worsening traffic conditions and improving the commuting situation. The integration involved concerted action through coordination among various government agencies. The objectives have been to improve urban transport efficiency, promote socio-economic development in the city,

make land use development more efficient, create a good transport environment and combine parking fees with transport management. In practice, three major plans of action have included (a) an extension of the road infrastructure that included ring roads, several throughway corridors, distributing backbone roads, sub-arterial roads and spur tracks; (b) improving the parking management system by increasing and differentiating parking fees for different times and regions; and (c) establishing an intelligent transportation system, including a transportation control centre, a command and deployment system, a transportation monitoring system, a signal control system, a transportation induction system and a global positioning system (GPS) for traffic police vehicles. A "122" call-the-police system for traffic accidents and an automatic monitoring system for traffic violations were also introduced. These efforts have reduced traffic flow in central urban areas, reduced congestion and increased traffic management efficiency. The higher parking fees have also increased revenues (*Case A51*).

Car use reduction

- ***Singapore adds quantity measures to initial reliance on incentive measures alone:*** Displaying foresight, the leaders of Singapore imposed demand management policies – such as usage and ownership measures to avoid the effects of vehicle growth in a land-scarce city state – as early as 1974. When the initial incentive measures – including vehicle ownership measures, taxes, registration fees and excise duties – proved inadequate in restricting growth at a sustainable pace given the country's road infrastructure, Singapore, in 1990, introduced a quantity measure – the vehicle quota system (VQS), along with a supporting mechanism, the Certificate of Entitlements (CoE) – for which each potential vehicle owner had to bid under specified categories of vehicles. The VQS/COE success (in reducing vehicle growth to three per cent per year) depended on continuous assessment and refinement, technical feasibility studies, economic affordability estimates and a transparent and impartial bidding process. Meanwhile, the existence of a relatively inexpensive and efficient public transport system resulted in public acceptance of restrictions (Case A7).

- ***Congestion charge makes a difference in London:*** Road pricing to address congestion was pioneered by Singapore as early as 1975. Since then, technological advances enabling electronic road pricing (ERP) and Mayor Ken Livingstone's determined implementation of congestion charges in London have popularized these measures. The charges were applied to a clearly defined zone of central London and encouraged car users to choose other forms of transport. Benefits experienced by the city included: traffic entering the zone decreased by 21 per cent, cycling increased by 43 per cent, accidents and key traffic pollutants were reduced and public transport accommodated many displaced users of private cars. Following the success of the scheme, public and other stakeholders were consulted on improvements, and charges were styled as CO_2 charges by encouraging

drivers to travel with vehicles emitting lower levels of CO_2 and discouraging the opposite scenario. The congestion charging zone was also extended *(Case A2)*.

- ***South Korea experiences some difficulty in countrywide extension of congestion pricing:*** With a policy of combining road railway networks, vehicle-related taxation, congestion pricing, parking fees and private car-use restraints, Seoul experienced positive results. By enacting a congestion toll (and collection ordinance) on private vehicles carrying only one or two persons in the central business district, the city authorities learned that (i) it was possible to influence transport demand and choice by levying a congestion charge and (ii) when average traffic speed is increased because of a reduction in congestion and toll booths are used for charge collection, there is no net increase in travel time. Through selective road pricing on a few roads, South Korean authorities were able to reduce traffic on the entire road network. The lessening of congestion reduced fuel consumption and emissions from hydrocarbons, carbon monoxide and carbon dioxide. However, in spite of employing several complementary measures, such as raising awareness, capacity building programmes and spreading information to ensure public acceptance, the extension of the policy to other cities has met public opposition, because citizens consider congestion pricing to be double taxation *(Case A3).*

- ***Bonus rebates in France for buyers of new vehicles with low CO_2 emissions:*** France introduced consumer-directed incentive measures in the form of bonus rebates for buyers of new vehicles with low CO_2 emissions and ecopastille (penalties) for buyers of high-emission vehicles. The bonus level depends on the level of emissions, with a maximum allowable of 130g of CO_2 per square kilometre. The agency of environment and energy management provides information for buyers about the programme. The bonus for vehicles emitting under 100 grams is five times more than the old maximum, and there is a super bonus for scrapping old vehicles at the time when new vehicles are purchased. This policy succeeded in integrating CO_2-reducing incentive measures with car registration procedures *(Case A16).*

- ***Singapore's area licensing system since 1975:*** Singapore introduced the Area Licensing System (ALS) in 1975 which, to reduce congestion, included a cordon pricing system designating the central business district (CBD) as a restricted zone for the purpose of road pricing. The scheme required advanced purchase of a licence to enter the zone during morning peak hours. At the 22 entry posts that isolated the zone, verification took place and non-compliance resulted in fines via mail. Public parking charges were raised and additional surcharges levied on private parking operators to discourage car use. ALS implementation has played an important role (i) in keeping the inbound traffic volume in the CBD less than it was before implementation three decades ago; and (ii) in maintaining the environmental impact from transport at acceptable limits *(Case A8).*

- Sapporo's travel feedback programme: After trying several travel demand management measures without substantially reducing traffic, the Hokkaido Development Engineering Centre developed a (TFP) Travel Feedback Programme in Sapporo. This was an example of internalizing environmental costs through local education. The programme included regular meetings with local communities based on family tracking of vehicle use and feedback in classroom lectures about the levels of CO_2 emissions recorded in diaries. The TFP model resulted in significant behavioural change with possible long-term effects, given the availability of alternative modes of transport (Case A 24).

- ***Car-free days: Seoul uses incentives with the public and private sectors joining hands:*** Seoul enacted a "Weekly No-Driving-Day Programme", incorporating incentive measures for the public and private sectors, rather than banning cars on car-free days as many cities have done. The programme had a 30 per cent participant rate, resulted in a 12 per cent reduction of emissions, a 7 per cent decrease in traffic and an increase of 13 per cent in operating speeds. It also resulted in fuel cost savings of US$600 million and reduced particulate matter PM_{10} by 3.5 mg/m. Proposed by a NGO, the programme involved citizens voluntarily choosing one weekday as a no driving day, with participants receiving a set of information, including an e-tag and stickers. The NGO campaign was enhanced by incentive measures that (i) resulted in a 1-6 per cent discount on gas prices and (ii) a ten per cent discount on car maintenance costs and free or discounted car washes. The public sector benefited from a five per cent reduction on auto-taxes, a 50 per cent discount on congestion charges and a 10-20 per cent discount on public parking fees. An innovative transport (IT), which registered the individual choice of a car-free day was also helpful *(Case A20).*

- ***Fukuoka launches a multi-stakeholder initiative in car sharing for reducing CO_2 emissions:*** The creation of new markets is an important policy instrument, and this occurred in a multi-stakeholder initiative launched for car sharing in Fukuoka city on Kyushu Island, Japan. A car sharing initiative became a Car Sharing Network (CSN) or NGO. It was created by the joint action of the West Japan Ecology Network (NGO), the city authority and an electric power company. The CSN succeeded in attracting frequent media attention from newspapers, local television stations, news magazines, etc. It started buying power generated by wind, which is reportedly the first example of this in any car sharing venture. Social acceptance is essential for such a system which, in turn, is enhanced by a good mix of vehicles having lower emissions, flexibility in driving range and efficient car passenger capacity. The CSN established effective partnerships with the local community to decide on participation in the car sharing rides. For those who generally drive short distances, there is a significant economic benefit to car sharing: for example, almost 30,000 yen per month can be saved by switching from an individual car to the HyperMini used in the CSN. Moreover, a Green Power Certification system was employed as an incentive to encourage corporate and other customers to use renewable energy as a voluntary measure to improve energy conservation and environmental protection *(Case A21)*.

Public transit

- ***Bangalore overcomes perennial losses in running its bus service:*** Using a combination of fleet modernization, augmentation of service, revenue mobilization, fare policy and cost-minimization measures, Bangalore created a programme relying on regulatory instruments to counter the perennial problem of incurring substantial losses in providing bus service. The Bangalore Transport Service was reformed and restructured by creating the Bangalore Metropolitan Transport Corporation (BMTC). Along with this restructuring, BMTC undertook fleet modernization to augment the service, created revenue mobilization measures, provided effective fare policies and introduced cost-minimization measures. The programme has contributed to the reduction of private vehicle use and the improvement of air quality *(Case A13)*.

- ***Ann Arbor, Michigan, USA bus pass programme reduces car use by ten per cent:*** The high price of car parking space, combined with significant growth in traffic congestion in the downtown area, led the city of Ann Arbor to establish a bus pass programme that resulted in a 10 per cent reduction in downtown car use, US$200,000 of annual savings in fuel costs and a 734 ton reduction of greenhouse gas emissions per year. The programme, termed *get Downtown*, involved municipal, government and environmental institutional partners for its financing and development. During the first two years, it offered free unlimited-use bus passes, called *go!passes*, to all downtown employees. Later, the passes were offered to downtown businesses at cost, and the remaining cost per pass was subsidized by the Downtown Development Authority. A complementary regulation that requires employers to provide all full-time employees with go!passes is also being implemented. Moreover, the Ann Arbor Transportation Authority (AATA) began the process of converting its entire bus fleet to hybrid electric technology when it introduced its first 15 hybrid electric buses in October 2007 and an additional five in March 2008. The use of hybrid electric buses strengthens AATA's commitment to protecting the environment by consuming less fuel and emitting fewer pollutants *(Case A38)*.

- ***Bangkok's van transit service works as ride sharing contributes to reducing traffic congestion:*** The van transit system of the Bangkok Metropolitan Region, provided by private operators and supported by customer fares with no government funding, created a new means of transport for Bangkok and has proved to be efficient and effective in terms of cost and energy savings. Initially begun to meet the needs of travel between the centre and suburban areas, as well as to those of highly congested areas, it became so popular that the number of vans increased from a few hundred to around 8,300 in nine years. In 2004, approximately 800,000 people used the van service per day. The system has played an important role in promoting ride sharing in congested areas and has attracted a large number of private operators to help reduce traffic congestion *(Case A39)*.

- ***Institutional, technological and financing innovations and Beijing's MRTS:*** Beijing's integrated public bus, subway and light railway systems as it focused on creating a Mass Rapid Transit System (MRTS) for hosting the 2008 Olympics. Key features of the programme were international bidding for construction, public involvement in price-setting and the introduction of private sector competition in the provision of public transport. Institutional and technological innovation and innovative financing offset the problems caused by high construction costs and substantial investments. The impacts of the programme included improved air quality (from gradual reduction of NOx and CO in spite of a gradual increase in vehicles), reduced downtown traffic congestion, reduced oil consumption and economic development along the MRTS line *(Case A40)*.

- ***Jakarta uses BRT to reduce the use of private cars:*** Chronic public transportation problems spurred action that led to the creation of TransJakarta, Asia's largest bus rapid transit system (BRT) and one of the first in the region. Before TransJakarta came into operation, public transport in Jakarta was highly unsatisfactory with no orientation to comfortably serve users. An old fleet, along with the questionable attitude of public bus drivers, as well as persistently ubiquitous congestion, triggered an increase in private car users and a constantly degrading urban air quality. A crucial decision of Jakarta's Governor Sutiyoso, amid strong resistance from private car users, was behind the success of the BRT's busway development. Analysts consider the BRT to be a good candidate for adoption by developing countries, due to its lower costs in comparison with similar mass transit systems. Other than the command and control (CAC) measures employed in establishing the system, complementary instruments used included financing for improved infrastructure, fines and penalties for vandalization, increased bus capacity and numbers, more compressed natural gas (CNG) stations and improved bus ride and station facilities and feeder systems. Providing special buses for women also contributed to TransJakarta's image. Early evidence showed that 14 per cent of passengers shifted from private cars to the system. This may be an underestimate since, in the absence of BRT, more residents would likely have purchased cars. Expected impacts include improved equity in transportation services, reduced traffic, improved air quality, reduced travel time and increased life spans *(Case A42)*.

- ***Bogota's BRT operation funded entirely by fare collection:*** Bogota opted for bus rapid transit (BRT) due to its cost effectiveness in comparison with a railway system. BRT is managed by TransMilenio, a public-private partnership. Design, planning and investment for its infrastructure was carried out by public institutions, such as the mayor's office, while operations are overseen by private entities, such as trunk line operators and fare-collection concessionary feeder bus operators. Other planning, road and transportation agencies are key partners. The system incorporates a sustainable private participation plan. Although it is bus-based, the system's operation is similar to that of a rail-based system. It is funded entirely by fare collection and no subsidies are provided. A single flat-fare pricing system and organizational arrangements supported by a ticketing system, among others, are the instruments that contributed to the success of the BRT. It is reported that benefits have included a reduction of 93

per cent fatalities from traffic accidents, 40 per cent of some air pollutants and 32 per cent of passenger travel time (Kyoon-Lee, Myung 2003) *(Case A43).*

- ***Dar es Salam receives crucial ODA support for its transition to BRT system:*** While Daladalas (12-seater small buses) served a duel role in Dar es Salam's transition from public to private transport service, proliferation of their number has increased traffic congestion which, in turn, has made Daladalas slow and less attractive. The operators did not make any reinvestment to improve the service because of low profitability. Consequently, as is the case with most bus services in developing countries, Daladala service is based on "second-hand vehicles that are overcrowded, unsafe, uncomfortable and fuel inefficient". In these circumstances and with the accompanying menace of increasing carbon emissions alone from the transport sector, Dar es Salam's transport authorities decided to opt for a BRT system. The United Nations Environment Programme (UNEP) and the Institute for Transportation and Development Policy (ITDP) have been supporting the city in pilot demonstrations with a 10 km BRT trunk line and an additional 100 km of feeder lines to the BRT system. The decision to opt for BRT has been timely. Because the Daladala's service has become obsolete, the emergence of BRT was a logical choice. In its absence, citizens' propensity to individually own cars would continue to increase. The vanguard role of ODA through UNEP and ITDP has been pivotal in providing technical assistance for developing the project and exploring funding support for its implementation (*Case A 53*).

- ***Beijing finances investment for public transit and creates disincentives for car use:*** Beijing's strategy of substituting for private travel involved building mass transit (intra-city transport and rail transport systems) and creating disincentives to car use by increasing parking fees, especially in central areas. The parking fee increase had an impact on car use. Diverse sources of funding – including domestic loans, foreign investment bonds, revenue from the local market, earmarked taxes, fees based on a beneficiary-pay system and a policy of requiring residential developers to improve the transport infrastructure in the vicinity of their developing areas – increased financial resources and reduced costs. Another significant financing policy involved allowing the private sector and foreign enterprises to invest in the transport infrastructure, formerly a monopoly of the public sector *(Case A12).*

Free/low emissions travel modes

- ***An encouraging bikeway programme in a Philippine city:*** The success of the Marikina Bikeways Network, relying purely on planning and persuasive measures, created a so-called win-win programme for environmental improvement by settling an on-going issue between illegal settlers and the city authority. The authority considered that illegal settlers were degrading the city's image and creating environmental problems, which, in fact, was due to the immigrants' powerlessness to receive appropriate services from the authority,

e.g., electricity, water and waste collection. Mayor Fernando, after relocation of the illegal settlers satisfactorily and conversion of the area into a pedestrian-friendly environment, then created another useful project. This was a river rehabilitation programme with ten kilometres of jogging bikeways built along the Marikina River, involving the recovery of 220 hectares of public space formerly occupied by the settlers. This was then developed into theme parks and playgrounds. Factors that contributed to the success included the city's integration of the bikeway construction with its regular road improvements or widenings; bicycle safety education; information, dissemination and advocacy campaigns; continuing recovery of all public places to increase mobility and green spaces; and a Global Environmental Facility (GEF) grant *(Case A4).*

- ***Bangkok launches a walking street programme:*** The walking street programme in Silom Road, Bangkok is an example of how one city tried to promote a pedestrian-friendly environment. To counter the notorious image of Bangkok as a pedestrian-unfriendly city, a pilot programme in a heavily congested street was initiated. The concept has since been extended to other Thai cities – Pattaya, Nakhonratchasima, Phuket, Nakhonpratom and Chiang Mai. The objective of the programme was to improve urban air quality by setting aside part of the city as a walking street. There was no particular instrument used in the programme except a campaign to appeal to citizens' ethical and moral sense. Unfortunately, however, community education alone could not sustain the programme over the long-term due to the lack of strong commitment from the authorities and inadequate traffic planning. Nonetheless, citizens realized that without cars the local urban air quality improved – a significant lesson learned from this case. Despite its being discontinued, the walking street programme helped to improve the quality of life and, during its implementation, increased the earnings of communities located along and near the Silom Road. The case reveals that a well-designed traffic plan must be adopted before closing any street for public use. In addition, the authorities need to ensure that there is the requisite political will to support these programmes *(Case A 22).*

- ***An Africa-wide initiative for cycling out of poverty:*** This initiative seeks to "make a world of difference in Africa with a bicycle". Since its initiation in 2006, it has incorporated partner organizations in six African countries – Uganda, Kenya, Rwanda, Ghana, Togo and Burkina Faso – and has launched 17 projects centered on using the bicycle as a means of coming out of poverty. Although no source other than the organization's own could be traced for evaluating this initiative, it appears that several theoretically sound and practically feasible ideas have made this initiative spread to several African countries. These ideas include fostering the positive aspects of the poverty-environment nexus; micro-finance; and utilization of underemployed labour/entrepreneurs, particularly women. The project shows that even small support from a developed country can bring tangible changes to promote an emissions-free transportation mode. In this instance, bicycle use has utilized the informal labour sector and enterprises in African developing countries (*Case A 54*).

4.2 Reducing emissions

Cleaner fuel

- ***Mexico increases the gasoline price and makes CNG the least expensive fuel:*** Mexico City, with funding from the World Bank for the achievement of Millenium Development Goals (MDGs), embarked on a comprehensive transport air quality management project using demand and supply measures. On the demand side, gas prices were increased to make unleaded gasoline competitive, while on the supply side, vehicles were retrofitted to run on compressed natural gas (CNG), and existing taxis were replaced by more efficient models that ran on clean fuels. CNG was made the least expensive of all the available fuels, and clean fuels were generally encouraged. With fine-tuning over time, the project improved air quality and had a favourable impact on emissions *(Case A29).*

- ***Shift from leaded to unleaded gasoline, Thailand:*** The shift from leaded to unleaded gasoline in Thailand demonstrated the comprehensive use of three environmental management measures. The government introduced regulatory measures to reduce the lead and sulphur dioxide content of fuels over a period of time. In 1993, unleaded gasoline was introduced, and in 1996 all types of leaded gasoline were completely phased out. From 1993 to 1999, the sulphur content of diesel was also significantly reduced. Suasive measures were utilized by making information available in both the print and TV media. This public awareness campaign led people to accept the use of unleaded gasoline. When unleaded gasoline was introduced, economic measures were put in place to make the price of it favourable compared to leaded gasoline, which was still available during the transition period. This was done by increasing the tax on leaded gasoline, an example of internalizing the cost of pollution. The combination of regulatory, economic and persuasive measures led to a relatively quick switch in use from leaded to unleaded gasoline, particularly in Bangkok *(Case A27).*

- ***Vietnam simultaneously used all three sets of EMM to switch from leaded to unleaded gasoline:*** Vietnam's quick success in switching from leaded to unleaded gasoline can be traced back to the interplay of regulatory, persuasive and economic measures. After an earlier failed attempt to eliminate leaded gas through transport-related regulation, the Canadian International Development Agency (CIDA) sponsored a workshop focused on alleviating fears about the possible high cost of switching to unleaded fuel for the large number of vehicles that would be inoperative when this fuel was introduced. The workshop was attended by members of the media and this, along with follow-up activities, changed the public's view so that, in 2000, the prime minister issued a directive for the switch to unleaded gasoline. Economic measures to follow up the regulation involved a subsidy for importing unleaded gasoline and taxes on imports of octane used by domestic fuel refineries. Suasive measures included dissemination of information prior to the fuel switch *(Case A30).*

- ***China adopts Shanghai's alternative fuel vehicles:*** Official documents and presentations make it clear that China has an interest in learning from other countries. This is reflected in Shanghai's use of alternative fuel vehicles (AFVs). The Shanghai government organized a programme to study the use of liquefied petroleum gas (LPG) and compressed natural gas (CNG) in other countries before adopting them for use in Shanghai. By 2000, 70 LPG service stations had been built and around 1000 existing buses were reconstructed as LPG or CNG vehicles. The city aims to rebuild all public buses and taxis in the same way. The success of the programme was due largely to the following: learning from other countries' experience; the use of R&D for AFV development; the use of incentive measures (investments, loans, taxes, pollution fees) to promote AFVs; establishing organizational arrangements; and using regulatory measures for safety and standards. The guidelines for AFV development and the incentive measures used for their promotion were carefully prepared "according to the rules of a market economy with no monopoly or vicious competition" (Yu and Jiang, 2003, p. 2) *(Case A11).*

- ***Delhi CNG programme follows a Supreme Court mandate:*** A writ petition filed in 1985 by environmentalists challenging the inaction of the government of New Delhi in combatting the causes and impacts of air pollution led to the Supreme Court of India handing down its landmark decision requiring a massive air pollution control programme for the city. The Delhi CNG programme is an example of a successful transformation to CNG in phases. While there is controversy about the extent of improvement in Delhi's air quality, the peak levels of various air pollutants have clearly come down. The average levels have also stabilized despite an increase of more than 200,000 vehicles in the city. Mumbai also pressed ahead with a programme to use CNG vehicles (Parikh 2002). Initially, the deadline for CNG buses in Delhi was met by public buses, not private operators. This led to the court ordering fines for diesel bus operators which, in turn, stimulated a significant increase in private CNG buses and a demand for private bus conversions to CNG use. Since then, the development of the CNG refueling infrastructure has gained momentum. The penalty provisions, a better CNG refueling infrastructure and associated safety measures all proved to be key to the breakthrough in New Delhi. The city found that to effect a large-scale change in the CNG vehicle fleet was possible within a short time if incentive measures, sending consistent messages, building public opinion and acting simultaneously on vehicle conversion and infrastructure improvements were used *(Case A14)*.

- ***Calgary makes its wind-powered commuter train a reality by involving private companies:*** The City of Calgary's "Ride the Wind" initiative, using wind to power the city's light rail mass transit (LRT), took off after the initial electric powering (from former coal and natural gas fuel) of the system began to work. Vision Quest, a power generation and wholesale marketing company, entered into a contract for green energy with Enmax, which, in turn, entered into an agreement with City Transit to deliver wind power to the LRT. All emission reduction credits were transferred to City Transit via Enmax, and ten new wind turbines were financed, constructed, owned and operated by Vision Quest.

Before the switch to wind power, the Calgary C-Train's energy supply resulted in around 20,000 tonnes of greenhouse gases and other air pollution emissions being emitted every year, less than 1/10 of the pollution that would have resulted if all C-Train passengers had driven in their own cars. Under the Ride the Wind programme, these emissions have been reduced to practically zero. This makes the C-train one of the most environmentally friendly forms of transportation. The project also contributed considerably to solving traffic problems. There are a total of 116 light rail vehicles in the system, and each day riders board the C-Train 189,000 times. If each commuter had travelled alone in his or her car instead of on the C-Train, the daily mileage would have amounted to 1.2 million kilometres *(Case A25).*

- ***China incorporates a fuel cell initiative in its high technology development programme:*** China's renewable energy law came into effect on January 1, 2006. Some measures have been introduced to apply the law, including a priority given to public transportation development in urban and renewable energy development programmes. Additionally, fuel-cell systems, fuel-cell sedans and city buses were listed as "High Technology Developments" in its five-year plan (2001-2005), and the Beijing Hydrogen Refueling Station for the Demonstration for Fuel Cell Bus Commercialization in China was set up at Beijing's Hydrogen Park *(Case A6).*

Greener vehicles

- **Hybrid technology cars and trains**

  - *Japan's hybrid technology cars:* Japan is pioneering the use of diesel electric hybrid trains for commercial service after its success with hybrid cars. In a hybrid train, the batteries are recharged when the train slows down. After the power is switched off, the motors continue to turn for a time, and the energy — wasted in a non-hybrid train — is used to recharge the batteries. The Japanese policymakers extended the hybrid concept to light duty vehicles. Several automakers have begun to produce hybrid vehicles, because of their greater economy of fuel use and lower emissions compared to conventional internal combustion engine vehicles (ICEVs). The obvious advantages of using hybrid cars are that they save gasoline and emit lower toxic emissions in comparison with conventional gasoline-powered cars. In some countries, users can also enjoy tax benefits from using hybrids. Another advantage is the improved environmental safety of the electric batteries used in hybrid vehicles.

  - *Toyota Prius:* The Toyota Prius is a hybrid electric mid-sized car developed and manufactured by the Toyota Motor Corporation. The Prius first went on sale in Japan in 1997, making it the first mass-produced hybrid vehicle. It was subsequently introduced worldwide in 2001. The Prius is sold in more than 40 countries, with its largest markets being those of Japan and North America. According to the United States

Environmental Protection Agency (EPA), the 2008 Prius was the most fuel-efficient car sold in the U.S. The UK Department for Transport says the Prius is tied with the Mini Cooper D as the third least CO_2-emitting vehicle in the UK.

- *Honda Insight:* The Honda Insight, a two-seater, uses hybrid engine technology, optimized aerodynamics and a lightweight aluminum structure to maximize fuel efficiency and minimize emissions. Introduced in 1999, the Insight was the first mass-produced hybrid automobile sold in the United States, achieving 70 miles per U.S. gallon. Honda sold 2,000 Insights in 2005. The company is to introduce a new small hybrid-specific car – a hybrid version of a Honda Fit or similar – and to discontinue production of the Insight.

- *Kenworth hybrid truck:* Kenworth Truck Company introduced a hybrid-electric truck in March 2007 called the Kenworth T270 Class 6. "During steady driving conditions above 30 mph, the T270 hybrid operates like a standard diesel vehicle with all power coming from the engine. Below 30 mph, it uses a combination of diesel and electricity. The system automatically switches between the two modes of operation", reports Kenworth's chief engineer. Since 2007, Kenworth has produced medium-duty hybrid trucks for municipal fleets and utility companies and has had full-scale production from 2008. The goal for the T270 hybrid was to improve fuel economy by 30 per cent in start-and-stop applications, such as those used by utility trucks and pick-up and delivery vehicles. At the end of August 2009, the company came out with another innovation: the Kenworth T470, which is available with extra horsepower. The company says that buyers of this model can now purchase the truck with the 9-litre Cummins ISL engine with 365 horsepower and 1,250 pounds-feet of torque. Previously, the truck was available with only the Cummins ISL with 345 horsepower and 1,150 pounds-feet of torque. Fuel economy from the T470 is higher than that of the T270 *(Case A45).*

- ***Tata's Nano Car: concern about the trade-off between the "people's car" image and energy efficiency:*** Tata, India's largest automaker, introduced its new "energy efficient" vehicle, the "Nano Car", in 2008. The vehicle's high level of fuel efficiency also ensures that it has low carbon dioxide emissions, thereby providing the twin benefits of an affordable transportation solution with a low carbon footprint. The "people's car" image comes from its price of US$2,500. If the Nano Car is a success, however, this implies that millions more new cars will be on Indian roads in the years ahead. Such a massive increase in number of cars is likely to offset per vehicle fuel efficiency. Consequently, the concern is about total CO_2 emissions from the expected mass-scale use of the Nano *(Case A44)*.

- ***"Hybrid only"' parking in Suffolk, New York, USA to promote the use of green vehicles:*** The New York state county of Suffolk, in seeking to provide incentives for efficient transportation choices and to promote fuel conservation, introduced preferential parking for hybrids. The county announced legislation to designate "hybrid only spaces" in county office buildings and county-owned facilities. Suffolk's legislator, Wayne Horsley, initiated this process, termed The Green Spaces Initiative. In doing so, he enhanced the already existing parking spots for fuel-efficient cars operated by private businesses and followed the adoption of similar parking programmes in other U.S. cities (e.g., Los Angeles). Although this is only an indirect measure to promote green vehicle use, it does suggest that manufacturing green vehicles is expected to increase *(Case A46).*

- ***Beijing's programme to transform vehicles for alternative fuel use:*** In 1998, the Beijing government conceded that air pollution had resulted in significant environmental degradation, and it undertook a project to introduce alternative low-emission fuel vehicles. Beginning with the greatest polluters — buses and taxis — the government embarked on a programme of conversion into alternative fuel vehicles (AFVs). As a result of the programme, the number of natural gas vehicles (GNV's) and Liquefied Petroleum Gas (LPG) buses has been steadily rising. Thousands of taxis have been modified to become bi-fuel cars. To achieve its targets, the authorities emphasized the construction of CNG and LPG stations, development of single fuel (LPG) vehicles (mainly taxis) and the development of new CNG buses. Although in recent years the total number of vehicles has increased rapidly in Beijing, the concentration of NOx and CO has not correspondingly risen. In fact, the concentration of these pollutants dropped by 16.4 per cent and 21.2 per cent, respectively, in the three years since the start of the programme *(Case A48).*

- ***Two-stroke to four-stroke motorcycles in Thailand:*** To encourage the use of the more fuel-efficient four-stroke motorcycles in Thailand, particularly in Bangkok, the city administration, the Bangkok Metropolitan Administration (BMA), adopted emission standards accompanied by institutional arrangements, stakeholders' participation and awareness/capacity-building programmes. The shift from two- to four-stroke engine motorcycles reduced the rate of major urban air pollutants. As one consequence, in recent years there has been a sharp rise in four-stroke motorcycles sales in Thailand. Strict enforcement of the standards has made this regulatory measure successful *(Case A47).*

- ***Kathmandu introduces electric three-wheelers to replace diesel vehicles:*** Since 1999 in the Kathmandu Valley, the domination of the streets by heavily polluting diesel-based three-wheelers has started to come down with the introduction of zero-emissions electric three-wheelers. This was preceded by unprecedented social pressure culminating in policy and technological debates and filling the policy and innovation gaps between prohibition and practice. Although public awareness and pressure from NGOs existed prior to the street protests and blockades of 1999 (in which local artist groups, clubs and activists took part), the government's 1992 ban of the polluting but popular three-wheelers had remained largely ineffective due to the absence of incentives for owners to

abandon their vehicles. In 1999, following the movement's peak and significant media coverage, incentives for owners were incorporated into the national budget in the form of a 75 per cent customs holiday on the import of 12- to 14-seater public transportation vehicles. Meanwhile, the industry made some effort to use local technology to replace expensive imported technology, thereby reducing the cost of batteries. The Kathmandu Metropolitan's earlier initiative in partnering with the US-based NGO, the Global Resources Institute, resulted in a demonstration project, which convinced the private sector, the public and the government of the plausibility of a new industry. The support of the Danish Agency for Development Assistance (DANIDA) and the United States Agency for International Development (USAID-US-AEP) played a vanguard role in enabling national policy makers to take action. This case has shown the value of civil society initiatives, demonstration projects and integrating different stakeholders' needs and capacities to create the necessary space and momentum to bring about change *(Case A49).*

- ***Electric trolleybus system in Quito, Ecuador made a reality by emphasizing financing and cost recovery:*** The electric trolleybus system was chosen in Quito, Ecuador as the most cost-efficient and sustainable transport solution compared with other alternatives such as metro and light rail train (LRT). The system was chosen to address the problem of increasing population demand on public transport and the consequent environmental impacts. The effective roles of the Municipality of the Metropolitan District of Quito, Operating Unit of the Trolleybus (UOST), the Municipal Transportation Bus Company and the Transportation Planning and Management Unit were key to the success of the system. This project would not have materialized without financial assistance from the Spanish Development Fund and the Spanish Banco de Bilbao Vyzcaya. The operation and maintenance costs were entirely covered by fares endorsed by the municipality *(Case A26).*

Vehicle emissions control

- ***EU switches from largely voluntary commitments to a comprehensive set of measures for reducing CO_2 emissions from cars:*** The EU's revised strategies for cutting CO_2 emissions involved a shift from largely voluntary commitments – awareness raising among consumers and promotion of fuel-efficient cars through fiscal measures – to a comprehensive set of measures to influence both the supply and demand sides of the EU market for cars and vans. The increase in the number of new cars on the road resulted in only limited progress towards the target of 2012, leading to new priorities focused on reducing car use and/or encouraging the purchase of new cars. The principal measures, announced in 2007, include (i) a legislative framework allowing the automobile industry sufficient lead time to adjust to regulatory change; (ii) the imposition of a target of 120g CO_2/km average emissions by 2012, based on improved motor technology and efficiency improvements for car components with the highest impact on fuel consumption (i.e. tyres, air conditioning) and a gradual reduction in the carbon content of road fuels through greater use of bio-fuels; (iii) more stringent emission

targets for vans; (iv) promotion of fuel-efficient vehicles through an amendment to the automobile labeling directive to make it more effective and by encouraging member states to impose road taxes based on CO_2 emissions; and (v) an EU code of good practice on car marketing and advertising to promote more sustainable consumption patterns *(Case A15).*

- ***China's regulatory system for fuel economy improvements: incentives provided to lighter vehicle manufacturers:*** China's strategy to achieve fuel economy improvements involves providing incentives to manufacturers that produce lighter vehicles. It is based on a stringent mandatory regulatory system centered on transmission type and weight, with a requirement that each individual model meet the target for each of the 16 weight classes *(Case A19).*

- ***Mexico City achieves improvements in air quality by a vehicle inspection and maintenance programme:*** Mexico City achieved improvements in air quality through a vehicle inspection programme that requires mandatory testing for vehicle emissions in the city. A new protocol permitted the use of tighter standards and reduced the number of false approvals through the use of an accelerated simulation model that resulted in more reliable test results. The Mexican experience shows that the comprehensive use of a staged (i.e., phased in) emission control programme encompassing various measures is required to progressively deal with vehicular emissions. The programme went through several revisions and evolved to reflect tighter standards, more reliable testing procedures and "days without a car". Aspects of the programme include a legal and regulatory framework allowing for independent monitoring of the testing stations, an easily monitored certificate for passing the test, testing technology capable of preventing temporary tuning and an optimal number of centres related to the volume of traffic to be tested *(Case A33).*

- ***Japan's vehicle emission control and the new green purchasing law:*** Japan's "Low Emission Vehicle Initiative" was based on a law that promotes green purchasing. The law, enacted in 2000, required vehicles used for administrative purposes in all ministries and agencies to be replaced with low-emission vehicles (LEV) by FY 2004. As a result, the LEV proportion of cars owned by governmental ministries and agencies accounted for about 73 per cent of the total of official cars. In this case, the public sector served as a role model in green purchasing, and the progressive increase in the introduction of LEV in the sector worked well *(Case A32).*

- ***Beijing combines standards regulations, technology and fiscal incentive measures in vehicle emission control:*** Beijing shifted from having no emission standards until 1998 to a series of standards and controls: regulations involving stringent tail pipe emission standards, as well as technology and fiscal incentives. Stringent regulations for disposing of older vehicles were also implemented. Through a vehicle classification system, vehicles were exempted from random inspections and were not allowed to operate when pollution is severe. Fiscal incentives included tax deductions for vehicles meeting enhanced emission standards (30 per cent on light-duty vehicles meeting EU-2 standards), while

technology supported the introduction of unleaded gasoline, as well as the retrofitting of gasoline-powered vehicles with electronic fuel injection equipment and three-way catalyst mechanisms *(Case A36).*

- ***Shanghai's vehicle emission control programme involves implementation of EU-1 standards:*** Shanghai responded to severe air quality degradation from tail pipe exhaust pollution by implementing strict emission standards and regulatory measures involving changing fuel-and-car-types, transportation planning, prohibitions against the most polluting vehicles and fuel and certification policies. These measures included the implementation of emission limits equivalent to the EU-1 standards; strengthening the monitoring and maintenance of current-use vehicles; promoting the elimination of old vehicles and prohibiting the operation of motorcycles; as well as controlling the total annual number of vehicle licences for private use and selling new licences by auction. Air quality control planning was based on an Air Environment Protection Plan consisting of revised standards, emissions testing, limits on the operation of heavily polluting vehicles, more clean-fuel buses and taxis and improvements in public transport. Transportation planning – comprised of a public transport first policy with corresponding policies involving planning, investment, taxation and management of vehicles – was also introduced. Rail transport (from new types of trolley cars to urban light rail) was promoted to make this mode the core feature of urban public transit. In addition, leaded gasoline was prohibited. A significant improvement in air quality was achieved in the city with a reduction of CO, HC and NOx respectively by 30, 50 and 50 per cent *(Case A37).*

- ***Novelty in U.S. fuel economy improvement system:*** One feature of the U.S. fuel economy improvement system not available in other countries having similar policies is the CAFE credit system, whereby manufacturers can earn credits if the average fuel economy of the models they produce exceeds the standards set for that particular year. Another noteworthy feature is that the CAFÉ standards provide special treatment for vehicle fuel economy calculations of alternative fuel vehicles, as well as of dual-fuel vehicles. The CAFE is the sales-weighted average fuel economy, expressed in miles per gallon (mpg), of a manufacturer's fleet of passenger cars or light trucks with a gross vehicle weight rating (GVWR) of 8,500 lbs or less, manufactured for sale in the United States in any given model year. The standards are set by considering the technological feasibility, economic practicability, effects of other standards on fuel economy and the needs of the nation to conserve energy. They were implemented gradually and made more stringent until March 31, 2003, when the National Highway Traffic Safety Administration (NHTSA) issued new light truck standards. When automobile manufacturers fail to meet certain standards in a particular year, they are fined US$5.50 per tenth of a mile per gallon for each tenth under the target value, times the total volume of these vehicles manufactured in a given model year *(Case A17).*

- ***Japan allows manufacturers to accumulate credits from fuel economy improvements:*** Similar to the U.S. CAFE standards, Japan set standards in 2001 allowing manufacturers to accumulate credits in one class of vehicles and

to use them for another weight class. Recently, the government proposed that carmakers increase the fuel efficiency of their cars by 23.5 per cent by 2015 under new regulations put forward by the Ministry of Transport and the Ministry of Economy, Trade and Industry. In Japan's weight-based system's regulations, vehicles must comply with standards based on the particular weight class they belong to. The results of this system include reduction of carbon dioxide emissions by about 19 per cent while producing the same calorific value; reduction of carbon monoxide by 65 to 90 per cent and of non-methane hydrocarbons (NMHC) by up to 97 per cent. Particulates were virtually eliminated, and ozone reactivity from natural gas vehicles (NGVs) is up to 80 to 90 per cent better than that from gasoline emissions *(Case A18).*

5. Suggested Ingredients of Policy Design to Motivate Changes

This report's contents suggest that to alter the less than optimal outcomes associated with ongoing efforts to reduce transport emissions, public policy and action programmes need to be based on a sound understanding that (i) behaviourial change is a central ingredientin maintaining sustainable transport mode choices by citizens; (ii) financing is essential in order to accomplish objectives (i.e., from creating pedestrian and bicycle ways to building mass transit systems); and (iii) incentive measures are an important means of influencing individual behaviour towards positive actions.

In varying degrees, all three sets of measures – regulatory, economic and persuasive – that have the potential to influence travel behaviour are being used, but rarely are they used simultaneously or in a concerted way. As a result, policy measures fail to comprehensively address all three elements influencing behaviour – fear of change, economic interests and moral and ethical considerations (Figure 3.5). Therefore, the scope for influencing behaviourial change has not been fully realized. When the concepts are applied systematically and in tandem, as in the cases of the successful change from leaded to unleaded gasoline in Thailand and Vietnam (Cases 27 and 30), the results have been highly positive.

A new generation of tools to change travel behaviour are in use in order to reduce CO_2 emissions. These essentially involve education, awareness and training**,** which are seen as key to effecting quantum leaps in emissions reduction. What is less well-known is the role of the physical infrastructure in influencing travel behaviour. For example, most developing countries' bus services are "overcrowded, uncomfortable, undependable, slow, uncoordinated, inefficient and dangerous" (Kashirsagar, Bhusan and Prakash 2008 p. 5). As a result, Local inhabitants frequently turn to car purchases and their use to offset in the disadvantages of travelling by bus. The cases concerning bus service in Curitiba and Jakarta (Cases 9 and 42) illustrate how investment in bus service has positively influenced travel behaviour towards BRT. Similarly, the walk and bicycle way cases (Case 4) illustrate that investment even in low-cost physical infrastructure can facilitate citizens' switch to the use of these highly desirable transport modes.

Arguably, the role of urban planning in changing travel behaviour is the least discussed and understood of all the means employed to reduce emissions. Unfortunately, neither urban planning education nor the profession of urban planning commands the role in influencing policy that economics, for example, commands. This has been even more evident since the 1980s when free market, signal-based individual, household and industry decision making has assumed an overwhelming dominance. Since then, the planning paradigm has been neglected. As a result, development controls, land use planning and zoning have lost political, hence, policy support, the consequences of which are manifested in suburbanization, urban blight and the growth of extended metropolitan regions (EMRs) around major cities. This perverse development defies the basic purpose of effective urbanization, namely to

make the city an agglomeration of high-density economic activities and compact living. This, coupled with the absence of mass transit, has made the automobile an essential mode of travel in developing country cities as opposed to its earlier use as a luxury item or a status symbol. Six cases presented in this report – urban planning and densification for reducing car use in Vancouver; employing urban planning paradigms by Curitiba with particular reference to its transportation system; restoring the Cheonggyecheon stream in Seoul; reducing parking spaces; the Marikina bikeways network in a Philippine city and the pedestrian malls in Singapore and several European countries – are examples of positive results that can be achieved, because each of these cases make substantial use of urban planning paradigms for reducing car use, hence, CO_2 emissions.

6. Conclusions

The increase in the use of private cars has long been a major concern for countries worldwide. The problems caused by the increase include the road space that cars require, the emissions they generate, their consequences for human health, their share of road accidents, their impact on the safety of walkers and cyclists and the fossil fuels they consume per passenger kilometre of travel. Since the Kyoto Protocol agreement on the reduction of greenhouse gases, a new dimension has been added to the list of problems associated with cars. This is their dominant position in road transport and their consequent contribution to CO_2 emissions. Nevertheless, the number of cars on the road continues to rise. It is predicted that they will increase by ten-fold from 2008 to 2050.

Taking account of these developments, this study, among other related issues, focuses on (i) understanding the circumstances under which individuals continue to make the choice of buying a car for urban mobility; (ii) analysing and explaining the reasons for the limited success of numerous public policies and actions to reduce emissions and a dependence on car use; and (iii) exploring the scope for influencing individual decisions to choose low-cost, low-emission transport (e.g., public transit) and free transport (e.g., walking and cycling) for urban mobility. Although the focus has been on exploring ways and means to influence individual behaviour, individuals in the study are understood to include, not only “citizens”, but also the policymakers and implementers in government and decision makers in the fuel and automotive industries.

Motivation guiding the report

This report was written to suggest the ingredients of policy design that can (i) create momentum to apply the positive changes underway globally (as reflected in the cases reviewed); (ii) contain the countervailing forces that facilitate the sale or purchase of automobiles (e.g., aggressive marketing by the industry for “people’s cars” and/or “reconditioned” cars (both of these strategies are aimed at expanding the market for lower- and middle-income groups) and the lending practices by financial institutions and employers directed at making automobiles affordable to customers and employees; (iii) promote the choice of low- or free-emission travel modes (e.g., transit, cycling and walking); and (iv) provide government support to industry for the purposes of innovating and applying emission control devices, clean fuel and green vehicles.

Two-pronged strategy

The investigation shows that theoretical discussions and public policy actions directed at private cars are now focused on reducing emissions in general and CO_2 emissions in particular. In this report, the ways and means of pursuing these goals have been grouped into two broad categories: (i) reducing transport demand and (ii) reducing emissions.

Reducing transport demand

To reduce transport demand, some of the actions now being used include: (i) employing urban planning paradigms such as land use planning, development controls and urban containment to restrict urban sprawl and suburbanization – all of these tools are expected to reduce travel and commuting distances; (ii) transport planning to facilitate accessibility and modal complementarity and to ensure adequate provisioning of green transport infrastructures, such as public transit, walkways and bikeways, so that low- or emissions-free travel mode choices by citizens become possible; (iii) integration of urban planning and transport planning to lead to a compact city development and a reduction of energy-intensive travel requirements; and (iv) reduction in car use by facilitating a switch to public transit or modes having similar emissions, as well as low or free travel modes.

Emission reductions

The actions taken to reduce emissions are largely technology-based. Public policies and actions are centered on: (i) vehicle emissions control; (ii) cleaner fuel; and (iii) green vehicles. Technological innovations are taking place directed at each of these three ways to reduce emissions; however, it should be emphasized that technology alone cannot solve the problems related to emissions control and climate change.

Regulatory, economic and persuasive measures

All three sets of policy instruments – regulatory, economic and persuasive – have been widely used to address the excessive use of automobiles and the means of controlling emissions. Commonly used regulatory measures include: (i) vehicle quota systems that control the right to vehicle ownership; (ii) mandatory fuel economy programmes; (iii) vehicle emissions standards; and (iv) area licensing systems. Economic and financial measures in use include: (i) congestion charges; (ii) road pricing; (iii) rebates/penalties based on low/high emissions of new cars purchased; (iv) increasing the gasoline price; and (v) reducing the price of cleaner fuels. Persuasive measures in use include: (i) car-free days; (ii) car sharing; (iii) walking and biking shows; (iv) community travel feedback programmes; and (v) education and awareness campaigns.

Lessons learned from useful examples

Whether regulatory, economic or persuasive measures are concerned, encouraging examples exist. In urban planning, these include: (i) Vancouver's densification strategy for reducing car use; (ii) Curitiba's urban planning that integrates transport planning; and (iii) pedestrian malls in several European countries.

In transport planning, Singapore stands out among Asian countries, because of the country's integration of transport and land use. Beijing's ''integrated road transport system development" is also drawing global attention. By financing investment for public transport, it has created disincentives for car use.

To achieve car use reduction, cases that offer useful lessons include: (i) Singapore's adding of quantity measures to initial reliance on incentive measures; (ii) the London mayor's determined action in levying congestion charges; (iii) France's bonus rebate scheme to buyers of new vehicles with low emissions; (iv) Singapore's area licensing system; (v) Sapporo's (Japan) travel feedback programme; (vi) Seoul's car-free days programme that also offers considerable financial incentives put together jointly by the public and private sectors; and (vii) Fukuoka's multi-stakeholder initiative in car sharing for reducing CO_2 emissions.

To promote public transit, the cases that offer interesting insights include: (i) Bangalore's (India) effort to overcome perennial losses in providing bus service by a combination of fleet modernization, augmentation of service, revenue cost mobilization, fare policy and cost minimization; (ii) Ann Arbor's (Michigan, USA) bus pass programmes that have reduced car use by ten per cent; (iii) institutional, technological and financing innovations that allowed Beijing to overcome the barriers to create its Mass Rapid Transit System (MRTS); (iv) Jakarta's Bus Rapid Transit (BRT) that has encouraged 15 per cent of car users to switch to this transit service; and (v) Bogota's BRT operation, entirely funded by fare collection.

Other than the cases in several European countries, free-emissions travel mode developments worthy of attention are: (i) Marikina Bikeways Network in a Philippine city made possible by a Global Environmental Facility (GEF) grant; and (ii) Bangkok's failed walking street programme, which suggests that the closing of any street for public use without a well-designed traffic plan and a public relations campaign should be avoided.

A number of emissions reduction initiatives centered on the use of cleaner fuels were in place when oil prices rose to unprecedented levels in 2008. But the collapse of the oil price towards the end of 2008 impeded technological innovation and the commercialization of alternative fuels (e.g., bio-fuel). Nevertheless, considerable positive changes that replace more polluting fuels with cleaner ones have been taking place globally. Examples include: (i) Mexico's commonsense economic policy of increasing gasoline prices and making compressed natural gas (CNG) the least expensive fuel (similar policies exist in other cities, such as Dhaka in South Asia); (ii) Thailand's and Vietnam's switch from leaded to unleaded gasoline by adopting all three sets of environmental management measures; (iii) Delhi's CNG adoption, made possible by a Supreme Court mandate; (iv) Calgary's making its wind-powered commuter rail programme a reality by involving private companies; and (v) China's adoption of an alternative fuel strategy marked by the country's tradition of learning from other country experiences.

Most countries have vehicle emissions control programmes. Among others, the following offer some lessons for strengthening this well-established route for reducing emissions: (i) the EU's switch from the initial reliance on largely voluntary commitments to a comprehensive set of measures to reduce CO_2 emissions from cars; (ii) China's regulatory system for fuel economy improvements that includes incentives for lighter vehicle manufacturing; (iii) Mexico City's air quality improvement

using a vehicle inspection and maintenance programme that includes a new protocol of emission controls encompassing the comprehensive use of different policy measures; (iv) Japan's use of its new green purchasing law for emissions control; (v) Beijing's combining standard regulations, technology and fiscal incentive measures; (vi) Shanghai's adoption of strict emissions controls that involve implementation of EU-1 standards; (vii) the USA's credit system that allows manufacturers to earn credits if the average fuel economy of the models they produce exceeds the standards set for that particular year; and (viii) Japan's following the American lead in allowing manufacturers to accumulate credits from fuel economy improvements.

Examples of the automobile industry's adoption of strategies to innovate and market green vehicles include: (i) hybrid technology cars; (ii) Tata's ''Nano Car" (promoted as "energy efficient" and a "people's car", but the latter image has obvious implications in terms of a significant increase in automobile ownership); and (iii) several cases of transferring from diesel vehicles into electric vehicles in different regions. In some instances, this switch has been possible because of donor support, e.g., in the case of Kathmandu, Nepal. The use of the electric trolleybus in Quito, Ecuador is particularly useful example for policy makers because of its adopting cost recovery as a tool of financing.

Changes of a more fundamental nature required

A serious analysis of the two-pronged strategies being utilized (i.e., transport demand management and reducing emissions) to reduce of automobile use and CO_2 emissions could justifiably make one optimistic about progress and prospects in this field. Success using these strategies also carries the potential to reduce urban mobility related stress – a daily experience for those living in cities. However, this potential is not going to be realized unless some fundamental changes occur in public policy formulation and implementation.

Inadequacies and failures

Nonetheless, analysis suggests that the results of public policy proposals and actions taken remain less than optimal, if not insignificant. The analysis in this report traces the following failures and inadequacies: (i) neglect of urban planning as if in a free market economy, planning paradigms have no role; (ii) failure to adopt comprehensive, environmentally sustainable transportation strategies; (iii) partial and piecemeal use of incentive measures without realizing the significance or value of using regulatory, economic and persuasive measures simultaneously; (iv) inadequate understanding of the motives behind car ownership use; (v) failure to utilize the full potential of changes and innovations in fuel and vehicle technologies; (vi) lack of appreciation of the substantial investments required to create a green transport infrastructure; and (vii) failure to attract the necessary investment funds because of a reluctance to allow cost recovery.

Need for international assistance and cooperation

Lessons from the experiences detailed in this report should help to overcome these inadequacies and failures. However, this will not happen without international assistance. The scope of the problems is too great for political leaders or policymakers, particularly in developing country cities, to undertake initiatives and actions without encouragement and support from international agencies, access to official development assistance (ODA), external capital markets and foreign direct investment (FDI). Support and cooperation should follow a logical sequence. International agencies need to take the lead in providing technical assistance (as they have traditionally done) and in disseminating learning experiences, new ideas and technological innovations. ODAs need to assume a vanguard role in demonstrating good practices (again a role they have traditionally assumed). More importantly, successful completion of these two phases should be followed by a flow of FDI in sufficient amounts to support a green transport infrastructure – from the construction of pedestrian ways to mass transit, particularly for the mega-cities of developing countries.

Crucial role of political leaders

For the changes above to be effective, politicians need to take a proactive role in informing citizens that their quality of life will be better, their property values higher and their transport-related expenses lower if they are willing to pay for public services in general and transit service in particular. Moreover, politicians need to devote more to these tasks and to discard the notion that they will lose elections if citizens are required to pay for good bus or train service. The culture of replacing a “natural” public service (transit) by an individually owned one (private cars) has reached harmful levels.

Hopefully, readers and users will find some insights in this report, not only for reversing climate change, but also for building less stressful and healthier lives by discarding automobiles or limiting their use to an absolute minimum. Individual citizens on their own, however, will not be able to do much if governments do not take action to implement effective solutions.

Appendix

Case Summaries and Lessons Learned

1. Urban planning and densification for reducing car use, Vancouver, Canada, 2007

In 2007, Mayor Sam Sullivan called on the municipalities of his cities, as well as senior levels of government, to open the debate on increasing urban density as a way to reduce dependence on car use in order to address global climate change. Speaking to Vancouver citizens, business people and those in the development, housing, social services, and the environmental community, he said: "We should be talking about how *better urban planning and densification* (emphasis added) of our cities can significantly reduce our impact on the environment."

The mayor's discussion of choices, among others, included the following:

- whether people wanted the city to take more advantage of streets and nodes well served by transit or areas located around Sky Train and the future Canada Line stations by increasing density significantly in those areas;
- whether the city should reduce its parking requirements for new developments, and if so, which type of developments;
- whether the city should require spaces for car sharing or electric plugs in new underground garages to promote the use of electric vehicles; and
- whether the city should establish car-free neighbourhoods.

The above initiative obviously relied on the good sense of citizens to start with. Subsequent policy measures, based on the feedbacks from citizens and businesses, will focus more on enforceability and effectiveness of the measures.

Source: Based on World Bank, *Climate Resilient Cities* (Washington D.C.: World Bank) (2008, pp. 83 – 84).

2. Congestion charges to reduce car use in central London

Although Singapore pioneered road pricing to address congestion in city centres as early as 1975, two events since then have contributed to popularizing congestion charges. These are (i) technological advances enabling electronic road pricing (ERP) and (ii) London Mayor Ken Livingstone's implementation of congestion charges in London.

The greater London (central zone) Congestion Charging Scheme was introduced in February 2003. Since then a number of variations to the schemes – dealing with the legal framework – have been made in order to make adjustments and improvements in its operation.

The scheme requires vehicles that drive within a clearly defined zone of central London between 0700 to 1800 hours on Monday through Friday to pay a £8.00 daily congestion charge.

The charge serves as an encouragement to car users to choose other forms of transport. Revenues from the charge are spent on transport facilities. Since implementation, London has experienced the following benefits:

- Traffic entering the original charging zone has been reduced by 21 per cent;
- There has been an increase of 43 per cent in cycling within the zone;
- There has been a reduction in accidents and key traffic pollutants; and
- Public transport has successfully accommodated displaced car users.

In February 2007, following the initial success of the scheme, the congestion charging zone was extended to the west.

Following consultations with the public and other stakeholders the mayor, from 27 October 2008, confirmed some variations in charges, styled as CO_2 charges, to:

- encourage drivers within the charging zone to travel in vehicles that emit lower levels of CO_2 ;and
- discourage the use of vehicles with high CO_2 emissions.

The principal aims of the charge remain: (i) tackling congestion, (ii) encouraging drivers to shift from private vehicles to public transport, walking and cycling and (iii) reducing greenhouse gases.

Mayor Livingstone's determined efforts, backed by the responsible citizens of London, are seen as the backbone of this policy's success and will provide for its continuation beyond his tenure as mayor.

Source: Based on Transport for London: About the Congestion Charge
http://www.tfl.gov.uk/roadusers/congestioncharging/6710.aspx

3. Traffic congestion pricing, Seoul, South Korea, November 1996

Most arterial roads in Seoul are heavily congested throughout the day. Building new roadways to an extent that they will mitigate the traffic congestion of Seoul is constrained by the lack of land and the high cost of construction. Consequently, the Seoul Metropolitan Government (SMG) has taken measures to reduce traffic congestion in the inner city and to shift the transportation modal choice in favour of public transportation by (i) expansion of road railway networks and (ii) vehicle-related taxation, congestion pricing, parking fees and private car-use restraints.

Starting in November 1996, SMG began to charge 2,000 won (about US$1.50) as a "congestion toll" for private vehicles carrying only one or two persons (including the driver) as they pass through the Namsan#1 and #3 tunnels, linking the southern part of the city to the central business district (CBD). The toll charges are collected on vehicles travelling in both directions per entry from 0700 to 2100 hours Saturdays and Sundays. National holidays are free of charge. The penalty for a violation amounts to 10,000 won (five times the regular congestion fee). Vehicles exempted from charges are private vehicles with three or more passengers, all buses, vans, taxis, emergency vehicles, handicapped persons' vehicles and diplomats', reporters, government office and ceremonial vehicles used for welcoming foreign guests.

Essential complementary measures included enactment of the congestion pricing collection ordinance and raising awareness and spreading information to ensure public acceptance of the new policy. A capacity building programme was also undertaken.

The lessons learned from the Seoul congestion pricing case include the following:

- It is possible to influence transport demand by using congestion charges;
- Through selective road pricing on a few arterial roads, a city can reduce traffic volume on the entire road network;
- Using toll booths to collect tolls does not cause a net increase in travel time when the average traffic speed is increased due to a reduction in congestion;
- It is possible to enhance transportation choices. Congestion pricing increases these choices by allowing citizens to consider additional transportation options; and
- Reduced congestion reduces fuel consumption as well as emissions of hydrocarbons, carbon monoxide and carbon dioxide. If overall trips are reduced, emissions of nitrogen oxides will also be reduced.

Despite these positive results, implementing this policy in other cities has been placed on hold because of public opposition based on the idea that congestion pricing represents double taxation.

Sources: Based on Yoon, S W (2003). Introduction of Traffic Congestion Pricing in Seoul, Korea. Institute for Global Environmental Strategies (IGES), 'Emission Control Measures in Beijing, China", "Good Practices Inventory", Asia-Pacific Environmental Innovation Strategies (APEIS), Research on Innovative and Strategic Policy Options (RISPO).

4. Marikina bikeways network: an encouraging local government programme in a Philippine city

Marikina, located about 21 kilometres from Manila along the eastern border, has become a bicycle-friendly city. This was made possible because of political commitment in the form of an initiative by Mayor Bayani Fernando and its continuation by Mrs. Fernando after she succeeded him as mayor. The success of the Marikina Bikeways Network is also said to represent a win-win scenario in that it evolved from a "river rehabilitation programme", an initial 10 kilometres of jogging paths and bikeways built along the Marikina River. This involved recovery of 220 hectares of public space formerly occupied by "illegal settlers".

The recovered area was then developed into theme parks and playgrounds. People began coming to the water to participate in the "celebration of the city's success in saving the Marikina River". The majority who came used bicycles. This led to the adoption of a pilot project for a non-motorized mode as an alternative and, in some instances, a complementary mode of travel to employment centres and LRT stations.

The city's initiative attracted the attention of the Global Environmental Facility (GEF). Their funding support led to a gradual implementation of the bikeways network. Currently, 52 kilometres of bikeways connect the city's residential areas to the employment centres, markets, schools, government service providers and to an LRT station.

The success of the Marikina Bikeways Network appears to have resulted from a combination of the following:

- the city's integration of the bikeways' construction into its regular road improvements or widenings (wherever feasible) and sidewalk/drainage improvement projects, complemented by consistent implementation of traffic rules and regulations;
- bicycle safety education, information dissemination and advocacy campaigns;
- continuing recovery of all public places to increase mobility and create green spaces; and
- a GEF grant that financed 19 kilometres of the current 52 kilometres of the bikeways network.

To overcome the common barriers to bicycle use, the city has also several supporting programmes. These include:

- a loan programme for city employees;
- bicycle safety information dissemination;
- sponsorship of annual cycling competitions and bicycle advocacy events to promote public enthusiasm for cycling as a sport and public support for air quality protection; and
- building more complementary bicycle facilities, such as better bicycle traffic flows and informative signage, innovative design on bicycle lane pavement markings and installing bicycle parking and bicycle stations to enhance bicycle trips.

Source: Based on the Marikina Bikeways Programme brochure, Marikina City Bikeways Office. Also see Harvard Kennedy School Ash Institute for Democratic Governance and Innovations, http://www.innovations.harvard.edu/awards.html?id=41311

5. Hydrogen fuel: outcome of an automaker's investment for sustainable mobility

Similar to sun and wind, hydrogen is a renewable source of energy. As part of a commitment to contribute to sustainable mobility and a clean environment, BMW's research and development (R&D) spending for hydrogen as a fuel has already reached the commercialization stage. For safety and convenience, BMW has created a two-tank fuel car so that drivers can switch from one fuel to the other by simply pressing a button on the steering wheel. To promote and popularize its use, the company has set up a whole range of hydrogen infrastructures from mobile fuel stations to workshops.

California has started promoting "clean hydrogen fuelled mobility". The state has built more than a dozen hydrogen refuelling stations of the 150 to 200 fuel stations planned by the year 2010. The typical distance between two fuel stations is 20 miles. This network is a joint project between the government and industry, with energy companies, carmakers and high-tech firms also playing a significant role.

Hydrogen fuel innovation reflects the growing commitment of automakers to make investments to support sustainable mobility and a clean environment. There is a sense that this is necessary for continued success in business.

Source: Based on BMW's brochures, *Clean Energy* and *Tomorrow's Solution Today, 2008.*

6. China's fuel-cell vehicle initiative

Total primary energy consumption in China in 2004 reached 1386.2 million tonnes of oil equivalent, accounting for 13.6 per cent of global consumption and making China the second largest consumer of energy in the world behind the U.S. (22.8 per cent). China is also the second largest emitter of CO_2, making up roughly 13 per cent of global emissions. Mindful of these statistics, the Chinese government has adopted a strategy of "sustainable development" and a policy of "energy saving production and an environmental friendly and resource-cyclic economy". A renewable energy law came into effect in January 2006. Some measures have been taken to apply these policies – for example the priority given to public transportation development in an urban and renewable energy development programme. Fuel-cell systems, fuel-cell sedans and city buses are listed as "High Technologies Development" in the five-year plan (2001-2005). Beijing's hydrogen refuelling station for the demonstration for fuel-cell bus commercialization in China was set up at the city's Hydrogen Park.

Source: Based on Hydrogen-Fuel Cell Vehicle Development in China (Jingguang 2006) retrieved on 17 September 2008 from:
http://www.un.org/esa/sustdev/csd/csd14/lc/presentation/hydrogen4.pdf

7. VQS as a quantity measure to restrict vehicle ownership

As a land-scarce and island city state, Singapore was made aware of the danger of uncontrolled private car ownership and usage very early. Heeding a 1974 comprehensive transportation study recommendation, the government undertook a combination of vehicle usage and ownership measures. Usage measures included (i) parking charges; and (ii) an Area Licensing Scheme (ALS, later Electronic Road Pricing (ERP). Steps to control ownership included (i) vehicle taxes, such as the Additional Registration Fee (ARF), and (ii) excise duties. These incentive measures, however, were inadequate to restrict vehicle growth at a sustainable pace in view of Singapore's road infrastructure.

With the above backdrop, in early 1990 Singapore introduced a quantity measure – a Vehicle Quota System (VQS). This was accompanied by a mechanism, a Certificate of Entitlements (COE), to obtain the right to own a vehicle. Under this system, each potential vehicle owner has to bid for a COE for a specified category of vehicle. This system has been used to restrict vehicle growth to 3 per cent per year.

Lessons from VQS experience include the following:

- Leaders must display courage and foresight in implementing demand management policies and instruments such as the VQS;
- Public acceptance of car ownership restrictions has been less problematic because of the availability of a relatively cheap and efficient public transport system comprising rail, bus and taxi services; and
- A VQS bidding process, if imposed, must be technically feasible, economically reasonable, easily understandable, transparent and impartial.

As a result of continuing assessment and refinement, VQS/COE remains a centerpiece in restricting vehicle ownership in Singapore.

Source: Based on Foo T. S. (1998). “A Unique Demand Management Instrument in Urban Transport: The Vehicle Quota System in Singapore”, *Cities*, Vol. 15(1), pp. 27 – 39 and Omar M. and Rahman N. A. (2006). Certificates of Entitlement (COEs). Commentary on Article Infopedia Talk Written on 04-07-2006 at National Library Board, Singapore.

8. Singapore's Area Licensing System

In 1975, Singapore introduced, the Area Licensing System (ALS) centered on road pricing to reduce congestion in the central business district (CBD) of this city-state.

As a ‘‘cordon pricing system", ALS, by constructing 22 entry points, was used to designate a part of the CBD area as a ‘‘restricted zone", thereby isolating it from the rest of the city. The scheme required advance purchase of a licence to enter the restricted zone during morning peak hours (0730 to 0930) at a cost of $S3 (later changed to $S4) a day (or $S60 per month, later changed to $S80).

As a paper-based system, ALS requires verification at the entry posts. Non-complying vehicles are issued a fine slip sent by mail to the owner's home. At the same time, to discourage car use, public parking charges in the restricted zone have been raised and an additional surcharge has been levied on private parking operators. As a result of ALS implementation, the inbound traffic volume in the CBD during morning peak hours is still lighter than it was before ALS implementation three decades ago.

Despite strong economic growth and a 20-fold increase in office space and associated employment, Singapore is considered to have kept the environmental impact from transportation systems to acceptable limits. Its motorization level is significantly lower than cities having one-third of its income-level.

Source: Based on Dhakal S (2003). Environmentally Sound Transportation Planning in Singapore. Asia-Pacific Environmental Innovations Strategy Project (APEIS), Research on Innovative and Strategic Policy Options (RISPO), Final Report (Vol. 3), March 2005, IGES, Japan.

9. Curitiba, Brazil: A model in urban planning, with particular reference to its transportation system

Curitiba's master plan, implemented since 1965, addresses urban planning issues with efficient public transit and environmental and social programmes. The plan focused on:

- minimizing urban sprawl by zoning laws and a land use plan;
- having a transit-oriented city;
- reducing vehicular traffic; and
- making use of transport users to aid in effective city planning.

With regard to urban planning and transportation planning, the major strategies have been as follows:

Key Urban Planning Strategies	Key Transportation Strategies
- Zoning laws - Land use plan - Restructuring the city's radial configuration into a linear model of urban expansion - Creation of an urban planning agency and making it responsible to develop, supervise, monitor and continually update the master plan	- Limiting car use and promoting other modes of transport - Integrating public transit with biking and walking (Curitiba has 150 kilometres of bicycle ways) - Building an extensive BRT network - Determining bus fares, based on a cross-subsidization principle: low fares for those who live on the city periphery (predominantly low-income groups) compared to those who take shorter journeys

Lessons

- Successful integration of urban planning and transportation planning seems to have been made possible through the mutually reinforcing use of respective paradigm's tools, i.e., zoning laws and providing maximum accessibility;
- The extensive public transportation system has served as a "big push"/"leading sector" role, a factor in making Curitiba a prosperous and growing city;
- Curitiba's success did not come rapidly. Its first plan (conceived in 1943 by Alfred Agache, a French urban planner and architect) failed due to funding constraints – particularly funding for the large infrastructure changes required by the plan. Although the early plan was unsuccessful, it did raise local public awareness about the need for city planning in the future;
- The creation of the Institute de Pesquisa a Planejamento Urbane de Curitiba (Research and Urban Planning Institute) (IPPUC) – the eventual formulation of a master plan (created in 1965 and implemented in 1971) and strong government leadership (such as that of Mayor Jaime Lerner) offer insightful lessons about the need for institutional cooperation and the ability of a city to implement an effective and coordinated urban planning programme.

Source: Based on Karis B. Veilleux J. McCartney K. and Yannes C. (2006). Transportation Case Study: Curitiba, Brazil. 21p.

10. Curitiba's busways: a model of Bus Rapid Transit (BRT)

Curitiba's busways are viewed as a model of bus rapid transit (BRT). The busway programme was developed as an integral part of the city's master plan and is widely recognized for its many innovative features. Trunk and feeder bus lines, routed through terminals, allow convenient fare-free transfers. Downtown and the neighbourhoods are linked through exclusive traffic lanes, which increase bus speed considerably without jeopardizing safety.

The operation of the bus system is financed completely by bus fares, without any public subsidies. The bus line project was financed by the Inter American Development Bank, the private sector and the Municipality of Curitiba.

Lessons

The overall system, which is used by about 70 per cent of Curitiba's commuters, was the result of:

- many incremental decisions aimed at improving service quickly, pragmatically and affordably;
- ensuring cost recovery;
- Using a ‘‘single-fare" or ‘‘flat fare" system that works as a subsidy to low-income peri-urban area residents (because these residents pay the same fare as that of the city-centre residents); and integration of land use, road systems and mass transit components.

Source: Based on TCRP (n.d.). Curitiba, Brazil: BRT Case Studies. Transit Research Cooperative Programme (TCRP) Report No. 90. 21p. and Matsumoto N. (2002). Integration of Land Use and Bus System in Curitiba, Brazil. Asia-Pacific Environmental Innovations Strategy Project (APEIS), Research on Innovative and Strategic Policy Options (RISPO), Final Report (Vol. 3), March 2005, pp. 417 – 422, IGES, Japan.

11. Alternative fuel vehicles: the Shanghai case

Official documents and presentations make it clear that China is interested in learning from the experiences in other countries. This is reflected in Shanghai's adoption of Alternative Fuel Vehicles (AFVs). The Shanghai Government organized a programme to study the use of liquefied petroleum gas (LPG) and compressed natural gas (CNG) in other countries before using them in Shanghai. The investigation of LPG started in 1995, and by 1997 Shanghai had implemented its LPG Vehicles Promotion Programme. Similarly, anticipating access to a huge source of natural gas from a pipeline running from Xingjian to Shanghai (West to East Gas Pipeline), the city started addressing the key technical problems associated with dedicated CNG vehicles, CNG bi-fuel vehicles and their engines. By 2000, 70 LPG service stations were built and around 1000 existing buses were reconstructed as LPG or CNG vehicles. The aim is to refit all public buses and taxis in the same way.

The city collaborated with Shanghai's Tongji University and the Volkswagen Co. Ltd. for research and development (R&D) on AFVs. To set up the necessary organizational arrangements, it established the LPG Vehicle Promotion Coordination Group.

The guidelines for AFV development and the incentive measures used for their promotion were carefully prepared "according to the rules of a market economy with no monopoly or vicious competition" (Yu and Jiang, 2003, p.2). The incentive measures used included investments, loans, taxes and pollution fees. Regulatory measures were used to ensure safety and to develop standards for the LPG & CNG stations.

Features of the programme

- an ability to learn from other countries' experiences;
- the use of R&D for AFV development;
- the use of incentive measures to promote AFVs;
- the need to establish organizational arrangements; and
- the use of regulatory measures to ensure safety and establish standards.

Source: Based on Yu S. and Jiang K. (2003). Introduction of Alternative Fuel Vehicles in Shanghai. Asia-Pacific Environmental Innovations Strategy Project (APEIS), Research on Innovative and Strategic Policy Options (RISPO), Final Report (Vol. 3), March 2005, IGES: 445 – 448.

12. Beijing's plan involving "substituting" for private travel: a two-pronged strategy

Initiated in 1985 against the backdrop of a widening gap between transport demand and supply, Beijing's integrated road transport system development programme was directed at "substituting [for] private travel". In doing so, it adopted a two-pronged strategy: (i) building mass transit and (ii) creating disincentives to car use. Intra-city public transport and rail transport were the chosen modal strategies for reducing car use, whereas, among other incentive measures, increased parking fees were imposed, especially in eight central areas of the city.

To build a new transport infrastructure, Beijing successfully increased financial resources by diversifying its sources of funding. Apart from funds appropriated by the central government and local governments, it drew on (i) domestic loans; (ii) foreign investment bonds; and (iii) revenue from the local market, earmarked taxes and fees based on the beneficiary-pay system.

Foreign enterprises and the private sector could invest in the transport infrastructure, which was formerly monopolized by the public sector. The city also reduced the financial burden of building a road infrastructure by requiring residential developers to improve the transport infrastructure in the vicinity of their developing areas.

Lessons

To improve its transport infrastructure, Beijing depended on the following:

- diversification of funding sources;
- parking fees at a level to have an effect on automobile use;
- making (private sector) housing developers build transport infrastructure in the neighbourhoods of their respective projects.

Source: Based on Liu *et al* (2003).

13. Bangalore bus service: an encouraging programme in a developing country city

Although the bus is the most affordable mode among the various mass transit modes, developing countries have generally failed to provide good bus services. This failure is one reason that car ownership is a common goal of middle-income urban residents in developing country cities. Low-income urban residents or those who cannot buy a car often opt for a motorcycle. The consequence of the affordability of cars is most vividly manifested in cities such as Bangkok, and that of motorcycles in cities such as Hanoi and Ho Chi Minh City.

A reasonable bus service – assuming that other modes of mass transit such as Sky Train or underground rail are too expensive for most low-income countries – is an attractive option. Bangalore, India is a good example in this respect (setting aside BRT in Curitiba or Jakarta, since BRT has another level/dimension).

The present level of bus service in Bangalore did not emerge rapidly. The Bangalore Metropolitan Transport Corporation's (BMTC) predecessor – the Bangalore Transport Service (BTS) – long experienced the perennial problem of incurring substantial losses in providing bus service.

This changed with the creation of BMTC in August 1997, which was started up by restructuring the Karnataka State Road Transport Corporation (KSRTC). The restructuring and the associated reforms made the BMTC a positive force for transport change dating from the years 1998/99 – 2006/07.

Of the five major metropolises of India (Bangalore, Chennai, Delhi, Kolkata and Mumbai), only Bangalore's bus service is "riding along the path of profit" (BMTC 2007, p.27). Its fleet has increased to number 4,354 vehicles, and it carries over 3.5 million commuters (Bangalore's population in 2001 stood at 5.69 million).

Factors that shaped BMTCs' success include the following:

- fleet modernization;
- augmentation of service;
- revenue mobilization measures;
- fare policies; and
- cost-minimization measures.

Source: Based on Bangalore Metropolitan Transport Corporation (BMTC), Sustainable Transport System: BMTC – An Example, presentation of BMTC Director to the Asian Mayor's Policy Dialogue for the Promotion of Environmentally Sustainable Transport in Cities, 23-24 April 2007, Kyoto, Japan.

14. New Delhi's CNG Programme: a significant move to clean fuel

New Delhi is one of the most populous cities and is also among the ten most polluted cities in the world. It has a circular urban form and is continually growing beyond its original boundaries. Its transportation is predominantly road-based. In recent years, there has been a sharp change in Delhi's vehicle composition. Scooters and other two-wheelers have become the most common choice for personal transport. The increasing vehicular population and its changing composition have been the major causes of the deterioration in urban air quality. Studies have shown that particulate matter in the air is far above acceptable levels.

Against this background, a writ petition was filed in 1985 by environmentalists challenging the inaction of the government of Delhi in combatting the causes and impacts of air pollution. The petitioners claimed that the government had done nothing to relieve the suffering of residents from the effects of pollution, nor to prevent it. Since citizens have the constitutional "right to life", the petition said, it was the duty of the government to protect the quality of the environment. On July 28, 1998, the Supreme Court of India handed down its landmark decision requiring a massive air pollution control programme for Delhi. Since then, the Delhi CNG programme has rapidly developed as an example of the successful transformation to the use of CNG in phases:

- On March 31, 2001: the deadline for CNG buses was met by using public buses but not those of private operators;
- May 2001: the CNG programme was reviewed by an expert group. The experts said the programme was "poised for outstanding success". Numerous technical recommendations concerning technical details and implementation were made;
- April 2002: the court ordered fines for diesel bus operators, which led to a substantial increase in the number of private CNG buses and a demand for private bus conversions to CNG use; and
- Since then, development of the CNG refueling infrastructure has gained momentum.

While there is controversy about the extent of the improvements in Delhi's air quality, it is nonetheless true that the peak levels of various air pollutants have come down. The average levels have also stabilized despite an increase of more than 200,000 vehicles in the city. Mumbai, looking at Delhi's example, is now pressing ahead with a programme to increase the number of CNG vehicles (Parikh 2002).

Lessons

- Environmental activism, a Supreme Court mandate, penalty provisions, a CNG refueling infrastructure and associated safety measures – all proved to be key in a breakthrough in the use of CNG;
- Large-scale change in a CNG vehicle fleet is possible in a short time when incentive measures, the signaling of consistent messages, the building of public opinion and acting simultaneously on vehicle conversion and the infrastructure building are employed.

Source: Based on Weaver (2004), Parikh (2002), Bose (1999), and Sidharta (1999).

15. Cutting CO_2 emissions from automobiles: the EU switches from largely voluntary commitments to a comprehensive set of measures

As with its other environmental initiatives, the EU is providing leadership in cutting CO_2 emissions from private cars. Not satisfied with the results of its 1995 strategy, which relied largely on voluntary commitments of the auto industry and users, the European Commission announced a revised strategy in 2007. This is based on a comprehensive set of measures to influence both the supply and demand sides of the EU market for cars and vans. The objectives of these measures are to promote affordable fuel efficiency improvements and reductions in CO_2 emissions, as well as to obtain substantial fuel savings for car and van drivers. Together with the recent proposal to update the fuel quality directive, which is aimed at reducing greenhouse gas emissions from transport fuels by 10 per cent between 2010 and 2020, the strategy represents the first concrete implementation of the Commission's recent Energy Efficiency Action Plan and its Energy and Climate Change Package.

Three-tier strategy since 1995

Since 1995, the EU has employed a three-tier strategy to reduce harmful emissions. This has included the following:

- voluntary commitments by the European, Japanese and Korean car industries to reduce CO_2 emissions from their new cars sold in the EU to an average of 140g/km by 2008 (for European manufacturers) and 2009 (for Japanese and Korean manufacturers);
- raising awareness among consumers. An EU directive requires the display on each new car of a label showing its fuel consumption and CO_2 emissions, as well as publication of fuel efficiency information in other formats, including in printed advertisements.
- promoting fuel-efficient cars through fiscal measures. Several member states have passed legislation aimed at including a CO_2 element in national car taxes.

Progress (as of 2007)

- There has been only limited progress towards achieving the target of 120g CO_2/km by 2012. Between 1995 and 2004, the average emissions from new cars sold in the EU-15 fell by 12.4 per cent: from 186g CO_2/km to 163g CO_2/km. Over the same period, new cars sold in the EU became significantly larger and more powerful. The Commission's review of the strategy therefore concluded that the voluntary commitments have not succeeded and that the 120g target could not be met without further measures.

Revised strategy (announced in February 2007)

The principal measures in the revised strategy are as follows:

- a legislative framework to reduce CO_2 emissions from new cars and vans will be developed. The auto industry will be provided with sufficient lead time so that it can count on regulatory certainty;
- Average emissions from new cars sold in the EU-27 would have to reach the 120g CO_2/km target by 2012. Improvements in motor technology are to reduce average emissions to no more than 130g/km, while complementary measures would contribute a further emissions cut of up to 10g/km, thus reducing overall emissions to 120g/km. These complementary measures include (i) efficiency

improvements of car components with the highest impact on fuel consumption, such as tyres and air conditioning systems, and (ii) a gradual reduction in the carbon content of road fuels, notably through greater use of bio-fuels. Efficiency requirements will be introduced for these car components;

- For vans, the fleet average objectives will be 175g by 2012 and 160g by 2015, compared with 201g in 2002;
- There will be support for research efforts aimed at further reducing emissions from new cars to an average of 95g CO_2/km by 2020;
- Measures will be introduced to promote the purchase of fuel-efficient vehicles, notably through an amendment to the car labeling directive to make it more effective and by encouraging member states that levy road taxes to base them on a car's CO_2 emissions. The Council of Ministers will be encouraged to adopt the Commission's proposal on road taxes without further delay; and
- An EU code of good practice for marketing automobiles will be promulgated and there will be publicity to promote more sustainable consumption patterns. The Commission has invited car manufacturers to develop the latter immediately.

Lessons

- Voluntary commitments are not adequate;
- An increase in the number of new cars on the road did not allow an overall reduction in CO2 emissions from the previous set of policy measures; and
- Reductions in automobile use and/or purchase of new cars should be priorities.

Source: Based on EUROPA Press Release, Brussels, 7 February 2007.

16. France Introduces rebates and penalties to encourage new car purchases based on low and high CO_2 emissions

From 5 December 2007, a buyer of a new vehicle in France was eligible for a rebate for purchasing new vehicles or liable to pay a penalty depending on the CO_2 emissions from his/her vehicle. The incentive measures were broadly categorized as (i) bonus rebates for low CO_2 emission vehicles and (ii) ecopastille (penalty) for high-emission vehicles.

Bonus

They buyer of a vehicle with emissions lower than 130 grams of CO_2 per sq km was eligible for the bonus rebate. The rebate depends on the level of emissions and was awarded as follows:

- €1,000 for vehicles emitting under 100 grams of CO_2 per kilometre;
- €700 for vehicles emitting between 101 and 120 grams CO_2 per kilometre; and
- €200 for vehicles emitting between 121 and 130 grams CO_2 per kilometre.

If a vehicle older than 15 years is traded in to be scrapped at the time the new car was ordered, the buyer received a further €300 rebate – the super bonus.

Penalty

From January 2008, there has been a penalty due on any new car with high emissions – over 160 grams of CO2 per km. The penalty is paid at the point of first registration and is called the ecopastille. It applies to vehicles with emissions as follows:

- €200 for vehicles with emissions from 161 to 165 grams of CO_2 per kilometre;
- €750 for vehicles with emissions from 166 to 200 grams of CO_2 per kilometre;
- €1600 for vehicles with emissions from 201 to 250 grams of CO_2 per kilometre; and
- €2600 for vehicles with emissions over 250 grams of CO_2 per kilometre.

The relevant agency (ADME (Agence de l'Environnment et de la Maitrise de l'Energie)) provides comprehensive information on vehicles and their emissions. Potential car buyers have access to a full list of CO_2 emissions per vehicle make and model.

Lessons

- France has found a way to use consumer-directed incentive measures to reduce CO_2 levels from emitting cars; and
- CO_2 reducing incentive measures integrated with car registration procedures have been an effective means to implement the programme.

Source: Government of France, Buying a Car in France: The Carte Grise French vehicle Registration Document, Angloinfo, Paris Ile de France Local Reference Information, 11.03 Saturday 11 October, 2008 (2008).

17. Fuel economy improvements: the U. S. CAFE standards

Apart from current global action to reduce CO_2 emission levels, there are also a number of local and national initiatives aimed at protecting the local and national environment and public health. Some of these that focused on fuel economy improvements were spurred by the Arab oil embargo of the early 1970s. This was the case for the establishment of Corporate Average Fuel Economy (CAFE) standards in the U.S under its 1975 Motor Vehicle Information and Cost Savings Act.

CAFE stands for sales-weighted average fuel economy, expressed in miles per gallon (mpg), of a manufacturer's fleet of passenger cars or light trucks with a gross vehicle weight rating (GVWR) of 8,500 pounds or less, manufactured for sale in the United States in any given model year. Originally, CAFE aimed to double the fuel economy of passenger cars by 1985 from the time it was enforced in 1975. These standards are overseen by the National Highway Traffic Safety Administration (NHTSA), while the Environmental Protection Agency (EPA) is responsible for calculating the average fuel economy for each manufacturer. The CAFE standards are set by considering technological feasibility, economic practicability, the effect of other standards on fuel economy and the need of the nation to conserve energy. They were implemented gradually and made more stringent recently so that on March 31, 2003, NHTSA issued new light truck standards, setting a standard of 21.0 mpg for model year (MY) 2005, 21.6 mpg for MY 2006, and 22.2 mpg for MY 2007, while that for passenger cars has remained at 27.5 mpg since 1985.

When auto manufacturers fail to meet certain standards in a particular year, they are fined US$5.50 per tenth of a mile per gallon for each tenth of a mile under the target value times the total volume of these vehicles manufactured for a given model year. One feature of the U.S. system not present in other countries' policies is the CAFE credit system, whereby manufacturers can earn credits if the average fuel economy of the models they produce exceeds the standards set for that particular year. Another noteworthy feature of the standards is that they provide special treatment to vehicle fuel economy calculations for alternative fuel vehicles, as well as dual-fuel vehicles.

Source: http://www.nhtsa.dot.gov/cars/rules/cafe/overview.htm

18. Fuel economy improvement measures in Japan

Japan's fuel economy regulations are one of the two most stringent sets of fuel economy standards in the world, the other being that of the European Union. It is a weight-based system: vehicles must comply with standards based on the particular weight class they belong to. The regulations specify 2010 as the target year for gasoline vehicles, while 2005 was set for diesel vehicles. In this sense, it is expected that there will be a 23 per cent improvement in the fuel economy of gasoline passenger cars and 14 per cent improvement in diesel passenger cars. The regulations also include penalties to manufacturers if standards are not met. Similar to the U.S. CAFÉ standards, the Japanese standards in 2001 allowed manufacturers to accumulate credits in one class of vehicles and use them for another weight class. Recently, the government proposed that carmakers increase the fuel efficiency of their cars by 23.5 per cent by 2015 under new regulations put forward by the Ministry of Transport and the Ministry of Economy, Trade and Industry.

Proposed Average Fuel Economy			
Vehicle class	**2004 value**	**2015 est. value**	**% change**
Passenger Cars	13.6 km/litre	16.8 km/litre	23.5%
	7.4 l/100km	6.0 l/100km	
	32.0 mpg US	39.5 mpg US	
Small Buses	8.3 km/litre	8.9 km/litre	7.2%
	12.0 l/100km	11.2 l/100km	
	19.5 mpg US	21.0 mpg US	
Light Cargo Trucks	13.5 km/litre	15.2 km/litre	12.6%
	7.4 l/100km	6.6 l/100km	
	31.8 mpg US	35.8 mpg US	

Source: Based on information from Japan's Ministry of Economy, Trade and Industry.

Other sources:
http://www.greencarcongress.com/2006/12/japan_proposes_.html

For a comparison of passenger vehicle fuel economy and GHG emission standards around the world:
http://www.pewclimate.org/docUploads/Fuel%20Economy%20and%20GHG%20Standards_010605_110719.pdf

19. China's regulatory system to achieve fuel economy improvements

Realizing the serious implications of the rapid increase in oil use for local and regional air quality and health, as well as its impact on global warming, China adopted fuel economy improvement regulations from October 2004.

The regulatory policy was to be implemented in two phases – in July 2005 and in January 2008 for new vehicles and in January 2009 for existing vehicles. This stringent mandatory fuel economy system was based on transmission types and weight, but each individual model must have eventually met the target for each of the 16 weight classes (no averaging was allowed). The regulations were more stringent for heavier vehicle classes than for lighter vehicles, giving more incentives to manufacturers to produce lighter vehicles. It also aimed to bring about changes in buying habits and to introduce newer technology to Chinese vehicle manufacturers. Although there were concerns that the standards could affect manufacturers' plans for introducing larger vehicles into the Chinese market, the average auto fuel economy was required to increase by 5 per cent in 2005 and 10 per cent in 2008. An increase in fuel efficiency will reduce GHG emissions from new vehicles to be sold in China.

Sources: Based on Fuelling the Future: Workshop on Automobile CO_2 Reduction and Fuel Economy Improvement Policies
http://www.iea.org/textbase/work/2004/shanghai/UNEP_IEA.PDF

China's New Fuel-Economy Standards to Challenge Automakers
http://www.industryweek.com/ReadArticle.aspx?ArticleID=9128

Climate Change Mitigation Strategies for the Transportation Sector in China
http://www.hm-treasury.gov.uk/media/9/8/Final_Draft_China_Mitigation_Transport_Sector_Research.pdf

20. Private and public sectors join hands to provide incentives for Seoul's Car-Free Days Programme

Events similar to car-free days originated as a result of the 1973/74 oil crisis. October 1994 was a milestone in this regard when a call was made at a conference in Toledo, Spain to reduce car dependence in cities. An informal World Car-free Days Consortium was inaugurated in Britain in 1997. The first major nationwide movement of car-free days started in France in 1998. Germany "upstaged" France by holding a car-free event in 2000 when the EU's Environment Directorate supported the event. International car-free days are now held annually on 22 September. Other cities outside Europe that hold these events include Jakarta, Taipei, Bogota and Toronto. Bangkok held its first car-free day in 2001, but has not continued on a regular basis.

Whereas some cities with car-free programmes have gone to the extreme of banning cars on a particular day or observing a day with a token campaign, Seoul's version of this programme – called the Weekly No Driving Day Programme – has incorporated incentive measures. Originally proposed by an NGO in July 2003, the programme's operational and incentive measures include the following:

- Citizens voluntarily choose one day among weekdays as a no driving day (0700 to 2200 hours) except on weekends and public holidays;
- Participants receive a set of e-tags and stickers; and
- Incentive measures to participants are provided by the public as well as the private sector (non-commercial vehicles carrying less than 10 passengers are eligible) as shown below:

Incentive Measures	
By Public Sector	**By Private Sector**
• 5 per cent reduction in auto-tax • 50 per cent discount on congestion charge • 10-20 per cent discount on public parking fees	• 1-6 per cent discount on gasoline price • 10 per cent discount on car maintenance cost • Free or discount on car washes

Results

- a participant rate of 30 per cent;
- a decrease in traffic volume of 7 per cent;
- an increase in operating speed of 13 per cent;
- a reduction in emissions of 12 per cent;
- a reduction of particular matter (PM) of 10: 3.5 mg/$m^{3;}$ and
- an annual fuel cost saving of US$600 million

Lessons

- Financial incentive measures work better than a sole reliance on voluntary action;
- IT/Internet use facilitated car users' registering the choice of a day not to drive and obtaining the e-tag and sticker to receive the discounts provided as incentive measures; and
- An NGO campaign and public-private sector cooperation in giving incentives produced good results.

Source: Based on Yeong-man (2007) and Matsumoto *et al* (2007).

21. Fukuoka's multi-stakeholder initiative in car sharing to reduce CO_2 emissions

Thousands of cars ply through city streets with only one passenger in them. Because of this, car sharing systems have been receiving public policy attention for some time.

The systems require use of a car by multiple individuals instead of one or two. In practice, it can be seen as an organized short-term car rental. The first car sharing system was reportedly introduced in 1987 in central Switzerland. Until recently, car sharing organizations were established mainly in developed countries. In Asia, car sharing schemes have been used in Singapore since the late 1990s and Japan since the early 2000s.

The car sharing system is expected to gain more acceptance by citizens in cities with serious problems caused by a shortage of parking space or experiencing a high cost of owning, maintaining and driving a car. Areas with a high population density, located near public transport stations and highly commercialized areas, etc., are most suitable for locating car sharing stations.

A multi-stakeholder initiative that launched a car sharing system was introduced in Fukuoka city on Kyushu Island, Japan in April 2001 with the aim of reducing emissions from vehicles. These emissions made up more than half of the total of 2,030,000 tonnes of CO_2 emissions by the transport sector.

How It started

A non-governmental organization named West Japan Ecology Network first started a study group on car sharing in collaboration with Fukuoka city and the Kyushu Electric Power Company. A car sharing institute was created by the joint action of the NGO, the city and the company. With a consensus among the three parties, a new NGO named the Car Sharing Network (CSN) was founded in May 2002. It launched operations in October 2002 with a special focus on reducing the amount of traffic coming into the Tenjin central business district. The ultimate objective of CSN is to address global warming and to establish an ecological transport system by promoting the sharing of car ownership and usage.

How It works

- CSN members include companies and associations as well as individuals. Under the car sharing system, a member can make reservations to use the shared vehicles for the hours needed and pay according to the time and/or distance that he/she drives;
- There are five stations where the shared vehicles are parked. Each member is issued an Integrated circuit (IC) card to use the system. When a member wants to use a car, he or she makes a reservation by internet, telephone or from a computer terminal at the station. The user can easily collect and return the car key by using the IC card at an automated station terminal. Users do not need to have personal contacts with system staff in order to use the cars.

Individual economic benefits

It is estimated that if an individual in Fukuoka purchased a new automobile with a 1500-cc engine and sells it five years later, the average monthly cost would be 47,443 yen, whereas if the person joins the CSN and drives a Hyper Mini for 30

hours per month, the monthly cost would be 19,000 yen. Therefore, for those who generally drive short distances, there is a significant economic benefit.

Salient conclusions of the car sharing system in Fukuoka include the following:

- The creation of new markets is an important policy measure under the system;
- A CSN system using a green power certification system as an economic instrument encourages corporate and other customers to use renewable energy in a voluntary manner for energy conservation and environmental protection. The CSN also started buying power generated by wind, marking the first recorded attempt of a car sharing business to use wind power;
- The CSN as a non-profit cooperative organization was created as a result of the collaboration of an NGO, a city and a private company. The CSN also succeeded in attracting frequent media attention from newspapers, local television stations, journals, etc.; and
- The CSN succeeded in establishing an effective partnership with the local community to locate its stations.

Lessons

- Car sharing operated by collaboration among the government, private companies and an NGO is one possible way to start a car sharing business on a small scale;
- Social acceptance is an essential element for this system to succeed;
- For ensuring continuing interest of users, a good mix of vehicles, particularly lower emission vehicles, is needed; and
- It is also important to provide flexibility in terms of driving range and passenger capacity.

Source: Based on Matsumoto *et al* (2007) and Matsumoto (2003).

22. Walking street programme in Bangkok, Thailand

The Bangkok Metropolitan Area has been undergoing rapid urbanization and industrialization for the last few decades. An ever-growing vehicle fleet contributed to serious traffic congestion and aggravated air pollution in the city. In late 2001, the Energy Policy and Planning Office of Thailand (EPPO) granted a contract to King Mongkut's University of Technology Thonburi to develop and promote the walking street concept in the country.

The Silom Walking Street was the first well-planned street closure project in Thailand and was implemented in Silom, one of the most congested streets in Bangkok. The project was launched through cooperation between the local government, academia and the local community.

The project was initiated to:

- help road users understand the problems of air pollution and other types of pollution created by vehicle use in urban areas;
- show-case the benefits of the roadway as a space for public activities;
- promote walking as a means of environmentally sustainable transportation and promote local activities in the urban areas in Thailand.

During the project period, Silom Street was opened for walking and for public activities every Sunday for seven consecutive weeks between 12 noon and midnight. Part of its success lay in the concerted effort by the businesses involved in selling along the street. As such, the project was easily adapted to the market-strolling culture of Thailand. The street was also filled with a range of planned events, one consisting of campaigns to educate and inform the public about conserving energy and curtailing emissions from road traffic. This was complemented by private actors and public entertainment. Measurements of air quality before and during the walking street programme clearly showed a reduction of CO_2 and particulate matter.

Other than improving air quality, the walking street programme also helped improve the quality of life and the economy of communities located along and near Silom Street.

Although the project was abandoned after just one year of its launch due to insufficient traffic planning, it gave the impression that the walking street programme could be applied to any large growing Asian city where air and noise pollution from car usage are major problems. This concept has since been extended to other cities, for example Pattaya, Nakhonratchasima, Phuket, Nakhonpratom and Chiang Mai (Laosirihongthong *et al* 2004), with success.

However, the Silom case also demonstrated the need for a well-designed traffic plan before closing any street for public use, as well as the need for sustained political will.

Source: Based on Laosirihongthong T, Pattarapmuinikul S, Chaiwiriyachote A, Tangpaisalkit C, Pant. A P, Kumar S and Shrestha R M (2004). Walking Street Programme in Bangkok, Thailand. Asia-Pacific Environmental Innovations Strategy Project (APEIS), Research on Innovative and Strategic Policy Options (RISPO), Final Report (Vol. 3), March 2005, pp. 509 – 515, IGES, Japan.

23. Restoring Cheonggyecheon Stream in Seoul

Until recently, Cheonggyecheon, a stream inextricably linked to Seoul's history and running through the centre of the city from east to west, experienced heavy metal pollution from transportation emissions due to the old and heavily used Chenggye road that covered it. The road, 50-80 metres wide and approximately 6 kilometres long, was completed in November 1984. The construction of the Cheonggye elevated highway started in 1967 and was completed in 1976. The elevated highway was 16 metres wide and 5.8 kilometres long and was a four-lane, two-way highway exclusively for automobiles. With the passage of time, these structures deteriorated and polluted the stream's bed.

As a result of public opinion and a recognition of the importance of Cheonggyecheon Stream, in 2001 Seoul Mayor Lee Myung-Bak restated the idea of restoring the stream. The restoration started in July 2003, and it is believed the project will transform Seoul's image by converting a once grey concrete environment to a lush green city where clear waters flow.

The restoration measures involved the following:

- Traffic information facilities were introduced and traffic guides deployed to the sites where there was serious traffic congestion;
- Construction of a two-lane road and two-metre wide sidewalk on either side of stream was planned;
- A number of streets have been designated as one-way streets;
- Bus-only lanes were established and downtown shuttle buses operated for the convenience of public transport users; and
- Car owners were encouraged to leave their cars at home one out of every ten days.

The project restored 508 kilometres of waterways, pedestrian bridges and green spaces. It also generated an opportunity for Seoul to expand its low-emission public transportation system and to encourage wider use of public transportation, thereby facilitating city activities without the need for cars.

Source: Based on Cheonggyecheon Restoration Project
http://www.wfeo.org/documents/download/Cheonggeycheon%20Restoration%20Project_%20Korea.pdf

24. Travel Feedback Programme (TFP) in Sapporo

Sapporo city centre in Hokkaido, Japan has been facing traffic congestion problems, largely due to traffic coming from the suburbs. The Hokkaido Regional Development Bureau tried various travel demand management measures but could not reduce traffic substantially. The Travel Feedback Programme (TFP) was developed by the Hokkaido Development Engineering Center in collaboration with academic scholars, based on the Travel Blending Programme in Adelaide, Australia. Attempts were made to implement several parts of the TFP from 1999 to 2000.

The TFP in Sapporo implemented two different programmes: a Community Programme for local community associations and an Education Curriculum Programme for the elementary education level. These targets were selected so that awareness would be raised, not only on an individual but also on a family and/or community basis. The sole objective of the programme was to facilitate changes in travel behaviour so as to reduce the use of automobiles and lessen problems caused by traffic. Participants in the TFP submitted their travel records to the programme coordinator and received feedback in the form of processed data concerning their travel activities, including information of CO_2 emissions from their vehicles.

The TFP regularly conducted meetings with local communities and gave lectures to elementary school classes. Participants were provided with explanatory pamphlets and survey materials (Diary 1) and asked to fill them in for seven consecutive days in collaboration with their families. Based on the results of the survey materials, participants were provided with comments under the feedback system. Students were also asked to calculate the CO_2 produced by their own activities. This process continued for another week with the same survey materials (Diary 2). The difference in CO_2 emissions between their two diaries for each mode of transport was calculated, and the results were shared with the participants.

Critical instruments used for the TFP in Sapporo included personal feedback on transportation activities and relating the feedbacks in class lectures. Filling the TFP diaries generated active discussions within the family. Comparisons between Diary 1 and Diary 2 showed significant changes in participants' travel patterns, along with a reduction of CO_2 emissions. If properly designed and applied at community levels, it was clear that the TFP could reduce automobile use as well as environmental damage and have long-term effects. Along with the availability of alternative measures of transportation, the TFP would also be able to contribute to the reduction of CO_2. The TFP has potential as an instrument to use in areas where reliable transport alternatives such as bus and/or rail are readily available and where automobiles are mainly used for shopping and leisure.

Source: Based on Matsumoto N. (2004). Awareness Raising for Wise Use of Automobiles by the Travel Feedback Programme, Sapporo. Asia-Pacific Environmental Innovations Strategy Project (APEIS), Research on Innovative and Strategic Policy Options (RISPO), Final Report (Vol.3), March 2005, pp. 474-79, IGES, Japan.

Matsumoto N. King P. N. and Mori H, (2007). "Policies for Environmentally Sustainable Transport". *International Review for Environmental Strategies*, Vol. 7(1), pp. 97 – 116.

25. Wind-powered commuter system in Calgary, Canada

The City of Calgary is known worldwide as a pioneer in the use of renewable energy in mass transit. The C-train is Calgary's light rail transit system, one that once was powered by coal and natural gas, but that now runs on electricity. Thousands of daily commuters board the C-Train to go to school, to work, to shop and more. In September 2001, based on this success, the City of Calgary announced its decision to use commercial wind energy as the primary source of the C-train's electricity. The programme is called "Ride the Wind", since the users of C-Train are actually traveling with the help of energy captured from the wind. The project was fully approved by City Council on February 12, 2001.

The highlights in the history of the project are as follows:

- Vision Quest (a power generation and wholesale marketing company) entered into a contract for green energy with Enmax;
- Enmax entered into an agreement with City Transit to deliver the wind power to the LRT;
- All emission reduction credits were transferred to City Transit via Enmax;
- Ten new wind turbines were financed, constructed, owned and operated by Vision Quest; and
- The new wind turbines started delivering clean wind power by August 31, 2001.

Calgary sources note that before the switch to wind power, the C-Train's energy supply accounted for about 20,000 tonnes of greenhouse gases and other forms of air pollution every year, less than 1/10 of the pollution that would have resulted if all C-Train passengers had driven in their own cars. Under the Ride the Wind programme, these emissions have been reduced to practically zero. This makes the C-Train one of the most environmentally friendly forms of transportation.

Calgary officials claim that the C-Train contributed greatly to solving traffic problems. There are a total of 116 light rail vehicles, and each day riders board the C-Train 189,000 times. If each commuter had travelled alone in his or her car instead of on the C-Train, the daily mileage would have amounted to 1.2 million kilometres. These car commuters would have used 107,000 litres of fuel and produced some 270,000 kg of carbon dioxide, nitrous oxide, carbon monoxide and other pollutants.

Unlike fossil fuels, wind energy is pollution-free and virtually limitless. Wind turbines have become efficient and reliable. Wind energy facilities can also be installed faster than any other large-scale electricity generating technology. Using this feasibility context, wind energy can be considered as a substitute for commonly used conventional energy sources in the transportation sector.

Source: *Ride the Wind!*^{TM}
http://www.re-energy.ca/ridethewind/about.shtml
http://www.re-energy.ca/ridethewind/backgrounder.shtml

26. Electric trolleybus system in Quito, Ecuador

In the 1990s, Quito, the capital of the Republic of Ecuador, experienced large population growth along with an increased demand for transportation. As a consequence of the inability of the public transport system to meet the increasing demand, the number of private cars substantially increased. This, together with an existing old and poorly maintained bus fleet, gave rise to a significant increase in congestion and air pollution, which considerably degraded the environment of Quito.

The trolleybus system was chosen as the most cost-efficient and sustainable transport solution for Quito compared with other alternatives such as metro and a Light Rail Train (LRT). The construction of the integrated electric trolleybus system started in 1994. The system is driven by electricity supplied by the Quito Electricity Company, and the trolleybuses run along a reserved lane going between the south and north of the city. The development and implementation involved the Municipality of the Metropolitan District of Quito, the Operating Unit of the trolleybus (UOST), the Municipal Transportation Bus Company and the Transportation Planning and Management Unit. This project was financed by the Spanish Development Fund and by the Spain's Banco de Bilbao Vyzcaya. The operation and maintenance costs were covered entirely by fares endorsed by the municipality.

The trolleybuses run on an exclusive lane, making the transport of their passengers extremely smooth. Some supporting policies implemented along with the trolleybus system were the following:

- integration with feeder buses, allowing passengers to reach most areas of Quito;
- implementation of a one-month free ride, which gave the population the possibility to use the system and test its reliability and convenience;
- very low fares (a reduced tariff for the elderly, disabled and infants) were introduced to increase the affordability for the low-income population. A single fare policy, which allows passengers to transfer to feeder buses using the same payment, was applied in order to increase the system's attractiveness; and
- frequent inspections by UOST under the Municipality of Quito's direction allowed the trolleybuses to run in a continuous and reliable way.

Quito's trolleybus system is considered to be one of the world's most successful urban transport solutions. The integrated system has substantially decreased the use of private vehicles, decreased congestion, reduced air pollution, reduced travel time and allowed for better traffic flows due to the elimination of the old bus system.

An environmentally sustainable transport option such as the trolleybus system may constitute a feasible solution for medium-sized cities in developing countries. In contrast with other alternatives such as metro and LRT, the trolleybus represents an affordable and cost-effective transport mode.

Source: Based on Rogat, Jorge (2003). The Electric Trolleybus system of Quito, Ecuador. Asia-Pacific Environmental Innovation Strategies, Research on Innovative and Strategic Policy Options.

27. Shift From leaded to unleaded gasoline, Thailand

The City of Bangkok, Thailand experienced the impacts of air pollution heavily in the 1990s. Air pollution in the city and the metropolitan area came from industrial sources, energy, construction, household emissions and mainly the transport sector. The transport system in Bangkok spread over a vast area, and people had to travel longer distances to get to their places of work and business. Emissions from millions of vehicles plying the city streets polluted the air and led to serious impacts on people's health.

The government tried to control the harmful emissions by phasing out leaded gasoline and, at the same time, lessening the sulphur content of fuels in the short term and improving air quality in the medium term. The solution was to shift from leaded to unleaded gasoline, and the success of the change illustrates the effective use of environmental management measures.

The government proceeded by promulgating regulatory measures to reduce the lead and sulphur dioxide content of fuels over a period of time. In 1993, unleaded gasoline was introduced and in 1996, all types of leaded gasoline were completely phased out. From 1993 to 1999, there was a significant reduction in the sulphur content of diesel. Suasive measures were also utilized by making information available in both printed and TV media, which explained the impact of air pollution on people's health and the need for changes. This public awareness campaign helped citizens to accept the use of unleaded gasoline. Moreover, when unleaded fuel was introduced, economic measures were put in place to make the use of it favourable when compared to leaded gasoline, which was still available during the transition period. These measures included increasing the tax on leaded gasoline and making the price of unleaded gasoline less expensive, an example of internalizing the cost of pollution. The combination of regulatory, economic and suasive measures led to a relatively quick switch from leaded to unleaded fuel, particularly in Bangkok.

Source: Based on Amin, A.T.M. Nurul, Soparatana Jarusombut, Trinh Thi Bich Thuy and Worawan Thanaprayochask (2006). Environmental Management Measures for Influencing Human Behaviour. *Regional Development Dialogue*, 27(1):85 – 100.

28. Bio-fuels in Thailand: momentum in E85 adoption

Thailand started using E85 ethanol fuel to replace petrol. It was the first country in Asia to announce a national policy for bioethanol (2000) and biodiesel (2001). Experiments using E85 were carried out using research and development incentives, and this has made E85 widely available in the country. Currently, E10 and E20 fuels are available under names such as gasohol.

The government also established policies to promote the production and utilization of E85. Among these was the Board of Investment's decision to build a fuel ethanol plant, a waiver of the excise tax for the ethanol blended in gasohol, a low rate of fund levy and market incentives making the price of E85 much less expensive than other fuels sold in Thailand.

However, a number of issues still hamper the swift adoption of E85. The automobile industry is clamouring for more incentives to manufacture E85 cars, and there is still no clear directive on the type of fuel to be used, whether E10, E20 or E85; the energy industry is still asking for the government's position on this matter.

Ethanol is produced from sugar cane and tapioca. The use of sugar and tapioca has to be considered carefully, since these products are also needed for food production. Another issue concerns the availability of refineries to produce E85. Present refineries for E10 and E20 fuels are seen as practical, but if E85 production is boosted, refineries specifically outfitted for E85 production have to be constructed. Moreover, although suppliers are ready for the sale of E85, pricing it is still an issue. In short, more needs to be done to make the utilization of E85 beneficial to both producers and consumers. The government also has to rethink its policy on E85, as well as to design more incentive measures that ensure the viability of ethanol-based fuels.

Source: Based on Boondor Sajjakulnukit, Bio-fuels in Thailand, presentation to the Asean-U.S. Enhanced Partnership, Biofuels and the Automotive Industry Seminar, October 24, 2007 and Achara Deboonme, "Suppliers ready for E85 fuel, but pricing still an issue", an article in the Bangkok daily, *The Nation,* June 6, 2008.

29. Transport air quality management project: Mexico's increase in gasoline prices to make CNG the least expensive fuel

The Transport Air Quality Management Project in Mexico City, a project to ensure the environmental sustainability of the Millennium Development Goals, was funded and spearheaded by the World Bank. The principal objective of the project was to support a comprehensive programme to reduce air pollution in the Mexico City Metropolitan Area. Other objectives included improving fuel quality and restraining car use.

The project had five interrelated components:

Vehicle component: This component included the following:

- development and enforcement of emission standards;
- progressive improvements to in-use emission standards;
- lines of credit to finance the replacement of old high-fuel use vehicles with new vehicles; and
- improvement of the vehicle registration system.

Fuel component: This component included the following:

- installation of vapor recovery systems at service stations; and
- alternative fuel pilot programme for vehicle conversion.

Transport policy and management component: This component involved preparing an integrated transport and air quality management strategy that meets the objectives of air quality and transport.

Scientific base component. This component aimed at strengthening air-quality planning through an integrated research plan and the development of equipment to extend the air-quality monitoring system.

Institutional strengthening component: This involved capacity building for technical support teams and agencies charged with air pollution independent annual environmental audits.

The project was implemented through measures on the transport demand side as well as on the supply side. On the demand side, gasoline prices were increased in order to make unleaded gasoline competitive in the market. The use of CNG was also enhanced by making it the least expensive among all available fuels. On the supply side, vehicles were retrofitted to run on CNG, and existing taxis were replaced by more efficient models running on clean fuels. Fuels were also reformulated, and the use of clean fuels for all vehicles was encouraged. The use of cleaner fuels created an impact on emissions and contributed to the improvement of air quality in the metropolitan area. Although the project encountered some difficulties, it was fine-tuned over time.

Sources: Based on World Bank (2008). Transport Air Quality Management Project for the Mexico City Metropolitan Area http://web.worldbank.org/external/projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P007694

Heil, Mark and Pargal Sheoli (1991). Reducing air pollution from urban passenger transport: a framework for policy analysis. World Bank, Washington, D.C. http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/1998/11/17/000178830_98111703524419/Rendered/PDF/multi_page.pdf

30. Leaded to unleaded gas: using three sets of simultaneous incentive measures in Vietnam

Vietnam's switch to unleaded gasoline has been seen as a success that was attributed to the comprehensive use of environmental management measures. These included the provision of economic incentives, issuance of regulatory and administrative directives and charges and initiation of public awareness campaigns. Although an initial attempt to eliminate leaded gasoline began in 1995 with the introduction of transport-related environmental regulations, the implementation was stalled due to concerns over the possible high cost of switching and the fear that a large number of vehicles in the country would be deemed inoperative for unleaded gasoline without major modifications to their bodies and engines.

The views opposed to the project raised issues in the print and TV media concerning the thousands of older automobiles and millions of motorcycles in the country. In 1999, the Canadian International Development Agency (CIDA) sponsored a workshop on this subject attended by journalists and reporters from various local and national newspapers. The workshop and subsequent follow-up activities started changing the public's view of the need to switch from leaded to unleaded gasoline. In November 2000, the Deputy Prime Minister, Nguyen Tan Dung, issued directives targeting the three environmental management measures, as shown below.

Regulatory measures:
Concerning "Switching to Unleaded Gasoline in Vietnam", the directive stated that leaded gasoline would cease to be used by 1 July 2001.

Suasive measures:
A workshop in February 2001 was held to prepare a public information plan. Posters were also prepared and distributed to gasoline stations in time for the 1 July 2001 fuel switch.

Economic measures:
A subsidy for the importation of unleaded gasoline was put in place. Taxes on the importation of octane used by domestic fuel refineries were reduced.

The interplay of the regulatory, suasive and economic measures allowed Vietnam to switch from leaded to unleaded gasoline on schedule, avoiding a lengthy and costly phase-out programme.

Source: Amin, A.T.M. Nurul, Jarusombut Soparatana, Trinh Thi Bich Thuy and Thanaprayochask, Worawan. Environmental Management Measures for Influencing Human Behaviour. *Regional Development Dialogue*, Vol. 27, No. 1, Spring 2006.

31. Vehicle emissions control technology – European Union (EU) member countries

Vehicle emissions control can be undertaken in various ways. One of them is through the use of emission control technology, which aims at reducing emissions by means of technology such as exhaust controls, exhaust gas recirculation and the like. To enforce limits on the emissions of new cars and vans sold in the European Union (EU), the European Commission (EC) has made it mandatory by 2012 for new cars to emit on average only 120 g/km of CO_2. The regulation came into effect on February 7, 2007.

Vehicles currently emit an average of 163 g/km, but the trend to more and larger cars will result in increasing emissions from road transport. Statistical data reveals that in the EU member countries road transport emissions increased by 26 per cent between 1990 and 2004. The sector is now responsible for around 12 per cent of the EU's total CO_2 emissions.

The newly adopted measure includes the following:

- a legislative framework to reduce CO_2 emissions from new cars;
- support for research efforts to further reduce emissions from new cars to an average of 95 g/km by 2020;
- fuel-efficient vehicles to be promoted by, for example, encouraging the reduction of taxes on low-emission models;
- inviting auto manufacturers to sign an EU code of good practice (by mid-2007); and
- EU-supported research efforts to further reduce emissions from new cars to an average of 95 g/km by 2020.

Sources: Based on (1) European Commission website, http://europa.eu/rapid/pressReleasesAction.do?reference =MEMO/07/46&format=HTML&aged=0%3Cuage=EN&guiLanguage=en

(2) The Guardian Online Newspaper website, http://www.guardian.co.uk/environment/2007/feb/07/business.motoring

(3) Tightening of emission standards from new vehicles is best way to reduce mobile source pollution; Limits on vehicle emissions proposed by Europe, *NewScientist.com news service*, 17:19 07 February 2007 [Online] http://environment.newscientist.com/article/dn11127

32. Vehicle emissions control: green purchasing – Japan

Japan introduced the "Low Emission Vehicle Initiative" as an action-based programme based on a law passed to promote green purchasing. The initiative required all vehicles used for administrative purposes in all ministries and agencies (c.a. 7000 vehicles) to be replaced with low-emission vehicles by fiscal year 2004. The "Low Emission Vehicle Initiative" was implemented based on the Law on Promoting Green Purchasing, which was enacted in May 2000 to promote green purchasing by the public sector. Under the law, central and local governments and other national entities, which have important purchasing power in the national economy, are expected to take the lead in purchasing environment-friendly goods and services, including energy-efficient products. They are also expected to assist in the effort to encourage the purchase of low-emission vehicles by other citizens.

As part of the programme, low-emission vehicles (fuel-cell vehicles) have been adopted as official cars by various government ministries. In the green purchasing programme, the number of low-emission vehicles (LEVs) being used by ministries and agencies was 1,676 in FY 2003; the total number of government-owned LEVs was 4,407 as of March 31, 2004, and it gradually increased over time. The percentage of LEVs as official cars owned by governmental ministries and agencies now represents approximately 73 per cent of total official cars.

The use of LEVs as required by the green purchasing programme has contributed to the reduction of emissions from mobile sources. More importantly, the government has set a example to its citizens concerning the need for environmental awareness. From the viewpoint of good governance, the examples policy makers set are important, because they have a significant impact on public attitudes.

Sources: Based on Takeshi SEKIYA (2001), emission reduction initiatives in the public sector in japan, *Ministry of the Environment*, Japan, *Office of International Strategy on Climate Change*, Workshop on Good Practices in Policies and Measures, 8-10 October 2001, Copenhagen [Online]
http://unfccc.int/files/meetings/workshops/other_meetings/application/pdf/sekiya.pdf

Ministry of Environment, Government of Japan website.
http://www.env.go.jp/en/press/2005/0529a.html

Promoting an Energy-efficient Public Sector website.
http://www.pepsonline.org/countries/japan.html

Ministry of Environment, Government of Japan website.
http://www.env.go.jp/recycle/3r/en/info/09.pdf

33. Private sector vehicle inspection and maintenance – Mexico City

Mexico City's Vehicle Inspection Programme (revised in 1997) required mandatory testing for vehicle emissions in Mexico City. The testing element was first introduced in 1988. Initially, it was performed in government test-only centres as well as in private garages that were permitted to both test and repair. The new protocol – the accelerated simulation mode – aimed at generating more certain test results and permitted the use of tighter standards, thereby reducing false approvals.

The programme included the following:

- a legal and regulatory framework that allowed independent monitoring of the testing stations;
- an easily monitored certificate for passing the test;
- testing technology capable of preventing temporary tuning; and
- the optimal number of centres relative to the volume of traffic to be tested.

The evolution of programme measures in Mexico City is chronologically shown below (Kojima and Bacon, 2001):

1982: Voluntary inspection programme initiated, operated by the Mexico City government
1988: Mandatory annual emissions inspection introduced for 1982 and earlier models; test-and-repair centers authorized
1989: "Day without a car" programme initiated
1992: Mandatory testing introduced for all vehicles
1993: Test-only centres operated by the Mexico City government closed, multi-lane "macro-centres" opened and dynamometre tests introduced for all vehicles not privately owned
1994: Emissions standards tightened
1996: Test-and-repair centers closed. New "verificenters" authorized. "Double day without a car" programme started. Emissions standards tightened further
1997: "Clean" cars exempted from "day without a car" programme. More verificenters authorized. Requirement that vehicles registered in the Federal District be tested there lifted. Hybrid testing protocol (based on acceleration simulation mode) started in second half of year
1999: New testing procedure fully adopted, replacing catalytic converters mandatory for 1993 models and emissions standards modified
2000: Standards for nitric oxide introduced, replacing catalytic converters mandatory for 1994 and 1995 models
2001: Requirement that vehicles registered in the Federal District be tested there re-imposed

The Mexican experience shows that a staged emission control programme that comprehensively addresses various measures is required to progressively deal with vehicular emissions. As a result, air quality in Mexico City has improved, although it is still considered one of the most polluted cities in the world.

Sources: Based on Kojima, M. and Bacon, R. (2001), ''Privatizing Vehicle Inspection and Reducing Fraud in Mexico City", Emission Control, The World Bank Group, Private Sector and Infrastructure Network, No. 238 [Online] http://rru.worldbank.org/documents/publicpolicyjournal/238Kojim-831.pdf and World Bank (2001), available online at http://www.worldbank.org/transport/urbtrans/cities_on_the_move.pdf

34. Traffic signal control for reducing vehicle CO_2 emissions – Kawasaki City, Japan

Kawasaki City, Japan has applied a traffic flow simulation model to obtain an improvement in wide area traffic flows. The simulator was established to obtain an estimated figure of CO_2 emissions generated by travelling vehicles and to consider the state of each vehicle. An analysis of relations between CO_2 emissions, delay time and the number of stops at intersections was performed with the simulator, which resulted in a proposal for a new traffic signal control method to reduce CO_2 emissions. The simulation resulted in a reduction of these emissions of roughly 7 per cent from the levels of the exhaust gas produced by the current traffic signal control method.

Source: Based on Traffic Signal Control for Reducing Vehicle Carbon Dioxide Emissions on an Urban Road Network, Toshihiko Oda, Masao Kuwahara and Satoshi Nikura
[Online] http://www.transport.iis.u-tokyo.ac.jp/PDFs/2004/2004-013.pdf

35. Tehran transportation emission reduction project, Tehran, Iran

In 1993, the World Bank estimated that in Tehran, Islamic Republic of Iran, urban transport operations consumed an estimated 2.0 million tons of gasoline/diesel fuel per year, releasing around 6 million tonnes of CO_2 into the atmosphere. Transport operations generated almost as much carbon emissions per capita (0.7 tonnes per annum) in Tehran as in Mexico City (0.9 tonnes per annum), which suffers from one of the world's most serious air pollution problems.

Various efforts to reduce the emissions released by the transportation sector were undertaken. The emission reduction project contained measures to better urban air quality. The measures included the following:

- emissions inventory and air quality monitoring;
- traffic management and restraint;
- vehicle fleet and fuels improvement;
- strategic urban planning for transport emissions reduction; and
- project support and conducting a transport and air quality seminar.

Tehran authorities have assessed the above measures and consider that they will be able to meet their objectives, namely to reduce greenhouse gas emissions from vehicular traffic, while improving local air quality.

Source: Based on World Bank (1993), Global Environment Facility, Tehran Transportation Emission reduction Project, [Online] http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/1993/10/01/000009265_3961219142740/Rendered/PDF/multi_page.pdf

36. Vehicle emissions control – Beijing, China

Until 1998, Beijing had no emission standards or emission control measures. As a result, it was one of the top ten cities with the worst air pollution in the world. In Beijing, emissions from motor vehicles were pinpointed as one of the three main sources of pollution. Rapid growth of the vehicle stock in the city was one of the reasons; in 1998, the vehicle stock amounted to 1.4 million, and it was growing at a rate of 25 per cent annually.

A series of actions were carried out starting in 1998 to reduce air pollution caused by motor vehicles. One of these was to implement more stringent tail pipe emission standards. Accordingly, the Emission Standard for Exhaust Pollutants from Light-duty Vehicles was issued, and took effect from 1 January 1999.

The efforts to control vehicular emissions in Beijing included the following:

- Tail pipe emissions from new light duty vehicles were mandatorily required to meet emission standards. The European Union EU-I standards entered into effect in January 1999. EU-II standards were introduced in January 2003;
- Stringent regulations for disposal of older vehicles were implemented, requiring the scrapping of all old and badly polluting taxis before September 1999;
- Beginning in January 1999, newly manufactured vehicles that could not meet the new standards were not allowed to be sold. Three-way catalyst mechanisms and electronic jet equipment were installed in new vehicles unable to meet the emission standards before they were sold;
- By the end of 2001, 190,000 gasoline-powered vehicles registered before 1995 were retrofitted with electronic fuel injection equipment and three-way catalyst mechanisms;
- Inspections of on-road vehicles were enhanced. Vehicles that were not able to meet the emission standards were penalized;
- All vehicles were classified in three categories: green, yellow and red. Green label vehicles were considered to be environment-friendly and were exempted from random inspections. Owners of vehicles with yellow labels were asked to make the necessary changes within a limited time period. When air pollution was severe, vehicles with red labels were not allowed to operate;
- Since 2003, all vehicles have had to pass annual inspections in order for their owners to obtain a green label, which has to be visible on the front windshield of the vehicles.

Simultaneously, measures with technology and economic (fiscal) incentives were introduced. These included the following:

- Technology was employed to obtain high-quality fuel standards: The first step, in June 1997 was the provision of unleaded gasoline. In order to introduce and meet the emission standards of European Standard III in 2007, fuel providers were asked to produce cleaner gasoline and diesel before 2007;
- Fiscal incentives: Beijing encouraged vehicle sales and focused on fiscal incentives such as tax deductions for new vehicles meeting enhanced emission standards. These strategies and measures have had an impact on the control of vehicular emissions. Since late 2001, a 30 per cent tax deduction has been awarded to owners of light duty vehicles meeting Euro II standards.

Documented information suggests that Beijing's thrust for air quality improvement has been maintained since the Olympic Games of 2008. A 2009 report shows that a variety of measures are in place (NRDC 2009) to improve the air quality of the city.

Sources: Based on Songli, Z and Jiang Kejun (2003). Emission Control in Beijing. Institute for Global Environmental Strategies (IGES), 'Emission Control Measures in Beijing, China", "Good Practices Inventory", Asia-Pacific Environmental Innovation Strategies (APEIS), Research on Innovative and Strategic Policy Options (RISPO).

Hao, J. (2004) Sub-workshop session 15: Air quality Management Policies and Implementation, Progress of Beijing in Controlling Vehicular Emission. [Online] http://www.walshcarlines.com/china/Vehicle%20Emissions%20Control%20in%20Beijing%20JimingHao.pdf

Hao, J.; Hu, J and Fu, L (2007), Controlling vehicular emissions in Beijing during the last decade, Centre National de La Recherche Scientifique [Online] http://cat.inist.fr/?aModele=afficheN&cpsidt=17836276

37. Vehicle emission controls – Shanghai, China

Tail pipe exhaust pollution from vehicles has become one of the main factors affecting the air quality of Shanghai. According to statistical data, by 2002 there were a total 1.4 million vehicles in the city, and the numbers were increasing at an annual growth rate of 14 per cent. Annual emissions of NOx from vehicles were about 128,000 tons, 1.33 times higher than the norm.

To cope with the air quality degradation, the following measures were taken:

- Improvement of the environmental performance of vehicles. Shanghai implemented a national second-phase emission limit for vehicles (equivalent to the EU-II emission standard) in March 2002. The owner of any vehicle that did not meet the standard in its category could not obtain a licence. Besides the stricter emission standards on vehicles, the government also strengthened the monitoring and maintenance of current-use vehicles and promoted the elimination of old vehicles;
- Prohibiting the operation of motorcycles. There were 640,000 registered motorcycles in Shanghai, accounting for about 55 per cent of all vehicles. The emission generated by motorcycles is quite high because of the low-level technology used in manufacturing them. The local government prohibited the operation of two-wheel motorcycles on main roads and in some other regions;
- Controlling the number of vehicle licences for private use. Early in 1990, Shanghai introduced regulatory instruments directed at the selling and certification of new private vehicles. The measure's purpose was to limit the total number of annual new vehicle licences for private use and to sell new licences using an auction system. When the policy was first implemented, the licences were auctioned off at a base price. Since October 2002, licences for domestic and imported vehicles have all been auctioned off without a base price;
- Air quality control planning. The city's Air Environment Protection Plan was announced in 2001 with the "Tenth-Five Year Plan". Counter measures dealing with emission controls from transport were listed, including further adoption of emission standards, emissions testing of existing vehicles, limits on the operation of heavily polluting vehicles, more clean-fuel buses and taxies and improvements in public transport;
- Transportation planning. A "public transport first" policy was formulated. The local government established and continues to improve policies involving planning, investment, taxation and the management of vehicles. A rail transportation network composed of subway, urban light rail and new-model trolley car systems was promoted to make rail transportation the core of urban public transit;
- Environmental friendly public transit. In order to mitigate pollution from public vehicles, public transport departments selected environmentally sound buses with good performance that met the EU-II standards; and
- Use of unleaded gasoline. Starting in 1997, unleaded gasoline was used in Shanghai, and the use of leaded gasoline was prohibited.

With the above measures, various pollutants discharged by mobile sources have been significantly reduced. CO, HC and NOx were reduced by 30, 50 and 50 per cent respectively in the city, leading to a significant improvement of air quality.

Source: Based on Liuqiang (2003). Emissions control measures in Shanghai, China. Institute for Global environmental Strategies (IGES), 'Emission Control Measures in Shanghai, China', 'Good Practices Inventory", Asia-Pacific Environmental Innovation Strategies (APEIS), Research on Innovative and Strategic Policy Options (RISPO).

38. Bus pass programme in Ann Arbor, Michigan, USA

The high price of parking space for automobiles combined with significant growth in traffic congestion in the downtown area led the city of Ann Arbor, Michigan to establish a bus pass programme. The programme, called “Get Downtown”, was launched in 1999 and involves a partnership between the Ann Arbor Downtown Development Authority, the Ann Arbor Area Chamber of Commerce, and Ann Arbor Transportation Authority (AATA). The programme was financed by a Congestion Mitigation and Air Quality Improvement Programme grant. During the first two years, it offered free unlimited use bus passes, called “go!passes”, to all downtown employees. At present, the Get Downtown programme offers the passes to all downtown businesses at a cost of US$5 per employee; the remaining cost per pass is subsidized by the Downtown Development Authority.

A complementary regulation that requires employers to provide all full-time employees with go!passes is also being implemented. The programme has resulted in a 10 per cent reduction of downtown car use, US$200,000 of annual savings in fuel costs and a 734 tonne reduction of greenhouse gas emissions per year.

In an effort to minimize impacts on the environment, AATA began the process of converting its entire bus fleet to hybrid electric technology when it introduced its first 15 hybrid electric buses in October 2007 and an additional five in March 2008. The buses feature a combination of a battery-powered electric motor, to provide most of the power at slower speeds, and a smaller clean-diesel engine that takes over at higher speeds. AATA says that the use of hybrid electric buses strengthens its commitment to protecting the environment by burning less fuel and emitting fewer pollutants into the air. AATA plans to continue this conversion over the long term as older buses reach their 12-year life expectancy.

Source: Based on Ann Arbor Transportation Authority website http://www.theride.org/faq.asp retrieved on 19 November 2008.

39. Van transit system in the Bangkok Metropolitan Region, Thailand

The Bangkok Metropolitan Region (BMR) Authority has established a van transit system to meet transport needs in very congested areas as well as for travel between city centres and suburban areas. First initiated in 1995, the system has been so popular that the number of vans increased from a few hundred in 1995 to about 8,300 in early 2004. The service was provided by private operators in BMR and supported by fares received from customers. There is no funding from government agencies.

Van transit operates on public streets and expressways in mixed traffic. The routes are fixed by the operators themselves based on the principle of supply and demand. They are designed to offer the shortest travel time between origin and final destination by having only two stops.

Some supporting instruments implemented included the following:

- The design and plan developed need-responsive routes where the needs of the customer travel had not been addressed;
- The system was based on self-regulation by establishing a service providers association; and
- The design's operation policy allowed the system to accommodate passengers at full capacity with comfortable seating and in a pleasant environment.

The van transit system has created a new means of transportation by the BMR and is considered to be an efficient and effective mode of transport in terms of cost and energy savings. The service has attracted a large number of private car operators, as well as bus users who could have switched to private vehicles if the van service had not been available. Estimates are that in 2004 there were approximately 800,000 users of the van system per day. The system now plays an important role in promoting ride sharing for mobility in congested areas serviced by the BMR. As a result, it is expected that the service will help reduce traffic congestion.

Source: Based on Laosirihongtong, T., Pattanapairoj, W., Kunasol, B., Pant, AP., Kumar, S., and Shrestha, RM. (2004). Van Transit System in Bangkok Metropolitan Region. Asia-Pacific Environmental Innovation Strategies, Research on Innovative and Strategic Policy Options.

40. Public transportation system in Beijing, China

To improve air quality in the city, the Beijing government decided to focus on developing a public transport plan for the new century and launched a detailed project with a focus on the Mass Rapid Transit System (MRTS). The programme also relies on integration with public bus service, subway and light railway. The plan was developed in 1998 and involved the city government as well as the Urban Research and Planning Institute. Its main objectives were to create a good transport system in time to host the 2008 Olympics, to improve the efficiency of urban transport in Beijing and to create a service accepted by the public.

The development of a public transport system required the integration of some measures as following.

- In the effort to create a well-designed city planning programme with public transport as its top priority, an international bidding system to modify the existing MRTS construction plan was implemented;
- The programme allowed for public involvement in price-setting as an economic instrument. Although bus and subway fares are decided based on cost, the public was able to participate in the process;
- Competition was introduced in the provision of public transport by the private sector.

Some impacts of the programme have been identified. These include improved air quality, reduced downtown traffic congestion, reduced oil consumption because of the operation of the MRTS and economic development along the MRTS line. However, the development of the MRTS involved high construction costs and substantial investments. Two ways to solve these problems were seen to be lowering construction costs through institutional and technological innovations and raising funds through innovative financing.

The drive to improve Beijing's air quality was stimulated by its hosting the 2008 Olympics. Some observers claimed that the city's efforts had been exaggerated and were only public relations devices to coincide with the games; however, a 2009 report suggests that Beijing has not relaxed its drive to improve the quality of its air. A variety of measures, including phasing out of high polluting vehicles, discounting car loans to purchasers of green label cars and introducing cleaner buses have been implemented.

As a result of the programme, urban air quality has improved as demonstrated by the gradual reduction of NOx and CO over the years despite a gradual increase of number of vehicles in the city.

Sources: Based on Songli, Z, Shengmin, Y, and Kejun, J (2003). Development of Public Transportation System in Beijing China. Asia-Pacific Environmental Innovation Strategies, Research on Innovative and Strategic Policy Options.

Natural Resources Defense Council, "After Olympics, China Still Worried About Clean Air for Beijing", The Earth's Best Defense – June 19, 2009.

41. Rail-based mass rapid transport system in Shanghai, China

The Shanghai municipal government has invested in the construction of urban transportation by developing a rail-based MRTS in the city. Construction began in 1990, and the system went into operation in April 1995. In view of growing passenger travel demand, the low efficiency of other current transportation modes and pressing environmental requirements, a detailed plan was developed in 2001 that became the basis of a significant expansion of the system. The plan was designed by involving city government and the Urban Research and Planning Institute.

The plan's implementation was supported by the following:

- A well-designed MRTS construction plan was modified several times to keep pace with developing trends in the economy, society and the environment in Shanghai;
- Financial innovation to fund MRTS development. A multi-entity investment system was set up, which included government investments, local bonds, loans from domestic banks and foreign governments or international financial organizations; and
- The MRTS plan was integrated with development policies along the subway lines.

Some impacts identified include reduced traffic jams in the downtown area, reduced travel time, reduced oil consumption from the operation, reduced air pollution, economic development along MRTS path and a reduced cost of congestion in the downtown area, thereby helping the central downtown core city to function fully as the service center of production. One lesson learned from this experience was that MRTS construction required thorough long-term planning due to its high construction costs, meaning that innovative measures were required to finance the system. Another lesson: a blueprint of development also needs to be prepared based on detailed feasibility studies, which will allow for future regional economic and environmental development.

Source: Based on Shengmin, Y (2002). Development of a rail-based mass rapid transport system in Shianghai. Asia-Pacific Environmental Innovation Strategies, Research on Innovative and Strategic Policy Options.

42 Bus rapid transit system in Jakarta, Indonesia

Jakarta is one of the first three cities to implement a Bus Rapid Transit (BRT) System in Asia. The BRT system called TransJakarta is run by operating the bus system in an exclusive lane along designated existing roads. This type of public transportation was chosen due to its lower cost in comparison with other similar mass transit systems, such as metro, subway and sky-train. Therefore, it could well be adopted by developing countries having a limited budget. The system charges a flat fare (less than 0.5US$ per trip), and its overall operational cost is subsidized by local government.

The BRT in Jakarta is Asia's most extensive BRT. It has been established since January 2004 and is expected to be extended until it reaches a total of 15 corridors in 2010. The system's overall performance has yet to be evaluated; however, early evidence indicates that 14 per cent of BRT passengers shifted from using private passenger cars. Some of the expected impacts include an improved quality of life of Jakarta citizens, reduced air pollution, improved equity in public transportation services and reduced traffic volume and congestion along the corridors.

Some supporting instruments are also being implemented. These included the following:

- regulations providing fines and punishment for those who vandalize the TransJakarta facilities;
- improving quality of the TransJakarta infrastructure;
- increasing number of buses and more bus capacity through the use of articulated buses;
- provision of warning signage;
- increased number of compressed natural gas stations;
- improved facilities in the bus stations;
- improved feeder system, allowing TransJakarta to connect with railway transport for the comfort and convenience of users;
- improved image and quality of service of the system: special buses provided for women;
- reduced travel times for the system; and
- improved park and ride facilities.

Even though there is no hard evidence demonstrating the improvement of air quality in Jakarta, the fact that a number of private car users have shifted to BRT and the growing numbers of BRT riders may soon confirm that BRT is making a contribution to the improvement of air quality.

Sources: Based on Institute for Transportation Development Policy (2005). Making TransJakarta a World Class BRT system. Available online at http://www.itdp.org/documents/TransJakarta%20Final%20Report%205.pdf

Hook, W and Ernst, J (2005). Power Point Presentation Bus Rapid Transit in Jakarta and Some Lessons Learned. Available online at http://www.worldbank.org/html/fpd/transport/learning/presentations/Urban%2520Transport/hook_Jakarta%2520pres.%2520world%2520bank%2520mar%252005_revised.ppt+BRT+TransJakarta&hl=en&ct=clnk&cd=10&gl=th

43. Bus rapid transit system in Bogotá, Colombia

TransMilenio is a Bus Rapid Transit (BRT) System that has been implemented in Bogotá since 2000. The system was chosen due to its cost effectiveness in comparison with a railway system. It is structured as a public-private partnership in which design, planning, and investment in the infrastructure is carried out by public institutions such as the Bogotá mayor's office. Other organizations such as FONDATT (the Fund for Education and Road Safety in the office of the Secretary of Transit and Transportation), IDU (Urban Development Institute), IDCT (the District Institute of Culture and Tourism) and Metrovivienda are also involved. The operations of BRT TransMilenio are overseen by private entities, including trunk line operators, feeder bus operators, fare collection concessionaires and control centre providers.

Development of the system will continue until 2016. Its infrastructure is being funded by the national government, a loan from the World Bank, the Bogotá mayor's office and stakeholders from the transport sector. To cover operating costs, the system is charging flat fares (less than 0.3US$ per trip), and its operation is funded entirely by fare collection with no subsidies provided. It incorporates a sustainable private participation scheme and, although the system is bus-based, its operation is similar to that of a rail-based system.

Some supporting instruments being implemented include the following:

- a specialized infrastructure designed for trunk line services;
- use of advanced technology for ticketing and control;
- establishment of a new institution for system planning, development and control called TransMilenio S.A.; and
- provision of integrated feeder buses called "alimentadores" on local streets.

it is reported that with TransMilenio there has been a 93 per cent reduction in fatalities from traffic accidents; a 40 per cent reduction of some air pollutants; and a 32 per cent drop in travel time for users. It is estimated that TransMilenio will be one of the world's largest BRT systems, second only to that in Curitiba, Brazil, which started up some 40 years ago.

Source: Based on Lee M-Y (2003). TransMilenio Bus Rapid Transit System of Bogota, Colombia. Asia-Pacific Environmental Innovation Strategies. Research on Innovative and Strategic Policy Options.

44. Tata's Nano Car in India

Tata, India's largest automaker, introduced its new energy-efficient vehicle, the "Nano Car", in 2008. It has rear-wheel drive, is composed of light weight all-aluminum and has a two-cylinder petrol engine. According to Tata, the Nano Car's overall weight helps maximize performance per unit of energy consumed and delivers high fuel efficiency.

The first model got around 20 kilometres per litre of gasoline and met stringent European emission standards that have yet to be adopted in India. Its fuel efficiency ensures that it has low carbon dioxide emissions.

Tata has been promoting the Nano by citing the following advantages:

- Fuel-efficient engine. The car has 623 cc, 33 PS, multi-point fuel injection petrol engine. This was the first time a two-cylinder gasoline engine was used in a car with a single balancer shaft. The lean design strategy helps to minimize weight, which helps to maximize performance per unit of energy consumed while delivering high fuel efficiency. Performance is controlled by a specially designed electronic engine management system.
- It meets all safety requirements. The Nano Car's safety performance exceeds current regulatory requirements. With an all sheet-metal body, it has a strong passenger compartment, with safety features such as crumple zones, intrusion-resistant doors, seat belts, strong seats and anchorages and rear tailgate glass bonded to the body. Tubeless tyres further enhance safety.
- Environment-friendly. The Nano Car's tail pipe emission performance also exceeds regulatory requirements. In terms of overall pollutants, it emits less pollution than two-wheelers being manufactured in India today. The high fuel efficiency also ensures that the car has low carbon dioxide emissions, thereby providing the twin benefits of an affordable transportation solution with a low carbon footprint.

But the main concern is that, at a projected retail price of US$2,500, this so-called "people's car" is likely to bring hundreds of thousands more new cars onto Indian roads. Even though it meets the highest emission standards, the Nano's use will increase number of cars and will consequently cause a significant increase in total carbon dioxide emissions.

Source: Based on Tata's Nano Website, available online at http://www.tatapeoplescar.com
Jalopnik website available online at http://jalopnik.com/343003/the-2500-tata-nano-unveiled-in-india and Newsweek's Environment feature, "How Green is a Mini?" http://www.newsweek.com/id/91380/page/1

45. Hybrid technology cars to reduce emissions: some examples

Kenworth hybrid truck

The Kenworth Truck Company introduced a hybrid-electric truck in March 2007 called the Kenworth T270 Class 6. "During steady driving conditions above 30 mph, the T270 hybrid operates like a standard diesel vehicle with all power coming from the engine. Below 30 mph, it uses a combination of diesel and electricity. The system automatically switches between the two modes of operation and is seamless to the driver," claims Kenworth's Chief Engineer. Kenworth had only limited production of medium-duty hybrid trucks for municipal fleets and utility companies in its first year, but full-scale production followed. The goal for the T270 hybrid was to improve fuel economy by 30 per cent in start-and-stop applications, such as those characteristic of utility trucks and vehicles used for pick-ups and delivery. "The more stop-and-go in the application, the better the truck's performance," said the chief engineer. By the end of August 2009, the company had come out with another innovation: the Kenworth T470, which is available with extra horsepower. The company says that buyers of this model can now purchase the truck with the 9-litre Cummins ISL engine with 365 horsepower and 1,250 pounds-feet of torque. Previously, the truck was available with only the Cummins ISL with 345 horsepower and 1,150 pounds-feet of torque. Fuel economy from the T470, the company notes, is better than that of the T270.

Source: http://www.kenworth.com/6100_pre_mor.asp?file=2105

Honda Insight

The Honda Insight is a two-seater hybrid automobile manufactured in model years 2000-2006 and employing hybrid engine technology, optimized aerodynamics and a lightweight aluminum structure to maximize fuel efficiency and minimize emissions. Introduced in 1999, the Insight was first sold in the United States, achieving 70 miles per U.S. gallon. Honda sold 2000 Insights in 2005. The company decided to introduce a new small hybrid-specific car in 2009 – a hybrid version of a Honda Fit or something similar and to discontinue production of the Insight. The company says that its new innovation, the 2010 Honda Insight, will make the use of the most cost-effective hybrid technology. This 40-mpg+compact car, selling for less than US$20,000, has been designed to undercut its competitor, the Toyota Prius. The company claims that the 2010 model has already passed independent world highway fuel economy tests showing it obtained above 60 miles to the gallon. The new model went on sale on April 22 – Earth Day, 2009.

Source: Based on http://www.hybridcars.com/compacts-sedans/honda-insight-overview.html

Toyota Prius

The Toyota Prius is a hybrid electric mid-sized car developed and manufactured by the Toyota Motor Corporation. The Prius first went on sale in Japan in 1997. It was subsequently introduced worldwide in 2001. According to the United States Environmental Protection Agency, the 2008 Prius was the most fuel-efficient car sold in the U.S. The UK Department for Transport said the Prius was tied with the MINI Cooper D as the third least CO_2-emitting vehicle in the UK. The third-generation 2010 Toyota Prius, officially unveiled at the Detroit auto show in January 2009, went on sale in April of the same year. The updated Prius is bigger and more powerful than its predecessor. The company claims that despite its added power and size, the 2010

Toyota Prius is the only vehicle available at present that offers 50 miles per gallon in combined city/highway driving. The manufacturer claims that Toyota achieved this level of fuel efficiency by keeping the vehicle's weight down, maintaining the best aerodynamics of any production vehicle in the world and re-engineering the powertrain to extend the range of all-electric gas-free driving.

Source: Based on http://www.hybridcars.com/compacts-sedans/toyota-prius-overview.html

World's first hybrid train in Japan

In July 2007, a two-car hybrid train came into service in rural northern Japan, one of the latest entrants in the battle against global warming. Following its runaway success with hybrid cars, Japan focused on developing hybrid trains. The train's regular passenger runs was to begin on a short mountain route – the first time a diesel-electric hybrid train has been put into commercial service. This hybrid system is on course for expansion. In 2008, it was running on the East Japan Railway's Koumi Line, and it was further extended in 2009. These hybrid rail cars are effectively designed to be beneficial to the environment because of their reduced fuel usage (as much as 10 per cent less) and lower carbon emissions (approximately 60 per cent less) when compared with existing resort train cars.

The batteries of the train are recharged when the train slows down. After the power is switched off, the motors continue to turn for a time, and that energy — wasted in a non-hybrid train — is used to recharge the batteries.

Several automakers have begun to produce hybrid vehicles because of their greater economy of fuel use and lower emissions compared with conventional internal combustion engine vehicles (ICEVs). These savings are primarily achieved by three elements of a typical hybrid design:

- recapturing energy normally wasted during braking, etc.;
- having significant battery storage capacity to store and reuse recaptured energy; and
- shutting down the gasoline or diesel engine during traffic stops, while coasting or during idle periods.

One issue is the environmental safety of the electric batteries used in hybrid vehicles. Most hybrid car batteries are one of two types: (i) nickel metal hydride or (ii) lithium ion. Both are considered to be more environmentally friendly than lead-based batteries which constitute the bulk of car batteries today.

Source: Based on International Herald Tribune website
http://www.iht.com/articles/ap/2007/07/29/asia/AS-FEA-GEN-Japan-Hybrid-Train.php
http://news.cnet.com/8301-13908_3-9896596-59.html
http://www.japanrail.com/index.php?page=JR-News-q1-09

All of the examples above suggest that the common advantages of using hybrid vehicles include gas savings, and lower toxic emissions in comparison with conventional gasoline-powered cars. In some countries, owners of these cars may also enjoy a tax benefit when purchasing or using them.

46. Hybrid only parking in Suffolk, New York, USA

On 21 August 2008, Suffolk, the easternmost county in New York State and the New York Metropolitan Area, announced preferential parking for hybrid vehicles only. Preferential parking for hybrids has already been adopted by the City of Los Angeles and Miami-Beach, Florida. In addition, many private businesses such as IKEA, Home Depot and Office Depot have spots for fuel-efficient cars.

Suffolk was also seeking to incentivize energy-efficient transportation choices and promote fuel conservation. Legislator Wayne Horsley (D-Babylon) announced legislation to designate "hybrid-only" parking spaces at county office buildings and county-owned and operated facilities. The proposal introduced by Horsley was entitled "The Green Spaces Initiative". The accompanying legislation directed the Commissioner of Public Works to designate a minimum of five per cent of parking spaces at all county facilities for the exclusive use of parking by the owner/operators of hybrid vehicles.

Source: Based on
www.hybridcar.com/index.php?option=com_content&task=view&id=671&Itemid=60

47. Shift from two- to four-stroke motorcycles in Thailand

Bangkok, the capital of Thailand, has been undergoing rapid urbanization and industrialization, especially since the 1960s. Like other fast-growing cities, Bangkok has an ever-increasing vehicle fleet contributing to serious traffic congestion and aggravating air pollution. As a result of the enforcement of several air pollution standards in the period from 1993 to 2004, the use of cleaner four-stroke motorcycle engines was encouraged and polluting two-stroke engines displaced.

Motorcycles are a popular, easy and inexpensive mode of transport for carrying people and goods. At the same time, they have been major contributors to air pollution in Bangkok. In the early 90s, motorcycles in Bangkok numbered about 1.3 million, were increasing at a rate of 10-15 per cent per annum and constituted almost 50 per cent of the total fleet of vehicles.

In Bangkok, motorcycles were considered to be the largest mobile source of hydrocarbon (HC) emissions (at 70 per cent), contributed 30 per cent of the carbon monoxide (CO) and 14 per cent of the particulate matter less than 10 microns in diametre (PM10) originating from mobile sources in 1997. The motorcycles are of two categories based on whether the engine is two-stroke or four-stroke. Four-stroke engines have several benefits over their two-stroke counterpart, such as the following:

- Four stroke engines emit half as much HC and suspended particulate matter (SPM) as do the two–stroke types; and
- Four-stroke has improved fuel economy, created less noise, has a comparable price and established technology, although the two-stroke motorcycles have lower engine weight, smaller size, higher output and greater operating smoothness than four-stroke ones.

To encourage the use of four-stroke motorcycles in Thailand, particularly in Bangkok, the city administration BMA (Bangkok Metropolitan Administration) adopted the regulatory measures of emission standards accompanied by other tools, such as institutional arrangements, stakeholders' participation and awareness/capacity building programmes that assist in reducing emissions. After adopting the first emission standard for motorcycles in 1993, Thailand implemented a fifth new standard in 2004. Following enforcement of the stricter new vehicle emission regulations, in recent years there has been a sharp rise in four-stroke motorcycle sales in the country.

Because four-stroke engines are more fuel-efficient than two-stroke ones, the shift from two- to four-stroke engine motorcycles will reduce the rate of major urban air pollutants, and could be beneficial as well for other cities striving hard for a higher growth rate with fewer adverse effects on the environment.

It is clear that motorcycle emission standards play an important role in reducing vehicular pollution. Through the enforcement of these standards, the use of cleaner four-stroke engines can be encouraged and polluting two-stroke engines can be displaced. Regulatory measures accompanied by other tools, such as institutional arrangements, stakeholders' participation and awareness/capacity building programmes clearly assist in reducing emissions.

Source: Based on Pant, A P, S. Kumar and R. Shrestha (2004). Shift from two- to four-stroke motorcycles in Bangkok. Asia-Pacific Environmental Innovation Strategies. Research on Innovative and Strategic Policy Options.

48. Alternative fuel vehicles in Beijing, China

In 1998, the Beijing government recognized that its air pollution had resulted in severe environmental degradation, and it implemented a project to introduce alternative low-emission fuel vehicles. Because the emissions from transit buses and taxis accounted for a large share in total vehicle emissions, the government decided that the first alternative fuel vehicles (AFVs) developed should be buses and taxis.

In September 1999, the first CNG (compressed natural gas) transit bus appeared in Beijing, marking the beginning of the project. By the end of 2001, the city had 1,630 NGVs (natural gas vehicles), the most of any city in the world. In addition, 3,000 buses were modified to become LPG (liquefied petroleum gas) buses (bi-fuel). By the end of 2001, more than 30,000 taxis had been modified to become bi-fuel cars (using taxi-LPG-gasoline). To achieve its targets, the authorities focused on the construction of CNG and LPG stations, the development of single fuel (LPG) vehicles, mainly taxis, and the development of new CNG buses.

Of all the liquid or gaseous fuels ready for commercial transportation use, CNG offers the greatest reduction in emissions compared to gasoline, as illustrated by the results of Beijing's initiative below.

- Carbon dioxide emissions from CNG were approximately 19 per cent less, while producing the same calorific value;
- Carbon monoxide using CNG was reduced by 65 to 90 per cent;
- CNG resulted in a reduction in non-methane hydrocarbons (NMHC) of up to 97 per cent;
- Particulates were virtually eliminated; and
- Ozone reactivity from NGVs was up to 80 to 90 per cent better than that from gasoline emissions.

A study of NOx and CO concentration was carried out in 2001 for Beijing. Although the total number of vehicles in the city had increased rapidly in the three years since the programme began, the concentration of NOx and CO had not correspondingly increased. In fact, their concentration dropped by 16.4 per cent and 21.2 per cent, respectively, in three years.

For cities with a plentiful supply of natural gas, NGVs, when compared with gasoline vehicles, are a good choice to reduce emissions of NOx, CO and PM. However, CH4 emissions from NGVs are higher when compared with that of conventional vehicles, and CO_2 emissions from NGVs are also greater than that of efficient diesel vehicles. Other shortcomings of NGVs include high initial costs, heavy weight, short range and safety problems. Bi-fuel vehicles may not be as environmentally efficient as anticipated due to poor quality of LPG, low efficiency caused by two fuelling systems and relatively high operational costs.

Source: Based on Songli, Z and Kejun, J (2003). Introduction of Alternative Fuel Vehicles in Beijing. Asia-Pacific Environmental Innovation Strategies. Research on Innovative and Strategic Policy Options.

49. Introduction of electric three-wheelers in Kathmandu Valley, Nepal

In the Kathmandu Valley, the domination of the streets by heavily polluting three-wheelers was replaced by zero-emissions electric three-wheelers in 1999 after unprecedented social pressure culminated in policy and technological debates. Although public awareness and pressure from NGOs existed prior to the street protests and blockades of 1999 (in which local artist groups, clubs and activists took part), the government's 1992 ban of the polluting but popular three-wheelers had remained largely ineffective due to the absence of incentives for owners to abandon their vehicles. In 1999, following the movement's peak and significant media coverage, incentives for owners were incorporated into the national budget in the form of a 75 per cent customs holiday on the import of 12- to 14-seater public transportation vehicles.

The Kathmandu Metropolitan's earlier initiative in partnering with the US-based NGO, the Global Resources Institute, resulted in a demonstration project, which convinced the private sector, public and the government of the plausibility of creating a new industry. The significance of foreign donors, namely, the Danish Agency for Development Assistance (DANIDA) and the United States Agency for International Development (USAID-US-AEP), which supported the initiative, cannot be underestimated in countries where donors heavily influence national policy makers, as in Nepal.

The government's favourable policy extended to a 50 per cent discount from taxable income for a period of seven years to industries involved with energy efficiency, conservation and pollution abatement, Economic (and fuel-related) instruments included the low tariff rates for battery charging, based on the net economic value (NEV), and transport policies and fiscal benefits, including a waiver on annual vehicle registration fees.

By 2002, heavy investment and the creation of the Electric Vehicle Association of Nepal, led to over 600 EV wheelers being in operation on 16 routes, employing 70 women drivers. Meanwhile, the industry has made some effort to adapt to local technology in order to replace expensive imported technology and thereby reducing the costs of batteries.

This case demonstrates that it was essential to offer fair choices and alternatives to stakeholders when phasing out the polluting diesel vehicles. Civil society can play a constructive role in this regard. At the same time, it can create a forum where the private sector and the public can share their concerns and provide a feedback mechanism between the government and its citizens. When a new idea is advanced, demonstration programmes provide considerable help in influencing public opinion. In Kathmandu Valley, the demonstration programme was one of the major stimuli creating entrepreneurial interest.

Source: Based on Dhakal, Sobhakar (2003). Introduction of electric three-wheelers in Kathmandu, Nepal. Asia-Pacific Environmental Innovation Strategies. Research on Innovative and Strategic Policy Options.

50. Environmentally sound transportation planning in Singapore, 1970 to date

Integration of transportation planning into land use planning is a precondition for establishing a sustainable transportation system. Singapore has been doing this since the 1970s. This integration of land use and transport planning in the city/state was undertaken with consideration given to the environmental impact of transportation. The effectiveness of Singapore's land transport policies was based on two foundations: effective implementation and the workability of the policies themselves.

The land transport policies of Singapore aimed to deliver an effective land transport network that is integrated, efficient, cost-effective and has a sustainable plan to optimize the use of transport resources and safeguard the well-being of the travelling public. This involved developing and implementing policies to encourage commuters to choose the most appropriate mode of transport

To achieve these objectives, the coordination and integration of pertinent actions, such as: investment and maintenance of the road infrastructure; investment in, and improvement of, public transport; traffic management schemes; implementing road user charges; fiscal measures directed at car ownership; and comprehensive land use planning were elements of the programme.

Along with these efforts, Singapore used the following strategies to create an environmentally sustainable transportation system:

- Emission standards. Vehicle emission standards have been imposed since 1984 by adopting UN/ECE R15.03 standards for petrol vehicles. In 2006, the EURO IV standards for diesel vehicles were adopted;
- Cleaner fuels. In 1998, leaded petrol was phased out in Singapore. The use of ultra-low sulphur diesel was imposed in 2005;
- Legislation/enforcement. Smoke test and mandatory smoke inspection programmes were applied;
- Education. Education of fleet owners and drivers about driving habits, proper pay loads and proper and regular vehicle maintenance was frequently carried out; and
- Government as enabler. Economic as well as command and control instruments, such as a vehicle quota system, electronic road pricing, efficient public transport comprising a seamless public transit system and promotion of green cars were implemented.

Singaporeans are already enjoying benefits of these measures in terms of reduced emissions of sulphur, ultra-low sulphur diesel, SO_2 and PM 2.5 (Peng 2006), as well as overall improvements in air quality (Wong 2009).

Sources: Based on Peng Y. P. (2006) Towards Environmentally Sustainable Transport: Singapore, presented to the Second Regional Environmentally Sustainable Transport (EST) Forum, Yogyakarta, Indonesia, 11-12 Dec. Available on-line at http://www.uncrd.or.jp/env/2nd-regional-est-forum/presentations/Singapore.pdf

Chin, Anthony (2000). Land use planning and transport integration: the experience of Singapore. World Bank Transport Strategy Review, Yokohama, Japan. Available online at http://siteresources.worldbank.org/INTURBANTRANSPORT/Resources/chin.pdf

51. Integrated road transport system development, Beijing, China

Rapid growth of GDP and population in China has had a number of consequences. One of these is a wide gap between transport demand and supply, which has led to worsening traffic and commuting conditions in Beijing.

To respond to these problems, an integrated road transport system was developed for the city. This was introduced to address the worsening traffic conditions and to improve the commuting situation. Having an integrated system was a recognition that concerted action was necessary, requiring coordination among a number of different government agencies, to achieve results. The objectives were to improve urban transport efficiency, promote socio-economic development, make land use development more efficient, create a good transport environment and align parking prices with transport management.

The system was developed by implementing the following three practices:

- Extension of the road infrastructure. The average road network density on particular ring roads was improved to 2.62 km/km2 and 4.66 km/km2, respectively, in 2000. Road infrastructure development proceeded by organizing a highly efficient road network in several corridors, which included throughway corridors, distributing backbone roads, sub-arterial roads and spur tracks;
- Parking management. To improve parking management, parking fees were increased and differentiated for different times of the day and by region;
- Intelligent transportation systems. Beijing first established 12 intelligent transportation systems monitored by a transportation controlling centre. Also established were a command and deployment system; a transportation monitoring system; a signal controlling system; a transportation induction system; a global positioning system (GPS) for traffic police vehicles; a “122” call-the-police system for traffic accidents; and an automatic monitoring system for traffic violations. Other developments included a traffic information collection system, a computer system for traffic management, a digitalized management system and an information management system.

These efforts have reduced traffic flow in central urban areas, reduced congestion and improved traffic management efficiency. The increased parking fee has also brought in additional revenue.

Source: Based on Qiang, L., Shengmin, Y., and Kejun J., (2003). Integrated road transport system development in Beijing. Asia-Pacific Environmental Innovation Strategies. Research on Innovative and Strategic Policy Options.

52. Pedestrian malls

Car-free zones or pedestrian zones are designated areas of a city where the use of automobile is prohibited. In these zones, pedestrians can benefit from a pedestrian-friendly environment, lined with retail shops. Malls constitute a promising strategy to discourage the use of motorized trips and to use limited city space in a more efficient manner, since a pedestrian uses 20 times less space than an automobile. Moreover, pedestrians are able to communicate and interact with one another as they travel (Wallar, n.d.). A pedestrian zone is basically a street lined with storefronts closed off to most automobile traffic. Emergency vehicles have access at all times, and delivery vehicles are restricted to either limited delivery hours or entrances on the back streets.

Pedestrian malls are found in a number of large cities: Bonn, Cologne, Hamburg and Munich (Germany), Copenhagen (Denmark), Norwich (UK), and Singapore, among others. The significant advantages of developing the malls are that they preserve central city functions, facilitate access for shoppers, reduce noise and air-pollution and improve a city's appearance.

Source: Based on Wallar, Michele (n.d.). How to create a Pedestrian Mall. Culture website, http://www.culturechange.org – retrieved on 28 August 2008.

53. Dar es Salam's transition from small buses to a BRT system

Tanzania's capital city, Dar es Salam, has been growing rapidly since its rapid economic expansion in the mid-1990s. The need for increased mobility could no longer be met by slow and ineffective bus service. As a result, private motorization (made up of taxis, cars and motorcycles) increased which, in turn, increased traffic congestion.

Meanwhile, the city experienced several changes in the administration of transport service. Until 1970, the service was predominantly provided by a British firm (a colonial legacy). In 1974, a public transit agency – Usafiri Dar es Salam (UDA) – was created (in line with the country's President, Julius Nyere's socialist ideal). In 1983, however, the state permitted privately owned buses to operate (as the pendulum swung to the supremacy of a free market economy), known as Daladala (12–seater small buses) – the number of which increased from 824 in 1992 to 7,000 in 2003, accounting for about 65 per cent of the city's bus fleet. The remaining 35 per cent was comprised of 24-30 seater buses.

While Daladalas served a duel role in Dar es Salam's transition from public to private transport service, proliferation of their number increased traffic congestion, which, in turn, made Daladalas slow and inefficient. The service became less attractive, and its operators did not make any reinvestment to improve the service because of its low profitability. Consequently, as is the case with many such bus services in developing countries, Daladala service was based on "second-hand vehicles that were overcrowded, unsafe, uncomfortable and fuel inefficient" Dulac and Ernest (2009, p.14).

In these circumstances, and with the accompanying menace of increasing carbon emissions from the transport sector, projected to increase by 50 per cent to nearly 1.5 million metric tonnes by 2010, Dar es Salam's transport authorities decided to opt for a BRT mode of transport. The United Nations Environment Programme (UNEP) and the Institute for Transport Development Policy (ITDP) have been supporting the city in pilot demonstrations with a 10 km BRT trunk line and an additional 100 km of feeder lines to the BRT system. On completion, the system will have a daily operating capacity of roughly 400,000 passengers and will provide quality bus services using articulated buses, fully enclosed pre-paid boarding stations and exclusive bus lanes. Once the entire system is completed, the resulting modal shift is expected to reduce CO_2 emissions by 430,000 metric tonnes in the first year and more than one million metric tonnes by the fifth year of the system's operation.

Lessons

- The decision to opt for BRT has been timely. With Daladals becoming obsolete, the emergence of BRT was a logical replacement. In its absence, citizens' propensity to individually own private cars would increase; and
- The vanguard role of ODA through UNEP and ITDP has been pivotal in providing technical assistance to develop the project and to explore funding support for its implementation.

Source: Based on information provided in Dulac J. and Ernest K. (2009). *Sustainable Transport Project Demonstration: Bus Rapid Transit, Bus Regulation and Planning and Non-motorised Transportation,* a report prepared for UNEP's Division of Technology, Industry and Economics, Nairobi.

54. Cycling out of poverty: an Africa-wide initiative

Cycling Out of Poverty is an initiative that seeks to "make a world of difference in Africa with a bicycle". Since its initiation in 2006, it has incorporated partner organizations in six African countries – Uganda, Kenya, Rwanda, Ghana, Togo and Burkina Faso – and has launched 17 projects centered on using the bicycle as a means of coming out of poverty. These projects include Cycle to School (Katakwi, Uganda, 2008-2009), Bicycle Ambulances (Katakwi, Uganda, 2008-2009), Bicycle Workshop (Kisumu, Kenya, 2009-2010), Cycle to School (Kisumu, Kenya, 2009) and Curriculum Development for Bicycle Mechanics (Kenya, 2009).

These projects demonstrate the positive aspects of a "poverty-environment"' nexus, i.e., creating poverty-reduction projects in a way that can also improve the environment and vice-versa. The initiative is based on observations that many poor African underemployed men and women are compelled to walk long distances everyday, often carrying a heavy load because they lack the means to use other modes of transport and to buy a bicycle.

Cycling Out of Poverty and their partner organizations in Africa support small entrepreneurs with:

- bicycles purchased using micro-credits;
- providing designs for modified bicycles, suitable for small businesses;
- education for bicycle mechanics;
- seed money to establish a business;
- training of community groups for the implementation of bicycle micro-finance projects in their groups (leadership skills, credit and savings, etc.);
- training bicycle users about the technical aspects of the bicycle; and
- training centre/workshops.

The organizational structure of Cycling Out of Poverty consists of a six-member board. Based in the Netherlands, it has established an East Africa Office. The principal activities of the organization include:

- fundraising and awareness raising, motivating companies, institutions and donors;
- supporting and coaching partner organizations in Africa to develop projects and focus on target groups and approaches;
- linking global partners for knowledge exchange, e.g., on bicycle designs; focusing on small entrepreneurs – mainly women; and
- facilitating access to bicycles via micro-credits using local partner organizations in Africa.

Lessons

- Although no source other than the organization's own could be found to evaluate this initiative, it is nonetheless the case that several theoretically sound and practically feasible ideas have made it spread to several African countries. These ideas include fostering positive aspects of the poverty-environment nexus, micro-finance and utilization of underemployed labour/entrepreneurs, particularly women; and

- Proof that even limited support from a developed country can bring tangible changes to promote emissions-free transportation modes. In this instance, this has been demonstrated by utilizing the informal sector, e.g., labour and enterprises in African developing countries.

Source: Based on information provided in www.cyclingoutofpoverty.com

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