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ROAD TRANSPORTATION ENERGY CONSERVATION: NEEDS AND OPTIONS IN DEVELOPING COUNTRIES

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ACRONYMS

AID	Agency for International Development
GDP	Gross domestic product
HOV	High Occupancy Vehicles
LDC	Less Developed Countries
SSTM	Small-Scale Traffic Management
TEC	Transportation energy conservation

EXECUTIVE SUMMARY

INTRODUCTION

The transportation sector is one of the largest energy users in developing countries, and is often the primary consumer of oil. On average, developing countries use 44 percent of their petroleum products in the transportation sector. Moreover, transportation energy consumption is rising as fast as, or faster than, economic growth in developing countries, indicating that it will continue to have a major impact on their balance of trade and economic development.

Over the past ten years, most countries have sought to reduce the growth in fuel use in the transportation sector while maintaining economic growth. Several countries, mostly industrialized nations, have been successful in this effort. As a group, developing countries have fared less well, although a number of them have pioneered ambitious projects in fuel substitution. Developing country efforts to conserve energy in the transportation sector have generally been limited to fuel pricing policies, vehicle import restrictions, and public information campaigns. International donor and lending institutions have sponsored many transportation infrastructure programs but have seldom provided sizable support to fuel efficiency improvement programs. Because there have been few transportation energy conservation programs, it is not clear 1) what the measurable impact of such programs is, 2) how replicable they are, and 3) what approaches work and do not work in developing countries in general.

To help international development organizations and developing countries find answers to these questions, the U.S. Agency for International Development Office of Energy of the Bureau for Science and Technology has sponsored the preparation of this report as part of its Energy Conservation Services Program. The purpose of the report is to provide a reference manual to facilitate decision-making on specific conservation measures. To prepare the report, Hagler, Bailly & Company, the prime contractor, carried out the following tasks:

- Gathered and analyzed relevant statistics on transportation energy use[1] in developing countries

[1]This effort concentrated on road transportation, since it is the primary consumer of energy in the sector. References to transportation energy conservation can be assumed to refer to road transportation unless otherwise stated.

- Analyzed those statistics and other information to rank developing countries according to their need for transportation energy conservation projects, and their potential for successfully implementing and benefiting from such projects
- Identified, described, and evaluated relevant transportation energy conservation projects in developing countries
- Identified, categorized, and described measures that can be used to improve transportation energy efficiency
- Evaluated these measures for their relevance to developing countries, their ease of implementation, and their ease of transfer -- from developed countries to developing countries and within developing countries
- Quantified the potential impact of these measures in developing countries
- Provided recommendations and conclusions for developing countries and international development organizations
- Developed a detailed bibliography to facilitate further research.

TRANSPORTATION ENERGY CONSERVATION MEASURES

Many actions can be taken to improve the energy efficiency of the transportation sector. Many of these have been used extensively in developed countries, but few have been used in the Third World. To select those measures that show the greatest promise in developing countries, all relevant transportation energy conservation measures were identified, evaluated, and categorized.

The measures chosen as most promising for achieving cost-effective, lasting results in developing countries are as follows (the categories are presented in order of overall cost):

Infrastructure projects

Infrastructure projects are the most expensive type of transportation energy conservation measure, but they also offer the largest energy savings. While infrastructure projects have great promise for developing countries and are certainly necessary for economic development, their drawbacks indicate that they are not necessarily good investments when the objective is

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transportation energy conservation. Other projects, especially low-cost, quick-payback projects, offer greater potential for limited funds.

Infrastructure projects

- Improve road network and surface quality
- Build freight terminals and clearinghouses
- Create express lanes with limited access and few lights
- Create extra lanes for through traffic
- Create streets devoted to high-occupancy vehicles
- Create parking areas outside high-traffic areas
- Create parking areas near train and bus terminals
- Install traffic islands to channel traffic more efficiently
- Provide turning lanes
- Provide bus stops
- Build bus terminals

Comprehensive traffic management projects

Comprehensive traffic management projects improve the flow of traffic by combining several components into a large unified project. Such projects can produce significant energy savings at low cost if well designed but can vary greatly both in cost and in energy savings potential. Since most results will be produced with permanent changes in the structure of the transportation system, the results can be expected to last. The major drawback of comprehensive traffic management projects, in addition to a potentially high cost, is the significant management burden they can impose.

Comprehensive traffic management projects (using a combination of the following)

- Parking restrictions
- Extensive street signs and lights
- Special streets and lanes for high occupancy vehicles
- Area licensing
- Road use permits
- Re-routing traffic to improve traffic flow
- Area/street tolls
- Temporary car bans

Small-scale traffic management projects

The distinction between small-scale traffic management (SSTM) projects and comprehensive projects may be somewhat artificial, but it is useful for categorizing measures and choosing transportation energy conservation projects. For the sake of this discussion the difference lies in the the number of measures implemented, the size of the project, and the overall cost. SSTM projects either combine a small number of measures in a limited area or implement a single measure in a larger area. By keeping the scope of the project limited, they present a smaller management burden and require fewer resources, nevertheless, many SSTM measures can be implemented in isolation and still produce significant results. As with comprehensive traffic management projects, most of these projects can produce measurable results that should last, although their more limited benefits could be overwhelmed by rapid growth.

Small-scale traffic management projects

Traffic signals
- Synchronize signals
- Improve signal timings
- Provide demand-responsive timing
- Replace four-way stop with a signal
- Replace four-way stop with two-way stop
- Replace signal with two-way stop
- Allow right turn on red
- Operate off-peak flash

Parking restrictions
- Restrict parking during rush hour
- Reduce parking supply in high-traffic areas
- Impose high fees in high traffic areas
- Graduate fees to encourage short-term parking
- Provide fiscal regulation of private parking areas

High-occupancy vehicle lanes
- Create contra-flow bus lanes on one way streets
- Create with-flow bus lanes
- Create HOV lanes

Tolls in high-traffic areas

One-way streets

Reversible lanes

Regulated turning movements
- Ban conflicting turning movements
- Add exclusive left-turn lane
- Allow permissive left-turns

Traffic management measures for public transit
- Add special phases at traffic lights that favor public transportation
- Allow exclusive turning movements at intersections
- Use bus convoys

Fuel efficiency monitoring

Education and training projects

Education and training projects have produced significant results on a small scale. If implemented broadly, they can have a large impact on energy consumption and vehicle emissions. One of their major advantages is the low marginal cost of expanding training programs. Once the initial instructor training is completed, the education and public information material is created, and the institutions are in place and experienced with the program, it is relatively simple and inexpensive to expand the program. The major disadvantage of these projects stems from the fact that their effectiveness depends on people and institutions, and their ability to change habits, behavior, and modes of thinking instead of creating physical and legal restrictions that are difficult to circumvent. Experience in developing countries is too limited to provide direct evidence on the lasting power of transportation energy conservation education and training projects. It is likely that the benefits will gradually dissipate unless a constant effort is undertaken to keep energy conservation in the public eye.

Education and training projects

Driver education
- Bus, taxi, and truck driver education
- Public information campaign

Improve vehicle maintenance and efficiency
- Driver education
- Mechanic education

Organization management -- public transit
- Improve routing
- Improve scheduling
- Improve company management
- Create training programs
  - -- Driver training
  - -- Mechanic training
  - -- Planner/scheduler training
  - -- Management training

Improve fleet efficiency

- Improve fleet management
  - -- Set standards
  - -- Implement training programs
  - -- Increase backhaul load factors
- Improve fleet operations
  - -- Upgrade standards of driver training tests
  - -- Institute periodic driver testing.
- Improve fleet maintenance
  - -- Institute training programs
  - -- Increase inspection frequency

Fuel-saving equipment

- Radial tires
- Aerodynamic add-ons for trucks

CONCLUSIONS

This paper represents a single step in an ongoing exercise to evaluate transportation energy conservation activities. Preliminary conclusions have been drawn, yielding recommendations for developing countries and development organizations. Subsequent discussions and analysis will further refine this set of recommendations and the analysis of developing country needs and transportation energy conservation measures.

Implications for Developing Countries

Transportation energy consumption in developing countries is rapidly rising. As development continues, the transportation sector will grow in importance, accounting for a larger share of the total energy bill. To forestall serious traffic congestion problems and large fuel import bills, it is imperative that developing countries take steps now to plan for the future of their traffic system.

Transportation energy conservation has a large potential. It can delay expensive infrastructure projects while saving energy and foreign exchange, improving economic efficiency, and reducing pollution. However, projects need to be chosen with care. Some of the larger and more expensive transportation projects may not be cost-effective, therefore, a careful examination of the options is needed.

Perhaps the most important variable in the success of transportation energy conservation projects is the degree of follow-up. Many transportation energy conservation measures require changes in habits and behavior. Some changes are made easier by physical restrictions (road barriers, speed limiters on vehicles), while others must be enforced, either by traffic policemen or by self-motivation. Enforcement is made easier if public

limiters on vehicles), while others must be enforced, either by traffic policemen or by self-motivation. Enforcement is made easier if public information campaigns, signs, and institutionalized training programs provide continual reminders.

There are a wide variety of possible actions to improve the energy efficiency of the transportation sector. Four actions stand out as particularly important, because they can be implemented quickly, at low cost, and -- often -- relatively easily. As a beginning, developing countries should:

- Adjust prices, ultimately the key to the long-term health of the transportation sector. Adjust fuel prices to represent shadow prices and reduce demand for private transportation; adjust parking charges to discourage commuting; adjust road charges to encourage use of public transit and discourage use of private vehicles in congested regions. These measures can be among the least expensive -- economically -- but their political and social costs may be prohibitive.

- Incorporate transportation planning in city planning.

- Improve road maintenance. Basic road maintenance can have a dramatic impact on traffic flow, vehicle maintenance, and fuel economy.

- Institute an information and awareness campaign to begin to educate the public on the importance of fuel-efficient driving, vehicle maintenance, and saving energy.

These actions are necessary to establish the groundwork for other transportation energy conservation activities. As funding permits, additional projects should be implemented.

Implications for Development Organizations

Given sufficient funds, development organizations should give first priority to integrated traffic management projects with medium-sized infrastructure components. These projects promise the greatest potential for energy savings and improving the functioning of the economy and development organizations have substantial experience in the field. Since funds are necessarily restricted, however, priorities must be established. Since experience in transportation energy conservation projects is limited, the first step should be to select modest projects with low risk and low cost. Priority should be given to projects that can produce measurable results and can be expanded if successful.

Education and small-scale traffic management projects generally satisfy these criteria. Many such projects can be implemented quickly and at low cost, while placing no great management demand on developing countries. They also have the advantage of being modular; they can be implemented in single fleets or small sections of cities, and, given success in the initial stages, can be expanded into programs that can have a large impact on the country.

Education projects of particular promise include: driver education, public information campaigns, vehicle maintenance programs, and the promotion of fuel-saving equipment such as radial tires and aerodynamic add-ons for trucks. Promising small-scale traffic management projects include: creating priority lanes for buses and high-occupancy vehicles, upgrading traffic signals, and creating a coordinated parking control strategy.

Projects aimed at achieving changes in regulations, government policies, and laws to encourage transportation energy conservation can be among the most affective in achieving significant change. Institutional barriers to energy conservation can eliminate natural incentives for implementing energy conservation actions. Projects to reform fuel pricing, revise transportation subsidies, eliminate traffic management barriers, and improve traffic policing, can have a very significant, immediate impact and will ensure that the groundwork is prepared for the development of a rational and energy-efficient transportation sector in the future. It is very important that policy and traffic law reform projects be accompanied with extensive surveys of the transportation sector and the constraints on energy conservation, so that an effective plan of action for the government can be produced.

Particular care should be taken in choosing countries for transportation energy conservation efforts. Since experience in the field is limited, development organizations should target those countries that show greatest promise for producing significant results. First priority should go to those countries that have had recent extensive surveys of the transportation sector, such as Sri Lanka, Tunisia, Pakistan, India, and Costa Rica, or to countries that have had surveys of one portion of the transportation sector. Coordination among development agencies will be particularly crucial in choosing target countries to greatest advantage.

Second priority should go to countries that, at a minimum, have the following attributes:

- A moderately-developed road system[2]

[2]Countries with poorly developed road systems may be in greater need of development support, but the infrastructure projects required in their cases are beyond the scope of this report.

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- Effective traffic management and traffic law enforcement institutions
- One or more cities of strategic importance to the economy (as opposed to a largely rural country).

These countries, while perhaps not the poorest, will present the greatest chance for successfully implementing transportation energy conservation projects. Once developing countries and development organizations gain more experience in such projects, other countries can be tackled with a greater chance of success.

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1. INTRODUCTION

The transportation sector is one of the largest energy users in developing countries, and is often the primary consumer of oil. On average, developing countries use 44 percent of their petroleum products in the transportation sector. Moreover, transportation energy consumption is rising as fast as, or faster than, economic growth in developing countries, indicating that it will continue to have a major impact on their balance of trade and economic development.

Over the past ten years, most countries have sought to reduce the growth in fuel use in the transportation sector while maintaining economic growth. Several countries, mostly industrialized nations, have been successful in this effort. As a group, developing countries have fared less well, although a number of them have pioneered ambitious projects in fuel substitution (e.g. alcohol fuels in Brazil and Central America, compressed natural gas in Thailand, liquefied petroleum gas in the Dominican Republic). Nonetheless, smoking trucks and buses, outdated vehicles, and the lack of traffic management indicate a substantial potential for using fuel more efficiently in most developing countries.

Developing country efforts to conserve energy in the transportation sector have generally been limited to fuel pricing policies, vehicle import restrictions, and public information campaigns. International donor and lending institutions have sponsored many transportation infrastructure programs but have seldom provided sizable support to fuel efficiency improvement programs. Among the few exceptions are the U.S. Agency for International Development (AID), Bureau for Science and Technology, which recently funded a successful demonstration program in Costa Rica.

Because there have been few transportation energy conservation programs, it is not clear 1) what the measurable impact of such programs can be, 2) how replicable they will be, and 3) what approaches will work in developing countries in general.

To help international development organizations and developing countries find answers to these questions, the AID Office of Energy of the Bureau for Science and Technology has sponsored the preparation of this report as part of its Energy Conservation Services Program. The purpose of the report is to provide a reference manual to facilitate decision-making on specific conservation measures. To prepare the report, Hagler, Bailly & Company carried out the following tasks:

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- Developed a detailed bibliography to facilitate further research.

This report is organized in five chapters, including this introduction (Chapter 1). Chapter 2 discusses the importance of increasing the efficiency of energy use in the transportation sector in developing countries. Chapter 3 reviews transportation energy conservation projects that have been implemented in developing countries. Chapter 4 evaluates the potential for transportation energy conservation. In this analysis, statistics on the need for conservation in transportation in developing countries are reviewed, the various measures that can be used to improve energy efficiency in the transportation sector are examined, and finally, the potential impact of these measures is analyzed. Chapter 5 reviews the lessons learned from transportation energy conservation projects and provides general guidelines for developing countries and international aid and development organizations.

[1]This effort concentrated on road transportation, since it is the primary consumer of energy in the sector. References to transportation energy conservation can be assumed to refer to road transportation unless otherwise stated.

Several appendices provide detailed reference information. Appendix A contains case studies of transportation energy conservation projects in developing countries. Appendix B provides statistics on transportation energy consumption and indicators of the need in developing countries for transportation energy conservation efforts. Appendix C explains the analysis used in creating the transportation energy conservation needs indicator and provides the relevant statistics. Appendix D provides a matrix of transportation energy conservation measures. The matrix organizes all measures into categories based on type of action and end goal to facilitate understanding all the options. Each measure is then rated according to some of the more important advantages and disadvantages. Finally, Appendix E is an extensive bibliography.

2. THE IMPORTANCE OF INCREASING ENERGY EFFICIENCY IN TRANSPORTATION

In addition to often being the largest consumer of energy in developing countries, the transportation sector also plays a crucial role in the functioning of the economy. The transportation sector needs to expand in concert with the economy to ensure that development can proceed unhindered.

TRANSPORTATION AND ECONOMIC DEVELOPMENT

Transportation is a vital ingredient in economic development. Many sectors of the economy in developing countries depend on the transportation sector for their daily operations. Transportation services are needed to move goods, to develop commercial networks, and to integrate market structures.

In some developing countries, inadequacies and inefficiencies in the transportation sector are beginning to restrict economic development. If present trends continue, this situation can be expected to deteriorate. In Ivory Coast, for example, extensive congestion in central Abidjan used to last for as long as 12 hours a day, seriously hampering the city's ability to carry on business and creating repercussions that were felt throughout the national economy.[1] A major traffic management program has since brought significant relief. According to the World Bank, similar problems were found in Lagos and Bangkok, where the average vehicle traveled at only half the speed of vehicles in London or Frankfurt.[2]

Transportation inadequacies also hamper economic development by restricting the flow of agricultural goods to markets and to ports for export. For example, some regions of Tanzania have great agricultural potential and could produce such cash crops as fruit, potatoes, and coffee. The rudimentary state of the transportation system, however, has prohibited the successful development of these crops.[3]

TRANSPORTATION AND OIL CONSUMPTION

In most developing countries, the transportation sector is the largest consumer of oil. On average, developing countries use 44 percent of their petroleum products for transportation fuels. In 29 countries the transportation sector accounts for more than 50 percent of total petroleum consumption (see Exhibit 2.1). Even in Brazil, which has an extensive fuel substitution program under way, the transportation sector accounts for 47 percent of all petroleum consumption.[4] In addition, as the economic

EXHIBIT 2.1 CONSUMPTION OF OIL IN TRANSPORTATION (1983)

	Transport Consumption As % of Total Oil Consumption	Transport Oil Consumption (TOE 000)	Transport Oil Consumption Per Capita (TOE x 10-3)	GNP per Capita (1983 $)
Kuwait	93	3,410	2,006	17,880
* Kenya	91	937	50	340
* Uganda	80	160	12	220
* Zimbabwe	75	403	51	740
* Nepal	72	65	4	160
Algeria	69	3,227	157	2,320
Ethiopia	66	349	9	120
* Burma	65	669	19	180
Trinidad & Tobago	64	1,001	910	6,850
* Sudan	63	674	32	400
* Bolivia	63	661	110	510
* Malawi	60	81	12	210
* Zaire	59	531	18	170
* Uruguay	59	667	222	2,490
* Zambia	58	395	63	580
* Costa Rica	58	401	167	1,020
* Ecuador	58	2,186	267	1,420
* Colombia	57	4,255	155	1,430
* Mauritius	55	102	103	1,160
* Pakistan	55	2,904	32	390
* Haiti	54	113	21	300
Venezuela	54	9,448	546	3,840
Ivory Coast	53	581	61	710
Chile	53	2,490	213	1,870
* Panama	53	502	251	2,120
* El Salvador	53	283	54	710
Argentina	52	10,520	355	2,070
Nigeria	52	3,220	34	770
* Guatemala	50	504	64	1,120
* Tunisia	50	1,242	180	1,290
* Gambia	49	25	36	290
* India	47	13,998	19	260
* Thailand	46	4,400	89	820
* Sri Lanka	42	559	36	330
* Mexico	40	24,267	324	2,240
* Honduras	39	213	52	670
Hong Kong	39	1,884	355	6,000
* Djibouti	38	59	148	
Nicaragua	38			880

*AID-Assisted Countries

EXHIBIT 2.1 CONSUMPTION OF OIL IN TRANSPORTATION (1983) (cont.)

	Transport Consumption As % of Total Oil Consumption	Transport Oil Consumption (TOE 000)	Transport Oil Consumption Per Capita (TOE x 10-3)	GNP per Capita (1983 $)
* Bangladesh	38	431	5	130
* Morocco	36	1,402	67	760
* Peru	35	2,246	125	1,040
* Turkey	34	5,200	110	1,240
* Indonesia	32	7,192	46	560
Saudi Arabia	31	7,602	731	12,230
* Seycheiles	30	12	185	2,400
Iran	30	7,569	178	
* Niger	29	56	9	240
* Rwanda	27	15	3	270
* Dominican Rep.	26	534	89	1,370
* Portugal	26	2,064	204	2,230
Korea, Rep. of	24	5,676	142	2,010
* Philippines	24	2,321	45	760
Iraq	23	1,384	94	
* Egypt, Arab Rep.	23	3,375	75	700
United Arab Emirate	23	1,214	1,012	22,870
* Togo	23	83	30	280
Malaysia	21	1,861	125	1,860
* Senegal	18	122	20	440
* Jamaica	18	372	162	1,300
* Cape Verde	16	5	16	320
* Papua New Guinea	15	90	28	760
Singapore	10	944	378	6,620
* Brazil	6	2,264	17	1,880
* Guinea	4	12	2	300

SOURCES: World Bank, World Development Report 1985
International Energy Agency, Energy Balances of Developing Countries 1971-1982
World Bank/UNDP, Issues and Options in the Energy Sector, various countries

*AID-Assisted Countries

development of the Third World progresses, the transportation sector will account for a growing share of total oil consumption.

For most countries, 80 percent of the fuel consumed in the transportation sector is used for road transport, with rail, air, and water transport accounting for the remainder.[5] Over 90 percent of transportation fuel in Mexico, Indonesia, and Nigeria is consumed by road transport, while India, with an extensive rail network, consumes 56 percent of its transportation fuel in road transport (see Exhibit 2.2).

Exhibit 2.2

ROAD TRANSPORT ENERGY CONSUMPTION:
PERCENT OF TOTAL TRANSPORTATION CONSUMPTION

Low-Income Developing Country		Middle-Income Developing Country		High-Income Developing Country		Industrial Country	
India	56	Indonesia	92	Argentina	88	France	87
Kenya	35	Korea	63	Brazil	84	Italy	90
Pakistan	56	Nigeria	95	Chile	82	UK	79
		Turkey	83	Greece	59	US	85
		Mexico	93			Germany	86

SOURCE: Joy Dunkerley, et.al., Transport Energy: Determinants and Policy, AID/Resources for the Future, September 1985.

OIL IMPORTS AND ECONOMIC DEVELOPMENT

Paying for oil imports, even in a time of falling oil prices, seriously taxes the economy of many developing countries. Even oil exporters suffer when internal oil consumption restricts supplies available for export. Energy imports in developing countries averaged about 33 percent of merchandise exports in 1983 (the average for the 57 developing countries in Exhibit 2.3). Eleven AID-assisted countries spend more than 50 percent of their foreign exchange from merchandise exports on energy imports. Many of the 57 developing countries listed in Exhibit 2.3 also suffer from serious foreign debt problems. Their average debt service is 5 percent of GNP and 18 percent of exports. For many of these countries, oil imports not only

EXHIBIT 2.3 ENERGY IMPORTS AS A PERCENTAGE OF MERCHANDISE EXPORTS (1983)

	Energy Imports As % of Merchandise Exports	GNP per Capita (1983 $)	Debt Service As % of Exports	Debt Service As % of GNP
* Jordan	101	1,640	11.3	5.2
* Panama	82	2,120	6.8	11.6
* Dominican Rep.	71	1,370	22.7	2.8
* Guatemala	69	1,120	11.7	1.6
* Turkey	66	1,240	28.9	4.6
Greece	59	3,920	18.3	3.8
* Spain	59	4,780		
* Senegal	58	440		1.9
* El Salvador	57	710	6.4	1.8
* Morocco	57	760	38.2	8.3
* Sudan	57	400	11.2	1.2
* Brazil	56	1,880	28.7	3.5
Ethiopia	53	120	11.5	1.4
* Burkina	50	180		1.3
* Pakistan	49	390	28.1	3.4
* Portugal	48	2,230	26.7	9.5
Nicaragua	46	880	18.3	3.2
* Philippines	44	760	15.4	3.7
* Seychelles	42	2,400		
Japan	40	10,120		
Singapore	40	6,620	1.3	2.4
* Sri Lanka	40	330	11.9	3.3
* Thailand	39	820	11.3	2.4
* Kenya	36	340	20.6	5.5
Italy	34	6,400		
Yugoslavia	33	2,570	7.6	2.2
* Madagascar	32	310		4.9
* Tunisia	31	1,290	22.3	7.4
Czechoslovakia	30			
United States	30	14,110		
* Haiti	29	300	5.0	0.9
* Israel	29	5,370	19.6	9.1
Finland	28	10,740		
France	28	10,500		
* Honduras	28	670	14.9	4.3
Korea, Rep. of	28	2,010	12.3	
* Uruguay	28	2,490	19.8	5.6
Chile	24	1,870	18.3	5.1
* Papua New Guinea	24	760	11.2	4.7

* AID-Assisted Countries

Continued

EXHIBIT 2.3 ENERGY IMPORTS AS A PERCENTAGE OF MERCHANDISE EXPORTS (1983) (cont.)

	Energy Imports As % of Merchandise Exports	GNP per Capita (1983 $)	Debt Service As % of Exports	Debt Service As % of GNP
* Poland	24			
Netherlands	23	9,890		
* Costa Rica	22	1,020	50.6	22.7
Hungary	22	2,150	18.5	9.3
Sweden	22	12,470		
* Zimbabwe	22	740	31.6	8.1
* Colombia	21	1,430	21.3	2.4
* Bangladesh	20	130	14.7	1.3
Denmark	20	11,570		
* Indonesia	20	560	12.8	3.4
Germany, West	19	11,430		
* Zambia	19	580	12.6	4.0
Belgium	18	9,150		
New Zealand	18	7,730		
* Togo	18	280	16.8	6.3
Austria	17	9,250		
* Niger	17	240		5.6
Australia	16	11,490		
Ivory Coast	16	710	31.0	12.9
Malaysia	16	1,860	5.9	3.5
* Mauritius	16	1,160		
Ireland	14	5,000		
Switzerland	13	16,290		
* Egypt, Arab Rep.	12	700	27.5	6.5
* Lesotho	12	460	2.5	1.9
United Kingdom	12	9,200		
Argentina	9	2,070	24.0	3.1
Norway	8	14,020		
Hong Kong	7	6,000		0.2
Canada	6	12,310		
* Cameroon	4	820	13.9	3.1
Trinidad & Tobago	4	6,850	2.8	2.7
Algeria	2	2,320	33.1	9.8
* Peru	2	1,040	19.6	4.6
Libya	1	8,480		
* Oman	1	6,250	3.2	2.1
* Paraguay	1	1,410	14.9	2.1
Venezuela	1	3,840	15.0	4.0

SOURCE: World Bank, World Development Report 1985

* AID-Assisted Countries

burden the economy but limit the amount of foreign exchange available for retiring debt.

TRANSPORTATION DEMAND AND ECONOMIC GROWTH

Demand for transportation tends to grow more rapidly than the economy in developing countries.[6] From 1971 to 1982, the average annual growth in consumption of all transportation fuels in a general cross-section of 37 developing countries was 6.7 percent (see Exhibit 2.4). The average annual growth in gross domestic product (GDP) for these same countries was 5.1 percent. In 19 of these countries (51 percent), transportation fuel use growth exceeded GDP growth.

The ratio of transportation demand to economic growth tends to vary directly with the relative rate of economic growth. In 9 of the 14 countries (64 percent) with high GDP growth -- 6 percent or more -- transportation demand growth exceeded GDP growth by an average of 1.5 percent. Between 1971 and 1981, the transportation sector grew at about 1 percent a year in low-income developing countries, at about 3.5 percent in middle- and high-income developing countries, and at about 14 percent in high-income, oil-exporting developing countries. Transportation energy consumption increased by 1.5 percent in developed countries during the same time period.[7]

Transportation demand also rises faster than income, in part because private transportation is typically viewed as a luxury. As income rises, the purchase and use of cars rises proportionally faster as cars replace less preferred modes of transportation.[8] In Asia, for example, car ownership grew almost twice as fast as GDP from 1978 to 1983. Ownership of trucks and buses grew about 2 1/2 times as fast as GDP. There remains a substantial potential for growth in vehicle ownership in Asia since the ratio of cars to the population is still low compared to Latin American countries.[9] An AID/Resources for the Future study found that developing countries as a whole have an income elasticity of 1.4 for motor gasoline consumption, 1.2 for all transport fuel consumption, 1.65 for automobile registrations, and 1.1 for truck registrations. Thus, a 1-percent increase in per capita income will cause a 1.2 percent increase in the consumption of transportation fuels and a 1.65 percent increase in automobile registrations.[10]

Increasing the price of transportation would not significantly moderate this trend, since the price elasticity for transportation fuel consumption in developing countries tends to be less than one, thus, an increase in the price of fuel will result in a less than proportional decrease in demand for fuel. In developing countries, the price elasticity is -0.4 for motor gasoline consumption, -0.15 for all transportation fuel consumption, -0.6 for automobile registrations, and -0.5 for truck registrations.[11]

TRANSPORTATION ENERGY CONSUMPTION GROWTH

	Transportation Consumption Annual Growth (%) 1971-82	GDP Annual Growth (%) 1970-82
Hong Kong	6.3	9.9
Korea	10.0	8.6
Singapore	10.9	8.5
Egypt	11.0	8.4
Ecuador	20.2	8.1
Indonesia	15.9	7.7
Malaysia	14.4	7.7
Brazil	4.0	7.6
Thailand	3.7	7.1
Tunisia	10.2	7.0
Algeria	15.6	6.6
Mexico	8.9	6.4
Dominican R.	-1.9	6.0
Philippines	-2.2	6.0
Ivory Coast	0.5	5.7
Kenya	2.2	5.5
Colombia	4.1	5.4
Turkey	0.4	5.1
Pakistan	7.8	5.0
Morocco	6.5	5.0
Burma	2.9	5.0
Panama	0.1	4.7
Portugal	4.1	4.5
Gabon	6.5	4.4 GNP
Greece	5.4	4.1
Venezuela	14.2	4.1
Bangladesh	31.3	4.1
Nigeria	15.2	3.8
Bolivia	8.4	3.7
India	1.7	3.6
Uruguay	1.5	3.1
Peru	-2.6	3.0
Chile	-0.3	1.9
Argentina	0.1	1.5
Zambia	2.1	0.9
Zaire	2.3	-0.2
Jamaica	-5.9	-1.1
Average	6.7	5.1

SOURCE: World Bank, World Development Report 1984; International Energy Agency, Energy Balances for Developing Countries, 1971/1982, Organization for Economic Cooperation and Development, 1984; and Dunkerley, Joy, Irving Hoch, with Caroline Bouhdili, Transport Energy: Determinants and Policy, Resources for the Future, for USAID, September 1985.

In addition, road transport tends to increase faster than other forms of transport (except perhaps air transport, which starts from a much smaller base and thus has a smaller effect). Passenger traffic -- and in some cases, freight transport -- rises two or three times as fast as GDP in developing countries, while rail freight transport tends to decrease.

TRANSPORTATION ENERGY CONSERVATION AND DEVELOPMENT

Because demand for transportation services will rise with economic development, developing countries must ensure that their motor fuels are used as efficiently as possible. As the transportation sector grows, energy conservation efforts will become increasingly important as a means of controlling demand for petroleum, preventing crippling traffic congestion problems, and reducing the need for large investments in transportation infrastructure.

Transportation energy conservation projects are especially important since they tend to be relatively inexpensive and yet can have a large impact. For example, transportation management efforts can be undertaken with minimal cost in many cases -- requiring only street signs, traffic lights, paint for marking lanes, and the services of a traffic management expert. These efforts can, however, reduce fuel consumption by 10 to 20 percent or more and delay or obviate the need for expensive road building projects that have the same aim: speeding the movement of public transit and commercial vehicles. The economic rate of return for transportation projects often exceeds many other development projects. Between 1973 and 1981, of 61 urban projects funded by the World Bank, the transport projects produced an average economic rate of return of 31 percent, compared to 23 percent for sites and services projects, 21 percent for integrated projects, and 22 percent for regional projects.[12]

Relatively inexpensive measures to increase the energy efficiency and effectiveness of bus systems can delay or eliminate the need to invest in expensive rail systems that may use more energy in their construction than would be saved by their greater energy efficiency. An integrated bus system using exclusive bus lanes, transfer terminals, and bus convoys can move as many as 20,000 people per hour. Using express busways with graded intersections and off-line stations, a bus system can move more than 30,000 people per hour.[13] Subway systems, on the other hand, can move more people -- up to 60,000 people per hour -- but they tend to be much more expensive than bus systems, costing as much as $117 million per kilometer.[14] In some cases the extra capacity can make a subway system economical, but the relatively inexpensive procedures for improving bus service can make a dramatic impact on the transportation system and should be considered first in most cases. An innovative bus system in Copacabana,

Brazil incorporates some of the convenience and speed features of a subway but does not require expensive tracks and tunneling. As with subways, passengers purchase a ticket to enter the loading platform, rather than paying the bus driver. They stand at designated spots to board the appropriate bus so that buses can load and unload passengers quickly and speed on their way. This feature, combined with exclusive bus lanes, greatly speed up bus service at only a fraction of the cost of a subway system.

TRANSPORTATION ENERGY CONSERVATION AND THE ENVIRONMENT

Air pollution is fast becoming a major problem in many cities in developing countries. The combustion of petroleum products for transportation is often one of the most significant sources of pollutants. Transportation energy conservation projects can help to significantly reduce these pollutants and ensure that future growth is not accompanied by crippling pollution problems. Traffic management projects that reduce travel time and increase travel speeds will reduce fuel consumption and thus reduce emissions. Education projects that teach good driving skills will accomplish the same goal. Education projects that teach vehicle maintenance needs and procedures will also reduce harmful emissions since poorly maintained vehicles produce more emissions than well maintained ones.

3. TRANSPORTATION ENERGY CONSERVATION INITIATIVES

A large number of transportation projects in developing countries have been funded by international development organizations, most of them, however, have focused on infrastructure improvements or improving the functioning of the transportation system, not on improving energy efficiency. Very few projects have focused primarily on transportation energy conservation.

Frequently transportation infrastructure projects have served to improve the energy efficiency of transportation. Vehicles get better gas mileage on improved roads, and improvements to railroads can lead to more energy-efficient freight transport. Some projects have even had specific energy conservation components such as driver training and vehicle maintenance. However, the primary aim of infrastructure projects is to build roads and bridges and improve the functioning of the transportation system. Even where these projects have improved the energy efficiency of transportation this result has usually been merely a beneficial side effect. Since infrastructure projects are not designed to test transportation energy conservation measures, they rarely have produced data that can verify the efficacy of specific measures. Thus they provide limited information to decision-makers evaluating transportation energy conservation measures.

Transportation energy conservation began receiving more attention when energy prices began to rise rapidly in the early 1970s. Since then several policy studies have been initiated to evaluate energy use in the transportation sector in individual developing countries. These studies generally performed two tasks: 1) they surveyed the transportation sector to identify its primary characteristics, its problems, and its energy use; and 2) they developed a set of recommendations for improvements. These studies have been very important for providing a basis of knowledge on transportation energy conservation needs but to date few have led to projects to implement the recommendations in order to improve the efficiency of transportation energy use.

Even though experience in transportation energy conservation projects in developing countries has been limited, there are still lessons to be learned from what has been accomplished. In this chapter, several transportation energy conservation projects are discussed. Detailed case studies on these projects and some infrastructure projects and policy studies are presented in Appendix A. The components and dates of the major projects outlined in the Appendix are shown in Exhibit 3.1.

Transportation projects in developing countries that have entailed concrete energy conservation actions and gathered data on impacts can be organized into

Exhibit 3.1

TRANSPORTATION ENERGY CONSERVATION PROJECTS

Country	Components	Date	Experiment Imple-mented[1]	Data Gathered[2]
Costa Rica	Driver training Mechanic training Radial tires Vehicle maintenance Public information	1985	Yes	Yes
Sri Lanka	Bus-only Lanes	1985	Yes	Yes
Brazil	Bus expressways Bus lanes in Porto Alegre and Rio de Janero	1978	Yes	--
Thailand	Bangkok bus lanes	1978	Yes	Yes
Thailand	Comprehensive traffic management	1984	Yes	No
Singapore	Area licensing Traffic restriction	1975	Yes	Yes
Hong Kong	Electronic road pricing	1982	Yes	Yes

[1]Indicates whether transportation energy conservation measures were implemented to evaluate their effects on the energy efficiency of the transportation sector.

[2]Indicates whether attempts were made to systematically gather data to evaluate the effectiveness of the procedures for improving transportation energy efficiency or reducing fuel consumption. "--" indicates insufficient information available to determine whether data were collected.

Exhibit 3.1 Continued

Country	Components	Date	Experiment Imple-mented	Data Gathered
Indonesia				
	Jakarta Bus Company Energy audit	1984	No	No
India				
	Survey of literature Energy conservation recommendations	1982	No	No
Tunisia				
	Analysis of national energy survey Evaluation of effects of maintenance	1983-4	No	Yes
Republic of Korea				
	Evaluation of transport energy use and needs	1982 & 1983	No	No
Pakistan				
	Comprehensive public transit planning study in Lahore	1978	Yes	Yes
Papua New Guinea				
	Transport planning for rural provinces	1981	No	No
Costa Rica				
	Comprehensive urban transport project Widening roads; traffic signals; traffic management bus routes; parking restrictions	1977 to present	Yes	No
Ivory Coast				
	Comprehensive traffic management in Abidjan	1981	Yes	--

Source: Hagler, Bailly & Company

four categories: 1) Driver training and vehicle maintenance; 2) bus lanes and bus system management; 3) traffic restrictions and road pricing; and 4) comprehensive transportation programs.

DRIVER TRAINING AND VEHICLE MAINTENANCE

In 1985, AID[1] sponsored a transportation energy conservation demonstration project in Costa Rica. The project was designed to demonstrate the fuel savings potential in privately owned and operated bus and taxi companies. The demonstration project applied fuel conservation measures to 24 buses and 16 taxis. Initial measures included optimum maintenance and the use of radial tires. After 4 weeks, all participating drivers were trained in fuel-efficient driving techniques. Following completion of driver training, driver incentives were given to bus drivers while the test continued for an additional 4 weeks. Data on kilometers traveled, fuel consumed, routes, drivers, and vehicle types were collected and analyzed.

The results were generally quite positive. Maintenance improved fuel consumption by 6.5 percent in the bus fleet and 1.8 percent in the taxi fleet.[2] Driver training improved fuel consumption by 4.2 percent in the bus fleet and 15.1 percent in the taxi fleet. Radial tires failed to produce the expected 4 percent improvement, perhaps because of underinflation.

The project demonstrated that training and vehicle maintenance can be very cost-effective. In addition, the project will be relatively inexpensive to replicate, as it created an in-country expertise in training and maintenance. Other private companies in Costa Rica can benefit from this expertise and should be able to achieve similar results. Whether the experience actually will be transferred to other companies, however, remains to be seen. The public information campaign is still ongoing and it is too soon to determine the long-term effects of the project.

Several additional lessons were learned in this project, including:

- It is important to provide enough people and time to ensure adequate control and documentation of activities. Shortages of both hampered the maintenance program.
- The public information program must follow the determination of demonstrable results to have maximum impact. Running the program in parallel reduced the effectiveness of the information program in Costa Rica.
- Demonstrations should be designed to be understandable by fleet operators. They should not be so statistically complex that they cannot be understood by non-technical personnel.

- The entire fleet should participate, if possible, so the effects will become readily apparent. Using a small segment of the fleet in Costa Rica diluted the impact to the point that fleet operators did not notice an improvement in their total fuel use.

- Finally, the measures should be demonstrated under real operating conditions to establish their validity.

A final point should be noted about vehicle maintenance in developing countries. Even if vehicle and fleet owners know the importance of maintenance for fuel economy and the life of their vehicles, they may not be able to provide adequate maintenance for any combination of reasons, including:

- Because of demand, it may not be feasible to take vehicles out of service for maintenance. The resultant loss of revenue might be viewed as prohibitive. Thus, funds for additional vehicle purchases may have to be provided before implementing maintenance projects.

- The costs of maintenance may be too high for most owner/operators and some form of assistance may thus be required.

- Facilities for maintenance may be inadequate, necessitating investments in tools and facilities before implementing maintenance projects.

BUS LANES AND BUS SYSTEM MANAGEMENT

Several developing countries have implemented programs to improve bus fuel efficiency by providing various types of exclusive bus lanes; programs in Sri Lanka, Brazil, and Thailand will be outlined here. In Colombo, Sri Lanka, the outside lane in each direction on one of the busiest streets was reserved for buses. In Porto Alegre, Brazil, 30 kilometers of lanes were paved and designated for exclusive bus use by means of signs, curbs, or low reflecting markers. Two transfer terminals were built to reduce congestion and facilitate transfers from feeder bus lines. In Bangkok, Thailand, 145 kilometers of lanes were set aside for the exclusive use of buses.

The success of these projects largely depended on efforts to prevent bus bunching at stops. For instance, initially buses in Sri Lanka and Bangkok were prohibited from passing each other, which led to excessive bunching and serious congestion problems. The average running speeds of buses in Sri Lanka actually decreased by 38.5 percent following implementation of the program. When the laws were changed in Bangkok to allow buses to pass each other, bus travel time decreased by 38 percent. In Brazil, an innovative

system of bus convoys was developed to avoid bus bunching. At the beginning of each corridor, a convoy of up to six buses was assembled. The convoy traveled the route together, stopping and starting together. Passengers lined up at the bus stops according to their final destination and the location of the buses in the convoy. Bus speeds in Porto Alegre increased by an average of 20 percent after the project was implemented.

The poor results in Sri Lanka were only partly attributable to bus bunching. Poor road quality forced bus drivers to drive outside their lane to avoid potholes, and slow-moving vehicles -- bicycles and carts -- operating in the outside lane slowed the buses down significantly.

Several guidelines for bus lane project design can be culled from these projects:

- Provide adequate publicity and enough street signs to ensure that drivers and passengers understand the new system
- Consult with affected businesses and other parties to gain cooperation
- Use interior lanes or ensure that lane width is adequate to avoid conflicts with slow-moving, often non-mechanized forms of traffic, and/or restrict slow-moving traffic to a slow lane
- Fill potholes and otherwise maintain roads to allow buses to travel at their optimum speed
- Restrict boarding and alighting from buses to designated bus stops to improve the flow of traffic and limit interference from pedestrians
- Restrict turns from or across the bus lane
- Improve policing to ensure compliance with restrictions on using the bus lane.

TRAFFIC RESTRICTIONS AND ROAD PRICING

Two developing country city-states have undertaken two different projects to control traffic in their central business districts. In 1975, the government of Singapore instituted an area licensing scheme to limit the volume of traffic during the morning rush hour. The central business district was cordoned off, limiting access to buses, commercial vehicles, and private vehicles with four or more passengers. Private vehicles with fewer than four passengers were permitted entry after paying a fee of $2.50 a day or $50 a month.

Parking restrictions were also enforced to discourage parking in the city center. The results have been very positive, with fuel consumption savings estimated at 30 percent. In addition, traffic speeds increased 20 percent, traffic accidents declined 25 percent and total traffic declined 44 percent. Revenues from the scheme have more than covered its capital and recurrent costs.

In 1985, the Hong Kong government implemented a test program to evaluate the practicality and effectiveness of electronic road pricing. Electronic number plates were installed on 2,600 test vehicles and 18 sensors were installed under the pavement at charging points throughout the city. The sensors collected information on each car and charges were computed by a central computer that took into account time of day and location. Mock road-use bills were created monthly and drivers could obtain a detailed statement of charges. The experiment was a technical success, demonstrating that electronic road pricing can work. However, the project was a political failure as the local government voted not to proceed to full implementation. Public reaction to the Hong Kong project was largely negative, indicating that a public information campaign will have to be undertaken before a full system can be implemented.

These two projects provide important lessons for cities in other developing countries. The Singapore area licensing scheme worked quite well, leading to a marked improvement in traffic flow in the central business district. However, Singapore's geography, street patterns, and high density made it relatively easy to restrict access to the central business district, set up a system for monitoring traffic, and create parking lots in peripheral areas. Singapore's police force was also capable of adequately enforcing the restrictions. Similarly, the Hong Kong electronic road pricing experiment was a technical success because of its geographic features and the technical sophistication of the agencies involved, among other things. Other cities in developing countries can successfully implement similar programs only to the degree that they share these characteristics.[3]

COMPREHENSIVE TRANSPORTATION PROGRAMS

International donor and lending agencies have funded many transportation management programs. Although energy conservation has not been a primary goal of these programs and detailed energy data have rarely been gathered, the programs have generally been successful in improving traffic flow, which results in improved energy efficiency. Two such programs are discussed below.

Costa Rica has begun a comprehensive urban transportation program aimed at improving the flow of traffic in San Jose's central business district. The program includes the construction and widening of a number of roads,

maintenance of roads, the installation of an integrated traffic signal system, and several traffic management measures such as parking restrictions and priority bus routes. The parking measures include: creating parking limitations on crucial bus routes; installing parking meters and setting parking charges to encourage quick turnaround; designating loading and unloading spaces; and greatly strengthening the enforcement program. To date, the program has improved traffic flow significantly. Unfortunately, data were not collected to allow the effects of specific aspects of the program to be measured.

The government of the Ivory Coast has implemented a comprehensive traffic management program in Abidjan consisting of one-way streets and improved signals, signs, and road markings. The program also made improvements to the bus system including creating exclusive bus lanes and a high-speed express bus network, upgrading bus terminals and bus stops, and constructing a bus depot. The program has met with considerable success, not only halving cross-town bus trip times and relieving congestion, but also enabling the government to postpone expensive infrastructure projects.[4]

These two programs, and others like them, have proven the effectiveness of comprehensive transportation programs in improving traffic flow, but their broad nature has made it impossible to identify efficiency improvements and energy savings for specific program components. Many individual transportation energy conservation measures can be effective on their own, but comprehensive plans have a much larger impact. Not only is the marginal cost of each component or measure less, but its impact is greater when it is part of a comprehensive program.

RECENTLY INITIATED ACTIVITIES

Other transportation energy conservation projects have been started recently in developing countries, but have not produced public reports on their results yet. In Sri Lanka, the World Bank is funding a review of the policy aspects of transportation energy conservation, including pricing and investments.[5] The World Bank has proposed a similar project in Tanzania to evaluate the potential for saving energy in the road transportation sector, but the project has been put on hold until the Bank reviews the results of the Sri Lanka effort.[6] Finally, another study is being conducted for the Organization for Economic Cooperation and Development (OECD), which is looking at fleet composition in developing countries.[7] Car and truck manufacturers in industrialized countries are being interviewed to identify technologies they would like to sell to developing countries.

4. POTENTIAL FOR TRANSPORTATION ENERGY CONSERVATION

Identifying and evaluating potential transportation energy conservation projects is a complex undertaking, this chapter provides background information and analysis to support that process. Specifically, this chapter will:

- Identify developing countries with the greatest need for transportation energy conservation programs
- Identify the transportation energy conservation measures that are most applicable to developing countries
- Quantify the potential impact of selected measures in specific countries

TRANSPORTATION ENERGY CONSERVATION NEEDS

Many variables factor into a country's need for improvements in the transportation sector. In this section, some of those variables have been used to create an indicator of transportation energy conservation need. Using this indicator, countries can be identified and ranked according to their need for transportation energy conservation projects.

Five sets of statistics make up this indicator:

- Transportation oil consumption as a percentage of total oil consumption; indicates the relative importance of transportation in the economy.
- Energy imports as a percentage of merchandise exports; indicates the potential impact of energy savings on the health of the economy. Since the transportation sector tends to be one of the largest consumers of oil in developing countries, reducing consumption can significantly reduce the oil import bill and ease pressure on foreign exchange reserves. Improving the efficiency of the transportation sector ensures that, as the economy grows, transportation oil consumption does not increase too rapidly, exacerbating balance of trade problems.
- Debt service as a percentage of exports; provides another indicator of the sensitivity of the economy to oil import bills.

- Urban population as a percentage of total population; the level of urbanization is an important indicator of transportation energy conservation potential for several reasons:

  1) Many of the most effective transportation energy conservation tools are aimed at urban transportation.

  2) While intercity freight transport tends to be the largest consumer of energy in the transportation sector of developing countries, options for fuel conservation in this sector are often less promising, and more expensive, than options for energy savings in urban passenger and freight transport.

  3) In some developing countries, a small number of cities dominate the economy and consume the majority of the transportation fuel. For example, about 60 percent of all motor vehicle fuels consumed in Thailand are consumed within a 150 kilometer radius of Bangkok.[1] Increasing urbanization will shift a greater portion of economic activity to cities in developing countries. By the end of the century there are expected to be over 60 cities in developing countries with populations over 4 million (versus around 20 in 1980),[2] making energy conservation efforts in cities increasingly important.

  4) Due to the concentration of people and economic activity in cities, transportation energy conservation projects in the urban sector can have a maximum impact on the economy. The urban sector in most developing countries provides at least 50 percent of the GNP.[3]

- Number enrolled in secondary school as a percentage of the total number in that age group; many transportation energy conservation projects have an extensive management aspect. The level of education in a society is an important indicator of the amount of skilled manpower available to implement transportation energy conservation projects. Other measures of managerial capability are either difficult to quantify or lack adequate statistics and cannot be used in this type of analysis.

Additional statistics that are useful in evaluating the transportation situation in developing countries are presented in Appendix B.

These five sets of statistics were used to create an indicator of transportation energy conservation need. Each set was adjusted according to its relative importance for transportation energy conservation. The adjusted values were added together to create the indicator (see Appendix C for a description of the process). The indicator was then used to rank developing countries according to their relative need for transportation energy conservation projects, as shown in Exhibit 4.1. The countries were grouped

Exhibit 4.1

PRIORITY RANKING -- TRANSPORTATION CONSERVATION NEEDS*

HIGH NEED	MEDIUM NEED	LOW NEED
* Panama	* Honduras	* Togo
* Jordan	Korea, Rep. of	* Papua New Guinea
* Turkey	Singapore	Malaysia
* Guatemala	* Mexico	* Niger
* Morocco	Venezuela	
* Dominican Rep.	* Israel	
* Kenya	* Seychelles	
* Sudan	* Bangladesh	
* Pakistan	* Egypt	
* Costa Rica	Trinidad & Tobago	
Ethiopia	* Indonesia	
* El Salvador	* Malawi	
* Uruguay	* Peru	
* Zimbabwe	Hong Kong	
Nicaragua	* Uganda	
* Brazil	Yugoslavia	
* Portugal	* Nepal	
* Tunisia	Nigeria	
Chile	* Mauritius	
* Colombia		
* Sri Lanka		
Kuwait		
* Philippines		
* Thailand		
Ivory Coast		
Algeria		
Argentina		
* Senegal		
* Zambia		
* Ecuador		
* Burma		
* Haiti		
* Bolivia		

* = AID-assisted country

SOURCE: Hagler, Bailly & Company

*This ranking results from the analysis presented in Appendix C.

by low need, medium need, and high need. Countries that were missing one or both of the first two sets of statistics and that would have fallen in the low need category were not included in the list. Some countries, however, were placed in the high or medium need category when only one of the first two sets of statistics was available.

TRANSPORTATION ENERGY CONSERVATION MEASURES

Many actions can be taken to improve the energy efficiency of the transportation sector. Many of these have been used extensively in developed countries, but few have been used in the Third World. To select those measures that show the greatest promise in developing countries, a number of steps have been taken. First, all relevant transportation energy conservation measures were identified and categorized. Next, they were evaluated according to the following criteria: total cost, foreign exchange cost, technical sophistication, ease of implementation, applicability to developing countries, and impact potential (see Appendix D for a definition of these criteria and the matrix of all transportation energy conservation measures).

Once the tools most appropriate for developing countries were selected, they were grouped into four categories, listed in order of decreasing cost:

1) Infrastructure projects: road building, highway maintenance, railroad building and improvement, construction of loading and freight handling facilities

2) Comprehensive traffic management projects (often with infrastructure changes): a combination of measures, including exclusive lanes for high-occupancy vehicles (HOV) and express lanes, traffic light systems, area licensing, turning lanes

3) Small-scale or inexpensive traffic management projects: fuel price changes, parking charges and restrictions, vehicle ownership charges, one-way streets, traffic signs, bus lanes

4) Education and training projects: driver education/training, maintenance programs and education/training, public information programs, management training (routing, scheduling).

Within each group, measures were ranked to identify the most promising tools for developing countries, using the following criteria:

- Low cost/high payback
- Applicability to developing countries

- Replicability and transferability (experience gained in one area or one country can be transferred successfully elsewhere)
- Low management burden
- Ability to produce measurable results
- Ability to produce benefits with lasting power (benefits gained faster than lost).

Infrastructure projects

Infrastructure projects are the most expensive type of transportation energy conservation measure, but they also offer the largest energy savings potential. Because intercity freight transport consumes the largest share of transportation energy in most developing countries, the construction of high-capacity, limited access roads can have the largest impact of any one project on transportation energy use. In addition, given the importance of transportation to the general development of an economy, infrastructure projects should be considered a necessary part of any overall economic development strategy. Infrastructure projects have three drawbacks, however, that limit their attractiveness as transportation energy conservation measures: 1) they tend to be very expensive and their payback in terms of energy savings alone is unlikely to justify their high cost; 2) they are complex undertakings that impose a significant management burden and in many cases severely tax or exceed the technical abilities of developing countries; and 3) they are time consuming, with results a long time in coming.

While infrastructure projects have great promise for developing countries and are certainly necessary for economic development, their drawbacks indicate that they are not necessarily good investments when the objective is transportation energy conservation. Other projects offer greater potential for limited funds.

Within the broader framework of economic development, the infrastructure projects with the greatest promise for cost-effective energy conservation in developing countries are listed in Exhibit 4.2.

Exhibit 4.2

INFRASTRUCTURE PROJECTS

- Improve road network and surface quality
- Build freight terminals and clearinghouses
- Create express lanes with limited access and few lights
- Create extra lanes for through traffic
- Create streets devoted to public transportation
- Create parking areas outside high-traffic areas
- Create parking areas near train and bus terminals
- Install traffic islands to channel traffic more efficiently
- Provide turning lanes
- Provide bus stops
- Build bus terminals

Comprehensive traffic management projects

Comprehensive traffic management projects improve the flow of traffic by combining several components, including bus lanes, lanes for high-occupancy vehicles, parking restrictions, one-way streets, traffic signs, and synchronized traffic lights, into a large unified project. Such projects can produce significant energy savings if well designed. For example, reversible lanes can produce 10-percent energy savings, permitting a right turn at a red light after stopping can produce 0.5-percent fuel savings, and synchronized lights can produce between 5- and 30-percent savings. As a general rule of thumb, any measure that produces a 10-percent reduction in the number of stop-and-go cycles in a typical urban trip will reduce fuel consumption by 2 percent.[1] Combining a variety of measures can produce significant savings. If traffic congestion is especially severe, fuel savings could approach 50 percent.[2] The most promising components for major traffic management projects in developing countries are listed in Exhibit 4.3

Traffic management projects can vary greatly both in cost and in energy savings potential. Some measures -- area licensing and re-routing traffic -- are included in Exhibit 4.3 and not in the small-scale traffic management category (Exhibit 4.4) because of their high cost. Other measures -- such as street signs, street lights, and parking restrictions -- can also be included in the small-scale category since they can be implemented on a small-scale at low cost if necessary.

Major traffic management projects can produce significant results, measured in reduced transit time, increased average speed, reduced idling and stop-and-go cycles, reduced traffic accidents, and reduced pollution. Since most results will be produced with permanent changes in the structure of the transportation system, the results can be expected to last. The rapid growth of many cities in developing countries could overwhelm modest traffic management projects but if the projects are well designed and competently implemented, they should be able to anticipate future growth and produce lasting measurable results.

To the extent that major cities in developing countries are similar, experience gained in these projects will be replicable in other regions and countries.

The major drawback of comprehensive traffic management projects, in addition to a potentially high cost, is the significant management burden they can impose. By definition, such projects require extensive planning. Many developing countries do not have adequate traffic engineering expertise, traffic law enforcement capability, or government motor vehicle departments. In addition, some aspects of these projects require continual monitoring, adjusting, and enforcing (parking restrictions, area licensing, HOV lanes, signal synchronization).

Exhibit 4.3

COMPREHENSIVE TRAFFIC MANAGEMENT PROJECTS
(Using a combination of the following)

- Parking restrictions
- Extensive street signs and lights
- Special streets and lanes for high occupancy vehicles
- Area licensing
- Road use permits
- Re-routing traffic to improve traffic flow
- Area/street tolls
- Temporary car bans

Small-scale traffic management projects

The distinction between small-scale traffic management (SSTM) projects and comprehensive projects may be somewhat artificial, but it is useful for categorizing measures and choosing transportation energy conservation projects. For the sake of this discussion the difference lies in the

number of measures implemented, the size of the project, and the overall cost. SSTM projects either combine a small number of measures in a limited area or implement a single measure in a larger area. By keeping the scope of the project limited, they present a smaller management burden and require fewer resources, nevertheless, many SSTM measures can be implemented in isolation and still produce significant results. Small-scale traffic management projects most applicable to developing countries are listed in Exhibit 4.4.

Many SSTM projects can be implemented at very low cost. Some cost little and offer high paybacks alone, such as fuel price increases and vehicle ownership charges (which may, however, have a high political cost).[3] Others do not offer large fuel savings, but come at such low cost that they offer attractive benefit/cost ratios, such as right-turn-on-red, increased parking charges, and taxi-ride sharing.

Other SSTM projects fall in the medium-cost range, but can produce significant energy savings. For example, reversible lanes can improve energy efficiency by reducing travel time by between 20 and 50 percent.[4] Projects such as creating one-way streets and bus lanes, installing traffic signs and lights, and painting lane markers, can be undertaken on a street-by-street basis, choosing areas with the greatest potential and thus gradually improving traffic flow.

As with comprehensive traffic management projects, experience gained in SSTM projects is replicable in other regions and countries, to the extent that major cities in developing countries are similar. In addition, most of these projects can produce measurable results that should last, although their more limited benefits could be overwhelmed by rapid growth.

Finally, because SSTM projects are more limited, their burden on the management capability of developing countries is relatively small. Some, such as one-way streets and bus lanes, require management capabilities to design and implement, but do not require much attention after that. Others, such as price changes and parking charges, require enforcement and implementation throughout their life.

Exhibit 4.4

SMALL-SCALE TRAFFIC MANAGEMENT PROJECTS

Traffic signals
- Synchronize signals
- Improve signal timings
- Provide demand-responsive timing
- Replace four-way stop with a signal
- Replace four-way stop with two-way stop
- Replace signal with two-way stop
- Allow right turn on red
- Operate off-peak flash

Parking restrictions
- Restrict parking during rush hour
- Reduce parking supply in high-traffic areas
- Impose high fees in high traffic areas
- Graduate fees to encourage short-term parking
- Provide fiscal regulation of private parking areas

High-occupancy vehicle lanes
- Create contra-flow bus lanes on one way streets
- Create with-flow bus lanes
- Create HOV lanes

Tolls in high-traffic areas

One-way streets

Reversible lanes

Regulated turning movements
- Ban conflicting turning movements
- Add exclusive left-turn lane
- Allow permissive left-turns

Traffic management measures for public transit
- Add special phases at traffic lights that favor public transportation
- Allow exclusive turning movements at intersections
- Use bus convoys

Fuel efficiency monitoring

Education and training projects

Education and training projects have produced significant results on a small scale. If implemented broadly, they can have a large impact while costing relatively little. Education and training projects most applicable to developing countries are listed in Exhibit 4.5. In addition to having a low cost and a potentially high payback, education and training projects also produce significant ancillary benefits such as reducing traffic accidents and increasing vehicle life. Where these projects improve driving habits and vehicle maintenance, and reduce driving, they can reduce vehicle emissions to help alleviate pollution problems.

One major advantage of these projects is the low marginal cost of expanding training programs. Once the initial instructor training is completed, the education and public information material is created, and the institutions are in place and experienced with the program, it is relatively simple and inexpensive to expand the program. By the same token, education and training projects should be relatively easily replicated in other countries.

Yet another advantage of education and training projects is that they can spur extensive private-sector involvement. After the government or an international development organization provides initial training, these projects can be developed and implemented entirely within the private sector.

The major disadvantage of these projects stems from the fact that their effectiveness depends on several factors largely beyond the control of program planners. They rely fc- success on people and institutions, and their ability to change habits, behavior, and modes of thinking instead of creating physical and legal restrictions that are difficult to circumvent.

Education and training projects by nature have an extensive management aspect. In developing countries with rudimentary communications and a marginal education system, this may prove a significant barrier. On the other hand, these projects do not require an extensive bureaucracy nor sophisticated technical expertise, and they can be tailored to the needs and abilities of each country.

Most education and training projects are primarily relevant to commercial vehicles. A public information campaign is the only recommended action directed toward private drivers. Driver education projects for non-commercial vehicles could have a great impact on transportation energy efficiency, but would be very expensive and require extensive management expertise.

Education and training projects should be able to produce easily-measured results, such as improved fuel efficiency and fewer breakdowns. Some developing countries already have institutions and procedures in place to

measure and track such statistics. In others, a project will have to include the establishment of a transportation database and a system for keeping it up to date.

Experience in developing countries is too limited to provide direct evidence on the lasting power of transportation energy conservation education and training projects. However, it is likely that the benefits will gradually dissipate unless a constant effort is undertaken to keep energy conservation in the public eye.

Exhibit 4.5

EDUCATION AND TRAINING PROJECTS

Driver education
- Bus, taxi, and truck driver education
- Public information campaign

Improve vehicle maintenance
- Driver education
- Mechanic education

Organization management -- public transit
- Improve routing
- Improve scheduling
- Improve company management
- Create training programs
  - -- Driver training
  - -- Mechanic training
  - -- Planner/scheduler training
  - -- Management training

Improve fleet efficiency
- Improve fleet management
  - -- Set standards
  - -- Implement training programs
  - -- Increase backhaul load factors
- Improve fleet operations
  - -- Upgrade standards of driver training tests
  - -- Institute periodic driver testing
- Improve fleet maintenance
  - -- Institute training programs
  - -- Increase inspection frequency

Fuel-saving equipment
- Radial tires
- Aerodynamic add-ons for trucks

POTENTIAL IMPACT OF SELECTED MEASURES

Measuring the potential impact of transportation energy conservation actions in developing countries is quite difficult. Many variables come into play, each adding a note of uncertainty. However, much work has gone into evaluating the effects of various conservation methods in developed countries. The results of these efforts provide a general indication of the potential savings in developing countries.

Effects of single measures

Estimates of the energy conservation benefits of single measures range from 0.4 percent for including wheel alignments in vehicle maintenance to 30 percent or more for area licensing and synchronizing lights (see Exhibit 4.6 for some examples).

Exhibit 4.6

POTENTIAL ENERGY SAVINGS FROM SELECTED TRANSPORTATION CONSERVATION ACTIVITIES*

Measure	Approximate Percent Savings
Area licensing	25-30
Better lubricants	2-4
Driver training	6-25
Vehicle maintenance	1-15
Radial tires	1-5
One-way streets	12-17
Reversible lanes	10
Ride sharing	10
Right turn on red	0.5-2
Synchronized lights	5-30
Wheel alignment	0.4

* This table gives some examples of potential savings for traffic directly affected by the activity. Most examples come from industrialized countries. Ranges are given where different estimates were identified in the sources checked.

SOURCE: Hagler, Bailly & Company, derived from several sources including OECD, Energy Savings and Road Traffic Management, 1985; Oak Ridge National Laboratory, Transportation Energy Data Book: Edition 8; Jason C. Yu and Leslie M.G. Pang, Identification and Ranking of Transportation Cost Reductions Through Energy Conservation Strategies, University of Utah, for the Urban Mass Transit Administration, January 1983.

Effects on individual fleets

Single measures implemented by themselves may not have a significant impact on a nation's energy use, but they can have a significant impact on individual fleets. For example, energy savings of $456,800 per year could be achieved in a taxi fleet in Costa Rica if the driver training and maintenance procedures demonstrated in an AID program are implemented throughout the fleet. Savings of $35,500 per year could be achieved by the bus fleet from the same program.[1]

Effects of multiple measures

Estimates of the effects of a combination of initiatives are harder to determine. In general, the estimates must be created from a combination of field trials and general knowledge of the subject. Since many activities can produce savings in the range of 5-10 percent, it does not seem unreasonable to expect that a concerted effort to implement several activities could produce savings in the 15- to 25-percent range for the transportation sector as a whole. The World Bank, for example, has estimated that it should be possible to achieve overall savings of approximately 20 percent of total transportation fuel use.[2]

In some developing countries, a savings of this magnitude could have a significant impact on the economy. Many developing countries import 80 to 90 percent of their oil and consume approximately 44 percent of that oil in the transportation sector. For them, savings of 20 percent could significantly improve their balance of trade. In Bolivia, for example, road vehicles carry 93 percent of all freight and 96 percent of all passengers. The transportation sector is entirely dependent on oil products and accounts for 61 percent of total petroleum consumption. Road vehicles account for 80 percent of all fuel used by the sector. In 1983, Bolivia consumed 669,000 tonnes of oil equivalent (toe) in transportation fuels; 80 percent of that amount is 535,200 toe, or 3,923,016 barrels. At today's price of $15 per barrel, Bolivia would spend $58,845,240 on oil for road transportation annually. A 20-percent savings would equal $11,769,048 per year.

In Thailand, road transportation consumed 3,694 million liters of crude oil in 1978,[3] or 23,237,089 barrels. At today's price of $15 per barrel, Thailand would spend $348,556,335 on oil for road transportation annually. A 20-percent savings would equal $69,711,267. Such savings would directly affect the balance of trade since Thailand imports 96 percent of its total oil demand.[4]

Kenya imports virtually all its petroleum. Motor gasoline and gas consumption in the transportation sector amounted to 383,000 toe, or 2,807,390 barrels, in 1983.[5] At $15 per barrel, Kenya would spend $42,110,850 on imported crude

oil for its road transportation sector annually. A 20-percent savings would equal $8,422,170.

In Costa Rica, according to AID's report on the transportation energy conservation demonstration project, a 17-percent savings in the bus and taxi fleet "would translate into annual foreign exchange savings of approximately $17 million (at December 1985 petroleum prices)."[6]

While the recent fall in the price of oil has helped most developing countries, many continue to pay prices far above the world price of oil. High oil transport costs, limited processing facilities, and low-volume purchasing (limiting volume discounts) can raise the border price of oil substantially for many countries. In addition, nominal border prices often do not reflect the real price of oil to consumers in developing countries. Using shadow or real prices for resources can provide a more realistic, and usually much higher, estimate of the cost of importing oil for transportation use. Thus the real savings from improving the energy efficiency of the transportation sector will often be much higher than the rough calculations in this report would indicate.

5. CONCLUSIONS

This paper represents a single step in an ongoing exercise to evaluate transportation energy conservation activities. The analysis and conclusions presented will be revised as more information is gathered and as input is received from experts in the field. Preliminary conclusions can be drawn, providing recommendations for developing countries and development organizations. Subsequent discussions and analysis will further refine this set of recommendations and the analysis of LDC needs and transportation energy conservation measures.

IMPLICATIONS FOR DEVELOPING COUNTRIES

Transportation energy consumption in developing countries is rapidly rising. As development continues, the transportation sector will grow in importance, accounting for a larger share of the total energy bill. To forestall serious traffic congestion problems and large fuel import bills, it is imperative that developing countries take steps now to plan for the future of their traffic system.

Transportation energy conservation has a large potential. It can delay expensive infrastructure projects while saving energy and foreign exchange, improving economic efficiency, and reducing pollution. However, projects need to be chosen with care. Some of the larger and more expensive transportation projects may not be cost-effective, therefore, a careful examination of the options is needed.

Perhaps the most important variable in the success of transportation energy conservation projects is the degree of follow-up. Many transportation energy conservation measures require changes in habits and behavior. Some changes are made easier by physical restrictions (road barriers, speed limiters on vehicles), while others must be enforced, either by traffic policemen or by self-motivation. Enforcement is made easier if public information campaigns, signs, and institutionalized training programs provide continual reminders.

There are a wide variety of possible actions to improve the energy efficiency of the transportation sector. Four actions stand out as particularly important, because they can be implemented quickly, at low cost, and -- often -- relatively easily. As a beginning, developing countries should:

- Adjust prices, ultimately the key to the long-term health of the transportation sector. Adjust fuel prices to represent shadow prices and reduce demand for private transportation; adjust parking charges to discourage commuting; adjust road charges to

encourage use of public transit and discourage use of private vehicles in congested regions. These measures can be among the least expensive -- economically -- but their political and social costs may be prohibitive.[1]

- Incorporate transportation planning in city planning.
- Improve road maintenance. Basic road maintenance can have a dramatic impact on traffic flow, vehicle maintenance, and fuel economy.
- Institute an information and awareness campaign to begin to educate the public on the importance of fuel-efficient driving, vehicle maintenance, and saving energy.

These actions are necessary to establish the groundwork for other transportation energy conservation activities. As funding permits, additional projects should be implemented.

IMPLICATIONS FOR DEVELOPMENT ORGANIZATIONS

Given sufficient funds, development organizations should give first priority to integrated traffic management projects with medium-sized infrastructure components (express lanes, paved access roads, turning lanes, road maintenance). These projects promise the greatest potential for saving energy and improving the functioning of the economy. However, because funds are necessarily restricted, priorities must be established. Since experience in transportation energy conservation projects is limited, the first step should be to select modest projects with low risk and low cost. Priority should be given to projects that can produce measurable results and can be expanded if successful.

Education and small-scale traffic management projects generally satisfy these criteria. Many such projects can be implemented quickly and at low cost, while placing no great management demand on developing countries. They also have the advantage of being modular; they can be implemented in single fleets or small sections of cities, and, given success in the initial stages, can be expanded into programs that can have a large impact on the country.

Education projects of particular promise include: driver education, public information campaigns, vehicle maintenance programs, and the promotion of fuel-saving equipment such as radial tires and aerodynamic add-ons for trucks. Promising small-scale traffic management projects include: creating priority lanes for buses and high-occupancy vehicles; upgrading traffic signals (installing signs and lane markings, installing lights where needed, and

synchronizing existing lights); and creating a coordinated parking control strategy.

Projects aimed at achieving changes in regulations, government policies, and laws to encourage transportation energy conservation can be among the most affective in achieving significant change. Institutional barriers to energy conservation can eliminate natural incentives for implementing energy conservation actions. Projects to reform fuel pricing, revise transportation subsidies, eliminate traffic management barriers, and improve traffic policing, can have a very significant, immediate impact and will ensure that the groundwork is prepared for the development of a rational and energy-efficient transportation sector in the future. It is very important that policy and traffic law reform projects be accompanied with extensive surveys of the transportation sector and the constraints on energy conservation, so that an effective plan of action for the government can be produced.

Much care needs to be given to choosing target countries. Since transportation energy conservation experience is limited, development organizations should target those countries that show the greatest promise for producing significant results. First priority should go to those countries that have had recent extensive surveys of the transportation sector, such as Sri Lanka, Tunisia, Pakistan, India, and Costa Rica, or to countries that have had surveys of one portion of the transportation sector. Coordination among development agencies will be particularly crucial in choosing target countries to greatest advantage.

Second priority should go to countries that, at a minimum, have the following attributes:

- A moderately-developed road system[2]
- Effective traffic management and traffic law enforcement institutions
- One or more cities of strategic importance to the economy (as opposed to a largely rural country).

These countries, while perhaps not the poorest, will present the greatest chance for successfully implementing transportation energy conservation projects. Once developing countries and development organizations gain more experience in such projects, other countries can be tackled with a greater chance of success.

In view of the general lack of experience in projects dedicated to transportation energy conservation, development organizations should pursue a variety of relatively small demonstration projects to develop such experience to guide future actions. Coordination between development organizations would

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speed the process of identifying those projects with the greatest potential for providing transferable experience. To this end, a meeting of experts in the field is recommended to examine the various options and develop a plan of action that will take advantage of existing expertise and build from previous transportation work.

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[10]Dunkerley, pp.6.2.

[11]Ibid.

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[13]World Bank, Urban Transport, pp.33.

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CHAPTER 3

[1]This project was implemented under the Energy Conservation Services Program of the Office of Energy in the Bureau for Science and Technology.

[2]The taxis were predominantly 1985 models, thus large gains from maintenance would not be expected.

[3]An area licensing system was planned for Bangkok, Thailand in 1979, however, its scope and difficulty was much larger, producing what proved to be insurmountable difficulties in gaining public and political acceptance. See Planning and Transport Research and Computation (International) Co. Ltd., Transport Planning in Developing Countries, Proceedings of Seminar G, Volume P207, July 1981. JCR Latchford, DB Shaw, GD Bellamy, "To What Extent is Area Traffic Control Appropriate in Developing Countries?"

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[1]Hagler, Bailly & Company, Implementation of Fuel Cost Reduction Measures in Costa Rican Private Bus and Taxi Fleets, June 11, 1986, Exhibit 5.1.

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[6]Hagler, Bailly & Company, Implementation of Fuel Cost Reduction Measures in Costa Rican Private Bus and Taxi Fleets, June 11, 1986, Executive Summary pp.1.

CHAPTER 5

[1]See Evaluation of Policies Influencing Road Transport Fuel Consumption in Developing Countries for a discussion of tax and pricing policies in 15 AID-assisted countries. The report is by Energy and Environmental Analysis, Inc., for the Bureau for Science and Technology, U.S. Agency for International Development, March 31, 1986.

[2]Countries with poorly developed road systems may be in greater need of development support, but the infrastructure projects required in their cases are beyond the scope of this report.

APPENDIX A: CASE STUDIES

The following projects will be outlined in this appendix:

1. Transportation energy conservation demonstration
   - Costa Rica (bus and taxi maintenance, radial tires, driver training, public information)
   - Sri Lanka (priority bus lanes)
   - Brazil (bus expressways and bus lanes in Porto Alegre)
   - Thailand (priority bus lanes in Bangkok)
   - Thailand (comprehensive traffic management plans)
   - Singapore (area licensing to restrict access to the central business district)
   - Hong Kong (electronic road pricing)

2. Transportation energy conservation survey/policy projects:
   - Indonesia (bus company energy audit in Jakarta)
   - India (survey of transportation energy use and recommendations for improvements)
   - Tunisia (analysis of the energy consumption and efficiency patterns and trends in the transportation sector)
   - Korea (evaluation of transportation energy use and needs)
   - Pakistan (comprehensive public transit planning study in Lahore)
   - Papua New Guinea (transportation planning for rural provinces)

3. Transportation infrastructure projects with energy conservation components:
   - Costa Rica (comprehensive urban transportation project including widened roads, traffic signals, traffic management measures, bus routes, and parking restrictions)
   - Ivory Coast (comprehensive traffic management in Abidjan)

More limited information on a few projects is provided at the end of this appendix.

COSTA RICA

Activity: Transportation energy conservation demonstration project involving bus and taxi fleets, maintenance, radial tires, driver training, and public education

Dates: 1985

Organizations Involved: Hagler, Bailly & Company, Oak Ridge National Laboratory,

Source of Funding: Bureau for Science and Technology, U.S. Agency for International Development

Source of Information: Hagler, Bailly & Company, Implementation of Fuel Cost Reduction Measures in Costa Rican Private Bus and Taxi Fleets, Final Report, Prepared for the Direccion Sectorial de Energia, San Jose, Costa Rica, and the U.S. Agency for International Development, June 11, 1986.

Description: The demonstration project applied fuel conservation measures to fleets of 24 buses and 16 taxis. Initial measures included optimum maintenance and radial tires. After 4 weeks all participating drivers were trained in fuel-efficient driving techniques. Following completion of driver training, driver incentives were given to bus drivers while the test continued for an additional four weeks. Data on kilometers traveled, fuel consumed, routes, drivers, and vehicle types were then collected and analyzed.

During the public information and awareness campaign, broad media coverage was obtained for key events such as the certificate award ceremony for taxi driver trainees and the fuel conservation seminar. Brochures for operators of light vehicles, buses and trucks were prepared and will be distributed through existing low cost channels.

Results:

The results indicated that driver training and proper maintenance together produced an estimated 10 percent savings for buses and approximately 17 percent for taxis.

The bus savings were:	Proper maintenance	6.5%
	Driver training	4.2%
	Driver incentives	1.2%*
	Radial tires	-1.8%
The taxi savings were:	Proper maintenance	1.8%*
	Driver training	15.1%
	Radial tires	0.2%*

*Not statistically significant

The savings from maintenance and radial tires might have been better but for certain limitations and monitoring problems.

SRI LANKA

Activity: Small scale survey of the effects of bus-only lanes on Galle Road in Colombo, Sri Lanka

Dates: 1985

Organizations Involved: Technical University of Nova Scotia; Indian Hume Pipe (Col) Ltd.

Source of Funding: National Engineering and Science Research Council of Canada, TUNS General Grant

Source of Information: "Effects of the Bus-Only Lane on Traffic Flow on Galle Road," Proceedings of the Sri Lanka Transportation Forum, Second Session, August 6-8, 1985, Vol. I, Department of Civil Engineering, University of Moratuwa, Moratuwa, Sri Lanka, Co-Editors: L.L. Ratnayake, G.W. Kodikara, T.A. Peries.

By Prianka N. Seneviratne, Dept. of Civil Engineering, Technical University of Nova Scotia, Halifax, Nova Scotia, B3J 2X4, Canada; and Sihil Daluwatte, Indian Hume Pipe (Col) Ltd., Lady Catherine Group, Galle Road, Ratmalana, Sri Lanka.

Description:

With-traffic bus lanes were created on Galle Road, one of the busiest roads in Sri Lanka, in an effort to increase average bus speed and encourage a shift from private cars to public transportation.

Results:

The results were a dismal failure. The average running speed of buses declined by 38.5 percent and the speed of cars declined by 40.1 percent. Several factors contributed to this result, including: The regulations that confined buses to the bus-only lane prohibited passing and led to bus bunching at bus stops; the bus-only lane was under-utilized since the volume of buses was usually way below the capacity of the lane; inadequate publicity and street signs led to confusion; consultation with affected parties was inadequate, which lead to anger and a lack of cooperation; lane width was inadequate to provide room for buses since the outside lane was also used by soft modes of transportation, and since potholes forced drivers to drive partly outside their lane; boarding and alighting from buses was unrestricted, which lead to delays as buses picked up passengers while waiting to reach the official bus stop; this also lead to delays as pedestrians crossed streets at unlawful points.

Two alternatives were suggested for improving the situation: The first involved, among other things, restricting right turns; improving lane demarcation; restricting soft modes of transportation to the slow lane; improving minor access roads; creating restrictions on picking up and discharging passengers; and improved policing. The second alternative suggested creating reversible lanes for peak periods.

BRAZIL

Activity: Bus expressways and bus lanes in Porto Alegre

Dates: Beginning in 1978

Organizations Involved: The World Bank and the Brazilian Company for Urban Transport

Source of Funding: World Bank

Source of Information: The World Bank, Urban Transport: A World Bank Policy Study, Washington, D.C., 1986

Description:

In 1978, the Porto Alegre city administration began a project to improve bus service in the city. Thirty kilometers of lanes were paved and designated for exclusive bus use by means of signs, curbs, or low reflecting markers. To avoid bus bunching at bus stops, an innovative system of bus convoys was developed. At the beginning of each corridor a convoy of up to six buses was assembled. The convoy traveled the route together, stopping and starting together. Passengers lined up at the bus stops according to their final destination and the location of the buses in the convoy. Such a convoy can almost double the bus lane capacity in congested areas. In addition to bus lanes and convoys, two transfer terminals were built to reduce congestion and facilitate transfers from feeder bus lines to the large buses operating on the bus expressway.

Results:

According to the World Bank, this system resulted in 20 percent higher bus speeds.

THAILAND

Activity: Bus lanes in Bangkok

Dates: Beginning in 1980

Organizations Involved: The World Bank; Asian Institute of Technology; Transport and Road Research Laboratory

Source of Funding: The World Bank and the Royal Thai Government

Source of Information: The World Bank, Urban Transport: A World Bank Policy Study, Washington, D.C., 1986; Transport and Road Research Laboratory, The Performance of High-Flow Bus Lanes in Bangkok, N.W. Marler, TRRL Supplementary Report 723, 1982

Description:

In 1980, 145 kilometers of traffic lanes were set aside for exclusive with-flow bus lanes. The bus lanes are set off from other lanes by a painted yellow line and operate during the morning and evening rush hours. Other vehicles, including non-motorized forms of transport and trucks, were prohibited from using the lanes except when turning into or out of a side road. Parking was prohibited at the curb along bus lanes during the rush hours in all locations, and for longer periods in some locations.

The initial rules prohibited buses from leaving their lane. Excessive bus bunching at bus stops, however, led planners to change the rules and allow buses to pass each other.

Results:

Before and after surveys of car and bus travel times indicated that in all cases the bus lanes reduced travel times for both buses and cars. Bus travel times decreased by 38 percent. Bus travel times improved even when the flow of buses reached 250 per hour in a single lane (nearly 400 buses/hour if minibuses are included). Car travel times decreased by 20 percent overall, including 29 percent on one road.

The project was highly successful and cost effective, with a total cost of less than $1.5 million.

THAILAND

Activity: Comprehensive traffic management

Dates: Beginning in 1978

Organizations Involved: Thailand National Energy Administration, Ministry of Science Technology and Energy; United Nations, Economic and Social Commission for Asia and the Pacific; the World Bank; BCEOM

Source of Funding: Government of Thailand; United Nations, Economic and Social Commission for Asia and the Pacific; the World Bank

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Description:

Officials in Thailand have expressed great interest in transportation energy conservation and have implemented a number of conservation measures, both on their own and under the guidance of outside consultants and organizations. According to their Fifth 5 Year Plan, the following transportation energy conservation measures have been implemented:

- Public relation activities to inform people about energy problems, the necessity to conserve energy, and potential benefits of energy conservation
- Driver education and the preparation of a guidebook, seminar, and workshop
- Driver and technician education about maintenance and correct adjustment of engines, including the preparation of a guidebook, seminar, and workshop
- The promotion of equipment that can save fuel
- Restrictions on the use of old, fuel-inefficient vehicles and promotion of new fuel-efficient vehicles. The creation of taxes to limit vehicle ownership

- The creation and enforcement of speed limits
- The creation of 19 bus lanes in Bangkok
- Prohibition on parking in main roads in Bangkok
- Exclusion of trucks from Bangkok at certain times
- Enforcement of traffic regulations, especially parking in prohibited area and driving in bus lanes
- Creation of bus lanes
- The reorganization of the public transport organization by creating improvements in structure, route, station location, and maintenance.
- Improvements in bus service, including an increased number of bus trips, improved punctuality, convenience, and security in service for regular and air-conditioned buses between provinces

The United Nations Economic and Social Commission for Asia and the Pacific funded a survey of the transportation sector in Thailand. Their report described the situation in Thailand and indicated that Thailand has done the following:

- Implemented an exhibition and education program on fuel-efficient driving style
- Changed tax rates to promote fair competition between modes of transportation
- Improved the routing and scheduling of intercity buses
- Improved the quality of intercity bus service
- Implemented a fuel conservation maintenance program
- Studied the use of LPG in city buses

A BCEOM draft study also indicated that the following energy conservation actions have been implemented in Thailand:

- Speed limits for private cars and buses on some public highways of not more than 90 kms/hr and 80 kms/hr respectively were created
- Parking limits on 39 roads in Bangkok increased
- 6-wheeled and 10-wheeled trucks prohibited from Bangkok during rush hours
- LPG prices for vehicular use raised to slightly below gasoline prices and higher than LPG prices for household use

Finally, an area traffic control system was created in Bangkok. Traffic lights were installed at 48 intersections and were synchronized by means of a simple computer system.

Results:

Specific results for most individual measures have not been gathered. However, some measurements indicate that the traffic control system has produced savings of approximately 25 percent for a projected overall rate of return of at least 100 percent per annum. A promising, extensive cordon road pricing scheme similar to the Singapore area licensing system was designed but never implemented due to the lack of political and popular support and the difficulties of implementing such a large project.

SINGAPORE

Activity: Area Licensing to restrict access to the central business district

Dates: Beginning in 1975

Organizations Involved: Singapore Government

Source of Funding: Singapore Government

Source of Information: The World Bank, Urban Transport: A World Bank Policy Study, Washington, D.C., 1986; Scott A. Noll, Transportation Energy Conservation in Developing Countries, Unpublished Discussion Paper D-73K, Center for Energy Policy Research, Resources for the Future, August 1982; and Joy Dunkerley, Irving Hoch, with Caroline Bouhdili, Transport Energy: Determinants and Policy, Resources for the Future for USAID, September 1985; A.T. Armstrong-Wright, "Road Pricing and User Restraint: Opportunities and Constraints in Developing Countries," Transportation Research, Vol.20A, No.2, pp.123-127, 1986.

Description:

In 1975, the government of Singapore instituted an area licensing scheme to limit the volume of traffic in the center of the city during the morning rush hour. The central business district was cordoned off, limiting access to buses, commercial vehicles, and private vehicles with four or more passengers. Private vehicles with fewer than four passengers were permitted entry after paying a fee of $2.50 a day or $50 a month. Parking fees were raised and restructured to encourage short-term parking while parking facilities were developed at the periphery of the restricted area and shuttle buses were provided for transportation to the center of the city.

Results:

The scheme enjoyed general support from the residents and has had relatively minor detrimental impacts. Results were very positive as traffic speeds increased 20 percent within the restricted zone, traffic accidents declined 25 percent, and total traffic declined 44 percent during the restricted period. Fuel consumption savings were not measured but it is estimated that savings are on the order of 30 percent. Revenues from the scheme more than covered its capital and recurrent costs.

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HONG KONG

Activity: Electronic road pricing

Dates: Beginning in 1982

Organizations Involved: Hong Kong Government

Source of Funding: Hong Kong Government

Source of Information: The World Bank, Urban Transport: A World Bank Policy Study, Washington, D.C., 1986; "Issues of the Electronic Road Pricing System in Hong Kong," Transportation Planning and Technology, Vol.10, #1 (1985); Hong Kong Office, British Embassy; Hong Kong Annual Report, 1986; A.T. Armstrong-Wright, "Road Pricing and User Restraint: Opportunities and Constraints in Developing Countries," Transportation Research, Vol.20A, No.2, pp.123-127, 1986; J.A.L. Dawson and I. Catling, "Electronic Road Pricing in Hong Kong," Transportation Research, Vol.20A, No.2, pp.129-134, 1986.

Description:

Faced with the highest vehicle density in the world, and a deteriorating traffic situation, the Hong Kong government implemented a test program to evaluate the practicality and effectiveness of electronic road pricing. Electronic number plates were installed on over 2,500 test vehicles, including about 1200 government cars, 700 buses, and the remainder private vehicles. Sensors were installed under the pavement at 18 charging points throughout the city. The sensors collected information on each car and charges were computed by a central computer that took into account time of day and location. The system used a modular design, requiring inexpensive microcomputers rather than large mainframe computers. Mock road-use bills were created monthly and drivers could obtain a detailed statement of charges.

Results:

The six month test was completed in June 1985. The equipment performed as expected and the experiment demonstrated that the system was technically feasible and could operate reliably in Hong Kong conditions. However, the local governing boards reacted negatively to the project and the government decided not implement the full project for the time being. Current traffic conditions are being monitored while other alternatives are being weighed and the road pricing system may be reconsidered at some future date.

INDONESIA

Activity: Bus company energy audit in Jakarta

Dates: 1984

Organizations Involved: By Mr. Claude Peyrebonne, BCEOM and Mr. Roger Rault of Budget Route, as part of France's Trans Energ-Program

Source of Funding: The Government of France

Source of Information: Jakarta, Pengangkutan Penumpank Djarkarta (PPD) Bus Company, Energy Audit, Report provided by Mr. Claude Peyrebonne, BCEOM

Description:

The Trans Energ mission performed an energy audit of the PPD Bus Company in Jakarta from March 16 to March 19, 1984 in order to examine several subjects related to fuel use. The mission checked the general organization of the company, the lay-out of the depots, and the operational methods. It provided recommendations on action to reduce energy consumption and improve efficiency but specified no actions that were actually planned or underway.

INDIA

Activity: Survey of transportation literature and transportation energy consumption data in India to develop energy conservation recommendations

Dates: 1982

Organizations Involved: The World Bank

Source of Funding: The World Bank

Source of Information: "Recommendations to Reduce Energy Use in the Transport Sector in India," by Dr. Martin J. Bernard III, Consultant, Under Assignment with the World Bank, September 1982

Description:

Dr. Bernard performed a comprehensive review of the literature on energy conservation both worldwide and for India, interviewed Indian transportation and energy experts, and observed the Indian transportation system to develop recommendations for saving energy in both the short term and long term. The report reviews the situation in India, makes conservation recommendations, and indicates areas where improvements have been achieved in energy efficiency.

Specifically, Indian vehicle manufacturers have been improving the efficiency of their vehicles. Truck manufacturers have been making some progress, but not radical progress by developed country standards. Two jeep manufacturers have been allowed to collaborate with Peugeot to use an engine with better fuel economy. Another has been allowed to collaborate with Fiat.

The Gujarat State Road Transport Corporation has implemented a number of fuel economy measures, including:

- Limiters were placed on buses to limit their top speed to 60 km/hr. Tampering was common at first, but consistent oversight brought some improvement.
- Prizes were given to the depots with the highest kilometer per liter rates; however, this did not prove to be very effective.
- Incentives were created, giving a percent of the savings to all involved, based on prior performance.
- Driver training was undertaken, at first only in the off-season and slow points (monsoon), now all year, concentrating on drivers with poor performance.

- Careful statistics are kept on fuel consumption.
- Gasoline spillage was reduced by filling fuel tanks to a predetermined level, rather than topping out, and ensuring that all vehicles had fuel caps and a resin cover fitted on the neck.
- Gasoline leakage within engines was stopped by regular maintenance.

TUNISIA

Activity: A detailed analysis of the National Survey of Vehicle Energy Use, an evaluation of energy use in Tunisia, and an evaluation of the effects of maintenance on fuel economy

Dates: 1983-84

Organizations Involved: Bureau for Science and Technology, U.S. Agency for International Development; Energy Division, Oak Ridge National Laboratory; Ministry of National Economy, Government of Tunisia

Source of Funding: U.S. Agency for International Development

Source of Information: Transportation Energy Use and Efficiency in Tunisia, A joint project of the Government of Tunisia and the U.S. Agency for International Development, by David L. Greene, Patricia S. Hu, Axel B. Rose, Final Report, February 15, 1984.

Description:

This analysis examined the energy consumption and efficiency patterns and trends in the Tunisian transportation sector. It also examined Tunisia's National Survey of Vehicle Energy Use to evaluate its usefulness. The project's report does not, however, describe activities that have been undertaken to increase transportation energy efficiency.

The Tunisian National Survey of Vehicle Energy Use was analyzed to evaluate the effects of vehicle maintenance on fuel economy. While there was not a concerted effort to encourage maintenance before gathering the data, the effort produced useful information: "The results indicated that vehicles which had recently taken actions which reduced vehicle rolling resistance, which used a multiviscosity lubricating oil, or which used radial tires achieved better fuel economy. Efficiency improvements on the order of 10 percent per inadequately maintained vehicle should be readily achievable through these and other improved vehicle operating procedures." [page I-12]

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KOREA

Activity: Evaluation of transportation energy use and needs

Dates: 1982, 1983

Organizations Involved: Two surveys, one conducted under the sponsorship and guidance of the Korean Ministry of Energy and Resources, by the Korea Energy Management Corporation in cooperation with Trans Energ, the French Government's official consulting group in energy planning and conservation, the other conducted by the World Bank.

Source of Funding: The Governments of France and the Republic of Korea, the World Bank

Source of Information: Energy Consumption in The Transport Sector: Identification Report, Republic of Korea, Korea Energy Management Corporation, Trans Energ, Paris, January, 1983; Korea: Transport Sector Issues Survey, World Bank Report No. 4423-KO, December 27, 1983.

Description:

From December 6 to 22, 1982, a project team from Trans Energ evaluated the transportation sector in Korea. The mission conducted interviews with government and private executives involved in the transportation system, it analyzed documents and statistical data, and it observed traffic conditions and control methods in Seol. The primary purpose of the study was to assess the share of the transport sector in total energy consumption; to determine the energy savings potential in the sector; to prepare an action plan defining general policies for energy conservation; and to define a specific program of steps to be taken in the future. The mission produced an "Identification Report" in January 1983 that provided recommendations for energy conservation actions. It provided no indications of efforts that had already taken place.

The World Bank also conducted an evaluation of Korea's transportation sector. Their primary aim was to identify specific policy adjustments and measures that could improve the functioning of the transport sector. Their report includes recommendations for fuel pricing changes, improvements to the institutional framework for transportation energy conservation, and public information and driver education initiatives.

PAKISTAN

Activity: Comprehensive public transit planning study in Lahore

Dates: Beginning in 1978

Organizations Involved: Punjab Urban Transport Corporation (the public bus company), Volvo International Development Corporation, independent consultants

Source of Funding: The Government of Pakistan and the Swedish Agency for International Technical and Economic Cooperation

Source of Information: "A New Approach to Implementing Bus Services - The Lahore Example," Ian Jenkins, Claes Westberg, Transport Planning in Developing Countries, Volume P223, July 1982. Proceedings of Seminar H, Planning and Transport Research and Computation (International) Co. Ltd. References given to: Volvo (1980) Model Urban Transport System - Summary of Findings and Recommendations, Lahore; "Lahore Model Urban Transport System Project and Development of Lahore Urban Bus Transport" 1986 report provided by USAID ENERCON project in Pakistan.

Description:

The project entailed designing a comprehensive five year program to develop public transportation in Lahore and establishing better operational procedures and appropriate training and planning. The initial program was extended in 1984 for another two years.

A major component of the project was the purchase of 649 bus chassis from Volvo, which were fitted with bodies built in Pakistan.

Specific activities included:

- Establishing a model for predicting the travel pattern in Lahore
- Proposing traffic management improvements in critical areas
- Defining the role for privately owned public transportation
- Designing the public transportation network, timetables, and schedules
- Designing workshops, depots, and a bus body building factory
- Proposing a new organization for the PUTC
- Establishing new activities in bus body assembly, maintenance, and spare parts supply
- Training personnel as part of the implementation of new services.

Results:

The overall results were generally positive. 52 bus routes were created, some, however, were altered for political reasons, which increased their circuity and decreased their efficiency. Efforts are now being made to re-organize routes. The fleet was originally *overscheduled, likely in an attempt to achieve impressive results. As a result, in 1980 only 40 percent of scheduled buses were making their rounds. This gradually improved to 90 percent in 1986. During a four month monitoring period, tickets sold per bus per day were close to the target as were tickets sold per productive bus hour. Revenue per bus per day and per productive bus kilometer were below targets by between 16 and 20 percent. Productive bus kilometer per bus per day was within 10 percent of the target. As of April 1986, 564 training classes had been held with 6190 participants. These courses covered traffic, technical, body, stores, workshop, traffic planning, and budgeting subjects with the majority of students attending the driver training course.

Passenger demand in Lahore would require approximately 1400 buses. The 649 buses are inadequate for the task and suffer from overloading and congestion on certain routes. Plans have been prepared to purchase additional buses.

PAPUA NEW GUINEA

Activity: Transportation planning for rural provinces

Dates: 1981

Organizations Involved: World Bank, PNG government, T.P. O'Sullivan & Partners, and Gitec Consult GMBH of Germany

Source of Funding: World Bank

Source of Information: "A Method for Multi-Modal Transport Planning Developed for Use in Rural Areas of Papua New Guinea," R.M. Weatherell, T.P. O'Sullivan & Partners, London, Transport Planning in Developing Countries, Proceedings of Seminar H, Planning and Transport Research and Computation (International) Co. Ltd., Volume P223, July 1982.

Description:

Papua New Guinea instituted a decentralized system of government, leaving transportation planning up to each province. This program sought to develop a rational method of transportation planning that could be applied in all provinces. The program produced a Rural Transport Planning Manual for use by provincial regional staff in planning activities and also for use in training future planners.

The study was designed to produce a transportation project ranking system, provide training, and prepare the first five provincial transportation plans.

COSTA RICA

Activity: Comprehensive urban transportation project including widened roads, traffic signals, traffic management measures, bus routes, and parking restrictions

Dates: 1977 to present

Organizations Involved: The World Bank

Source of Funding: The World Bank

Source of Information: The World Bank, Urban Transport: A World Bank Policy Study, Washington, D.C., 1986

Description:

Costa Rica has begun a comprehensive urban transportation project with the help of the World Bank. This project seeks to improve the flow of traffic in San Jose's central business district through the implementation of a number of measures. The project includes the construction and widening of a number of roads, road maintenance, the installation of an integrated traffic signal system, and the introduction of several traffic management measures including parking restrictions and priority bus routes. The parking changes include: parking limitations on crucial bus routes; the installation of parking meters and setting parking charges to encourage quick turnaround; formal designation of loading and unloading spaces; and a greatly strengthened enforcement program.

Results:

The effects of specific aspects of the program cannot be measured but the overall program has proven effective in improving traffic flow.

IVORY COAST

Activity: Comprehensive traffic management in Abidjan

Dates: Beginning in 1977

Organizations Involved: The World Bank, Government of Ivory Coast

Source of Funding: The World Bank

Source of Information: The World Bank, Urban Transport: A World Bank Policy Study, Washington, D.C., 1986; and Planning and Transport Research and Computation (International) Co. Ltd., Transport Planning in Developing Countries, Proceedings of Seminar G, Volume P207, July 1981

Description:

With World Bank assistance, the government of the Ivory Coast has been implementing a comprehensive traffic management program. According to the World Bank it consists of:

- Various traffic improvements, including the creation of one-way streets, the installation of integrated traffic signals, signs, and road markings in the central business district, and the extension of traffic management programs throughout the city
- Measures to improve the movements of pedestrians and buses in high-density, low-income communities
- The improvement of pedestrian facilities, including construction of footbridges
- The construction of a bus-way and reserved bus lanes in the central business district, including a counter-flow bus lane
- A high-speed express bus network, made possible by the construction of new road links
- The upgrading of bus terminals and bus stops and construction of a bus depot
- The construction of primary roads to improve public transportation access to low-income areas.

Results:

The project has had considerable success, halving cross-town bus trip times and relieving congestion. The project also enabled the government to postpone expensive infrastructure projects.

ADDITIONAL PROJECTS

The following is a short description of a few additional projects that have been undertaken in developing countries. These are presented to provide an indication of other activities and should not be interpreted as a comprehensive list of all such activities.

Venezuela

The government of Venezuela instituted a voluntary program whereby car owners were to abstain from driving one day a week based on the last digit of their license plate. This program apparently had very little effect, probably because the price of gasoline was so low.[1]

Brazil

The government of the state of Parana in Curitiba, Brazil instituted a training program for bus drivers and mechanics in order to improve operational efficiencies.[2]

A comprehensive bus improvement program has also been implemented with considerable success in Curitiba. The program included zoning changes, bus express lanes, the organization of feeder buses to express buses, easy transfers, and the restriction on passenger cars in the center of the city.[3]

Brazil also has an extensive fuel substitution program underway.[4]

South Korea

A diagnosis of energy use in six enterprises including container transport, a taxi fleet, and intercity buses was undertaken in 1985 by Beauvais Consultants, Paris.

Republic of Zaire

A study on fuel price determination and road user charges was undertaken in 1984 by Beauvais Consultants, Paris.

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[1]Source: Energy Demand in the Developing Countries: Towards A Better Understanding, Lee Schipper, Stephen Meyers, Jayant Sathaye, Lawrence Berkeley Laboratory, University of California at Berkeley, June 1983.

[2]Source: Scott A. Noll, Transportation Energy Conservation In Developing Countries, Resources for the Future for the U.S. Agency for International Development, August 1982, pp.81, referring to: Bussinger, Eng. Federico V.M. 1981. "Uma Proposta de Cooperacao Entre Poder Publico e Operado Privado no Transporte Colletivo," Semina TM Sobre Politica e Legislacao de Transporte, Sao Paulo, Nov. 17-19.

[3]Source: Joy Dunkerley, Irving Hoch, with Caroline Bouhdili, Transport Energy: Determinants and Policy, Resources for the Future, for USAID, September 1985, pp.10.18.

[4]See Fred Moavenzadeh and David Geltner, Transportation, Energy, and Economic Development: A Dilemma in the Developing World, Energy Research 5, Elsevier Science Publishers B.V., Amsterdam, 1984.

APPENDIX B: STATISTICS

The following statistics are presented in this appendix:

- GNP per capita
- Energy imports as a percentage of merchandise exports
- Transportation oil consumption as a percentage of total oil consumption
- Transportation oil consumption
- Transportation oil consumption per capita
- Energy petrol products consumption
- Total energy requirements
- Transportation oil consumption as a percentage of total energy requirements
- Population
- Urban population as a percentage of total population
- Urban population average growth rate
- Percent of urban population in largest city
- Number of cities with a population over 500,000
- Number enrolled in secondary school as a percentage of number in age group
- Debt service as a percentage of GNP
- Debt service as a percentage of exports of goods and services

TABLE B1: TRANSPORTATION STATISTICS (1983)

	GNP per Capita (1983 $)	Energy Imports as % of Merchandise Exports	Transport Consumpt. as % of Total Oil Consumpt.	Transport Oil Consumpt. (TOE 000)	Transport Oil Consumpt. Per Capita (TOEx10-3)	Energy Oil Products Consumpt. (TOE 000)	Total Energy Requirements (TOE 000)	Transport Consumpt. as of % Total Consumpt.
Afghanistan						313		
Albania						1,280		
Algeria	2,320	2	69	3,227	157	4,689	8,547	38
Angola						515		
Argentina	2,070	9	52	10,520	355	20,094	31,538	33
Australia	11,490	16				23,642		
Austria	9,250	17				8,708		
*Bangladesh	130	20	38	431	5	1,142	6,470	7
Belgium	9,150	18				14,495		
*Benin	290					115		
Bhutan						1		
*Bolivia	510		63	661	110	1,052	3,656	18
*Botswana	920			76	76		772	10
*Brazil	1,880	56	6	2,264	17	37,646	95,542	2
Bulgaria						13,310		
*Burkina	180	50				139		
*Burma	180		65	669	19	1,026	9,901	7
*Burundi	240					36	47	
*Cameroon	820	4				2,671		
Canada	12,310	6				67,313		
*Cape Verde	320		16	5	16	32	233	2
*Cent. African R	280					62		
*Chad						66		
Chile	1,870	24	53	2,490	213	4,670	7,735	32
China	300					60,601		
*Colombia	1,430	21	57	4,255	155	7,492	25,373	17
*Congo	1,230					95		
*Costa Rica	1,020	22	58	401	167	693	1,563	26
Cuba						9,419		
Czechoslovakia		30				13,083		
Denmark	11,570	20				9,052		
*Djibouti			38	59	148	154	649	9
*Dominican Rep.	1,370	71	26	534	89	2,055	3,767	14
*Ecuador	1,420		58	2,186	267	3,788	6,336	35
*Egypt, Arab Rep	700	12	23	3,375	75	14,650	23,539	14
*El Salvador	710	57	53	283	54	538	2,299	12
Ethiopia	120	53	66	349	9	526	8,016	4
Finland	10,740	28				8,186		
France	10,500	28				74,370		
*Gambia	290		49	25	36	51	180	14
Germany, East						13,728		
Germany, West	11,430	19				100,882		
*Ghana	310					641		
Greece	3,920	59				9,494		
*Guatemala	1,120	69	50	504	64	1,007	3,490	14

* AID-Assisted Countries

TABLE B1: TRANSPORTATION STATISTICS (1983) - (cont.)

	Population (Millions)	Urban Population as % of Total Pop.	Urban Population Average Growth (%) (1973-83)	% of Urban Population in Largest City (1980)	No. of Cities Over 500,000 (1980)	# Enrolled Secondary School as % of Age Group (1982)	Debt Service As % of GNP	Debt Service As % of Exports
Afghanistan	17.2	17	6.2	17	1	12		
Albania	2.8	38	3.2	25	0	66		
Algeria	20.6	46	5.4	12	1	36	9.8	33.1
Angola	8.2	23	6.0	64	1			
Argentina	29.6	84	2.1	45	5	59	3.1	24.0
Australia	15.4	86	1.5	24	5	90		
Austria	7.5	56	0.6	39	1	74		
*Bangladesh	95.5	17	7.6	30	3	15	1.3	14.7
Belgium	9.9	89	1.3	14	2	94		
*Benin	3.8	16	4.7	63	1	21	2.5	
Bhutan	1.2	4	4.6	0	0	3		
*Bolivia	6.0	43	3.3	44	1	34	7.0	30.5
*Botswana	1.0							
*Brazil	129.7	71	4.1	15	14	32	3.5	28.7
Bulgaria	8.9	67	2.1	18	1	82		
*Burkina	6.5	11	4.8	41	0	3	1.3	
*Burma	35.5	29	3.9	23	2	20	2.4	33.8
*Burundi	4.5	2	3.2		0	3	0.7	
*Cameroon	9.6	39	8.4	21	1	29	3.1	13.9
Canada	24 9	75	1.2	18	9	95		
*Cape Verde	0.3							
*Cent. African R	2.5	44	4.6	36	0	14	2.7	11.3
*Chad	4.8	20	6.6	39	0	3	0.1	0.6
Chile	11.7	82	2.4	44	1	59	5.1	18.3
China	1,019.1	21	..	6	78	35		
*Colombia	27.5	66	2.9	26	4	46	2.4	21.3
*Congo	1.8	55	5.5	56	0	69	12.2	20.5
*Costa Rica	2.4	45	3.2	64	1	48	22.7	50.6
Cuba	9.8	70	1.9	38	1	72		
Czechoslovakia	15.4	65	1.8	12	1	46		
Denmark	5.1	85	0.7	32	1	105		
*Djibouti	0.4							
*Dominican Rep.	6.0	54	4.7	54	1	41	2.8	22.7
*Ecuador	8.2	46	3.9	29	2	56	8.8	32.5
*Egypt, Arab Rep	45.2	45	2.9	39	2	54	6.5	27.5
*El Salvador	5.2	42	3.6	22	0	20	1.8	6.4
Ethiopia	40.9	15	6.0	37	1	12	1.4	11.5
Finland	4.9	60	1.9	27	1	98		
France	54.7	80	1.2	23	6	87		
*Gambia	0.7							
Germany, East	16.7	76	0.3	18	11	88		
Germany, West	61.4	86	0.2	9	3	50		
*Ghana	12.8	38	5.3	35	2	34	1.9	14.2
Greece	9.8	64	2.6	57	2	81	3.8	18.3
*Guatemala	7.9	40	4.1	36	1	16	1.6	11.7

* AID-Assisted Countries

TABLE B1: TRANSPORTATION STATISTICS (1983) - (cont.)

	GNP per Capita (1983 $)	Energy Imports as % of Merchandise Exports	Transport Consumpt. as % of Total Oil Consumpt.	Transport Oil Consumpt. (TOE 000)	Transport Oil Consumpt. Per Capita (TOEx10-3)	Energy Oil Products Consumpt. (TOE 000)	Total Energy Requirements (TOE 000)	Transport Consumpt. as of % Total Consumpt.
*Guinea	300		4	12	2	291	218	6
*Haiti	300	29	54	113	21	208	1,362	8
*Honduras	670	28	39	213	52	548	1,957	11
Hong Kong	6,000	7	39	1,884	355	4,864	4,380	43
Hungary	2,150	22				8,710		
*India	260		47	13,998	19	29,824	192,197	7
*Indonesia	560	20	32	7,192	46	22,506	72,050	10
Iran			30	7,569	178	25,445	25,427	30
Iraq			23	1,384	94	5,900	2,493	56
Ireland	5,000	14				3,799		
*Israel	5,370	29				5,841		
Italy	6,400	34				77,988		
Ivory Coast	710	16	53	581	61	1,089	3,119	19
*Jamaica	1,300		18	372	162	2,084	2,823	13
Japan	10,120	40				165,185		
*Jordan	1,640	101				2,078		
Kampuchea, Dem.						11		
*Kenya	340	36	91	937	50	1,027	11,430	8
Korea, Dem. Rep.						2,650		
Korea, Rep. of	2,010	28	24	5,678	142	23,222	56,359	10
Kuwait	17,880		93	3,410	2,006	3,678	5,117	67
Lao PDR						162		
*Lebanon						1,301		
*Lesotho	460	12		11	7		294	4
*Liberia	480					503		
Libya	8,480	1				5,527		
*Madagascar	310	32				341		
*Malawi	210		60	81	12	134	3,388	2
Malaysia	1,860	16	21	1,861	125	8,658	11,670	16
*Mali	160					137		
*Mauritius	1,160	16	55	102	103	185	563	18
*Mexico	2,240		40	24,267	324	60,187	65,883	37
Mongolia						692		
*Morocco	760	57	36	1,402	67	3,943	6,704	21
*Mozambique						495		
*Nepal	160		72	65	4	90	3,030	2
Netherlands	9,890	23				25,069		
New Zealand	7,730	18				3,023		
Nicaragua	880	46	38			550		19
*Niger	240	17	29	56	9	190	1,047	5
Nigeria	770		52	3,220	34	6,236	40,980	8
Norway	14,020	8				7,688		
*Oman	8,250	1				510		
*Pakistan	390	49	55	2,904	32	5,311	24,568	12
*Panama	2,120	82	53	502	251	946	2,573	20

* AID-Assisted Countries

TABLE B1: TRANSPORTATION STATISTICS (1983) - (cont.)

	Population (Millions)	Urban Population as % of Total Pop.	Urban Population Average Growth (%) (1973-83)	% of Urban Population in Largest City (1980)	No. of Cities Over 500,000 (1980)	# Enrolled Secondary School as % of Age Group (1982)	Debt Service As % of GNP	Debt Service As % of Exports
*Guinea	5.8	26	6.3	80	1	16	4.0	
*Haiti	5.3	27	4.2	56	1	13	0.9	5.0
*Honduras	4.1	38	5.8	33	0	32	4.3	14.9
Hong Kong	5.3	92	2.7	100	1	67	0.2	
Hungary	10.7	55	1.4	37	1	73	9.3	18.5
*India	733.2	24	4.2	6	36	30	0.7	10.3
*Indonesia	155.7	24	4.8	23	9	33	3.4	12.8
Iran	42.5	53	5.1	28	6	40		
Iraq	14.7	69	5.3	55	3	59		
Ireland	3.5	56	2.2	48	1	95		
*Israel	4.1	90	2.7	35	1	74	9.1	19.6
Italy	56.8	71	1.1	17	9	74		
Ivory Coast	9.5	44	8.5	34	1	17	12.9	31.0
*Jamaica	2.3	52	2.7	66	1	58	6.9	15.4
Japan	119.3	76	1.3	22	9	92		
*Jordan	3.2	72	4.8	37	1	77	5.2	11.3
Kampuchea, Dem.								
*Kenya	18.9	17	8.0	57	1	20	5.5	20.6
Korea, Dem. Rep	19.2	62	4.2	12	2			
Korea, Rep. of	40.0	62	4.8	41	7	89		12.3
Kuwait	1.7	92	7.8	30	0	77		
Lao PDR	3.7	15	5.7	48	0	18		
*Lebanon	2.6	78	1.6	79	1	58		
*Lesotho	1.5	12	21.4		0	20	1.9	2.5
*Liberia	2.1	38	6.1		0	20	3.2	6.6
Libya	3.4	61	8.1	64	1	67		
*Madagascar	9.5	20	5.5	36	1	14	4.9	
*Malawi	6.6	11	7.3	19	0	4	4.5	20.3
Malaysia	14.9	31	3.5	27	1	49	3.5	5.9
*Mali	7.2	19	4.4	24	0	9	1.3	6.1
*Mauritius	1.0		4.6	39	0			
*Mexico	75.0	69	4.1	32	7	54	7.3	35.9
Mongolia	1.8	54	4.2	52	0	89		
*Morocco	20.8	43	4.2	26	4	28	8.3	38.2
*Mozambique	13.1	17	10.2	83	1	6		
*Nepal	15.7	7	8.2	27	0	21	0.3	3.0
Netherlands	14.4	52	-1.1	9	3	98		
New Zealand	3.2	83	0.8	30	1	81		
Nicaragua	3.0	55	5.2	47	1	41	3.2	18.3
*Niger	6.1	14	7.0	31	0	5	5.6	
Nigeria	93.6	22	5.1	17	9	16	3.1	18.6
Norway	4.1	55	2.4	32	1	95		
*Oman	1.1	25	17.6			22	2.1	3.2
*Pakistan	89.7	29	4.3	21	7	14	3.4	28.1
*Panama	2.0	50	3.0	66	1	63	11.6	6.8

* AID-Assisted Countries

TABLE B1: TRANSPORTATION STATISTICS (1983) - (cont.)

	GNP per Capita (1983 $)	Energy Imports as % of Merchandise Exports	Transport Consumpt. as % of Total Oil Consumpt.	Transport Oil Consumpt. (TOE 000)	Transport Oil Consumpt. Per Capita (TOEx10-3)	Energy Oil Products Consumpt. (TOE 000)	Total Energy Requirements (TOE 000)	Transport Consumpt. as of % Total Consumpt.
*Papua New Guine	760	24	15	90	28	606	634	14
*Paraguay	1,410	1				403		
*Peru	1,040	2	35	2,246	125	6,432	11,644	19
*Philippines	760	44	24	2,321	45	9,689	25,634	9
*Poland		24				11,655		
*Portugal	2,230	48	26	2,064	204	7,993	12,180	17
Romania						13,378		
*Rwanda	270		27	15	3	56	1,007	1
Saudi Arabia	12,230		31	7,602	731	24,699	23,228	33
*Senegal	440	58	18	122	20	682	2,162	6
*Seychelles	2,400	42	30	12	185	40	31	39
*Sierra Leone	330					159		
Singapore	6,620	40	10	944	378	9,307	15,013	6
*Somalia	250					362		
*South Africa	2,490					10,753		
*Spain	4,780	59				34,672		
*Sri Lanka	330	40	42	559	36	1,335	4,561	12
*Sudan	400	57	63	674	32	1,065	9,687	7
Sweden	12,470	22				15,367		
Switzerland	16,290	13				10,971		
Syria	1,760					5,965		
*Tanzania	240					569		
*Thailand	820	39	46	4,400	89	9,645	27,284	16
*Togo	280	18	23	83	30	368	684	12
Trinidad & Toba	6,850	4	64	1,001	910	1,565	3,140	32
*Tunisia	1,290	31	50	1,242	180	2,489	4,124	30
*Turkey	1,240	66	34	5,200	110	15,150	33,500	16
USSR						368,484		
*Uganda	220		80	160	12	201	5,127	3
United Arab Emi	22,870		23	1,214	1,012	5,374	1,270	96
United Kingdom	9,200	12				61,771		
United States	14,110	30				639,714		
*Uruguay	2,490	28	59	667	222	1,123	2,123	31
Venezuela	3,840	1	54	9,448	546	17,479	25,769	37
Viet Nam						1,345		
*Yemen Arab Rep.	550					835		
Yemen, PDR	520					1,158		
Yugoslavia	2,570	33				12,906		
*Zaire	170		59	531	18	894	5,249	10
*Zambia	580	19	58	395	63	676	5,362	7
*Zimbabwe	740	22	75	403	51	538	6,304	6

* AID-Assisted Countries

TABLE B1: TRANSPORTATION STATISTICS (1983) - (cont.)

	Population (Millions)	Urban Population as % of Total Pop.	Urban Population Average Growth (%) (1973-83)	% of Urban Population in Largest City (1980)	No. of Cities Over 500,000 (1980)	# Enrolled Secondary School as % of Age Group (1982)	Debt Service As % of GNP	Debt Service As % of Exports
*Papua New Guine	3.2	14	5.1	25	0	13	4.7	11.2
*Paraguay	3.2	41	3.3	44	1	36	2.1	14.9
*Peru	17.9	67	3.6	39	2	59	4.6	19.6
*Philippines	52.1	39	3.8	30	2	64	3.7	15.4
*Poland	36.6	59	1.9	15	8	75		
*Portugal	10.1	30	2.5	44	1	50	9.5	26.7
Romania	22.6	51	3.1	17	1	71	9.0	
*Rwanda	5.7	5	6.6	0	0	2	0.3	2.6
Saudi Arabia	10.4	71	7.4	18	2	32		
*Senegal	6.2	34	3.8	65	1	12	1.9	
*Seychelles	0.1							
*Sierra Leone	3.6	23	3.3	47	0	12	0.9	7.2
Singapore	2.5	100	1.3	100	1	66	2.4	1.3
*Somalia	5.1	33	5.5	34	0	11	1.2	13.1
*South Africa	31.5	55	3.9	13	7			
*Spain	38.2	76	2.0	17	6	88		
*Sri Lanka	15.4	26	2.9	16	1	54	3.3	11.9
*Sudan	20.8	20	5.5	31	1	18	1.2	11.2
Sweden	8.3	85	0.7	15	3	85		
Switzerland	6.5	59	0.7	22	1			
Syria	9.6	48	4.2	33	2	51	1.8	11.2
*Tanzania	20.8	14	8.6	50	1	3	1.5	
*Thailand	49.2	18	3.6	69	1	29	2.4	11.3
*Togo	2.8	11	6.6	60	0	27	6.3	16.8
Trinidad & Toba	1.1	22	1.0		0	61	2.7	2.8
*Tunisia	6.9	54	3.7	30	1	32	7.4	22.3
*Turkey	47.3	45	3.7	24	4	39	4.6	28.9
USSR	272.5	65	-3.4	4	50	97		
*Uganda	13.9	7	0.3	52	1	8	1.9	
United Arab Emi	1.2	79	11.2			67		
United Kingdom	56.3	91	0.3	20	17	83		
United States	234.5	74	1.2	12	65	97		
*Uruguay	3.0	85	0.8	52	1	63	5.6	19.8
Venezuela	17.3	85	4.3	26	4	40	4.0	15.0
Viet Nam	58.5	20	2.4	21	4	48		
*Yemen Arab Rep.	7.6	18	8.8	25	0	7	1.0	13.9
Yemen, PDR	2.0	37	3.5	49	0	18	4.3	25.1
Yugoslavia	22.8	45	2.8	10	3	82	2.2	7.6
*Zaire	29.7	38	6.9	28	2	23	2.9	
*Zambia	6.3	47	6.5	35	1	16	4.0	12.6
*Zimbabwe	7.9	24	6.0	50	1	23	8.1	31.6

* AID-Assisted Countries

TABLE B2: SOURCES OF INFORMATION FOR TABLE B1

	GNP per Capita (1983 $)	Energy Imports as % of Merchandise Exports	Transport Consumpt. as % of Total Oil Consumpt.	Transport Oil Consumpt. (TOE 000)	Transport Oil Consumpt. Per Capita (TOEx10-3)	Energy Oil Products Consumpt. (TOE 000)	Total Energy Requirements (TOE 000)	Transport Consumpt. as % of Total Consumpt.
Afghanistan			Derived from Others		Derived from Others	I		Derived from Others
Albania						I		
Algeria	A	A		C		I	C	
Angola						I		
Argentina	A	A		C		I	C	
Australia	A	A				I		
Austria	A	A				I		
*Bangladesh	A	A		C		I	D	
Belgium	A	A				I		
*Benin	A					I		
Bhutan						I		
*Bolivia	A	A		C		I	D	B
*Botswana	A			C			B	
*Brazil	A	A		C		I	C	
Bulgaria						I		
*Burkina	A	A				I		
*Burma	A			C		I	D	
*Burundi	A					I	B	
*Cameroon	A	A				I		
Canada	A	A				I		
*Cape Verde	A			B		I	B	
*Cent. African R	A					I		
*Chad						I		
Chile	A	A		C		I	C	
China	A					I		
*Colombia	A	A		C		I	C	
*Congo	A					I		
*Costa Rica	A	A		B		I	B	
Cuba						I		
Czechoslovakia		A				I		
Denmark	A	A				I		
*Djibouti				H		I	H	
*Dominican Rep.	A	A		G		I	G	
*Ecuador	A			C		I	D	
*Egypt, Arab Rep.	A	A		C		I	D	
*El Salvador	A	A		F		I	F	
Ethiopia	A	B		B		I	B	
Finland	A	A				I		
France	A	A				I		
*Gambia	A			B		I	B	
Germany, East						I		
Germany, West	A	A				I		
*Ghana	A					I		
Greece	A	A				I		
*Guatemala	A	A		C		I	F	

* AID-Assisted Countries

TABLE B2: SOURCES OF INFORMATION FOR TABLE B1 (cont.)

	GNP per Capita (1983 $)	Energy Imports as % of Merchandise Exports	Transport Consumpt. as % of Total Oil Consumpt.	Transport Oil Consumpt. (TOE 000)	Transport Oil Consumpt. Per Capita (TOEx10-3)	Energy Oil Products Consumpt. (TOE 000)	Total Energy Requirements (TOE 000)	Transport Consumpt. as % of Total Consumpt.
*Guinea	A			B		I	B	
*Haiti	A	B		B		I	B	
*Honduras	A	A		F		I	F	
Hong Kong	A	A		C		I	C	
Hungary	A	A				I		
*India	A			C		I	D	
*Indonesia	A	A		C		I	D	
Iran				C		I	C	
Iraq				C		I	C	
Ireland	A	A				I		
*Israel	A	A				I		
Italy	A	A				I		
Ivory Coast	A	A		C		I	C	
*Jamaica	A			B		I	D	
Japan	A	A				I		
*Jordan	A	A				I		
Kampuchea, Dem.						I		
*Kenya	A	B		C		I	D	
Korea, Dem. Rep.						I		
Korea, Rep. of	A	A		C		I	C	
Kuwait	A			C		I	C	
Lao PDR						I		
*Lebanon						I		
*Lesotho	A	B		B			B	
*Liberia	A					I		
Libya	A	A				I		
*Madagascar	A	A				I		
*Malawi	A			C		I	B	
Malaysia	A	A		C		I	C	
*Mali	A	A				I		
*Mauritius	A	B		B		I	B	
*Mexico	A			C		I	C	
Mongolia						I		
*Morocco	A	A		C		I	D	
*Mozambique						I		
*Nepal	A			B		I	B	
Netherlands	A	A				I		
New Zealand	A	A				I		
Nicaragua	A	A				I		
*Niger	A	A		B		I	B	
Nigeria	A			C		I	C	
Norway	A	A				I		
*Oman	A	A				I		
*Pakistan	A	A		C		I	D	
*Panama	A	A		C		I	D	

* AID-Assisted Countries

TABLE B2: SOURCES OF INFORMATION FOR TABLE B1 (cont.)

	GNP per Capita (1983 $)	Energy Imports as % of Merchandise Exports	Transport Consumpt. as % of Total Oil Consumpt.	Transport Oil Consumpt. (TOE 000)	Transport Oil Consumpt. Per Capita (TOEx10-3)	Energy Oil Products Consumpt. (TOE 000)	Total Energy Requirements (TOE 000)	Transport Consumpt. as % of Total Consumpt.
*Papua New Guinea	A	B		B		I	B	
*Paraguay	A	A				I		
*Peru	A	A		C		I	D	
*Philippines	A	A		C		I	D	
*Poland		A				I		
*Portugal	A	A		B		I	B	
Romania						I		
*Rwanda	A			B		I	B	
Saudi Arabia	A			C		I	C	
*Senegal	A	A		B		I	B	
*Seychelles	A	B		B		I	B	
*Sierra Leone	A					I		
Singapore	A	A		C		I	C	
*Somalia	A					I		
*South Africa	A					I		
*Spain	A	A				I		
*Sri Lanka	A	A		B		I	B	
*Sudan	A	A		B		I	B	
Sweden	A	A				I		
Switzerland	A	A				I		
Syria	A					I		
*Tanzania	A					I		
*Thailand	A	A		C		I	D	
*Togo	A	A		E		I	E	
Trinidad & Tobag	A	A		C		I	C	
*Tunisia	A	A		C		I	D	
*Turkey	A	A		B		I	B	
USSR						I		
*Uganda	A			B		I	B	
United Arab Emir	A			C		I	C	
United Kingdom	A	A				I		
United States	A	A				I		
*Uruguay	A	A		C		I	C	
Venezuela	A	A		C		I	C	
Viet Nam						I		
*Yemen Arab Rep.	A					I		
Yemen, PDR	A					I		
Yugoslavia	A	A				I		
*Zaire	A			C		I	C	
*Zambia	A	B		C		I	C	
*Zimbabwe	A	B		C		I	C	

* AID-Assisted Countries

APPENDIX B

TABLE B2: SOURCES OF INFORMATION FOR TABLE B1 (cont.)

	Population (Millions)	Urban Population as % of Total Pop.	Urban Population Average Growth (%) 1973-83	% of Urban Population in Largest City (1980)	No. of Cities Over 500,000 (1980)	# Enrolled Secondary School as % of Age Group (1982)	Debt Service As % of GNP	Debt Service As % of Exports
ALL COUNTRIES				WORLD BANK WORLD DEVELOPMENT REPORT 1985				

Sources:
- A = World Bank, World Development Report 1985
- B = World Bank/UNDP, Issues and Options in the Energy Sector, Various issues
- C = International Energy Agency (IEA), Energy Balances of Developing Countries, 1971-1982
- D = IEA International Energy Annual 1983
- E = Overview of the Togo Energy Situation, Associates Rural Development, Inc. 1981
- F = Analysis del Sector Energetico en los Paises de Centroamerica y Panama, SIECA 1985
- G = USAID Mission in the Dominican Republic
- H = Djibouti energy initiatives, ISERST/VITA
- I = UN, Energy Statistics Yearbook, 1983
- J = Inter-American Development Bank, The Impact of Energy Costs on the Transportation Sector in Latin America, Bogota, Columbia, November 1982, p. 383

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APPENDIX C: TRANSPORTATION ENERGY CONSERVATION NEEDS INDICATOR STATISTICS

In order to rank AID-assisted countries according to their need and potential for transportation energy conservation projects, five sets of statistics were used to create a numerical ranking, or the "Transport Need & Potential Indicator" (see the following table). The Indicator is the sum of these five statistics after each has been adjusted according to its relative importance for transportation energy conservation.

To create the Indicator, each set of statistics was adjusted by a multiplier. The multiplier was created using the average value for each set (the average value for each set of statistics for all countries in the following table) and the conservation value assigned to that set (the "Relative Importance"), according to the following formula:

Relative Importance/Average Value = Multiplier

Each statistic in a set was adjusted by the multiplier to create an Adjusted Statistic. Adjusted Statistics for each country were added together to create the Indicator:

Sum of all Adjusted Statistics = Indicator

Statistic	Rank	Relative Importance	Average Value	Multiplier
A. Transport Consumption Percent of Total Petrol Consumption	1	35%	44%	0.80
B. Energy Imports as % of Merchandise Exports	2	35%	29%	1.21
C. Debt Service as a % of Exports	3	15%	17%	0.88
D. Urban Population as a % of Total Population	4	10%	47%	0.21
E. Number Enrolled in Secondary School as a % of Age Group	5	5%	46%	0.11
	Total	100%		

Example: Panama

	Statistic A • Multiplier #A	53	•	0.80	=	42.40
+	Statistic B • Multiplier #B	82	•	1.21	=	99.22
+	Statistic C • Multiplier #C	6.8	•	0.88	=	6.86
+	Statistic D • Multiplier #D	50	•	0.21	=	10.50
+	Statistic E • Multiplier #E	63	•	0.11	=	6.93
=	Indicator				=	165.91

Complete statistics are not available for all countries and thus some countries rank lower than they might otherwise. Several of the countries toward the bottom of the Indicator table are missing several statistics, altering their overall standing significantly. No country was assigned to the Low Need category in Chapter 4 if it was missing one or both of the first two sets of statistics, instead it was left out of the table until complete information can be obtained. Some countries, however, fell in the High or Medium Need category with only one of the first two statistics, these countries would be expected to rank even higher if complete information was available.

TRANSPORTATION NEED AND POTENTIAL INDICATOR (1983 Statistics)

	Transport Need & Potential Indicator	Transport Consumpt. As % of Total Oil Consumpt.	Energy Imports As % of Merchandise Exports	Debt Service As % of Exports	Urban Population As % of Total Pop.	# Enrolled Secondary School As % of Age Group
* Panama	165	53	82	6.8	50	63
* Jordan	156		101	11.3	72	77
* Turkey	146	34	66	28.9	45	39
* Guatemala	144	50	69	11.7	40	16
* Morocco	143	36	57	38.2	43	28
* Dominican Rep.	143	26	71	22.7	54	41
* Kenya	140	91	36	20.6	17	20
* Sudan	136	63	57	11.2	20	18
* Pakistan	135	55	49	28.1	29	14
* Costa Rica	132	58	22	50.6	45	48
Ethiopia	132	66	53	11.5	15	12
* El Salvador	128	53	57	6.4	42	20
* Uruguay	124	59	28	19.8	85	63
* Zimbabwe	122	75	22	31.6	24	23
Nicaragua	118	38	46	18.3	55	41
* Brazil	116	6	56	28.7	71	32
* Portugal	114	26	48	26.7	30	50
* Tunisia	112	50	31	22.3	54	32
Chile	112	53	24	18.3	82	59
Greece	110		59	18.3	64	81
* Colombia	109	57	21	21.3	66	46
* Sri Lanka	104	42	40	11.9	26	54
Kuwait	102	93			92	77
* Philippines	101	24	44	15.4	39	64
* Thailand	101	46	39	11.3	18	29
Ivory Coast	100	53	16	31.0	44	17
Algeria	100	69	2	33.1	46	36
Argentina	98	52	9	24.0	84	59
* Spain	97		59		76	88
* Senegal	93	18	58		34	12
* Zambia	92	58	19	12.6	47	16
* Ecuador	91	58		32.5	46	56
* Burma	90	65		33.8	29	20
* Haiti	90	54	29	5.0	27	13
* Bolivia	90	63		30.5	43	34
* Honduras	90	39	28	14.9	38	32
Korea, Rep. of	87	24	28	12.3	62	89
Singapore	86	10	40	1.3	100	66
* Mexico	84	40		35.9	69	54
Venezuela	80	54	1	15.0	85	40
* Israel	79		29	19.6	90	74
* Seychelles	75	30	42			
Japan	74		40		76	92
* Bangladesh	73	38	20	14.7	17	15
* Egypt, Arab Rep.	73	23	12	27.5	45	54

Source: Hagler, Bailly & Co. * AID-Assisted Countries

TRANSPORTATION NEED AND POTENTIAL INDICATOR (1983 Statistics) - (cont.)

	Transport Need & Potential Indicator	Transport Consumpt. As % of Total Oil Consumpt.	Energy Imports As % of Merchandise Exports	Debt Service As % of Exports	Urban Population As % of Total Pop.	# Enrolled Secondary School As % of Age Group
Trinidad & Tobago	70	64	4	2.8	22	61
* Indonesia	70	32	20	12.8	24	33
* Malawi	69	60		20.3	11	4
* Peru	68	35	2	19.6	67	59
Hong Kong	66	39	7		92	67
* Uganda	66	80			7	8
Yugoslavia	65		33	7.6	45	82
* Nepal	64	72		3.0	7	21
Italy	64		34		71	74
Nigeria	64	52		18.6	22	16
* Mauritius	63	55	16			
* Burkina	63		50		11	3
United States	63		30		74	97
Hungary	62		22	18.5	55	73
France	60		28		80	87
* Togo	60	23	18	16.8	11	27
* Zaire	58	59			38	23
Finland	57		28		60	98
* Papua New Guinea	55	15	24	11.2	14	13
Czechoslovakia	55		30		65	46
* India	55	47		10.3	24	30
Sweden	54		22		85	85
Malaysia	54	21	16	5.9	31	49
Denmark	54		20		85	105
Belgium	51		18		89	94
* Poland	50		24		59	75
Netherlands	50		23		52	98
New Zealand	48		18		83	81
* Niger	48	29	17		14	5
Australia	47		16		86	90
Germany, West	47		19		86	50
* Jamaica	45	18		15.4	52	58
* Madagascar	44		32		20	14
Saudi Arabia	43	31			71	32
United Kingdom	43		12		91	83
United Arab Emirat	42	23			79	67
Austria	40		17		56	74
Iraq	40	23			69	59
Iran	39	30			53	40
* Gambia	39	49				
Ireland	39		14		56	95
* Congo	37			20.5	55	69
Canada	33		6		75	95
Yemen, PDR	32			25.1	37	18
Norway	32		8		55	95

Source: Hagler, Bailly & Co. * AID-Assisted Countries

TRANSPORTATION NEED AND POTENTIAL INDICATOR (1983 Statistics) - (cont.)

	Transport Need & Potential Indicator	Transport Consumpt. As % of Total Oil Consumpt.	Energy Imports As % of Merchandise Exports	Debt Service As % of Exports	Urban Popula-tion As % of Total Pop.	# Enrolled Secondary School As % of Age Group
* Djibouti	31	38				
* Cameroon	28		4	13.9	39	29
Switzerland	28		13		59	
* Paraguay	27		1	14.9	41	36
Germany, East	26				76	88
Syria	26			11.2	48	51
* Rwanda	25	27		2.6	5	2
USSR	24				65	97
* Ghana	24			14.2	38	34
Bulgaria	23				67	82
* Lebanon	23				78	58
Cuba	23				70	72
* Lesotho	21		12	2.5	12	20
Libya	21		1		61	67
Mongolia	21				54	89
* Central African R	21			11.3	44	14
* Somalia	20			13.1	33	11
Romania	19				51	71
* Yemen Arab Rep.	17			13.9	18	7
* Liberia	16			6.6	38	20
Albania	15				38	66
Korea, Dem. Rep.	13				62	
* Cape Verde	13	16				
* Sierra Leone	12			7.2	23	12
* Oman	12		1	3.2	25	22
* South Africa	12				55	
* Guinea	11				26	16
* Mali	10			6.1	19	9
Viet Nam	9				20	48
China	8				21	35
* Benin	6				16	21
Lao PDR	5				15	18
* Chad	5			0.6	20	3
Afghanistan	5				17	12
Angola	5				23	
* Mozambique	4				17	6
* Tanzania	3				14	3
Bhutan	1				4	3
* Burundi	1				2	3
* Botswana	0					
Kampuchea, Dem.	0					

Source: Hagler, Bailly & Co. * AID-Assisted Countries

APPENDIX D: TRANSPORTATION ENERGY CONSERVATION MEASURES AND APPLICABILITY ANALYSIS

This appendix discusses all transportation energy conservation tools in order to evaluate their applicability to developing countries. This appendix consists of two parts. Part one presents a matrix of tools for promoting transportation energy conservation with ratings on 6 key variables. Part two evaluates each conservation tool, one by one, to describe key factors of relevance to developing countries.

TRANSPORTATION ENERGY CONSERVATION TOOLS MATRIX

The following pages present a detailed list of transportation energy conservation tools and techniques. Each is evaluated on 6 variables to provide a quick reference tool for discussing and evaluating potential transportation energy conservation projects in developing countries. The definitions of these variables are as follows:

Cost

The total cost to the government, business, or funding agency of implementing the tool

Foreign Exchange Cost

The foreign exchange cost to the government or business of implementing the tool (from importing vehicles, tools, equipment)

Technical Sophistication

A measure of the technical sophistication required of the developing country to be able to successfully implement the tool

Ease of Implementation

A measure of the complexity of the tool, the bureaucratic, institutional, and procedural barriers to implementing the tool, and the time and effort needed to implement the tool

Applicability to LDCs

A measure of the applicability of the tool to developing countries -- a function of the structure of developing country transport sectors, technical sophistication, economic needs, and a variety of other factors

Impact Potential

A relative measure of the potential for energy savings and efficiency improvement in developing countries. Measures only the technical and economic potential and does not take into account the likelihood that the tool could be successfully implemented (measured by the other five variables).

Each variable in the matrix is evaluated and ranked. The following scale indicates the importance or impact of each tool:

L = Low
M = Medium
H = High
V = Varies

[Note that a high ease of implementation indicates that the tool is easy to implement, not the reverse.]

	TRANSPORTATION ENERGY CONSERVATION TOOLS	Cost	Foreign Exchange Costs	Technical Sophis-tication	Ease of Implemen-tation	Applica-bility to LDCs	Impact Poten-tial
1	Vehicle Flow Improvements						
2	Manage Demand for Road Use						
3	Measures to spread out traffic demand						
4	Staggering office and school hours	L	L	L	H	H	M
5	Land use control/urban planning						
6	Zones to shift jobs from city center	L	L	L	M	M	H
7	Zones to limit land occupation density	L	L	L	M	M	H
8	Locating services/producers close to customers	L	L	L	M	M	H
9	Locating traffic generators in suburbs	L	L	L	M	M	H
10	Include traffic plans in urban planning	L	L	M	H	H	H
11	Measures to reduce road traffic demand						
12	Restrict road use to certain classes of vehicles						
13	Road use permits	L	L	L	M	H	M
14	Area Licensing	L	L	M	M	M	H
15	Temporary car bans	L	L	L	M	M	M
16	Fuel rationing	M	L	M	L	L	H
17	Mandatory car or vanpool programs	L	L	L	M	L	M
18	Improve telecommunications	H	H	H	L	H	M
19	Four day work week	L	L	L	M	L	M
20	Increase public transport capacity						
21	Switch from smaller buses to larger	M	H	L	M	V	M
22	Switch from buses to rail	H	H	M	L	V	M
23	Measures to increase freight transport load factor						
24	Larger vehicles	M	H	L	M	M	M
25	Increase backhaul loads (also as #119)	L	L	M	M	H	M
26	Route planning	L	L	M	H	H	H
27	Parking Restrictions						
28	High fees in high traffic areas	L	L	L	H	H	H
29	Graduated fees to encourage short-term parking	L	L	L	H	H	H
30	Incentives for car & van pools						
31	Eliminate employee parking subsidies	L	L	L	H	H	L
32	Reduced parking fees for pools	L	L	L	H	H	L
33	Provide preferential parking spots	L	L	L	H	H	M

Source: Hagler, Bailly & Co.

	TRANSPORTATION ENERGY CONSERVATION TOOLS	Cost	Foreign Exchange Costs	Technical Sophis-tication	Ease of Implemen-tation	Applica-bility to LDCs	Impact Poten-tial
34	Reduce parking supply in high-traffic areas	L	L	L	H	H	H
35	Restrictions on parking during rush hour	L	L	L	H	H	H
36	Fiscal regulation of private parking areas	L	L	L	H	H	M
37	Parking areas near train and bus terminals	M	L	L	H	H	M
38	Parking areas outside high-traffic areas	M	L	L	H	H	M
39	Organization to improve traffic flow						
40	Traffic signals						
41	Replace four-way stop with two-way stop	L	L	L	H	H	M
42	Replace signal with two way stop	L	L	L	H	H	M
43	Replace four-way stop with a signal	L	L	L	H	H	M
44	Right turn on red	L	L	L	H	H	M
45	Operate off-peak flash	L	L	L	H	H	M
46	Provide demand-responsive timing	L	L	L	H	H	M
47	Improve signal timings	L	L	M	H	H	H
48	Upgrade signal coordination/synchronize	M	M	M	H	H	H
49	Speed limits						
50	Match limits with vehicle efficiencies	L	L	L	H	H	M
51	Raise or lower speed limits to manage traffic	L	L	L	H	H	L
52	Regulate turning movements						
53	Ban conflicting turning movements	L	L	L	H	H	M
54	Add exclusive left-turn lane	M	L	L	M	H	H
55	Allow permissive left-turns	L	L	L	H	H	M
56	One-way streets	L	L	L	H	H	H
57	Reversible lanes	L	L	M	H	H	H
58	Re-routing traffic	M	L	L	M	H	H
59	High-occupancy vehicle lanes	M	L	L	M	H	H
60	Trading restrictions - congested areas	L	L	L	M	H	M
61	Infrastructure improvements for traffic control						
62	Road improvements						
63	Providing turning lanes	M	L	L	M	H	M
64	Extra lanes for through traffic	H	L	L	M	H	H
65	Express lanes with limited access and few lights	H	L	L	M	H	H
66	Improve road conditions	H	L	L	M	H	H
67	Installing traffic islands	H	L	L	H	H	M

Source: Hagler, Bailly & Co.

	TRANSPORTATION ENERGY CONSERVATION TOOLS	Cost	Foreign Exchange Costs	Technical Sophis-tication	Ease of Implemen-tation	Applica-bility to LDCs	Impact Poten-tial
68	Separate pedestrians and vehicles						
69	Footbridges	H	L	L	L	M	M
70	Flyovers	H	L	L	L	M	M
71	Pedestrian tunnels	H	L	L	L	M	M
72	Bicycle facilities	M	L	L	M	M	M
73	Modification of Travel Behavior						
74	Improve Driver Behavior						
75	Driver education						
76	Bus, taxi, & truck driver education	L	L	L	H	H	H
77	Public information campaign	L	L	L	H	H	H
78	Licensing requirements						
79	Require driver training/certification	L	L	L	H	H	H
80	Require testing to get license	L	L	L	H	H	H
81	Efficiency monitoring (mpg)	M	M	M	M	H	M
82	Price Incentives						
83	Road Pricing						
84	Toll booths	M	L	L	L	H	H
85	Area licensing	M	M	M	L	M	H
86	Electronic road pricing	H	M	H	L	L	H
87	User Taxes						
88	Limit purchase of cars						
89	Licensing & Registration fee	L	L	L	H	H	H
90	Import fees/excise taxes	L	L	L	H	H	H
91	Sales tax	L	L	L	H	H	H
92	Insurance premiums	L	L	L	H	H	M
93	Limit driving of cars						
94	Fuel pricing/tax	L	L	L	H	H	H
95	Tolls	M	L	L	M	H	M
96	Allow taxi ride-sharing	I	L	L	H	H	L
97	Fees for street parking-See Parking Restrictions						
98	Improve Fleet Efficiency						
99	Improve fleet management						
100	Set standards	L	L	L	H	H	M
101	Implement training programs	L	L	L	H	H	H
102	Convert state-run firms to private ownership	V	L	L	V	H	H

Source: Hagler, Bailly & Co.

	TRANSPORTATION ENERGY CONSERVATION TOOLS	Cost	Foreign Exchange Costs	Technical Sophis-tication	Ease of Implemen-tation	Applica-bility to LDCs	Impact Poten-tial
103	Improve fleet operations						
104	Upgrade standards of driver training tests	L	L	L	H	H	M
105	Institute periodic driver testing	L	L	L	H	H	M
106	Improve fleet utilization						
107	Establish clearing houses	H	L	L	M	H	H
108	Build freight terminals	H	L	L	M	H	H
109	Relocate terminal facilities	H	L	L	M	H	H
110	Reduce trip length and circuity						
111	Direct routing	L	L	L	H	H	M
112	Infrastructure improvements (shortcuts)	H	L	L	L	H	M
113	Increase backhaul load factors (also as #29)	L	L	M	M	H	M
114	Institute radio dispatching	M	M	M	M	H	M
115	Improve fleet maintenance						
116	Institute training programs	L	L	L	H	H	H
117	Increase inspection frequency	L	L	L	H	H	M
118	Preferential Treatment of High-Occupancy Vehicles						
119	Road Structure Improvements						
120	Streets/lanes devoted to high-occupancy vehicles						
121	Streets devoted to high-occupancy vehicles	M	L	L	H	H	H
122	With-flow bus lanes	L	L	L	H	H	H
123	Contra-flow bus lanes on one way streets	L	L	L	H	H	H
124	Road structure improvements for public transit						
125	Bus stops	M	L	L	H	H	H
126	Bus terminals	M	L	L	H	H	H
127	Parking restrictions on private vehicles	L	L	L	H	H	H
128	Traffic management measures for public transit						
129	Special phases at traffic lights	L	L	M	H	H	M
130	Exclusive turning movements at intersections	L	L	L	H	H	M
131	Bus convoys	L	L	L	H	H	H
132	Financial support for public transit						
133	Subsidize fares	L	L	L	L	H	M
134	Subsidize companies	L	L	L	H	H	M

Source: Hagler, Bailly & Co.

	TRANSPORTATION ENERGY CONSERVATION TOOLS	Cost	Foreign Exchange Costs	Technical Sophis-tication	Ease of Implemen-tation	Applica-bility to LDCs	Impact Poten-tial
135	Tax breaks						
136	On imported hardware	V	L	L	H	H	M
137	On income	V	L	L	H	H	M
138	On fuel	V	L	L	H	H	M
139	On maintenance costs	V	L	L	H	H	M
140	On investments in public transit	V	L	L	H	H	M
141	Pricing policy for park-and-ride systems	L	L	L	H	H	M
142	Financial support for car & vanpools						
143	Carpool cost subsidies	L	L	L	M	H	L
144	Carpool tax incentives	L	L	L	M	H	L
145	Gasoline rationing preferences	M	L	M	L	H	L
146	Parking subsidies for pools	L	L	L	M	H	L
147	Elimination of employee parking subsidies	L	L	L	H	H	L
148	Improve Public Transport Operations						
149	Technical improvements						
150	Modal allocation						
151	Switch from smaller buses to larger	M	M	L	M	M	L
152	Encourage switching to rail	H	H	M	L	V	L
153	Maintenance programs	L	L	M	H	H	H
154	Improve quality of equipment						
155	Import standards	L	L	L	H	H	H
156	Domestic production standards	L	L	H	M	V	H
157	Organization management						
158	Improve routing	L	L	L	H	H	M
159	Improve scheduling	L	L	L	H	H	M
160	Improve company management						
161	Organize and restructure management	L	L	L	M	H	M
162	Privatize public transit companies	L	L	L	V	V	H
163	Training programs						
164	Driver training	L	L	L	H	H	H
165	Mechanic training	L	L	L	H	H	H
166	Planner/scheduler training	L	L	L	H	H	H
167	Management training	L	L	L	H	H	H

Source: Hagler, Bailly & Co.

	TRANSPORTATION ENERGY CONSERVATION TOOLS	Cost	Foreign Exchange Costs	Technical Sophis-tication	Ease of Implemen-tation	Applica-bility to LDCs	Impact Poten-tial
168	Improve Vehicle Maintenance and Efficiency						
169	Driver Education						
170	Low wear-and-tear driving	L	L	L	H	H	H
171	Maintenance schedule	L	L	L	H	H	H
172	Maintenance needs	L	L	L	H	H	H
173	Mechanic Education	L	L	L	H	H	H
174	Improve infrastructure						
175	Preferential laws for equipment						
176	Import laws						
177	Tax preferences	L	L	L	H	H	M
178	Tariff exemptions	L	L	L	H	H	M
179	Fast-track red-tape	L	L	L	M	H	M
180	Investment laws						
181	Encourage investment in maintenance equipment	L	M	L	H	H	M
182	Tax deductions for maintenance work	L	L	L	H	H	M
183	Require emissions tests	L	L	M	H	H	H
184	Obligatory energy audits of transport companies	L	L	M	H	H	H
185	Improve Vehicle Stock						
186	Import/purchase restrictions						
187	Engine size limitations	L	L	L	H	H	H
188	Fuel consumption standards	L	L	L	H	H	H
189	Gasoline vs diesel limitations	L	L	L	H	H	M
190	Lower import duties on fuel efficient vehicles	L	M	L	H	H	H
191	Modify tax rates on diesel and gasoline vehicles	L	L	L	H	H	M
192	Fuel-saving equipment						
193	Radial tires	L	M	L	H	H	M
194	Electronic efficiency monitors	M	M	H	H	M	L
195	Aerodynamic add-ons	L	L	L	H	H	M
196	Aerodynamic designs	H	L	H	L	V	M
197	Optimize vehicle specifications to speed limits & roads	M	L	M	M	H	M
198	Adjust fuel prices						
199	Optimize gasoline and diesel differential	L	L	L	H	H	M
200	Raise price to change purchase preferences	L	L	L	H	H	M
201	Fuel Substitution						
202	Substitute indigenous energy resources	H	V	H	L	H	H
203	Regional cooperation to develop markets	L	L	L	H	H	M

Source: Hagler, Bailly & Co.

	TRANSPORTATION ENERGY CONSERVATION TOOLS	Cost	Foreign Exchange Costs	Technical Sophis-tication	Ease of Implemen-tation	Applica-bility to LDCs	Impact Poten-tial
204	Modal Allocation						
205	Encourage use of more energy efficient modes						
206	Improve rail and boat technology						
207	Substitute diesel trains for steam	H	H	M	L	H	M
208	Substitute electric trains for steam	H	H	M	L	H	M
209	Substitute electric trains for diesel	H	H	M	L	H	M
210	Substitute light rail or trolley buses for diesel buses	H	H	M	L	H	M
211	Improve tracks	H	M	M	L	H	M
212	Improve boats	H	M	M	L	H	M
213	Improve rail and boat operations						
214	Improve scheduling	L	L	M	H	H	M
215	More frequent service	L	L	L	H	H	M
216	Improve loading facilities	H	M	L	M	H	M
217	Encourage Non-Motorized Transport						
218	Improve animal-drawn carts	L	L	L	M	H	L
219	Improve rickshaws	L	L	L	M	H	L
220	Improve country boats	L	L	L	M	H	L
221	Improve bicycle facilities	L	L	L	M	H	L

Source: Hagler, Bailly & Co.

APPLICABILITY ANALYSIS

This section will evaluate the tools presented in the preceeding matrix to indicate their advantages, disadvantages, and relevance to developing countries. Where applicable, examples from developing countries will be presented. Each paragraph is referenced by a number corresponding to the number of a tool listed in the matrix table on pages D.3 to D.9. In the following paragraphs, the numbers listed under "Source" reference the numbered entries in the bibliography, Appendix E. Where applicable, page numbers are given following a colon.

1 VEHICLE FLOW IMPROVEMENTS -- #2-72
These measures improve the flow of traffic and thus reduce the energy consumed for a given amount of driving.

2 MANAGE DEMAND FOR ROAD USE -- #3-26

3 MEASURES TO SPREAD OUT TRAFFIC DEMAND -- #4-10

4 STAGGERING OFFICE AND SCHOOL HOURS
Notes: This can also can include flexible work hours and compressing the work week (see also #19).
Advantages: Decreases peak congestion period by spreading out traffic. Generally inexpensive and simple to implement.
Disadvantages: Compressed work weeks may not lead to decreased fuel consumption due to additional nonwork travel on additional days off. Resistance may be encountered from businesses that depend on interaction with clients and other businesses. The opportunity to travel during non-rush periods may lead some to abandon car/van-pools or public transit for personal driving.
Examples: Savings from staggered or flexible work hours in Ottawa, Canada, involving nearly 1/2 the downtown employees, were approximately 0.11 percent of the regional auto fuel consumption (66:43).
Source: 20; 56:14; 66:43

5 LAND USE CONTROL/URBAN PLANNING -- #6-10
Notes: See source 66:56-60 for a discussion of the various options.
Advantages: Careful urban planning can significantly reduce fuel consumption and ensure that future development is not accompanied by traffic congestion. It can reduce the demand for travel by bringing jobs closer to workers, spread out traffic, reduce traffic pressure on innercity roads, and reduce the trend toward increased

urbanization.
Disadvantages: Land use control is difficult to implement and enforce and is often ineffective in developing countries. It faces several difficulties including lack of proper enforcement, disregard for regulations, and public opposition. It can require extensive management expertise, planning, and coordination on the part of the government. It is expensive to establish new commercial and industrial zones.
Source: 39:479; 64:12; 66:56-60

6 ZONES TO SHIFT JOBS FROM CITY CENTER -- see #5, Land use control/urban planning

7 ZONES TO LIMIT LAND OCCUPATION DENSITY -- see #5, Land use control/urban planning
Examples: In certain areas of Curitiba, Brazil, the density of land occupation has been limited to the capacity of the public transport system.
Source: 64:12

8 LOCATING SERVICES AND PRODUCERS CLOSE TO CUSTOMERS -- see #5, Land use control/urban planning
Examples: Brazil has forbidden cement companies to locate new plants in states where cement production already exceeds consumption by 30 percent to reduce the amount of cement transportation.
Source: 39:479

9 LOCATING TRAFFIC GENERATORS IN SUBURBS -- see #5, Land use control/urban planning

10 INCLUDE TRAFFIC PLANS IN URBAN PLANNING -- see #5, Land use control/urban planning

11 MEASURES TO REDUCE ROAD TRAFFIC DEMAND -- #12-22

12 RESTRICT ROAD USE TO CERTAIN CLASSES OF VEHICLES #13-14

13 ROAD USE PERMITS
Advantages: Can produce substantial savings quickly. Relatively simple to implement. Low cost.
Disadvantages: Requires obedience to traffic signals and an effective traffic police force, factors often lacking in developing countries. Particularly susceptible to political and public resistance. Geographic, political, and institutional characteristics greatly restrict the applicability to developing countries.

14 AREA LICENSING

Notes: Restrictions to limit access to central business district.

Advantages: Can produce substantial savings quickly. Time savings of approximately 25 percent have been reported in Bangkok with an estimated 100 percent per annum rate of return.

Disadvantages: Requires obedience to traffic signals and an effective traffic police force, factors often lacking in developing countries. May require concurrent programs in driver education, police training and/or traffic management. Particularly susceptible to political and public resistance. Geographic, political, and institutional characteristics greatly restrict the applicability to developing countries. Requires relatively high technology, often imported and much of the system design, specification, and training may have to be carried out by foreign engineers. Surveying traffic to properly design the system may require more man-days than are available from planning staff. Road quality, maintenance capabilities, and electricity reliability problems may require the use of simpler systems.

Examples: Singapore, see Case Studies in Appendix A; An area licensing scheme was planned for Bangkok, Thailand, however it was not implemented due to public and political difficulties. It would have had to be much more complicated and expensive than the Singapore system and would have affected more people. Systems are being slowly installed in Kuala Lumpur, Malaysia, and Cairo, Egypt.

Source: 46; 47

15 TEMPORARY CAR BANS

Advantages: Can be very effective in reducing transport energy consumption. Relatively easy to implement (although enforcement may be difficult).

Disadvantages: Sometimes leads to widespread violations, which will decrease effectiveness and may erode respect for traffic laws.

Examples: Caracas prohibits vehicles from driving on city streets one day a week according the the last digit of their license plate. This program has been reported to reduce automotive fuel consumption by 1000 cu. meters per day.

Source: 23; 31:40; 39:460

16 FUEL RATIONING

Advantages: Time of day or day of week rationing may not prove especially effective in and of itself, if it is not severe, but it may serve as an important psychological tool in providing a frequent reminder to the public of the need to conserve fuel. Rationing schemes using coupons or stamps that can be freely

traded can be generally effective with relatively low administrative costs since trading coupons can serve to iron out some of the equity and distribution problems of more traditional schemes.
Disadvantages: May not be very effective. Some rationing schemes involve substantial administrative costs.
Examples: The Dominican Republic has limited the hours that gas stations can remain open (6 am to 6 pm) in an effort to reduce fuel consumption. They also rationed fuel to public institutions and controled the use of official vehicles. In Brazil, gas stations must remain closed from Friday evening to Monday morning, with the exception of alcohol pumps.
Source: 31:393, 460; 39:460-65

17 MANDATORY CAR OR VANPOOL PROGRAMS
Notes: See #142 for additional discussion
Advantages: May be very effective in reducing congestion.
Disadvantages: May be difficult to implement and enforce. Public opposition may prove critical.

18 IMPROVE TELECOMMUNICATIONS
Advantages: Reduces the need for travel and thus traffic congestion. Improves work efficiency.
Disadvantages: Can be expensive to implement, requires imported equipment, and technical expertise required may not be available. May be slow to show results in reduced congestion and fuel use.
Examples: NASA achieved a 10 percent savings in travel costs for one year using an audio-facsimile teleconferencing network, using 34 terminals throughout the U.S. (see 56:20).
Source: 10; 56:20

19 FOUR DAY WORK WEEK
Notes: This can also can include staggering office and school hours (see also #4).
Advantages: Decreases congestion by reducing the amount of commuting. Generally inexpensive and simple to implement.
Disadvantages: May not lead to decreased fuel consumption due to additional nonwork travel on additional days off. Resistance may be encountered from businesses.
Source: 56:14; 66:43

20 INCREASE PUBLIC TRANSPORT CAPACITY -- #21-22
Advantages: Can improve fuel efficiency.
Disadvantages: There are significant tradeoffs involved in most efforts to increase load factors, tradeoffs in convenience, trip time, and organizing effort being the most significant. Some of these tradeoffs can be mitigated or eliminated with appropriate

policies, such as HOV lanes and carpool organizing institutions. In many, if not most, developing countries load factors in public transit are already very high which reduces the potential for improvement. For example, in Central America, regular and microbuses have an average load factor (persons per seat) of 0.57, varying from 0.40 for a microbus in Guatemala to 0.80 for an autobus in El Salvador.
Source: 31:218; 39:276

21 SWITCH FROM SMALLER BUSES TO LARGER
Advantages: More fuel efficient, if buses are routinely filled close to capacity. Reduces the number of vehicles on the road. Can also decrease operating costs and possibly capital equipment costs.
Disadvantages: Economies of scale often do not exist in the size of bus companies, it can be more efficient for a number of small firms operating small vehicles than for a large firm operating large buses. Small buses, often cost less per seat since they can be mass-manufactured. Maintenance costs tend to be lower for small vehicles. Smaller vehicles can operate at higher speeds, increasing turnaround. A mixed fleet is generally to be recommended.
Examples: See source 64:26. As an example, the average private minibus operator in Istanbul makes a profit of about $1,100 per year whereas the average public bus loses $64,000.
Source: 18:10.19; 39:274; 59; 64:20, 25-26

22 SWITCH FROM BUSES TO RAIL:
Advantages: Low pollution; higher capacity; can be more fuel efficient.
Disadvantages: Higher cost (see 64:36), more restricted, limited operations, lower flexibility; Require passenger transfers; Require increases in shipment size and travel time and reductions in shipment frequency and reliability yielding extra costs for inventories. Energy used in construction of rail systems may exceed energy saved in operation, by a large margin. A 1978 study indicated that the Bay Area Rapid Transit system will not reach the energy payback point for 535 years under then current operating levels. Even at a more optimistic operating level, payback would still take 168 years. In addition, population density and expected passenger load has to be quite high to justify the costs. A minimum of 20,000 passengers per hour at peak would be needed to justify the costs, and perhaps as much as 40,000 if underground construction is required. Tramways are less expensive and thus require less volume to be economical, perhaps 10,000 passengers per peak hour and 5,000 the remainder of the day.

Examples: Sao Paulo, Rio de Janero, Caracas, Recife, Manila, Singapore, Baghdad, Cairo, Pernambaco, Lagos, and Abidjan have built subways and light rail systems.
Source: 17:200-1; 31:91; 39:299; 64:34

23 MEASURES TO INCREASE FREIGHT TRANSPORT LOAD FACTOR -- #24-26
Advantages: Considerable potential for energy savings exists.
Disadvantages: There are significant tradeoffs involved in most efforts to increase load factors, tradeoffs in convenience, trip time, and organizing effort being the most significant.
Source: 31:218; 39:276

24 LARGER VEHICLES
Notes: Relaxing truck size and weight limits and permitting truck tractors to haul two or more trailers at once may be required.
Advantages: Large potential energy savings possible. With low-density comodities, 20 to 30 percent fuel savings per payload ton can be achieved by extra large tractor-trailer combinations over single tractor-trailers. Higher density comodities reach axle weight limits before filling up large trailers. Requires fewer skilled drivers. Can also lower fuel, labor, maintenance and capital costs without necessarily increasing shipment transit times or decreasing reliability.
Disadvantages: Requires suitable road quality -- including surface quality, road width, and curve diameter. Increases wear and tear on roads. Might lead to modal transfers from rail to truck (which may or may not decrease efficiency). Can contribute to traffic congestion and safety problems might be serious due to the predominance of two-lane highways.
Source: 39:295

25 INCREASE BACKHAUL LOADS
Advantages: Improves fuel efficiency by reducing the number of trips needed to transport a given volume of goods. Improves business efficiency. Has relatively large potential for fuel savings. Some measures can be implemented at low cost.
Disadvantages: Requires additional management expertise and may require additional communciations equipment.
Examples: In some countries, lacking facilities or procedures to consolidate loads and organize trips trucks must travel throughout the city looking for return freight. A study in Brazil incidated that, on average, each truck traveled between 250 and 350 km in cities in search of return freight.
Source: 31:153

26 ROUTE PLANNING

Advantages: Reduces circuity of travel and thus reduces fuel use. Can be implemented at relatively low cost.

Disadvantages: Requires additional managerial expertise. Poorly developed infrastructure may limit potential for choosing routes.

27 PARKING RESTRICTIONS -- #28-38

Note: Some parking and stopping restrictions are designed to reduce the obstructions to traffic. Other parking restrictions are designed to reduce the flow of traffic into congested areas. Parked and waiting cars obstruct the flow of traffic, street trading increases the number of parked and waiting cars, and street trading increases the flow of pedestrians that may interfere with the flow of traffic. Restrictions can be effective but require strict enforcement.

Advantages: Improve congestion and traffic flow by: reducing obstructions; discouraging commuting by car (due to high cost and limited availability of long-term parking spots); limiting travel into congested areas during peak hours; improving business, especially if parking rates start out low and gradually increase, by encouraging short-term parking and increasing turnover;

Disadvantages: Enforcement may be difficult due to several factors, including: inadequate traffic police department and training; difficulty in identifying owners of vehicles; backlog in courts hampering collection of fines. Measures may cause increases in illegal parking; can cause additional trips during peak hours (if commuters are delivered and picked up by family members, producing two round-trips rather than one); can cause increased fuel consumption as drivers circulate in traffic waiting for passengers or looking for parking spaces;

Source: 42; 64; 67

28 HIGH FEES IN HIGH TRAFFIC AREAS

Advantages: May be particularly effective in reducing driving since out-of-pocket expenses usually exercise a strong influence on decisions to use a car. This may be one of the most effective ways of reducing urban travel by car.

Disadvantages: May be difficult to implement. Public opposition may be critical. See #27.

Source: 18:10.17; 22; 39:280; 42

29 GRADUATED FEES TO ENCOURAGE SHORT-TERM PARKING

Notes: Includes reducing long-term parking spots in favor of short term parking spots.

Advantages: Discourages long-term parking and thus discourages commuters, reducing congestion. At the same time it does not

discourage trips for business appointments and shopping. May receive significant support from businesses.
Disadvantages: More difficult to implement. May require new parking meters. Enforcement may be difficult.
Examples: Graduated fees have been implemented in Recife, Brazil (47:81), and in Singapore
Source: 22; 42; 47:81; 67

30 INCENTIVES FOR CAR & VAN POOLS -- #31-33

31 ELIMINATE EMPLOYEE PARKING SUBSIDIES
Advantages: Simple to implement and relatively effective in reducing driving.
Disadvantages: Depends on the existence of alternative modes of travel for success. May face significant public opposition.

32 REDUCED PARKING FEES FOR POOLS
Advantages: Simple to implement. Effective in encouraging car or van pooling.
Disadvantages: Depends on the existence of high parking fees for normal parking for effectiveness. Requires additional management attention.

33 PROVIDE PREFERENTIAL PARKING SPOTS
Advantages: Simple to implement. Effective in encouraging car or van pooling.
Disadvantages: Depends on the shortage of parking spaces for effectiveness.

34 REDUCE PARKING SUPPLY IN HIGH-TRAFFIC AREAS
Advantages: Provides road space for additional traffic, turning lanes, bus stops, and/or bicycles and other slow forms of traffic.
Disadvantages: May reduce flow of customers and adversely affect businesses in high-traffic areas. May face significant public opposition.
Examples: Long-term parking meters (more than 4 hours) have been reduced from the central business district of Salvador, Brazil to reduce traffic demand.
Source: 42; 47:79; 66:14;

35 RESTRICTIONS ON PARKING DURING RUSH HOUR
Advantages: Parking restrictions are easily implemented using only signs and enforcement staff, and perhaps tow trucks. Provides road space for additional traffic, turning lanes, bus stops, and/or bicycles and other slow forms of traffic.
Disadvantages: Alternative parking may have to be provided. Public objections may be crucial. Enforcement may be a problem

in many countries that lack strong traffic police departments.
Examples: San Jose, Costa Rica, see Case Studies in Appendix A.
Source: 42; 64:14, 15; 66:14

36 FISCAL REGULATION OF PRIVATE PARKING AREAS
Notes: Includes measures to encourage owners of private, off-street parking to conform to area parking goals. Such measures range from exhortations to parking permits to a parking area tax.
Advantages: Measures can be flexible and relatively easily and quickly implemented. They can be very effective in altering the parking situation.
Disadvantages: Requires an effective tax collection system and may encourage violations.
Source: 20; 22

37 PARKING AREAS NEAR TRAIN AND BUS TERMINALS
Advantages: Can be relatively inexpensive to implement and cost effective. Reduces vehicle miles and traffic congestion and thus fuel consumption. Encourages ride-sharing and use of public transit.
Disadvantages: Increased travel time may result. Requires marketing and education. Neghborhood and political opposition may be encountered. Negotiating right of way and obtaining land may be difficult.
Examples: In 1976, Salvador, Brazil opened three parking lots on the periphery of the central business district and provided minibus transport to the central area. The service is not extremely popular.
Source: 47:79; 66:40-41

38 PARKING AREAS OUTSIDE HIGH-TRAFFIC AREAS -- see #37

39 ORGANIZATION TO IMPROVE TRAFFIC FLOW -- #40-60
Advantages: A 5 percent increase in overall speeds due to reductions of stop and go traffic could bring an increase in fuel economy of 2.8 percent in urban truck movements.
Disadvantages: Can be expensive and hard to implement.
Examples: Example of successful comprehensive traffic management plan: Abidjan, Ivory Coast, see Case Studies in Appendix A, and 64:17.
Source: 4; 39:284; 64:17; 53

40 TRAFFIC SIGNALS -- #41-48
Advantages: A comprehensive signal improvement effort can reduce the number of involuntary stops by an average of 40 percent and save as much as 3.5 percent of all fuel consumed (in an urban

area in the U.S.). These measures are often particularly cost-effective, saving approximately 25 gallons of fuel for every project dollar spent in the U.S. They are also relatively easy to implement.
Disadvantages: Can be expensive to implement. Requires traffic management expertise. Jurisdictional problems may be encountered for extensive systems.
Source: 42; 53; 56:13-4; 66:11+

41 REPLACE FOUR-WAY STOP WITH TWO-WAY STOP
Advantages: Unwarranted signals may needlessly slow traffic, removing them or altering them can achieve significant savings. Removing unneeded signals may reduce accidents, especially rear-end accidents.
Disadvantages: Local resistence may be encountered to removing signals, as safety may be jeopardized.
Source: 5; 66:24-26;

42 REPLACE SIGNAL WITH TWO WAY STOP -- Discussion for #41, Replace four-way stop with two-way stop, is also applicable for this measure.

43 REPLACE FOUR-WAY STOP WITH A SIGNAL -- Discussion for #41, Replace four-way stop with two-way stop, is also applicable for this measure.

44 RIGHT TURN ON RED
Notes: Defined as allowing right turns after vehicle has come to a stop at a steady red light, after yielding to pedestrians and oncoming traffic. Similar policy allows left turns from a one-way street onto another.
Advantages: Reduces delays for all vehicles, reduces fuel consumption, and increases intersection capacity. Cost for conversion is relatively small.
Disadvantages: Poses a potential hazard to pedestrians (although opinion is divided on the significance of the hazard, see 66:21).
Source: 66:19-22; 5

45 OPERATE OFF-PEAK FLASH
Notes: Defined as flashing traffic signals during off-peak hours: the light for the main street will flash yellow allowing traffic to flow relatively unhindered; the light for the side street will flash red, allowing vehicles to enter or cross the main street after stopping, if traffic permits.
Advantages: Reduces needless stops during low-traffic periods on main streets. Reduces waiting time at lights on side streets. Can

be a very cost-efficient measure. Easily and quickly implemented.
Disadvantages: Some increase in accidents may occur.
Source: 66:27-29; 5

46 PROVIDE DEMAND-RESPONSIVE TIMING
Advantages: Reduces fuel consumption by reducing needless stops by traffic on the main street. Simple to implement. Well-established technology.
Disadvantages: The technology requires stable road surfaces, not often found in many developing countries.
Source: 5

47 IMPROVE SIGNAL TIMINGS -- comments for #48, Upgrade signal coordination/synchronize, apply here as well.

48 UPGRADE SIGNAL COORDINATION/SYNCHRONIZE
Notes: Computerized traffic control systems are appropriate for cities in developed countries with populations in excess of 80,000 (see 66:10), appropriate developing country cities may need to be larger, due to low vehicle ownership rates.
Advantages: Interconnecting and synchronizing previously uncoordinated signals can reduce travel time by approximately 25 percent by improving traffic flow. Can be a relatively low cost measure. Can reduce accidents and emissions.
Disadvantages: Requires hardware (likely expensive and imported) and engineering expertise, which may be scarce. Coordinating an area-wide effort may be difficult. Use of highly sophisticated computer-based traffic control systems may not be cost effective when compared to efficiently operated systems controlled by conventional equipment.
Examples: Signals have been synchronized in Bogota, Colombia (31:39), and Curitiba, Brazil (47:80).
Source: 5; 31:39; 66:10-11; 47:80

49 SPEED LIMITS -- #50-51

50 MATCH LIMITS WITH VEHICLE EFFICIENCIES
Advantages: Improved fuel efficiency; improved safety; Trucks can, on average, obtain 2.2 percent better fuel economy for each mile per hour slowed towards 55 mph (39). Automobiles get from 17 to 40 percent better fuel economy at 55 than at 70 mph (66:48).
Disadvantages: It is difficult to enforce maximum speed limits. There is limited potential in many countries since speeds are already slow due to the poor quality of the roads. Revenue gains from faster speeds may be greater than fuel losses.
Examples: Brazil and the Dominican Republic have reduced their

maximum speeds to reduce fuel consumption.
Source: 39:292, 288; 42; 43

51 RAISE OR LOWER SPEED LIMITS TO MANAGE TRAFFIC
Advantages: Relatively simple and inexpensive measure to implement.
Disadvantages: May be difficult to enforce.
Source: 42; 43

52 REGULATE TURNING MOVEMENTS -- #53-55
Advantages: Improves traffic flow by taking turning vehicles out of the general flow of traffic. Can be simple and inexpensive to implement and does not require significant management expertise.
Disadvantages: May require widening roads. May be difficult to enforce.
Source: 5; 42; 43

53 BAN CONFLICTING TURNING MOVEMENTS -- see #52

54 ADD EXCLUSIVE LEFT-TURN LANE -- see #52

55 ALLOW PERMISSIVE LEFT-TURNS -- see #52
Notes: Allowing left turns from an exclusive lane on a green arrow only.

56 ONE-WAY STREETS
Advantages: Fuel savings can be as high as 12-17 percent (66:15). Reduce travel time 20-40 percent. Increased street capacity of 20 to 50 percent. May facilitate the use of public transit, bicycles, and other fuel-efficient modes of transportation. Increased vehicle speed, improved traffic flow, and improved intersection capacity. Reduce accidents by as much as 60 percent.
Disadvantages: Some increase in distance traveled for some vehicles. Confusing to newcomers. May decrease traffic toward businesses catering to traffic from a particular direction. Pedestrian safety may decrease if traffic islands are eliminated from wide streets. Additional traffic control devices may be needed.
Source: 42; 53; 66:15-17

57 REVERSIBLE LANES
Advantages: Smoother traffic flow and fewer delays, especially if traffic flow is heavier in one direction than another at particular times of day. 30 percent average reduction in travel time with a range of 20-50 percent, 45 percent reduction in stopped time with a range of 30-70 percent, and 30 percent reduction in accidents. Added capacity without constructing new lanes.

Disadvantages: Cost for control devices may be high. Confusion may be common, especially with newcomers, producing numerous violations.
Source: 42; 53; 66:17-18

58 RE-ROUTING TRAFFIC
Advantages: Improves flow of traffic
Disadvantages: Public opposition may be encountered.

59 HIGH-OCCUPANCY VEHICLE (HOV) LANES
Advantages: Provides incentives to car-pool and use public transit. Improves the efficiency and reliability of public transit. Can improve traffic flow.
Disadvantages: May be expensive to implement. Public opposition may be critical. If HOV lanes are taken from existing lanes, instead of added, may serve to increase congestion on average and thus reduce fuel efficiency.

60 TRADING RESTRICTIONS IN CONGESTED AREAS
Advantages: Reduces conflicts between pedestrians and vehicles and thus improves traffic flow
Disadvantages: Public and political opposition may be encountered. May be difficult to enforce.
Examples: In Lima, Peru street trading seriously impeded traffic flow. Improved enforcement of trading regulations and diverting trading to more suitable locations, including the creation of pedestrian streets, improved traffic flow substantially.
Source: 42; 64

61 INFRASTRUCTURE IMPROVEMENTS FOR TRAFFIC CONTROL #62-72

62 ROAD IMPROVEMENTS -- #64-67
Advantages: Improve transportation energy per trip-mile rate. Total traffic may increase which can facilitate increases in economic activity.
Disadvantages: While expanding the network of roads and widening and improving existing roads may increase transportation energy efficiency it may also increase total transportation energy consumption at the same time. It is often true that "more roads breed more travel" and congestion may not diminish as much as hoped after road-building projects since the total volume of traffic may increase comensurately.
Source: 39:270; 53

63 PROVIDING TURNING LANES -- see #52

64 EXTRA LANES FOR THROUGH TRAFFIC
Advantages: Improves vehicle flow and reduces congestion.
Disadvantages: Expensive to build. May require acquiring additional land and rights of way.

65 EXPRESS LANES WITH LIMITED ACCESS AND FEW LIGHTS
Advantages: Improves vehicle flow and reduces congestion.
Disadvantages: Expensive to build. May require acquiring additional land and rights of way.

66 IMPROVE ROAD CONDITIONS
Advantages: Road construction can be very expensive, but road maintenance can be a relatively inexpensive means to improve traffic by allowing vehicles to move smoothly and at an appropriate speed. According to the World Bank, "routine and periodic maintenance of paved roads costs about $2,000 to $4,000 per kilometer per year." Road maintenance also reduces vehicle operating costs from between 15 percent and 40 percent.
Disadvantages: Manpower and resources may be inadequate to properly maintain roads. Many roads are unpaved and adverse weather conditions frequently create hazzards to vehicles, thus maintenance may be expensive, time-consuming, and repairs may not last long.
Examples: Paving and draining bus routes has brought a high rate of return in Brazil and keeping roads in good condition has produced good benefits in Kingston. Example: Kingston, Jamaica, see 64:31.
Source: 5; 64:27, 29, x

67 INSTALLING TRAFFIC ISLANDS
Advantages: Improves traffic flow with physical barriers and thus requires no enforcement.
Disadvantages: Fuel-efficiency benefits may be relatively minor.

68 SEPARATE PEDESTRIANS AND VEHICLES -- #69-71
Advantages: Improves the flow of traffic by reducing interaction between pedestrians and vehicles. Improves safety for pedestrians.
Disadvantages: Can be expensive relative to the fuel savings, depending on the situation.

69 FOOTBRIDGES -- see #68

70 FLYOVERS -- see #68

71 PEDESTRIAN TUNNELS -- see #68

72 BICYCLE FACILITIES
Advantages: Provides incentives for drivers to switch to bicycles. Reduces the interaction between bicycles and vehicles thus improving safety and traffic flow.
Disadvantages: May be expensive relative to fuel savings.

73 MODIFICATION OF TRAVEL BEHAVIOR -- #74-117

74 IMPROVE DRIVER BEHAVIOR -- #75-81

75 DRIVER EDUCATION -- #76-80

76 BUS, TAXI, & TRUCK DRIVER EDUCATION
Advantages: Reduces fuel consumption, improves vehicle maintenance, improves driving behavior and thus safety, increases vehicle life. Can be a very low-cost, high-payback means to improve energy efficiency.
Disadvantages: Must entail an extensive program to produce results felt on a national level. Results may not last without continuing efforts. Requires significant management expertise.
Examples: Costa Rica, see Case Studies in Appendix A.
Source: 27

77 PUBLIC INFORMATION CAMPAIGN
Advantages: Can be effective in improving driving habits and improving energy efficiency. Can be a relatively low-cost measure.
Disadvantages: May not produce results in the short run, and only produce results in the long run if effort is continual.
Examples: Costa Rica, see Case Studies in Appendix A.
Source: 27; 56:10

78 LICENSING REQUIREMENTS -- #79-80

79 REQUIRE DRIVER TRAINING/CERTIFICATION
Notes: Fuel-efficient driving training as a requirement/pre-requisite for obtaining license.
Advantages: Over the long-run can have a large impact on energy efficiency of transportation.
Disadvantages: Requires extensive changes in procedures and laws. Requires the development of a training/certification system with a high capacity. May exceed the managerial and institutional capabilities of the region. Public opposition may prove to be a significant barrier.

80 REQUIRE TESTING TO GET LICENSE
Notes: Require testing for knowledge of fuel-efficient driving

techniques as a requirement/pre-requisite for obtaining license.
Advantages: Over the long-run can have a large impact on energy efficiency of transportation.
Disadvantages: Requires changes in procedures and laws. May require the development of a training/education system. Public opposition may prove to be a significant barrier.

81 EFFICIENCY MONITORING (MPG)
Notes: Requiring vehicles to be tested or monitored for fuel efficiency.
Advantages: Will improve the state of maintenance of vehicles on the streets. Will remove excessively polluting vehicles from circulation.
Disadvantages: Public opposition may prevent implementation. Enforcement may be difficult. Requires changes in laws.
Source: 71

82 PRICE INCENTIVES -- #83-97
Advantages: Often one of the most economically efficient means to reduce traffic demand. 3:270
Disadvantages: May be hard to implement in some countries due to public protest. For example, in Peru, "gasoline prices have little direct effect on the costs of each family's basic consumption market basket but that strong public reactions are nevertheless encountered whenever fuel prices rise."
Source: 3:270; 19; 21; 22; 31:37; 41; 60;

83 ROAD PRICING -- #84-86
Source: 13; 41; 60; 67

84 TOLL BOOTHS
Notes: Prepayment may be preferred, as in area licensing, since it will not contribute to congestion around toll booths.
Advantages: Distributes costs to those using the roads, thus fairer and more attractive than taxes and licensing fees. Directly affects the cause of congestion. More effective than parking charges since it affects vehicles moving through the area as well. Encourages use of high-occupancy vehicles.
Disadvantages: They can actually increase congestion, if not properly placed.
Source: 13; 22; 47:88; 64:8; 66:45-47; 67; 68

85 AREA LICENSING
Notes: Prepayment is desirable to avoid congestion at entry/collection points. Some method of quickly identifying pre-paid vehicles is important and enforcement must be strict.

Alternate routes have to be provided. The layout of the roads has to allow restricting entry into the designated area. A substantial public information campaign is necessary to achieve public support.
Advantages: Distributes costs to those using the roads, thus fairer and more attractive than taxes and licensing fees. Directly affects the cause of congestion. More effective than parking charges since it affects vehicles moving through the area as well. Encourages use of high-occupancy vehicles.
Disadvantages: Particularly susceptible to political and public opposition. Requires careful monitoring and an effective traffic police force.
Examples: Singapore, see Case Studies in Appendix A; Kuala Lumpur, Malaysia, and Bangkok, Thailand undertook lengthy studies to implement area licensing schemes but neither has put the system into operation (47:88; 67:125)
Source: 46; 47:88; 64:8; 66:45-47; 67; 68

86 ELECTRONIC ROAD PRICING
Notes: Consists of electronic number plates on vehicles and sensors in roadways to monitor use of roads and charge users according to time of day, location, and vehicle type.
Advantages: Very efficient and accurate in charging users, thus very fair.
Disadvantages: Technically complex and costly. System is applicable only to urban areas with particular geographic characteristics. Requires significant management and engineering expertise. Political and public opposition may prevent implementation.
Examples: The Hong Kong road pricing scheme suffers from strong opposition from influential groups. Various technical, institutional, political, and administrative barriers stand in the way of successfully implementing this option.
Source: 64:2; 67; 68

87 USER TAXES -- 88-97
Advantages: Reduces fuel consumption by limiting the purchase of cars, limiting driving cars, and encouraging the use of public transportation.
Disadvantages: They can be inequitable by affecting the poor more than the rich. They do not affect when or where cars are driven.
Examples: Singapore and Hong Kong, see Case Studies in Appendix A, and sources 67 and 68
Source: 19; 21; 22; 60; 67; 68; 71

88 LIMIT PURCHASE OF CARS -- 89-92

Advantages: Primarily serves to slow down the growth in vehicle ownership.

Disadvantages: These measures do not influence the location and time of vehicle use. They can lead to the prolonged use of old, fuel inefficient, unsafe cars.

Source: 64:11; 18:5.5; 67; 19; 13; 22; 71

89 LICENSING AND REGISTRATION FEE

Advantages: Taxes on automobile ownership are the most effective way to keep ownership from rising as income rises, primarily because the charges cannot be recovered when the vehicle is sold. They tend to be more effective than restrictions on imports or increases in the retail price of cars, at least over the short to medium term.

Disadvantages: Political and public opposition may hamper implementation.

Examples: High taxes in Brazil have not prevented rapid growth in auto ownership.

Source: 13; 19; 22; 39:278; 64:11; 67; 71

90 IMPORT FEES/EXCISE TAXES

Advantages: Simple to implement and effective in reducing demand for vehicles.

Disadvantages: Taxes on tires or spare parts can encourage the prolonged use of old and unsafe vehicles leading to to greater breakdowns and accidents. Not effective in limiting driving of cars already purchased. Public opposition may be encountered.

Source: 13; 19; 22; 64:11-12; 67

91 SALES TAX

Advantages: Can be applied quickly within existing legislation. Taxes on automobile ownership are the most effective way to keep ownership from rising as income rises, primarily because the charges cannot be recovered when the vehicle is sold. They tend to be more effective than restrictions on imports or increases in the retail price of cars, at least over the short to medium term.

Disadvantages: Reduces vehicle turnover which increases average vehicle age to the detriment of efficiency, safety, and air quality. Can encourage the prolonged use of old, unsafe, and fuel inefficient vehicles, breakdowns can increase congestion (special incentives to replace older cars can be implemented). Sales tax costs can be offset by increasing the resale price. Not effective in limiting driving of cars already purchased.

Examples: Korea (62; 67)

Source: 13; 19; 22; 64:11-12; 67;

92 INSURANCE PREMIUMS

Advantages: Increases the cost of owning a vehicle and thus decreases the demand for vehicles. Can be applied quickly within existing legislation. Taxes on automobile ownership are the most effective way to keep ownership from rising as income rises, primarily because the charges cannot be recovered when the vehicle is sold. They tend to be more effective than restrictions on imports or increases in the retail price of cars, at least over the short to medium term.

Disadvantages: Not effective in limiting driving of cars already purchased.

Source: 64; 22

93 LIMIT DRIVING OF CARS -- #94-96

94 FUEL PRICING/TAX

Advantages: Easy to administer, flexible, and effective in the long run in reducing demand. Directly effective for reducing fuel consumption, however, per capita consumption of fuels falls less than proportionately as price increases. Several studies indicate that directly taxing the use of vehicles is the most effective way to reduce total urban travel by private vehicle. Decontrolling prices may actually decrease the administrative burden.

Disadvantages: Price elasticity of transport fuel is low in the short run so effectiveness is limited. (A ten percent increase in price might produce an immediate 1-2 percent decrease in demand.) Over the long run, however, elasticity may approach one. Differential taxes or subsidies for buses and trucks may be necessary to avoid constraining public transport and commercial activity. May be difficult to implement politically. May cause undesireable redistribution of wealth in society. Also may have adverse impacts on certain segments of the population, e.g. the poor. May contribute to inflation, temporarily. Also, it is argued that in developing countries "price increases are less able to reduce energy demand because of poor information, institutional rigidity, or lack of profit-maximizing (or net cost-minimizing) incentives in many firms." However this may not have much of an adverse impact.

Examples: Only a few developing countries use taxes to manage demand, most keep the cost of fuel below world prices; but the effects of raising fuel costs can be seen in the case of Ecuador (see 18:9.8+). Brazil has kept the prices of its transport fuels at or above world prices, gasoline has been above world prices.

Source: 13; 15; 18:ii, 5.4, 9.8; 19; 39:280, 478, 453-6; 22; 31; 41; 64:11; 67; 71; 73;

95 TOLLS -- see #84

96 ALLOW TAXI RIDE-SHARING
Advantages: Increases vehicle load factor and thus reduces congestion. Easy to implement at low cost.

97 FEES FOR STREET PARKING -- See Parking Restrictions, #27-38.

98 IMPROVE FLEET EFFICIENCY -- #99-117

99 IMPROVE FLEET MANAGEMENT -- #100-102

100 SET STANDARDS
Notes: Standards for vehicle type, options, and efficiency, and for driver training requirements.
Advantages: Improves efficiency of fleet management. Can have a significant impact on fleet energy efficiency. Can be relatively simple to implement.
Disadvantages: Requires management knowledge and dedication to energy efficiency improvements. Requires management willingness to dedicate time, energy, and resources to the effort. Resources may not be available.

101 IMPLEMENT TRAINING PROGRAMS -- see #169-172

102 CONVERT STATE-RUN FIRMS TO PRIVATE OWNERSHIP
Advantages: Publicly owned companies often are inefficient because they suffer from bureaucratic inertia, restrictions on competitors, and political interference. Economies of scale often do not exist for bus fleets, eliminating the primary rationalle for creating many public bus companies. Monopolies do not encourage efficiency and quality service which creates disincentives to use public transit. See 64:21+ for a fuller discussion.
Disadvantages: May be politically difficult to implement. Private sector may not have resources or interest in owning firm.
Examples: The average private minibus operator in Istanbul makes a profit of about $1,100 per year whereas the average public bus loses $64,000.
Source: 18:10.19; 21; 24; 64:2

103 IMPROVE FLEET OPERATIONS -- #104-105

104 UPGRADE STANDARDS OF DRIVER TRAINING TESTS -- see #168-172

105 INSTITUTE PERIODIC DRIVER TESTING -- see #168-172

126

106 IMPROVE FLEET UTILIZATION -- #107-114
Source: 72

107 ESTABLISH CLEARING HOUSES
Advantages: Two primary advantages: increase load factor by consolidating small shipments; and decrease circuity by organizing trips to minimize driving. Also could expect more efficient and coordinated use of equipment. A hypothetical study found fuel savings potential of between 12 and 47 percent for Calgary.
Disadvantages: Probably will offer a lower level of service since frequent, small trips will be curtailed for the sake of consolidation. Increases storage and capital carrying costs of goods waiting to be shipped. High cost for the fuel efficiency gains.
Examples: Brazil has been creating a National Freight Network to reduce low backhaul load factors by building shipment consolidation terminals near major cities, among other things.
Source: 31:39; 39:285-6

108 BUILD FREIGHT TERMINALS -- same advantages and disadvantages as #107

109 RELOCATE TERMINAL FACILITIES
Advantages: Can conserve energy by locating terminals nearer to supplies and customers, or nearer better quality roads or less-traveled roads.
Disadvantages: see #107-108

110 REDUCE TRIP LENGTH AND CIRCUITY -- #111-112

111 DIRECT ROUTING
Advantages: Reduces fuel consumption by reducing distances driven for a given volume of goods delivered. Relatively easy to implement. Requires no significant changes in technology.
Disadvantages: Rudamentary road development may limit the options available. Management infrastructure may be insufficient to implement.
Source: 72

112 INFRASTRUCTURE IMPROVEMENTS (SHORTCUTS)
Notes: Essentially road-building with the aim of facilitating the transfer of goods and services.
Advantages: Improves the functioning of the economy while improving transportation energy efficiency.
Disadvantages: Can be expensive to implement. Fuel savings unlikely to justify the high cost.
Source: 72

113 INCREASE BACKHAUL LOAD FACTORS -- See #25

114 INSTITUTE RADIO DISPATCHING
Advantages: Improves the efficiency of operations as well as energy efficiency.
Disadvantages: May require importing expensive technology.

115 IMPROVE FLEET MAINTENANCE -- #116-117
See #175-191 for advantages and disadvantages.

116 INSTITUTE TRAINING PROGRAMS -- see #115

117 INCREASE INSPECTION FREQUENCY -- see #115

118 PREFERENTIAL TREATMENT OF HIGH-OCCUPANCY VEHICLES -- #119-167

119 ROAD STRUCTURE IMPROVEMENTS -- #120-131

120 STREETS/LANES DEVOTED TO HIGH-OCCUPANCY VEHICLES
Advantages: Saves time for commuters and encourages car- and van-pooling and public transit use, which reduces congestion and improves average vehicle occupancy. Publ. transit reliability can be improved. If a lane is added for the use of buses and car/van-pools, fuel consumption per mile could improve by an estimated 2.4 percent (66:34) and measure can be implemented at low cost.
Disadvantages: If an existing lane is converted to a dedicated lane for buses and car/van-pools, overall energy efficiency may decline due to increased congestion on the non-reserved lanes. Fuel consumption could increase by an estimated 4.8 percent (66:34). Requires strict enforcement.
Examples: See Case Studies in Appendix A, and 64:16
Source: 54; 55; 66:33-36, 83;

121 STREETS DEVOTED TO HIGH-OCCUPANCY VEHICLES -- see #120

122 WITH-FLOW BUS LANES
Advantages: High capacity, peak-hour capacity in reserved lanes has reached 23,000 passengers an hour. In express busways with graded intersections and off-line stations capacities of greater than 30,000 passengers an hour can be reached. Costs are minimal for the simplest systems. "Exclusive busways with graded intersections cost from $2 million to $7 million per kilometer."
Disadvantages: -- see #120
Examples: see Sri Lanka, Brazil and Thailand in Case Studies in Appendix A, and 64:16
Source: 54; 55; 64:16, 33

123 CONTRA-FLOW BUS LANES ON ONE WAY STREETS
Advantages: -- see #122
Disadvantages: -- see #120
Examples: Contra-flow trolley bus lanes have been tried in Mexico City.
Source: 31:39

124 ROAD STRUCTURE IMPROVEMENTS FOR PUBLIC TRANSIT -- #125-127

125 BUS STOPS
Advantages: Eliminates restrictions to traffic movement from buses stopping to take on passengers.
Disadvantages: Requires possibly expensive changes to the roads, including adding lanes. May require obtaining land and rights of way to widen roads at bus stops.

Examples: See Ivory Coast in Case Studies in Appendix A
Source: 54

126 BUS TERMINALS
Advantages: Facilitates transfers between buses to improve public transit services and improve routing efficiency.
Disadvantages: Requires expensive investments in infrastructure. May require changing the nature of the bus system if several different companies and types of services are offered.
Examples: See Brazil and Ivory Coast in Case Studies in Appendix A.
Source: 54

127 PARKING RESTRICTIONS ON PRIVATE VEHICLES -- see #27-38

128 TRAFFIC MANAGEMENT MEASURES FOR PUBLIC TRANSIT -- #129-131

129 SPECIAL PHASES AT TRAFFIC LIGHTS
Notes: Special systems exist that can preempt normal traffic lights to allow public transit vehicles to proceed unhindered.
Advantages: Reduces waiting at signals and increases fuel efficiency. Improves performance of public transit and thus attracts more passengers. Travel time can be reduced by 9-26 percent. A significant increase in congestion at intersections has not been found (66:38).
Disadvantages: Generally only applicable to demand-actuated signals. Delays may occur for non-bus traffic, causing increased fuel consumption. The system does not function on heavily congested streets characterized by stop-and-go traffic.
Source: 66:38-40

130 EXCLUSIVE TURNING MOVEMENTS AT INTERSECTIONS
Notes: Permitting public transit vehicles to turn at intersections where normal vehicles are prohibited from turning.
Advantages: Speeds movement of public transit, which improves services and should attract more riders.
Disadvantages: Can cause extra congestion and delays for other traffic, perhaps leading to an increase in fuel consumption.

131 BUS CONVOYS
Advantages: Bus convoys improve loading and unloading operations and can increase speed and efficiency.
Disadvantages: Require smoothly operating traffic system and probably exclusive bus lanes. Require management expertise and extra training efforts.
Examples: Sao Paulo and Porto Alegre, Brazil, see 32:39 and

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Case Studies in Appendix A.
Source: 32:39

132 FINANCIAL SUPPORT FOR PUBLIC TRANSIT -- #133-141

133 SUBSIDIZE FARES
Advantages: Subsidizing fares, by providing transit stamps or coupons to low-income passengers, can eliminate the need to keep diesel prices artificially low to subsidize public transit. This helps to ensure that transit fees reflect the true cost of fuel and preserves incentives to conserve energy.
Disadvantages: Can be expensive and hard to implement.
Source: 22; 24; 41

134 SUBSIDIZE COMPANIES
Advantages: Opposition to such moves is usually weak, and support is easy to find. Costs are spread broadly and taxpayers may not notice the tax effects. Subsidies of public transit have to be approached very carefully for they often lead to inefficient operations and a growing burdensome cost to the government. Two options for subsidies that may not lead to inefficiency: 1) Subsidies tied to indicators of transportation performance; 2) User-side subsidies where the potential users are provided with vouchers. However, both methods are administratively complex. See source 64:22 for a fuller discussion.
Disadvantages: Subsidies tend not to be very effective at inducing large-scale reductions in petroleum demand within a transport sector for several reasons: Cross-elasticities between transport modes are small; competing, less efficient modes may not diminish in the face of subsidies but may operate at a lower load factor; reductions in competing modes must exceed increases in subsidized mode for savings to occur. Thus subsidies may be quite expensive for the fuel saved, representing a large cost to the government. It is difficult to calculate the effective level of subsidy. It is difficult to implement without leading, eventually, to inefficient operations and poor quality service.
Examples: In the Dominican Republic, tax exemptions have been granted for imports of buses for public transit.
Source: 22; 24; 31:35; 39:447-9; 41; 64:22

135 TAX BREAKS -- #136-140
Advantages: Supports public transit and helps keep fares at a low level to encourage use.
Disadvantages: Tax breaks tend not to be very effective at inducing large-scale reductions in petroleum demand within a transport sector for several reasons: Cross-elasticities between

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transport modes are small; competing, less efficient modes may not diminish in the face of subsidies but may operate at a lower load factor; reductions in competing modes must exceed increases in subsidized mode for savings to occur. Thus tax breaks may be quite expensive for the fuel saved, representing a large cost to the government. It is difficult to calculate the effective level of tax break. It is difficult to implement without leading, eventually, to inefficient operations and poor quality service.

136 ON IMPORTED PARTS AND SUPPLIES -- see #135
Advantages: Encourages fleets to keep vehicles well maintained, which will improve their fuel efficiency.
Disadvantages: May create problems for domestic vehicle manufacturers.

137 ON INCOME -- see #135

138 ON FUEL -- see #135
Disadvantages: Creates an artificially low price for fuel which diminishes the need for fuel conservation efforts.

139 ON MAINTENANCE COSTS -- see #135

140 ON INVESTMENTS IN PUBLIC TRANSIT -- see #135

141 PRICING POLICY FOR PARK-AND-RIDE SYSTEMS -- see #27-38

142 FINANCIAL SUPPORT FOR CAR & VANPOOLS -- 143-147
Advantages: Car and vanpools have a great potential for creating energy savings primarily because of their high load factors. A 10 percent shift of automobile commuters from cars to vanpools in the U.S. could produce a 1.1 percent savings in fuel consumption while a 10 percent shift to car pools could save 1.6 percent. Reduces traffic congestion and parking requirements. Relatively cost effective and easy to implement.
Disadvantages: Difficult to implement and probably presents only modest potential in developing countries. One primary advantage of the private car is the flexibility of travel it permits. Car and van pools limit that flexibility and thus go against the grain of personal tendencies. Pooling lengthens travel time, reducing its desireability over private cars. In many cases, successful strategies for pooling in developed countries have been too capital intensive to be feasible in developing countries. In industrialized countries, cars carry an average of 1.5 persons during rush hour and slightly over 2 persons during non-rush hour times. These numbers may not be significantly different in developing countries. The occupancy rate for the average business-related trip in the U.S. is 1.8-2.2 persons

per vehicle and the average rate for social and recreational trips is 2.9-3.1 persons.
Source: 31:212; 39:273, 291; 56:13; 66:29-32

143 CARPOOL COST SUBSIDIES -- see #142

144 CARPOOL TAX INCENTIVES -- see #142

145 GASOLINE RATIONING PREFERENCES -- see #142

146 PARKING SUBSIDIES FOR POOLS -- see #142 and #27-38
Advantages: Subsidies may be less expensive than building additional parking facilities for individual cars.
Source: 56:13

147 ELIMINATION OF EMPLOYEE PARKING SUBSIDIES -- see #31

148 IMPROVE PUBLIC TRANSPORT OPERATIONS -- #149-167
Notes: Some tools for private passenger transport apply for public passenger transport, e.g. Cost subsidies, all traffic regulation & control, most parking strategies, most travel cost strategies.
Source: 47; 48

149 TECHNICAL IMPROVEMENTS -- #150-156

150 MODAL ALLOCATION -- #151-152

151 SWITCH FROM SMALLER BUSES TO LARGER
Advantages: Improves load factor, thus improving energy efficiency.
Disadvantages: In many developing countries during rush hours, buses are already filled to capacity. In this case, improvements will only come with larger buses. Can be very expensive for only modest energy efficiency gains. Can use have large foreign exchange costs.
Source: 59

152 ENCOURAGE SWITCHING TO RAIL
Advantages: Improves load factor, thus improving energy efficiency.
Disadvantages: Can be very expensive for only modest energy efficiency gains. Can use have large foreign exchange costs.

153 MAINTENANCE PROGRAMS -- see #168-184

154 IMPROVE QUALITY OF EQUIPMENT -- #155-156
Notes: Create standards for energy efficiency of imported and domestically-produced vehicles.
Advantages: Can produce a direct effect on energy efficiency.
Disadvantages: May be expensive, hard to implement, and slow to show results.

155 IMPORT STANDARDS -- See #154

156 DOMESTIC PRODUCTION STANDARDS -- See #154

157 ORGANIZATION MANAGEMENT -- 158-167
Notes: See 66:36-38 for a discussion
Advantages: Improves operations of public transit, which can improve its energy efficiency.
Disadvantages: Difficult to implement, especially where public transit firms are private companies and where several different companies are operating in the same area. Requires management expertise and an extensive energy education effort.
Source: 24; 47; 48; 59; 66; 72

158 IMPROVE ROUTING -- see #157

159 IMPROVE SCHEDULING -- see #157

160 IMPROVE COMPANY MANAGEMENT -- #161-162, see #157

161 ORGANIZE AND RESTRUCTURE MANAGEMENT -- see #157

162 PRIVATIZE PUBLIC TRANSIT COMPANIES -- see #108

163 TRAINING PROGRAMS -- #164-167

164 DRIVER TRAINING -- See #169-172

165 MECHANIC TRAINING -- See #173

166 PLANNER/SCHEDULER TRAINING
Notes: Training to improve routing and scheduling of buses for greatest energy efficiency.
Advantages: As part of a general training program, this measure would produce important energy efficiency gains at relatively low cost.
Disadvantages: Complex to initiate and administer. Requires substantial managerial expertise.

167 MANAGEMENT TRAINING -- see #166

168 IMPROVE VEHICLE MAINTENANCE AND EFFICIENCY -- #169-184
Advantages: Low cost, high-payback measure that can have significant impact on fuel efficiency over the long run. Improves reduces wear and tear on vehicle, extends life of vehicle. Can increase vehicle life and fuel efficiency, reduce emissions and accident rates.
Disadvantages: Requires extensive program, over a long period of time to have an impact on the national fuel efficiency rate. Financial and institutional barriers inhibit long-term proper maintenance activities. Requires changes in behaviors which may not last.
Examples: Costa Rica, see Case Studies in Appendix A. Jamaica has been trying to improve auto fuel-efficiency through better maintenance practices, driver education, and the use of auxiliary fuel-saving devices in motors.
Source: 27; 31:39; 72

169 DRIVER EDUCATION -- #170-172
Advantages: Can improve fuel economy by up to 25 percent. A conservative estimate for the United States suggests 10 percent improvement as the norm. Can increase vehicle life, reduce emissions, maintenance needs, and accident rates.
Disadvantages: Must be implemented on a broad scale to have a significant impact on an area's fuel consumption. Requires changes in behaviors which may not last.
Examples: Costa Rica, see Case Studies, Appendix A. Jamaica has been trying to improve auto fuel-efficiency through better maintenance practices, driver education, and the use of auxiliary fuel-saving devices in motors.
Source: 25; 27; 31:39; 66:49-50

170 LOW WEAR-AND-TEAR DRIVING -- see #169

171 MAINTENANCE SCHEDULE -- see #169

172 MAINTENANCE NEEDS
Advantages: Significant energy savings possible, depending on original condition of vehicle. An average fleet in the United States could improve fuel efficiency by about 10 percent through proper maintenance, as a conservative estimate. Savings examples: Tuneup: up to 16% fuel savings; Front-end alignment: approximately 4%; Proper tire pressure: up to 6%; Reduce excessive brake drag: approximately 1%; Fuel-saving lubricants: up to 10%;
Disadvantages: see #169
Source: 25:A10+

173 MECHANIC EDUCATION -- see #169

174 IMPROVE INFRASTRUCTURE -- #175-182

175 PREFERENTIAL LAWS FOR EQUIPMENT -- #176-179

176 IMPORT LAWS -- #177-179
Notes: Laws to encourage importing fuel efficient vehicles and/or discourage importing fuel inefficient vehicles.
Advantages: Has a direct impact on the fuel efficiency of the nations fleet. Relatively easy to implement.
Disadvantages: Requires knowledge of vehicle efficiencies and options available, which may not exist or may be difficult to obtain. May encounter significant public opposition.
Examples: Korea, and many other developing countries, have import restriction in place.
Source: 62; 38

177 TAX PREFERENCES -- see #176

178 TARIFF EXEMPTIONS -- see #176

179 FAST-TRACK RED-TAPE -- see #176

180 INVESTMENT LAWS -- #181-182
Notes: Laws to encourage investments that improve the maintenance of vehicles.

181 ENCOURAGE INVESTMENT IN MAINTENANCE EQUIPMENT
Advantages: Can have a direct and significant impact on the maintenance practices of a nation's fleets. Economic difficulties often inhibit vehicle and fleet owners from performing adequate maintenance. Laws which encourage investment in maintenance equipment can go a long way toward improving the climate for proper maintenance.
Disadvantages: May be slow to show results. May only affect vehicle fleets, not private vehicles. May require advertising and promotion to be effective.

182 TAX DEDUCTIONS FOR MAINTENANCE WORK -- same advantages and disadvantages as #181

183 REQUIRE EMISSIONS TESTS
Advantages: Emissions testing requirements in the the United States have been effective in improving the fuel efficiency of the nation's vehicles
Disadvantages: Complicated and expensive to implement and

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administer. Requires effective traffic police force. Political and public opposition may be encountered.
Source: 71

184 OBLIGATORY ENERGY AUDITS OF TRANSPORT COMPANIES
Advantages: Can have a direct impact on the energy efficiency of transport companies. Relatively simple to implement.
Disadvantages: May produce only modest energy savings. Requires change in laws. May face political and public opposition. Requires effective enforcement effort.

185 IMPROVE VEHICLE STOCK -- #186-203
Source: For a general discussion, see sources 23 and 56.

186 IMPORT/PURCHASE RESTRICTIONS -- #187-191
Note: Restictions aimed at improving the energy efficiency of vehicles purchased.
Advantages: Directly affects the fuel efficiency of the nation's fleet. Relatively simple to design and implement.
Disadvantages: Significant public and political opposition may be encountered. Information on options may be limited, hindering the ability of consumers to make informed choices.
Examples: See Source 56:11 for examples of the effects of various technological changes on passenger car fuel economy.
Source: 56:11

187 ENGINE SIZE LIMITATIONS
Advantages: Compact cars can be as much as 50 percent more fuel efficient than large cars.
Disadvantages: Impact limited since relatively small cars already prevail in many developing countries and many also already have laws prohibiting the import of large cars for personal use.
Source: 39:273-4

188 FUEL CONSUMPTION STANDARDS
Advantages: Directly affects the fuel efficiency of the nation's fleet.
Disadvantages: Information on options may be limited, hindering the ability of consumers to make informed choices.

189 GASOLINE VS DIESEL LIMITATIONS
Notes: Many developing countries already have laws that favor the import of one class of vehicles over another, often favoring diesel vehicles.
Advantages: Diesel engines are from 10 to 40 percent more fuel efficient than gas vehicles. They also tend to last longer with lower maintenance costs. Substituting diesel engines for gasoline

can produce fuel savings of up to 40 percent in large or medium trucks, and between 20 and 50 percent in small trucks.
Disadvantages: If limitations are too strong, leading to a seriously imbalanced vehicle fleet, the nation's consumption of fuel may be significantly different from the production of its refineries. The ratio of diesel to gasoline produced from crude oil is limited to a relatively small range, if the ratio of consumption becomes radically different from the ratio of production the nation may have to import one fuel while exporting another, a very inefficient and expensive situation, generally. See also #191.
Source: 70

190 LOWER IMPORT DUTIES ON FUEL EFFICIENT VEHICLES
Advantages: Directly affects the fuel efficiency of the nation's fleet.
Disadvantages: Reduces vehicle turnover which increases average vehicle age to the detriment of efficiency, safety, and air quality.
Examples: Colombia has adopted a system where owners of large, fuel inefficient vehicles pay increasingly higher taxes than owners of small, fuel efficient ones. In the Dominican Republic and Jamaica, imports have been limited to low value vehicles -- presumably also fuel efficient ones.
Source: 31:35

191 MODIFY TAX RATES ON DIESEL AND GASOLINE VEHICLES
Notes: Many developing countries already have tax laws that favor one class of vehicles over another, often favoring diesel vehicles.
Advantages: Diesel vehicles are from 10 to 40 percent more fuel efficient than gas vehicles. They also tend to last longer with lower maintenance costs. Substituting diesel engines for gasoline can produce fuel savings of up to 40 percent in large or medium trucks, and between 20 and 50 percent in small trucks.
Disadvantages: Encouraging use of diesel vehicles can have a negative overall effect, however, because savings from the greater efficiency can be offset by several things, including: higher costs of diesel vehicles (and resultant foreign exchange drain); premature scrapping of gasoline cars; aggravating refinery ballance. Increased demand for diesel may lead to increased imports of diesel if domestic refinery capacity is not capable of meeting demand. This could agravate foreign exchange problems.
Examples: In the 1970s, gas was significantly more expensive than diesel in Brazil (and both were at or above world prices). In addition, alcohol fuel subsidies produced an attractive substitute for gasoline, but not for diesel. As a result, gasoline consumption declined significantly. However, since only a limited quantity of diesel can be produced from crude oil, in 1980 Brazil had to

produce more gasoline than it needed in order to meet its demand for diesel. The government intended to raise the price of diesel to 80 percent of the price of gasoline to rectify this situation.
Source: 39:266, 281, 286, 485; 18:10.10

192 FUEL-SAVING EQUIPMENT -- #193-196

193 RADIAL TIRES
Advantages: Their lower rolling resistance yields from 3 to 10 percent fuel savings. Radial tires last nearly twice as long as bias ply tires, they are less vulnerable to punctures and blow-outs, and improve traction.
Disadvantages: Radial tires are generally more expensive. The rolling resistance of bias tires is less than that for radial tires above approximately 55 mph, thus vehicles driving consistently at high speeds may not show fuel savings (see Source 56:12-13).
Source: 39:293; 56:12-13; 25

194 ELECTRONIC EFFICIENCY MONITORS
Notes: These include vacuum gauges, fuel efficiency gauges, and mpg or efficiency visual or auditory alarms to provide feedback to drivers on the fuel efficiency of their driving habits.
Advantages: Helps drivers to choose the most efficient acceleration and driving rates. Fuel efficiency improvements of up to 9 percent have been achieved.
Disadvantages: May not prove cost-effective compared to other, less costly methods of teaching and encouraging efficient driving habits.
Source: 25:A-5 to A-8

195 AERODYNAMIC ADD-ONS
Advantages: Wind deflectors installed above truck cabs to direct air flow over trailer can save between 4 and 8 percent of fuel costs. They are inexpensive, easy to install, and require almost no maintenance. Fuel reduction of up to 10 percent can be expected from several other devices, including: vanes to turn airflow around trailer corners; rounded trailer corners and fairings mounted on the flat forward face of the trailer; boat tails; smooth skins; side skirts; and devices to fill the gap between the truck and trailer to reduce turbulence.
Disadvantages: Require public information/education program to inform drivers/owners of their benefits.
Source: 39:293; 25:A-18; Jack Faucett Associates, Inc., Truck Fleet Experience With Fuel Economy Improvement Measures, Third Interim Report (February 1976).

196 AERODYNAMIC DESIGNS
Advantages: Produce fuel efficiency savings without the need for changing behaviors.
Disadvantages: Hard to implement, effects evident only over the long term. Foreign exchange costs may be high. Information on aerodynamic designs is limited, hindering consumers ability to make informed choices.
Source: See source 70 for truck fuel-saving features.

197 OPTIMIZE VEHICLE SPECIFICATIONS TO SPEED LIMITS & ROADS
Notes: Includes creating laws and regulations and standards to improve the vehicle stock to match vehicle efficiencies with prevailing speed limits and road quality. -- See #50 for a discussion of advantages and disadvantages.

198 ADJUST FUEL PRICES -- #199-200
Notes: Adjust fuel prices to encourage purchasing vehicles based on fuel efficiency.
Advantages: See #138, 189 and 191.
Disadvantages: May encourage replacement of existing stock sooner than otherwise necessary, raising costs, especially import costs. See #138, 189 and 191.

199 OPTIMIZE GASOLINE AND DIESEL DIFFERENTIAL -- see #198

200 RAISE PRICE TO CHANGE PURCHASE PREFERENCES -- see #198

201 FUEL SUBSTITUTION -- #202-203
Advantages: Fuel substitution may not improve energy efficiency, and may even reduce it, but it may be justified if the substitute is cheaper than petroleum products or if the impact on the country's petroleum import bill or export supply is especially important. The measure has environmental advantages since alcohol burns cleaner than gasoline.
Disadvantages: If all related costs are not taken into account, the advantages of fuel substitution schemes may be overestimated. Additional costs of changing vehicle technology, impacts on the environment and on food availability, import bills for different technology, etc. need to be taken into account. Alcohol production is fairly capital intensive and may require additional foreign exchange to import equipment. It may also take land and labor out of the food-production system which could lead to greater expenditures on food imports than savings from oil imports. Ethanol costs much more per Btu content than diesel fuel.

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Methanol is close in cost per Btu content to gasoline.
Examples: Brazil has implemented the world's most extensive fuel substitution program, seeking to substitute alcohol for approximately 40 percent of gasoline consumption. See 39:486+ for a good discussion. In addition to extensive work in Brazil, India and China have strong fuel-substitution programs and studies have been conducted in Guatemala, Colombia, Panama, and Costa Rica on the feasibility of creating a biofuels program.
Source: 31:31; 39:282, 486+; 56:16

202 SUBSTITUTE INDIGENOUS ENERGY RESOURCES -- see #201

203 REGIONAL COOPERATION TO DEVELOP MARKETS -- see #201

204 MODAL ALLOCATION -- #205-221

205 ENCOURAGE USE OF MORE ENERGY EFFICIENT MODES -- #206-216

206 IMPROVE RAIL AND BOAT TECHNOLOGY -- #207-212
Advantages: Rail and marine freight transportation, and in some situations passenger transportation, tend to be more fuel efficient than road transportation.
Disadvantages: Can be very expensive to implement. It is unlikely that projects to encourage modal switching will be economical based solely on fuel consumption savings. Institutional, geographic, and financial factors may impede efforts to switch freight from roads to rail and water. Public and political resistance may prevent any programs from having significant success.
Examples: In Brazil, government-controlled enterprises are required to ship by rail or water, where possible.
Source: 39:460

207 SUBSTITUTE DIESEL TRAINS FOR STEAM
Advantages: Diesel engines are more fuel-efficient than steam engines.
Disadvantages: Substitution programs can be very expensive, they may entail substantial foreign exchange costs for new equipment and they may induce early retirement of locomotives, producing waste.

208 SUBSTITUTE ELECTRIC TRAINS FOR STEAM
Advantages: Electric engines are more fuel-efficient than steam engines.
Disadvantages: Substitution programs can be very expensive, they may entail substantial foreign exchange costs for new equipment

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and they may induce early retirement of locomotives, producing waste.

209 SUBSTITUTE ELECTRIC TRAINS FOR DIESEL
Advantages: The primary advantage is in potential fuel savings and import substitution by deriving transportation energy from the most efficient fuel or from indigenous resources. Secondarily, electrification can reduce intercity pollution and saves costs through lower locomotive maintenance costs.
Disadvantages: May entail substantial foreign exchange costs for new equipment. May induce early retirement of locomotives, producing waste. Greatly dependent on fuel supply of the marginal power plants and the availability of surplus power (substituting abundant hydro-electric power for imported oil would be a desireable scenario).
Source: 31:154

210 SUBSTITUTE LIGHT RAIL OR TROLLEYBUSES FOR DIESEL BUSES
Advantages: Lower pollution; lower noise; use electricity generated from domestic resources, rather than using imported oil; Higher comfort level than conventional buses; longer economic lives; lower parts and maintenance costs than buses.
Disadvantages: Greatly dependent on fuel supply of the marginal power plants and the availability of surplus power (substituting abundant hydro-electric power for imported oil would be a desireable scenario).
Examples: In 1982 they were being examined by Colombia.
Source: 31:154, 281

211 IMPROVE TRACKS
Advantages: Improving railroad tracks can improve service and reliability making rail freight and passenger transport more attractive and making services more efficient.
Disadvantages: Energy savings may be relatively insignificant and slow in coming.

212 IMPROVE BOATS
Advantages: Improving boat technology can improve service and reliability making water freight and passenger transport more attractive and making services more efficient.
Disadvantages: Energy savings may be relatively insignificant and slow in coming.

213 IMPROVE RAIL AND BOAT OPERATIONS -- #214-216
Advantages: Improves efficiency of systems, which can improve

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their energy efficiency. Improves services and reliability, which makes them more attractive to customers.
Disadvantages: Difficult to implement, especially where several different companies are operating in the same area. Requires management expertise and an extensive energy education effort.

214 IMPROVE SCHEDULING -- See #213

215 MORE FREQUENT SERVICE -- See #213

216 IMPROVE LOADING FACILITIES -- See #213

217 ENCOURAGE NON-MOTORIZED TRANSPORT -- #218-221
Advantages: Savings in fuel use and cost of technology can more than offset losses from time and smaller capacity in many cases.
Disadvantages: Many non-motorized forms of transport are already extensively used in developing countries, therefore the potential for energy savings is limited. The technology and methods of use are often quite engrained in the traditions and habits of the people, inducing changes can be very difficult.

218 IMPROVE ANIMAL-DRAWN CARTS -- see #217

219 IMPROVE RICKSHAWS -- see #217

220 IMPROVE COUNTRY BOATS -- see #217

221 IMPROVE BICYCLE FACILITIES
Notes: Involves building bicycle paths, providing parking devices, and making arrangements for taking bicycles on public transportation.
Advantages: Can significantly reduce vehicle use while consuming few natural resources and producing no air pollution.
Disadvantages: Increased use of bicycles can lead to increased bicycle-car and bicycle-pedestrian accidents.
Source: 42; 66:51-52

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