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REPORT OF THE STAP WORKSHOP ON OPTIONS FOR MITIGATION OF GREENHOUSE GAS (GHG) EMISSIONS FROM THE TRANSPORT SECTOR

(Prepared by the Scientific and Technical Advisory Panel)

CONTENTS

REFERENCES AND LIST OF PAPERS PRESENTED AT THE WORKSHOP

PREFACE

1. It is a pleasure to present the report *The STAP Workshop on Options for Mitigating Greenhouse Gas Emissions in the Transport Sector*. The Workshop described in this report was held on March 14-15, 1997 at UNEP Headquarters, Gigiri, Nairobi, Kenya. The Workshop brought together international energy/transport experts from both developed and developing countries working on this issue. This group was convened by the Scientific and Technical Advisory Panel (STAP) of the Global Environment Facility (GEF) to solicit workshop participants' views on urban transport problems and the identification of opportunities for GHGs emissions reduction in developing countries.

2. The STAP report on *Options for Mitigating GHGs Emissions from the Transport Sector* as well as the case studies presented during the Workshop provide much of the basis for the finding and recommendations contained in this report. In addition, STAP will finalize and submit for Council's consideration, further guidance on Transport Sector Management and Advanced Transport Technologies.

3. This workshop report was written by the STAP Working Group on Climate and Energy under the chairmanship of Dr. Robert Williams.

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ABSTRACT

1. The Working Group on Energy and Climate of the Scientific and Technical Advisory Panel (STAP) of the Global Environment Facility (GEF) held a Workshop on Options for Mitigating Greenhouse Gas Emissions in the Transport Sector at UNEP Headquarters, Gigiri, Nairobi, Kenya, March 14-15, 1997. The Workshop brought together international energy/transport experts (from both developing and industrialized countries) who focused on actual experiences of past and ongoing efforts to implement both macro- and micro-level sustainable transport sector response options, the impact on GHGs and local pollutant emission levels and emerging technology options in the transport sector. In addition, relevant socio-economic and institutional issues that are important to the transport sector were highlighted as well as the identification of key barriers to the implementation of response options.

2. The major themes that emerged from the workshop were the following:

1. There was a general agreement of the need for the GEF to establish an Operational Programme focusing on the Transport Sector to help GHG emissions from this sector; and
2. Three priority initiatives were identified by Workshop which could be the focus of GEF's work in the Transport Sector were:

(i) Integrated transport planning and associated information/data needs.

3. Because the present course is unsustainable, there is a need for strategic plans for mitigating GHG emissions from the transport sector. Strategic planning must take into account both opportunities for improving the design and management of the urban transportation infrastructure, and the introduction of more efficient and less carbon-intensive transport technologies.

4. In this regard, the GEF should consider supporting:

(a) More realistic regional analysis and projections that describe the unsustainability of Business-As-Usual energy transport features by quantifying:

(i) Current and projected GHG emissions;

(ii) Current and projected air pollutant emissions and impacts on air quality and regional acidification;

(iii) Current and projected levels of congestion and noise;

(iv) Disparities in access to modern transportation services; and,

(v) The opportunity costs associated with automobile-oriented transport infrastructures.

(b) Pilot initiatives for:

(i) The development of sustainable transport plans that deal simultaneously with GHG and local concerns;

(ii) Formulation of approaches and policies that would be effective in overcoming barriers to the implementation of sustainable transport plans; and

(iii) Pilot information and data collection programmes in the transport to develop cost-effective methodologies and approaches that can assist the development of more realistic urban transport plans and projections.

(c) The establishment of integrated transport energy planning systems by supporting:

(i) Comparative case analysis of transport planning successes and failures, identifying the causes of each;

(ii) Analytical studies that identifies critical decision points and institutions that can influence future transport sector development paths; and

(iii) Capacity building initiatives, including training of relevant officials and local experts in transport energy planning and management.

(d) The development of reliable empirical information and analytical tools, including:

(i) Compilation of relevant transport sector emissions inventory statistics;

(ii) Development of urban air quality monitoring systems; and,

(iii) The development of appropriate analytical tools and models (e.g., energy/environment input output analysis, human behavior-oriented transport-environment simulation models) for the transport sector.

(ii) Institutional innovation that engender long-term commitment and consensus.

4. The increasing complexity of decision-making resulting from a multiplicity of authorities involved in transport issues, underline the need for improved understanding of the role of institutions and decision-making systems. This means that plans seeking to mitigate GHG emissions must also deal effectively with the interests of the stakeholders - in particular giving emphasis to the challenges posed by poor air quality, congestion and noise, disparities in the access to modern transport services, and the social opportunity costs associated with the choice of an automobile-oriented transport infrastructure.

5. In this regard, the GEF should consider:

(a) assisting pilot initiatives for formulation of innovative institutional approaches and policies that would be effective in overcoming barriers to the implementation of sustainable transport plans. Of special interest also is the development and pilot implementation of low-cost and innovative public awareness programs that can provide a model for replication in developing countries, and

(b) extending assistance to the development and wide-scale dissemination of model strategies and policy options that can influence critical decision points and institutions to work towards moving existing transport systems towards a more sustainable and climate-friendly growth path.

(iii) Technological assessment/absorption capability and demonstration initiatives

Many of the case studies demonstrated that technologies and practices needed to reduce GHGs emissions in the transport sector of developing countries are available in the public domain. Their deployment, however, faces major barriers. Technological barriers commonly found in developing countries include the absence of an enabling infrastructure.

6. In this regard, the GEF could support:

(a) Sustainable transport technology scoping and assessment programmes that would identify transport technologies that are appropriate for adoption in the target countries or target sub-sectors;

(b) Transport managements projects, giving priority to those that ensure that available technologies and policy options are adapted first, before resorting to more advanced or complex measures. Priority should be given to the removal of barriers to the rapid and wide-scale deployment of public domain sustainable transport technologies and practices such as: (i) Enhanced traffic management; (ii) Improved urban transport planning; (iii) Deployment of efficient and proven transport technologies; and, (iv) Non-motorized transport options;

(c) The establishment of appropriate adaptive national and regional research agencies and technology institutions that can adapt and modify GHGs mitigation transport response options available in the public domain as well as newer and advanced sustainable transport technologies to suit the prevailing conditions in developing countries;

(d) Model training and capacity building programmes aimed at creating a critical mass of expertise in transport energy management;

(e) Innovative pilot financing schemes that would provide less onerous terms allowing a larger segment

of the target group to access the new energy-efficient vehicles as well as promote the transfer of sustainable transport technologies by supporting technical training for developing country participants in international joint ventures (IJVs). To enhance the effectiveness of such joint ventures in transferring these technologies, consideration must be given to: (i) Lifecycle analysis for new climate-friendly technologies that involve potentially environmentally harmful materials; and, (ii) Development of appropriate regulatory frameworks to ensure that such materials do not degrade the environment (e.g. rules to ensure that lead-acid batteries is recycled); and

(f) Demonstration projects and market development support for small electric-driven vehicles and for electric-driven buses, the widespread use of which could lead to significant reductions in GHG emissions.

BACKGROUND

1. In response to interest shown in the transport sector by the Global Environment Facility (GEF) Council at its October, 1996 meeting as well as expressions of interest by the GEF Implementing Agencies (UNDP, UNEP and the World Bank) at follow-up meetings, the Scientific and Technical Advisory Panel (STAP) of the GEF decided to review the scientific and technical options in the transport sector in view of the rapidly growing greenhouse gases (GHGs) emissions from this sector, and to provide recommendations for what the GEF could do to reduce this growth. STAP decided to initially focus on the urban transport problems and identify opportunities for GHGs emissions reduction in developing countries. The STAP/Energy Climate Working Group commissioned case studies to be presented at a Transport Workshop in Nairobi in March, 1997 focusing on the following cities: Gaborone, Calcutta, Mumbai (formerly known as Bombay), New Delhi, Chennai and Singapore.

2. The Workshop brought together international energy/transport experts, some of whom presented case studies outlining key transportation issues in the aforementioned six developing country cities plus case examples from Bangkok, Curitiba, Mexico City and Santiago. These papers focused on actual experiences of past and ongoing efforts to implement both macro and microlevel sustainable transport sector response options, and in some cases, the impact on GHGs and local pollutant emission levels. The case studies highlighted relevant socioeconomic and institutional issues that are important to the transport sector, and identified key strategies and measures for overcoming the barriers to the implementation of response options. Papers were also presented on emerging technology options in the transport sector, giving focused attention to zero or near-zero electric drives technologies for small road vehicles and buses and to advanced battery technologies.

3. This summary overview paper brings together key findings of the aforementioned papers and identifies emerging issues and barriers pertaining to options for GHGs mitigation in the transport sector highlighted by the overview papers, case study papers and Workshop panel and discussion sessions. Drawing on recommendations from the Workshop papers and discussion sessions, the paper presents priority options for mitigation of transport sector GHGs that could be considered for support under the proposed GEF Transport Program.

GREENHOUSE GAS EMISSIONS FROM THE TRANSPORT SECTOR

4. Greenhouse gases (GHGs) emissions from energy use in the transport sector account for a large and growing proportion of global greenhouse gas emissions. The bulk of the emissions are linked to the use of fossil fuels, with CO2 constituting the main greenhouse gas. According to the Intergovernmental Panel on Climate Change (IPCC), energy use in the transport sector is estimated to account for close to 60% of all oil products consumed in 1990 (IPCC, 1996). In Africa, an estimated 50% of total petroleum use is utilized in the transport sector (Karekezi, 1996). The equivalent figures for Latin America and Asia are

54% and 45%, respectively. Ramanathan and Parikh (1996) estimate that in 1993-94 petroleum products accounted for 95.7% of fuel consumption in the Indian transport sector. Petroleum fuel use is closely linked to the transport sector in almost all countries of the world.

5. The IPCC estimates that the transport sectorÄincluding passenger travel and freight movements by road, rail, air and waterÄaccounts for 25% of the world consumption of primary energy in 1990 and 22% of CO2 emissions (IPCC, 1996). In addition to CO2, other important GHGs emissions from the transport sector include nitrous oxides (N2O) from tailpipe emissions of gasoline vehicles fitted with 3-way catalytic converters; methane (CH4) from petroleum fuels exploration, extraction, processing and transport; and chlorofluorocarbons (CFCs) from air conditioning units of motor-vehicles (IPCC, 1996). Vehicles also emit carbon monoxide, volatile organic compounds (VOCs) and nitrogen oxides (NOx), whose global warming potentials are still not well understood. The contribution of non-CO2 emissions from aircraft engines is still unclear although the IPCC states that it might be possible for NOx emissions from sub-sonic aircraft to be higher than terrestrial NOx emissions (IPCC, 1996). Other aircraft emissions include carbon monoxide, water vapor, sulfur gases, soot and other particles. The impact of these non-NOx and non-CO2 emissions is still to be fully assessed.

6. Several international bodies have attempted to assess transport CO2 emissions projections, notably the International Energy Agency (IEA), the International Institute for Applied Systems Analysis (IIASA), the IPCC and World Energy Council (WEC). The widely divergent projections are an indicator of the absence of consensus on what might be the most likely path for future transport CO2 emissions. Most of the projections are based on a number of assumptions on the relationships between transport fuel consumption and variables such as gross domestic product (GDP), fuel prices, urban population growth trends and vehicle energy efficiency (IPPC, 1996; Ramanathan and Parikh, 1996). Not all analysts concur with these assumptions.

7. Existing studies, are largely still reliant on a some form of a correlation between transport energy use and GDP. The variation among countries, however, can be very significant with growth of transport energy use in relation to income faster in rapidly-growing middle-income countries and lower for very-low-income countries. A study undertaken in Mauritius also showed that the link between GDP growth and increased transport demand exists but is not necessarily linear (Bhagavan, 1996). Available data on the US transport sector shows a significant decoupling between automobile energy consumption and GDP growth because of technological improvements. A number of analysts also question the belief that global car ownership patterns - a major driver of transport energy consumption - will follow North-American growth trends. Efficiency improvements combined with different settlements patterns prevailing in other parts of the world is likely to result in the attainment of saturation levels at lower levels than those attained in North America (IPCC, 1996). In addition, in several least-developed countries, particularly in Africa, existing constraints to vehicle ownership are likely to lead to a much slower growth in transport energy demand. For example, it is estimated that in many sub-Saharan African countries, the average professional would need to commit 12 years of his monthly salary to purchase a medium-sized car compared to 1.5 to 2.0 years salary in the mid-1970s (Karekezi, 1994).

8. Highly desegregated bottom-up transport energy studies provide additional insights on important drivers of GHGs emissions from transport. An understanding of the complex factors that drive transport energy growth is needed if a more realistic understanding of key factors that drive transport GHGs emissions is to be realized. Important factors include population growth, settlement patterns, new transport and communication technologies, and, the world-wide shift towards service industries. There is, however, a dearth of bottom-up transport energy studies, especially in developing countries, partly because of cost. As expected, available studies in developing countries indicate that survival and economic security needs are important drivers to transport energy demand. In more affluent industrialized countries, social needs appear to play a much greater role (IPCC, 1996). More detailed studies of travel

behavior, however, show startling differences even among countries of similar income levels. In industrialized countries, recent surveys indicate the tendency for travel time to be relatively fixed with travel distances varying according to speed of travel. This is likely to lead to greater demand for faster forms of transport which may explain the growing popularity of high-speed trains and air travel.

9. Road vehicle population continues to grow. Between 1970 and 1990, the global road vehicle population grew by 140%. Projections to the year 2025 indicate further growth rates of 60-120% (IPCC, 1996) with highest growths in South-east Asia, Africa, Latin America and countries in economic transition of central and eastern Europe. From 1980 to 1990, the number of cars and commercial vehicles in developing countries grew at an annual rate of 6.5% increasing the total stock from 49 million (12% of world total) to 92 million (16% of world total); in Asian developing countries, the total stock of cars and commercial grew at an annual rate of 10.8% a year (from 14 million in 1980 to 39 million in 1990) (Worrell et al., 1997). The World Energy Council projects in one of its base case scenarios for 2020 that the total stock of passenger cars in developing countries will six times the estimated total in 1990 (WEC, 1995).

10. In industrialized countries, one notable development has been the growing popularity of light-duty trucks (vans, pick-ups) which emit higher levels of GHGs than cars. A significant proportion of vehicles growth in developing countries consists of second-hand imports from more affluent industrialized countries which generally produce a higher level of emissions. For example, in 1975, imports of second-hand cars into Kenya exceeded the imports of new cars by almost 20%. A recent study in Nigeria indicated that between 1993 and 1995, over 92% of cars imported into the country were second-hand (GTZ, 1996). The average age of vehicle fleets in developing countries are estimated to be almost double that of vehicle fleets in more affluent industrialized countries. In Ethiopia, the average age of vehicles is 16 years while in Cairo, 25% of all cars are over 20 years old and 65% over 10 years old (Karekezi, 1994). Use of buses and trains has increased but not as rapidly as car traffic (IPCC, 1996).

11. The transport sector poses a special challenge to researchers, project managers and policy makers interested in climate change issues. The range of technologies used in road, rail, air and water transport systems are extremely diverse ranging from simple walking, cycling through to two-wheeled, three-wheeled and four wheeled motorized vehicles, trams, trains and array of motorized boats and air planes of varying sizing and sophistication. Transport energy includes various grades of petroleum-based fuels, biofuels, coal and electricity sourced from a wide range of fuels. Response options for mitigating GHGs emissions from the transport sector are equally diverse and include urban planning, traffic management, alternative fuels, efficient motorized vehicles, dual-fuel vehicles, modal shifts and regulatory and pricing reforms. The diverse range of transport modes, technologies, fuels and response options makes underlines the need for a comprehensive strategy for the transport sector.

GHGS MITIGATION OPTIONS FOR THE TRANSPORT SECTOR

12. Case studies and examples presented at the STAP March, 1997 Transport Workshop examined experiences in the following cities: Bangkok, Calcutta, Curitiba, Gaborone, Mexico City, Mumbai (formerly known as Bombay), New Delhi, Chennai, Santiago and Singapore. Overview papers also provided new and insightful data and information on Addis Ababa, Beijing, Cairo and Tehran.

13. In the contrast to the 1980s, the case studies, examples and discussions during the Workshop showed that the quality and reliability of empirical information on energy consumption in the urban transport sub-sector has significantly improved. Of particular interest is the growing availability of data on actual savings achieved by the following clusters of urban transport response options (listed in order of implementation time-line e.g short, medium to long-term):

1. Enhanced traffic management;
2. Urban transport planning;
3. Efficient and proven transport technologies;
4. Non-motorized transport options;
5. Pricing and regulatory reforms;
6. Advanced transport technologies; and
7. Capital-intensive urban transport infrastructure investments.

Enhanced traffic management:

14. This category of response options encompasses measures such as zone access restrictions or area licensing schemes; parking control; segregated vehicle lanes; and computerized and synchronized traffic signals An ambitious area licensing scheme has been implemented in Singapore and led to an estimated 30-35% reduction in traffic in the city's central business area (Fwa, 1996). Dedicated bus lanes have demonstrated the ability to increase average bus speeds by 25% thus reducing overall traffic congestion and reducing fuel consumption.

Urban transport planning

15. High-density urban centres that allow people to live, work and shop within a short distance can reduce reliance on automobiles. Most of the urban centres in the developing world were originally designed to accommodate relatively small fleets of vehicles. The vehicle population has increased several fold in the last two decades, and traffic congestion is becoming increasingly common. Studies of 32 cities in the world suggested that increasing land-use intensity in cities (density of jobs and residences) can contribute to lower urban private motorised transport use and thus lower transport energy consumption. Urban planning should, therefore, aim at a mixed land-use of work-place, residences, shopping and other services, so that daily activities can occur with minimum demand for urban transport.

16. The city of Curitiba in Brazil has one of the most outstanding public transport systems in the world, which has evolved over a twenty-year period to be fully integrated with the land use. The city's growth has been encouraged along pre-determined plans resulting in the development of new commercial and residential areas outside the central city area and along major roads (Rabinovitch and Leitman, 1996) . This arrangement reduced pressure on the city centre and enabled the commercial and residential areas to have access to public transport resulting in overall reduced transport fuel consumption.

17. The State and City Planning project of Singapore represents another important model example of effective urban transport planning. As shown in figure below, many of its recommendations prepared over a 4-year period (1967-1991) were implemented (Fwa, 1996):

FIGURE 1: IMPACT OF STATE AND CITY PLANNING PROJECT OF SINGAPORE

Recommendations of State and City Planning Project of Singapore	Actual Development
Check growth of private vehicles	Since 1971, policies to increase costs of owning vehicles have checked growth of private vehicles
Demarcate inner city zone for traffic control	Area Licensing Scheme implemented in 1975 for the central business district

Construct island-wide expressway roadway system of 111km and add 394km of complementary trunk roads	Construction of 120kms expressways completed in 1996 plus a total of 540km of major arteries.
Construct 32 km of rail transit system by 1992	MRT rail rapid transit system of 67 km completed in 1991

Efficient and proven transport technologies

18. Examples that can be placed under this category of response options include improving the fuel efficiency of vehicles in operation through proper maintenance and regular vehicle testing; incorporating fuel-saving features in new vehicles (e.g. cab deflectors on commercial trucks to reduce air drag thus improving fuel consumption); shifting the mix of new vehicles towards more efficient models; and , modal shifts to more efficient non-capital intensive mass transit options (buses and light rail transit systems). Improved maintenance of existing fleet of vehicles can result in significant energy savings. Some studies indicate that proper vehicle tuning can yield 20% decrease in fuel consumption. Other studies indicate somewhat lower savings of between 2% to 10% (IPCC, 1996). Replacement of cross-ply tyres with radial tyres can reduce fuel consumption by 10%. Poor tyre maintenance can increase fuel consumption. It is estimated that a 10% under-inflation of tyres results in a 2% increase in fuel consumption for buses and heavy duty vehicles or 1% in cars (Martin et al, 1995).

19. Public transport is often considered to be a better investment than the subsidizing auto transport, particularly for the world's most populous and congested urban areas. For example, a study in New Delhi demonstrated that buses are 8 times more efficient than cars in terms of energy use per passenger-kilometre (Martin et al, 1995) while Davidson (1992) estimates that cars use 10 times and 8 times more fuel than buses in Ethiopia and Sudan, respectively. A study undertaken in Mauritius under the auspices of the African Energy Policy Research Network (AFREPREN), provides convincing evidence that increasing the transport modal share of buses in Mauritius from the current 70% to 85% would decrease gasoline consumption by almost 55% (Bhagavan, 1996).

20. A two track rail line for example can carry the same number of people as 16 lanes of highway over a one hour period. Similarly, a subway train uses 1,100 Btu to move a passenger one kilometre - only one sixth the energy required by an automobile with one passenger (Boerne and Hatfield, 1994). A study of Santiago, Chile transport system showed that mass transit were particularly advantageous in controlling GHG emissions. On a per capita basis, the CO2 emissions of buses and the Metro were close to a tenth that of private passenger vehicles and taxis. Light duty private vehicles (autos and pickups) accounted for close to 40% of all CO2 emissions, taxis and collectivos for 24%, buses for 20% and trucks, 15%. The contribution of the Metro was relatively minor (Beg, 1996).

Non-motorized transport options

21. The use of bicycles and tricycles can provide an efficient urban transport alternative. These can be promoted by the manufacture of bicycles, provision of exclusive lanes and safeguarded parking lots suitably located near public transport stops to increase access to a variety of destinations. With the exception of walking (often resorted to because of absence of alternatives) non-motorised transport systems are very poorly developed in the South, particularly in Africa (Karekezi et al, 1994). Despite the low cost, high accessibility and energy efficiency of cycling and walking, many developing country urban planners consider provision of walking and cycling facilities as assistance to recreational activities

as opposed to strengthening a functional transport system.

22. Despite the potential of non-motorized transport, its users have been disadvantaged in various ways. First, they are physically vulnerable, as a consequence of the failure to separate motorized from non-motorized traffic - for example by providing side walks for pedestrians and bike paths for cyclists. Even where cycle paths exist, users of non-motorized transport are vulnerable to personal attack (World Bank, 1996). Governments often discriminate fiscally against non-motorized transport. In Africa, the diminishing stock of bicycles is partly a consequence of high taxation on imports (which treats bicycles as a luxury). Markups on border prices have ranged between 200-500% in Ethiopia, Ghana and Tanzania. In 1992, a bicycle cost an average per capita income of seven months in Uganda, ten months in Malawi and Tanzania and more than three years in Ethiopia (Karekezi, 1996). Although arrangements to provide relatively poor people with credit for non-motorized transport are rare, several recent schemes have been successful. In Burkina Faso and Zimbabwe, these have been associated with Government-financed integrated rural development programs (World Bank, 1996).

23. In Asia, however, non-motorized transport is particularly important accounting for a significant share of both passenger and freight transport. A recent study estimated that non motorized transport accounted for over 30% of freight transport in Bangladesh and close to 60% of passenger transport. In India, non-motorized transport was estimated to account for over 15% and close to 20% of freight and passenger transport, respectively (Martin et al, 1995).

Pricing and regulatory reforms

24. Examples include increasing fuel prices to reduce fuel demand; fuel prices, taxes and import duties which favour more energy-efficient vehicles; soft loans that encourage adoption of more efficient buses to replace individual taxis; incentives for fleet owners to adopt improved fuel management, driver training; preventing maintenance; and, cab deflectors that reduce air drag; increased taxation of company cars which are reckoned to travel longer distances (20% more) and consumer more fuel (10% higher) than individually-owned vehicles; and, road pricing that charges users for road use.

Advanced transport technologies

25. In the area of new transport technologies, vehicles characterized by zero or near-zero pollutant emissions warrant particular attention in light of the severe pollution problems posed by the rapidly growing populations of motor vehicles in densely populated urban areas and the difficulties inherent in meeting air quality goals by making incremental improvements in reducing emissions from internal combustion engine vehicles. In particular developing countries have the opportunity for *technological leapfrogging to emerging sustainable transportation technologies* such as electric-driven bicycles, tricycles, buses, delivery vans, trucks, and locomotives.

26. Such technologies used in conjunction with innovative transportation infrastructure designs and demand management strategies make it possible to bring about sustainable transportation systems. These vehicles can achieve zero or near-zero emissions of local air pollutants, without the need for tail-pipe emission control systems. Such technologies also make it possible to diversify transportation fuels away from petroleumÄoften to fuels that can be produced locally, thereby reducing foreign exchange requirements for oil imports. And some of these vehicle/fuel systems simultaneously offer the potential for achieving deep reductions in lifecycle GHG emissions from the transport sector. Moreover, electric-driven small vehicles (e.g., bicycles, tricycles) offer the potential for reducing the demand for automobiles, while substantially enhancing mobility, if coupled to demand management strategies that promote the safety of riders of such vehicles (e.g. creation of road lanes dedicated to use by qualifying small vehicles) and enhance the security of using such vehicles (e.g. via measure that reduce the risk of

theft of such vehicles).

27. *Electric drive technologies* are major candidates both for the transfer from industrial countries to developing countries of emerging sustainable transportation technologies and for developing country leadership roles in the production and marketing of such technologies. Developing countries have opportunities to become market leaders especially in the areas of *electric-drive technologies for small-vehicles* and *electric-drive technologies for buses*. Large internal markets provide opportunities for bringing down quickly the costs of these emerging technologies, and current wage-rate differentials between industrial and developing countries provide opportunities for lower production costs than would be feasible with imported technologies. Global market leadership opportunities would diminish if the introduction of such technologies were deferred, both because wage-rate differentials would narrow, and because slower internal market growth would lead to loss of opportunity for bringing down costs quickly. For both electric-driven small vehicles and electric-driven buses, the costs of demonstration projects, which are needed as first steps in the technological innovation process, would be quite modest.

Capital-intensive urban transport infrastructure developments

28. Examples include capital-intensive underground and above ground mass transit and rapid rail systems. While these systems can yield significant fuel savings and greatly enhance urban transport services, the investment requirements are usually extremely large. For example, a comprehensive mass-transit underground system for one of the large mega-cities of the development may require an investment equal or larger than the entire GEF financial resources.

EMERGING ISSUES

29. In seeking to identify and develop appropriate infrastructure designs and management systems and identify factors that are likely to influence future transport and related GHGs emissions trends, Workshop participants identified the following key emerging issues:

1. The increasing gaps between the rapid growth of economic activities and the establishment of a concomitant urban transport systems;
2. Changes in industrial structures (e.g. laborintensive to capitalintensive as well as the shift towards the service sector) and their effects on transport;
3. The growing importance private sector participation in the transport sector (for example, the advent of private-sector managed highways in Malaysia, Indonesia, India and Central and Eastern Europe); and
4. The large differences between the institutional capacity, socioeconomic levels, and physical infrastructure of industrialized and developing countries, and between developing countries, and thus the need to tailor transport GHGs mitigation options to the specific country/city in question.

RECOMMENDATIONS TO THE GEF

30. Workshop participants re-iterated the need for GEF to establish an Operational Program to help reduce GHG emissions from the transport sector but underlined the limited financial resources available to the GEF vis a vis investments needed to reduce GHGs emissions in the transport sector in developing countries. For example, the investments requirements of just one city-wide mass transit system in one of mega-cities of the developing could absorb all GEF financial resources. Workshop participants, however, identified important opportunities for GEF pilot initiatives in the removal of the significant barriers to implementation of climate-friendly transport options as well as demonstration projects for the more advanced transport technology options. Through its links with the large constituency of GEF Implementing agencies and member countries, the GEF could leverage its pilot initiatives and encourage

the mobilization of much larger investments towards a more climate-friendly transport system. Identified priority initiatives identified by Workshop participants include:

1. Integrated transport planning and associated information/data needs;
2. Institutional innovation that engender long-term commitment and consensus; and
3. Technological assessment/absorption capability and demonstration initiatives.

Integrated transport planning and associated information/data needs

31. Workshop participants stressed that virtually all Business-as-usual (BAU) transportation futures are unsustainable. BAU transportation futures indicate: (*i*) substantial increases in GHG emissions as a result of the continued rapid growth in the use of fossil fuels in transportation, (*i*) severe aggravation of urban air quality (which is already typically far worse in densely populated cities of developing countries than in the industrial countries), (*iii*) increased congestion and noise, (*iv*) growing disparities in access to modern transportation services, and (*v*) high opportunity costs and large investment requirements associated with the choice of an automobile-oriented transport infrastructure.

32. Because the present course is unsustainable, there is a need for strategic plans for mitigating GHG emissions from the transport sector. Strategic planning must take into account both opportunities for improving the design and management of the urban transportation infrastructure, and the introduction of more efficient and less carbon-intensive transport technologies.

33. GEF should consider support for more realistic regional analyses and projections that describe the unsustainability of BAU energy transport futures by quantifying:

1. Current and projected GHG emissions;
2. Current and projected air pollutant emissions and impacts on air quality and regional acidification;
3. Current and projected levels of congestion and noise;
4. Disparities in access to modern transportation services; and
5. The opportunity costs associated with automobile-oriented transport infrastructures.

34. In addition, GEF should consider assisting pilot initiatives for:

1. The development of sustainable transport plans that deal simultaneously with GHG and local concerns; and
2. Formulation of approaches and policies that would be effective in overcoming barriers to the implementation of sustainable transport plans.

35. The transport infrastructure in many developing countries is in its early stages of development. Consequently, there are both near-term threats of lock-in to inappropriate transport infrastructures and supporting transport fuel infrastructures, as well as near-term opportunities for selecting infrastructure development paths that are compatible with sustainable transport development. Possible near-term threats of lock-in to inappropriate transport infrastructures and supporting transport fuel infrastructures include: (*i*) selection of automobile-intensive paths in many countries that presently have few cars, (*i*) selection of petroleum-based transportation systems in countries that presently have little petroleum-based transportation (e.g. China), (*iii*) construction of natural gas pipelines with materials that make difficult their potential later adaption to transport of hydrogen (ultimately the fuel of choice for fuel cell vehicles), and (*iv*) shut-in of newly depleted oil and natural gas fields in ways that preclude their potential future use for storing CO2 that might be produced in the production of hydrogen from carbonaceous feedstocks (e.g. natural gas, heavy oils, coal, biomass, municipal solid waste) for use in fuel- cell vehicles.

36. Because many developing countries are not yet locked in to petroleum-based internal combustion engine vehicle-based transport infrastructures and vehicle systems, they have opportunities both for introducing innovative transport infrastructure designs and management systems and innovative vehicle technologies aimed at providing urban transportation services efficiently in ways that both reduce GHG emissions and deal effectively with the panoply of local concerns about the urban transportation system such as local air pollution and inadequate access to affordable and efficient transport services.

37. The GEF could assist in the establishment of integrated transport energy planning systems by supporting:

1. Comparative case analyses of transport planning successes and failures, identifying the causes of each;
2. Analytical studies that identifies critical decision points and institutions that can influence future transport sector development paths; and
3. Capacity building initiatives, including training of relevant officials and local experts in transport energy planning and management.

38. Workshop participants linked the failures of many transport plans to capture adequately the significant constraints and the opportunities offered by various institutional and technological options, as a result of poor statistics and analytical methodologies and limited data that are inadequate for constructing good projections. Typical information barriers include limited knowledge of existing transport energy saving measures; lack of information on detailed specifications, performance, costs and benefits of transport response options; inadequate understanding of the scale of fuel use and appropriate response options; poor understanding of how relatively modest changes in operation (e.g. speeding and braking) can yield significant fuel savings benefits; lack of expertise on fuel management among transport planners and analysts; and, absence of reliable case study information on transport energy interventions.

39. The GEF could consider supporting pilot information and data collection programs in the transport to develop cost-effective methodologies and approaches that can assist the development of more realistic urban transport plans and projections.

40. In addition, the GEF can assist the development of reliable empirical information and analytical tools, including:

1. Compilation of relevant transport sector emissions inventory statistics;
2. Development of urban air quality monitoring systems; and
3. The development of appropriate analytical tools and models (e.g., energy/environment input output analysis, human behaviororiented transportenvironment simulation models) for the transport sector.

Institutional innovations that engender long-term policy commitment and consensus

41. There are numerous institutional barriers to the deployment of transport energy response options in the developing world. Institutional weaknesses include the existence of legal loopholes, dishonest practices and absence of institutions with the required legal backing to ensure implementation of regulatory measures aimed at improving the efficiency of transport energy use. According to the World Bank, most of its traffic improvement project failures are linked to institutional problems within client problems (Martin et al, 1995). Engineering and technical problems are much easier to address. In addition, agencies responsible for transport decisions are, not necessarily interested in related energy and environmental concerns. For examples, Transport Ministries are largely pre-occupied with maximizing mobility and access to transport services. Energy and environment concerns are given low priority

although decisions made at Transport Ministries have enormous energy and environment implications (IPCC, 1996). Similar conclusions can be draw with respect to public transport authorities; local or municipal authorities; and, owners of large fleet vehicles (Ramaphane, 1996)

42. Unfortunately, the experience has been that many plans fail, with some notable exceptions (e.g. Singapore and Curitiba). Plans fail where there is a lack of consensus among the major stakeholders and where there is lack of a long-term commitment to a strategic plan on the part of key decision-making bodies. Successful plans must be designed on the basis of consensus among these stakeholders, to facilitate the realization of a long-term commitment on the part of these decision-making bodies.

43. The increasing complexity of decision-making resulting from a multiplicity of authorities being involved in transport issues, and thus the need for improved understanding of the role of institutions and decisionmaking systems. This means that plans seeking to mitigate GHG emissions must also deal effectively with the interests of the stakeholdersÄin particular giving emphasis to the challenges posed by poor air quality, congestion and noise, disparities in the access to modern transport services, and the social opportunity costs associated with the choice of an automobile-oriented transport infrastructure.

44. The GEF should consider assisting pilot initiatives for formulation of innovative institutional approaches and policies that would be effective in overcoming barriers to the implementation of sustainable transport plans. Of special interest also is the development and pilot implementation of low-cost and innovative public awareness programs that can provide a model for replication in developing countries.

45. In addition, the GEF can consider extending assistance to the development and wide-scale dissemination of model strategies and policy options that can influence critical decision points and institutions to work towards moving existing transport systems towards a more sustainable and climate-friendly growth path.

Technological assessment and absorption capability

46. Many of the case studies demonstrated that technologies and practices needed to reduce GHGs emissions in the transport sector of developing countries are available in the public domain. Their deployment, however, faces major barriers. Technological barriers commonly found in developing countries include the absence of an enabling infrastructure. For example, poor and congested roads would limit the benefits that can be derived from using larger, faster and aerodynamically streamline trucks and buses. Lower octane fuels commonly found in developing countries would constrain efforts to realize high compression ratios needed for higher energy efficiency. Widespread availability of low-cost second vehicles are likely to inhibit attempts to introduce new efficient vehicles and devices. Unreliable and limited telecommunications facilities common in non-industrialized countries would be unable to support sophisticated advanced traffic controls.

47. The GEF could support sustainable transport technology scoping and assessment programmes that would identify transport technologies that are appropriate for adoption in the target countries or target sub-sectors.

48. In addition, the GEF could consider extending support to transport managements projects, giving priority to those that ensure that available technologies and policy options are adapted first, before resorting to more advanced or complex measures. Priority should be given to the removal of barriers to the rapid and wide-scale deployment of public domain sustainable transport technologies and practices such as:

1. Enhanced traffic management;
2. Improved urban transport planning;
3. Deployment of efficient and proven transport technologies; and
4. Non-motorized transport options

49. In the short to medium term, the absence of qualified skilled technical personnel is, arguably, the single most important technological barrier. For example, sophisticated fuel injection and electronic engine management systems may require specialists firms to assist in routine maintenance increasing the loss-making "downtime" experienced by fleet operators. Comprehensive vehicle testing requirements may require access to expertise and equipment that is not available.

50. The GEF should consider assistance to developing countries for the establishment of appropriate adaptive national and regional research agencies and technology institutions that can adapt and modify GHGs mitigation transport response options available in the public domain as well as newer and advanced sustainable transport technologies to suit the prevailing conditions in developing countries. In addition, the GEF could support model training and capacity building programmes aimed at creating a critical mass of expertise in transport energy management.

51. Hidden costs associated with new technologies include information access costs; programme management costs; and, the opportunity costs associated with re-allocation of scarce technical and management expertise to managed transport energy management programmes. The GEF could consider supporting information and training programmes that would assist participants to overcome the hidden costs associated with new technologies. The first cost and hidden costs of new technologies barrier could conceivably be addressed by the GEF. The first cost barrier refers to the relatively high cost of new vehicles and related new technologies in developing countries relative to the low incomes prevailing in the non-industrialized countries.

52. GEF should consider support for innovative pilot financing schemes that would provide less onerous payment terms allowing a larger segment of the target group to access the new energy-efficient vehicles. In addition, the GEF could promote the transfer of sustainable transport technologies by supporting technical training for developing country participants in international joint ventures (IJVs). To enhance the effectiveness of such joint ventures in transferring these technologies, the GEF should consider support for:

1. Lifecycle analyses for new climate-friendly technologies that involve potentially environmentally harmful materials; and
2. Development of appropriate regulatory frameworks to ensure that such materials do not degrade the environment (e.g. rules to ensure that lead in lead-acid batteries is recycled).

53. GEF should also consider support for demonstration projects and market development support for small electric-driven vehicles and for electric-driven buses, the widespread use of which could lead to significant reductions in GHG emissions.

STAP FOLLOW-UP

54. The GEF Operational Strategy, adopted in October 1995, adopted ten operational programs and indicated two others for development. One of these programs was for mitigation of GHGs in transport, and the GEF Secretariat has started to develop this program. Secretariat staff and consultants working on the transport operational program joined the STAP Workshop so that the operational and programming aspects could be developed in the light of the scientific and technical guidance of STAP.

55. Initial follow-up will be in the form of dialogue with STAP on the draft operational program at the STAP meeting in September 1997. As in the previous discussions on operational programs, in September 1996, discussion is expected to focus on indicative areas of GEF support and appropriate indicators for monitoring and evaluating the success of the program. After the GEF Council has considered the program, which they are expected to do in November 1997, STAP would be in a position to follow up with more specific guidance on the nature of transport strategies and studies that would be implemented within the operational program as approved.

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