THE TRANSPORTATION SECTOR IN COSTA RICA AND OPPORTUNITIES FOR ENERGY CONSERVATION

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ACKNOWLEDGEMENTS

The following report is based on a reconnaissance mission to Costa Rica from June 3-16, 1984 by Robert Kowalski from Hagler, Bailly & Company, the Energy Conservation Services Program prime contractor, and David Greene and Frank Southworth from the Transportation Energy Group at Oak Ridge National Laboratory.

Without the help and guidance of our Costa Rican counterparts, this project could not have been successful. We especially thank Ing. Alexandra Hernandez, Dr. Jorge Blanco, and Dr. Alvaro Umana of the Direccion Sectorial de Energia. We are also grateful to the many private and public transportation officials who took time to meet with us.

We thank Pamela Baldwin and Robert Archer of USAID for their support and guidance and for their many valuable comments on an earlier draft of this report.

LIST OF ACRONYMS USED

CODESA	National Development Company of Costa Rica
COOPETICA	A major taxi cooperative
COTRACOOP	Consortium of bus cooperatives
DSE	Energy Sector Directorate
FECOSA	Costa Rican Railways, S.A.
GASH	A major trucking company
ICE	Costa Rican Electric Company
LACSA	Costa Rican Airlines
LRT	Light Rail Transit
MOPT	Ministry of Public Works and Transportation
RECOPE	Costa Rican Petroleum Refinery
SEPSE	Executive Secretariat for Energy Sector Planning
TRANSMESA	Metropolitan Transportation S.A. (for San Jose)
UNITRACSA	A major trucking cooperative

Costa Rica consumes 0.62 tonnes of oil equivalent (toe) per capita annually, compared with the Central American average of 0.3 toe per capita; total commercial energy consumption in 1980 was 1.3 million toe. The transportation sector accounts for 28 percent of the country's total energy consumption and 59 percent of its consumption of petroleum products.

For some time, the U.S. Agency for International Development (USAID) has been supporting activities in Costa Rica to encourage energy efficiency in the industrial sector. Recently, the Energy Conservation Services Program (ECSP) of AID's Office of Energy initiated a first look at the transportation sector to identify measures that might be undertaken in that sector to improve transport services while stretching the available fuel supplies and reducing costs. ECSP is designed to help developing countries use energy more efficiently, increase productivity, and save foreign exchange.

This report, which describes the first efforts of ECSP to address transportation energy conservation issues, is the result of a mission to Costa Rica by staff from the ECSP contractor -- Hagler, Bailly & Company -- and the Transportation Energy Group of the Oak Ridge National Laboratory. The mission sought to quantify and characterize energy use in the transportation sector. In addition, it sought to identify conservation opportunities and efficiency improvements in the major petroleum-consuming subsectors (i.e., automobiles, buses, and truck transport) and to specify short-term, practical measures that the government in Costa Rica could adopt and promote.

The report begins with an overview of the Costa Rican transportation sector, the roles of public and private organizations in Costa Rican transportation, and the use of energy within the sector, including a rough estimate of the potential for energy savings. It next looks in detail at patterns of energy demand in the transportation sector. It then presents recommendations for research, analysis, and action aimed at energy conservation and efficiency improvements.

ENERGY AND THE TRANSPORTATION SECTOR: AN OVERVIEW

Costa Rica's transportation system consists mainly of highways, with highway vehicles accounting for 98 percent of passenger-kilometers, and 74 percent of tonne-kilometers in 1980. Rail accounted for only 18 percent of tonne-kilometers, most of which were bananas; furthermore, in recent years, the movement of bananas has shifted largely from rail to road transport. As a result, only 4.3 percent of Costa Rica's petroleum consumption in transportation is used by the railroads. With few opportunities to change this basic modal structure, energy conservation efforts in Costa Rica should focus on highway transport.

In 1982, the transportation sector accounted for 48 percent of total secondary energy use (see Exhibit 1), and 24 percent of total primary and secondary energy use. The growth in energy use by the transportation sector has slowed in recent years, primarily because of economic slow down, high petroleum prices, and associated reductions in transport services. Transport-sector energy demand rose at an average annual rate of 10.3 percent from 1965 to 1973 and by 8.2 percent annually from 1973 to 1979, but fell by 8.4 percent annually between 1979 and 1983. Virtually all transportation energy is supplied by petroleum fuels, with diesel accounting for nearly two-thirds of transportation energy use, almost all of it on highways.

Within the highway subsector, heavy trucks appear to be the biggest single class of consumers, accounting for roughly 30 percent of highway energy use. All light vehicles together -- autos, light trucks, vans, etc. -- claim about 40 percent of the highway mode's energy consumption. Of these, taxis consume only about 5 percent, special vehicles (such as agricultural equipment) 10 percent, and buses, more than 10 percent. Within this diverse highway subsector, a combination of strategies focusing on the various segments simultaneously is needed.

PUBLIC- AND PRIVATE-SECTOR ROLES IN COSTA RICAN TRANSPORTATION

Identifying key actors and their specific roles is an important step toward determining what policies can be used to promote development of an energy-efficient transport sector for Costa Rica. The roles and responsibilities of organizations in the public and private sector are summarized below according to transport mode.

Public Sector

The Costa Rican government's involvement in providing transportation services varies by mode and type of service, as indicated below.

Rail -- FECOSA, the government-owned railway corporation, owns and operates all of the country's railroads, except the Ferrocarriles de Sur (which it will soon control). The Direccion de Ferrocarriles of the Ministry of Public Works and Transportation (MOPT) is responsible for the planning and oversight of all railroads in Costa Rica.

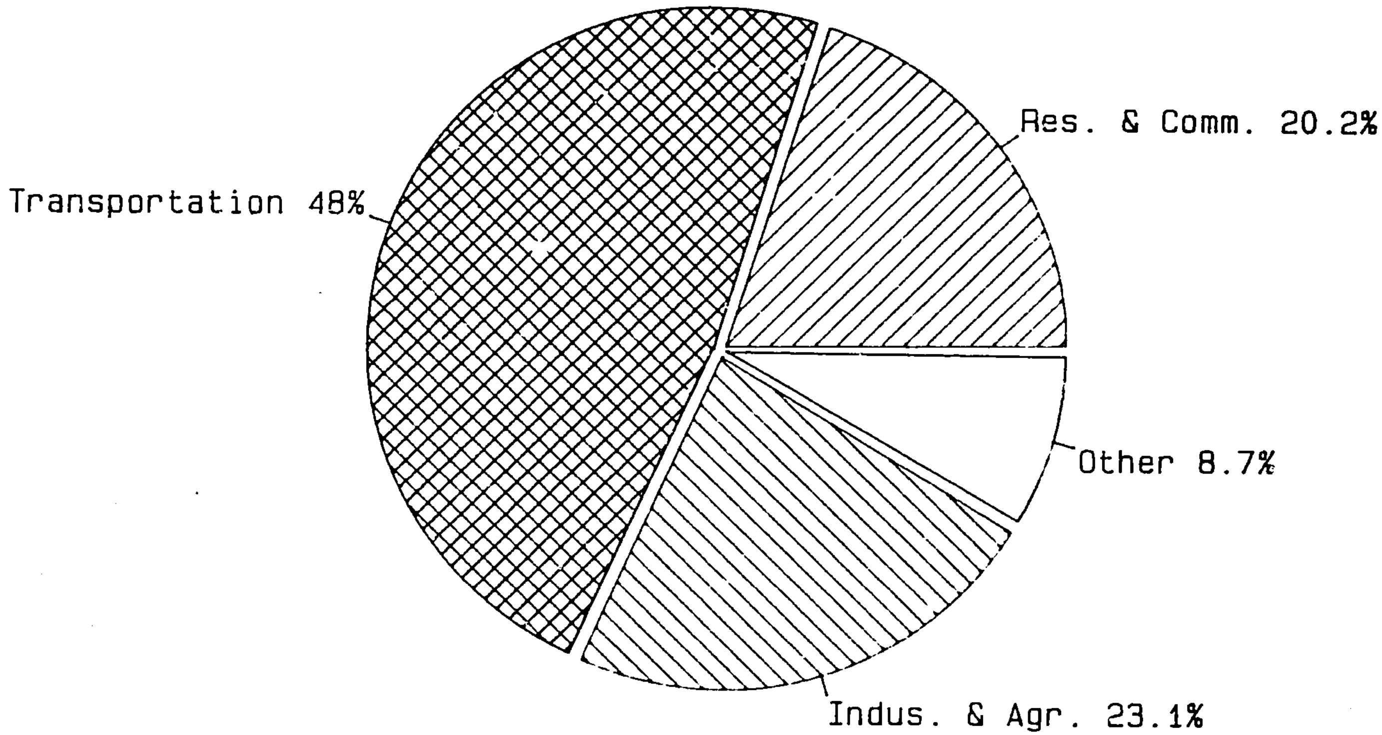
Marine and air -- The government plans and constructs terminal facilities.

Pipeline -- The country's only pipeline is owned and operated by RECOPE, the government-owned petroleum refining and distribution monopoly.

Bus -- TRANSMESA, a government agency, purchases buses and resells them to private operators at one-third of their import cost to subsidize bus service. MOPT is responsible for determining fares, establishing routes, and assigning concessions.

Exhibit 1

Sectoral Use of Secondary Energy
Costa Rica 1982



Taxi -- TRANSMESA is now responsible for buying all taxis that are resold to private operators at cost, without duty.

Private cars and light trucks -- The government exerts a powerful influence on vehicle ownership through tariffs and import duties, which range up to 400 percent of a vehicle's U.S. market value, depending on the engine displacement.

Energy supply -- Because it owns the country's oil refining monopoly, RECOPE, the government has direct influence over fuel prices, fuel quality, and fuel switching possibilities.

Private Sector

Highway -- Buses and taxis are operated, fueled, and maintained by private owners. Cooperatives of small owners dominate the taxi and bus subsectors. One taxi cooperative claims the majority of all taxis in Costa Rica as members.

Private operators conduct all aspects of truck freight operations. Commercial transporters may operate individually (there is a substantial number of independent truckers), but more often they are organized into cooperatives or unions. Especially in truck freight, there are occasionally large private companies providing service.

POTENTIAL FOR ENERGY AND PETROLEUM SAVINGS

Estimating potential energy savings is an unsure exercise, at best. Energy savings realized through conservation measures depend not only on the current state of affairs but on the rigor with which the measures are carried out. Nonetheless, it is necessary to estimate savings to gain some appreciation of the importance of pursuing energy conservation in transportation. The team estimates that petroleum use in the transportation sector could be cut by roughly 25 percent through conservation (19 percent) and fuel switching (6 percent).

Because the transportation sector is diverse, many different actions would be needed to produce the total effect. The savings possible through implementation of measures proposed in this report are summarized in Exhibit 2. In the case of operating improvements, technically feasible savings have been discounted by 50 percent, as a means of estimating realistic versus possible efficiency improvements, taking into account institutional and policy barriers. In the case of vehicle stock efficiency improvements, assumptions about the potential for efficiency improvements in private light vehicles and all heavy-duty vehicles are deliberately very conservative. More ambitious efforts in operating and stock efficiency improvements and in fuel switching are certainly possible (e.g., electric cars, neat alcohol fuels), but would entail substantial investment.

Exhibit 2

Estimated Energy and Petroleum Savings Achievable in Costa Rica's Transportation Sector
(Based on 1981 data)

Action	Applicable energy use		Percent savings likely	Savings as a percentage of transportation energy use	
Conservation					
Operational					
Driver training	Highway vehicles[1]	16,098 TJ	3.0	483 TJ	3.0
Maintenance	Highway vehicles[1]	16,098 TJ	4.0	644 TJ	4.0
Equipment	Highway vehicles[1]	16,098 TJ	1.5	241 TJ	1.0
Traffic flow	Urban highway[2]	8,000 TJ	1.5	120 TJ	1.0
Subtotal				1,488 TJ	9.0
Stock efficiency					
Government purchases	Taxis[3]	482 TJ	40.0	193 TJ	1.0
	Buses[3]	1,725 TJ	10.0	172 TJ	1.0
	Government and institutional vehicles[4]	327 TJ	30.0	98 TJ	1.0
Private purchases	Light-duty vehicles[1]	6,205 TJ	10.0	621 TJ	4.0
	Heavy trucks[1] (1,421 discounted by 9% to account for operational improvements)	4,770 TJ	10.0	477 TJ	3.0
				1,561 TJ	10.0
Fuel switching					
Gasohol	All gasoline use[5]	5,053 TJ	10.0	505 TJ	3.0
Trolley buses	About one-half of bus energy in San Jose[6]	180 TJ	100.0	180 TJ	1.0
Railroad electrification	Banana feeder lines[7]	198 TJ	80.0	158 TJ	1.0
	Rest of railroad operations* (951, discounted for stock efficiency and operational improvements)	186 TJ	100.0	186 TJ	1.0
				1,029 TJ	6.0
Total (accounting for interactions among actions)				**3,860 TJ**	**24.0**

[1] Highway energy use by vehicle type taken from Table 3.5 and adjusted downward by 13 percent to more closely match RECOPE estimates of gasoline and diesel use in transportation.

[2] Estimated by assuming that half of vehicle miles are under urban conditions.

[3] Calculated using data supplied by Transmesa on average efficiencies and km per month. Data are for 1983. See Table 3.7.

[4] 7,196 government and institutional vehicles at 9 liters/100 km, and 16,000 km/year.

[5] See Table 3.2.

[6] Number of kilometers per month for buses operating in San Jose area according to Transmesa (2,212,150.9) multiplied by the average consumption per bus kilometer for the San Jose area 0.3721, times 12. More precisely, 9,877,6?6 liters.

[7] Based on 80 percent of estimated diesel consumption in Table 6.4 (1,439,000 gal/yr).

[8] Table 3.1.

The distribution of estimated energy savings reflects the diversity of the transportation sector. A comprehensive plan aimed at many areas simultaneously is necessary to achieve substantial petroleum savings.

RECOMMENDATIONS

Study and Research

In this brief assessment, it has not been possible to map out a definitive energy-efficiency action plan for the transportation sector. Many questions have been raised; fewer have been confidently answered. Consequently, the team's recommendations begin by highlighting areas that require further study before plans of action can be formulated.

1. **Fuel quality analysis**

   Nearly everyone with whom the team spoke contended that transport fuels, especially diesel fuel, are of poor quality in Costa Rica. Taxi, bus, and truck operators seem convinced that diesel fuel supplied by RECOPE often contains contaminants such as water or sediment, is too viscous, and contains an excessive quantity of sulfur. They believe that poor quality fuel causes maintenance problems and excessive smoke emissions, and accelerates engine wear; these, in turn, lower fuel efficiency. Preventive maintenance of critical engine elements (injectors, pumps, filters) is also admittedly inadequate, contributing to further energy waste. If fuel quality is as bad as reported, improved maintenance will not achieve the desired effect. We believe that a comprehensive, objective investigation of fuel quality is necessary. If serious problems are found, solutions must be implemented before major investments in vehicle maintenance programs are undertaken.

2. **Feasibility of using ethanol as an octane enhancer**

   Costa Rica's previous gasohol experiment was generally regarded as a failure, chiefly because the fuel was contaminated by water and sediment dissolved by the ethanol, and vehicle owners were not told how to prepare their vehicles for the 20-percent ethanol blend. Economics were also a problem. Ethanol was used simply as a gasoline substitute, mixed directly with straight-run leaded gasoline. The team believes that it might be economical to use ethanol produced from surplus sugar cane as an octane enhancer, blending it with cheaper, low-octane gasoline in concentrations around 10 percent. Such a fuel would also control lead particle pollution. Before such a project is undertaken, a study of refinery operations, fuel distribution problems, and economic feasibility is required. Gasohol distribution problems could be investigated as part of the fuel quality study suggested above.

3. **Electricity to power certain bus routes and rail lines**

Substitution of domestically produced hydroelectricity for imported petroleum appears to be an attractive option because of excess installed capacity and the large untapped hydroelectric potential. The most promising applications appear to be an electric trolley bus system in the San Jose area and electrification of the Atlantic railroad banana feeder lines. Both options require further study.

4. **Vehicle tax policy assessment**

Although there is a 200-percent surtax on private automobiles with engines larger than 1,200 cc, some loopholes (e.g., microbuses) exist. A comprehensive study of vehicle taxation, including import duties, is needed to determine how the tax structure can promote economic efficiency and provide incentives for fuel efficiency of the vehicle fleet.

5. **Fuel pricing and taxation policy**

There are several important issues requiring analysis in the area of government fuel taxation and pricing policy. Fuel prices should be set at levels that encourage efficient operation of vehicles by reflecting the true cost of petroleum to the Costa Rican economy.

Gasoline and diesel fuel prices have increased dramatically between 1979 and 1983 (see Exhibit 3) because of the devaluation of the Costa Rican colon, the pre-1983 worldwide increase in petroleum prices, and a substantial increase in domestic taxes on diesel fuel. In March 1983, diesel fuel bore a tax of 21 percent and sold for 19 colones/liter ($1.65/gallon using an exchange rate of 43.5 colones to the dollar) and gasoline, a tax of 33 percent and sold at 24 colones/liter ($2.08/gallon) (see Exhibit 4). To determine whether these taxes maintain appropriate relative price levels for diesel fuel and gasoline, a study is required of the true economic cost of imported petroleum to the Costa Rican economy and the roles of the two fuels in the productive versus personal consumption sectors of the economy.

Fuel taxation could also be considered in conjunction with the question of using revenues for the supply and maintenance of the transportation infrastructure. The quality and quantity of highways in Costa Rica are inadequate. Fuel taxes are used in many countries, including the United States, as a primary source of revenues for road improvements. Thus, the question of the appropriate level of transportation infrastructure supplied by the government might be considered most productively in Costa Rica jointly with the question of the appropriate level of fuel taxes, as the issues are of critical importance to the Costa Rican economy.

Exhibit 3

Sales Prices of Gasoline and Diesel Fuel in Costa Rica

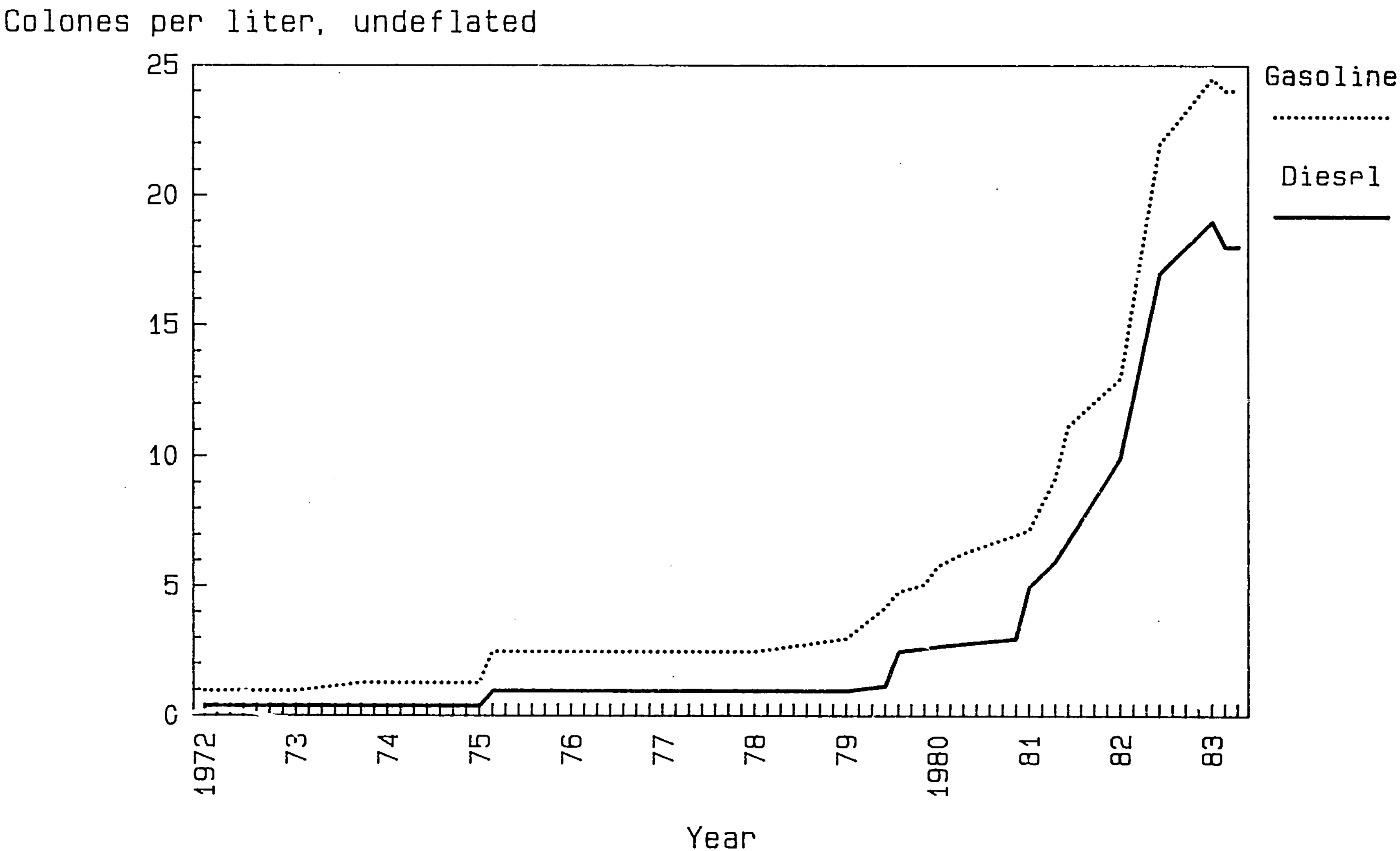


Exhibit 4

Cost Structure of Petroleum Fuels, March 1983
(Colones per liter)

	Product		
Component	**Gasoline**	**Diesel**	**Bunker C**
Sales price	24.000	19.000	8.500
Distributor's margin	1.000	1.000	-
Average transportation	0.362	0.362	0.362
Cost of production	10.432	9.783	7.065
Sales charges	0.483	0.483	0.483
Investments	1.348	1.348	1.348
Taxes	0.468	-	0.036
"Decretos"	0.083	0.083	0.083
Debt service	1.864	1.864	1.864
Profit (loss) per liter	7.960	4.077	(2.741)

Data on Energy Use, Efficiency, and Related Subjects

Accurate and reliable data are necessary to formulate energy policy. Aggregate fuel use data for the transportation sector are available from RECOPE, but there is no direct source of information on energy use by type of vehicle. Estimates are based on a crude method that multiplies the known vehicles in circulation (by type) by the estimated average annual kilometers and then by the estimated fuel efficiency (liters/km). In several instances, however, we found that the two estimated factors varied by 25 to 50 percent. Nonetheless, estimates from this method are useful for determining the relative magnitude of energy use by vehicle type to establish conservation priorities.

In the case of taxis and buses, very detailed data on operations are available. For other vehicle types, it is necessary to determine energy efficiencies, use, and consumption by survey. The DSE is designing such survey instruments. Priority should be given to heavy trucks and to private light vehicles, including automobiles, station wagons, pickups, mini-vans, and jeeps. There is probably no need for additional data on buses and taxis.

Some effort should be made to determine marine energy use more accurately and, for completeness, pipeline use, although the small energy demand represented by these modes does not warrant an expensive or time-consuming effort. Aircraft energy consumption is known from sales of aviation gasoline and jet fuel, but energy efficiencies are not known. Such data would be needed to determine whether the energy efficiency of domestic air operations can be improved.

Additional detail is also needed on the composition of light vehicle stock, either by weight or by make and model of vehicle. These data are needed to develop policies designed to improve efficiency and estimate the resulting energy savings. Such data could be estimated in conjunction with a survey of light vehicles.

Adequate fuel price data are available.

Immediate Actions

Conservation measures that can and should be initiated without further study include promotional campaigns (including consumer education) and demonstration programs. Based on extensive interviews, the team concluded that there is only limited public awareness of energy efficiency and how vehicle owners and operators could affect the fuel economy of their vehicles. On the other hand, there is a very strong economic incentive to conserve fuel, since fuel costs represent 30-40 percent of truck and bus operating costs. Given such costs, we believe that fuel economy information and demonstration programs could be very effective.

1. **Fuel economy information.** An international standard fuel economy test (e.g., DIN) should be selected by the DSE as a basis for fuel economy comparisons for vehicles in Costa Rica. This information could be provided to car buyers through vehicle labeling, pamphlets, press releases, etc.

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2. **Driver education for fuel economy.** Vehicle fuel economy can be significantly affected by the way the vehicle is operated and maintained. Educational materials should be developed to explain the benefits of efficient driving practices and maintenance measures such as keeping correct tire pressure, using friction-reducing lubricants, tune-ups, air filter replacement, wheel alignment and brake adjustment, radial tires, and eliminating unnecessary vehicle weight. Although published materials can be effective, driver training courses -- especially for professional drivers -- are probably the most effective means of disseminating this information.

3. **Demonstration program.** In Costa Rica, the commercial transportation sector consumes the majority of transportation fuel. Truck, bus, and taxi operators are organized into large cooperatives, unions, or companies that would be willing to cooperate with the DSE in conducting driver training and maintenance programs. We recommend that the DSE, in collaboration with private-sector organizations such as the Camara Nacional de Transporte, design fuel efficiency demonstration programs for freight trucks, buses, and taxis. USAID could assist by supplying technical assistance for program planning and design of a pilot program for one selected fleet or cooperative.

   Demonstration programs are important in overcoming two of the most difficult barriers to transportation energy conservation: lack of knowledge of the effects of operation and maintenance on fuel economy, and inadequate revenues to cover even depreciation of the capital equipment. Demonstration programs can be effective by showing vehicle operators that conservation measures are effective in immediately reducing operating costs.

4. **Conservation awareness promotion program.** Perhaps the greatest barrier to transportation energy conservation is lack of knowledge about factors that influence fuel efficiency. The team recommends a public promotional campaign aimed at vehicle owners and operators. Such a program would increase awareness of how tire inflation, speed, idling versus engine shutdown, lubricants with friction-reducing additives, wheel alignments, brake adjustment, tune-ups, and other factors can maximize fuel economy.

Roughly three-quarters of Costa Rica's 2.3 million inhabitants live in the highly urbanized Central Valley, which includes the capital of San Jose. The country's economy is largely based on agriculture and agro-industry; coffee, bananas, and beef are the leading exports. Costa Rica consumes 0.62 tonnes of oil equivalent (toe) per capita annually, compared with the Central American average of 0.3 toe per capita; total commercial energy consumption in 1980 was 1.3 million toe. The transportation sector accounts for 28 percent of the country's total energy consumption and 59 percent of its consumption of petroleum products. According to RECOPE (the state petroleum refining company), the transportation sector used approximately 363,000 toe in 1982, or 48 percent of all secondary energy consumption.

For some time, the U.S. Agency for International Development (AID) has been supporting activities in Costa Rica to encourage energy savings in the industrial sector. There is currently a project under way, funded by the AID mission in Costa Rica, to conduct industrial energy audits. Recently, the Energy Conservation Services Program (ECSP) of AID's Office of Energy initiated activity in the transportation sector. ECSP, which was initiated in September 1983, is designed to help developing countries use energy more efficiently, increase productivity, and save foreign exchange. The program, which is part of the Office of Energy's Policy Development and Conservation Project (EPDAC), is aimed at industrial operations, transportation, electric power generation and transmission, and the design and operation of commercial and institutional buildings. This report describes the first efforts of ECSP to address transportation energy conservation issues.

Oil consumption for highway transportation represents an enormous burden on Costa Rica's economy. The World Bank energy sector assessment of Costa Rica spoke of the transportation sector's "voracious appetite for petroleum products" and the need to seek substitution and conservation measures. The World Bank also noted that current pre-investment planning efforts, which are focused on rail improvements, and the feasibility of electrification of urban transport in San Jose, if implemented, will have have little or no impact on reducing overlal transportation energy consumption, although these efforts would clearly improve transport services and shift a portion of demand from imported petroleum to electricity generated from indigenous energy sources.

The report is the result of a visit to Costa Rica by staff from the ECSP contractor -- Hagler, Bailly & Company -- and the Transportation Energy Group of the Oak Ridge National Laboratory. The team sought to quantify and characterize energy use in the transportation sector beyond what the World Bank assessment team was able to accomplish. In addition, the team sought to identify conservation opportunities and efficiency improvements in the major petroleum-consuming subsectors (i.e., automobiles, buses, and truck transport) and to specify short-term, practical measures that the government in Costa Rica could adopt and promote.

The assessment was carried out in cooperation with the Direccion Sectorial de Energia (DSE). DSE is the designated Costa Rican energy agency within the Ministry of Industry, Energy and Mines (MIEM), and is jointly sponsored by RECOPE and ICE (the state electric utility). The study team consulted with national and local government transportation authorities; bus, truck, and taxi companies; and the transportation chamber of commerce. Team members also visited an engine repair shop, a tire company, and a truck distributor, and traveled the nation's principal freight corridor -- between San Jose and the Caribbean port of Limon -- served by both road and rail.

The team concluded that, given Costa Rica's heavy dependence on road transportation, any transportation energy conservation program must focus on this subsector.

The report is divided into five chapters. Chapter 1 describes the nature of the Costa Rican transportation sector and the mix between road and rail. Chapter 2 looks in detail at energy use in the transportation sector. The next three chapters discuss the findings and recommendations of the mission regarding:

- Opportunities for energy conservation and efficiency improvements
- Ways to improve vehicle maintenance and fuel quality
- Proposals on switching to electricity and alcohol-based fuels.

This report of energy conservation opportunities in Costa Rica's transportation sector represents one kind of assistance available from ECSP: the implementation of a sectoral energy consumption survey. Under review and discussion within and between AID's Office of Energy and Costa Rica's DSE are additional kinds of assistance from ECSP or other AID sources. ECSP program assistance includes training of engineers and managers, preparation of energy conservation promotional materials, and advisory services to implement energy conservation measures. This report makes clear that ECSP and other donor programs can assist in achieving a significant measure of transportation energy conservation in Costa Rica.

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Almost 80 percent of Costa Rica's population lives in the highly urbanized Central Valley, in which both the nation's industry and major coffee plantations are concentrated (see Exhibit 1.a). This region also contains Costa Rica's principal freight corridor, which runs between San Jose and the Caribbean port of Limon. The nation's transportation infrastructure consists mainly of highways. The movement of passengers and freight is accomplished primarily by truck, bus, and private automobile (see Exhibit 1.b).

THE HIGHWAY SYSTEM

Costa Rica has some 11,000 kilometers of highways in use, including a 1,900 km primary road system, plus a paved road and street network throughout the San Jose metropolitan area. On the periphery of this urban hub, however, many streets and roads are in poor condition, and outside the Central Valley, most roads are gravel or dirt surfaced. A new highway linking San Jose and Limon is due to be completed by 1985. This road will follow a much flatter route than the existing two-lane road through the mountains, cutting the current travel time of 4½ hours in half. In addition, the new road will have a third lane for heavy trucks on the steepest sections.

Most passenger travel is and will continue to be by bus. The bus system is centered on the metropolitan area of San Jose and the surrounding towns of Heredia, Alajuela, and Cartago. A small number of long distance buses also link the Central Valley towns to other areas of the country, including Limon, Puntarenas, and the more remote settlements to the north and south. The bus routes and schedules are set by the Ministry of Public Works and Transportation (MOPT) and the buses themselves are imported and sold to private operators (at a 70-percent subsidy) by the government-owned TRANSMESA (Metropolitan Transport S.A.) which serves only the Central Valley region. The current bus fleet has 3,320 vehicles, including 387 microbuses. An estimated 1,972 taxis also serve metropolitan San Jose.

THE RAILROAD SYSTEM

Costa Rica's railroad system, which is in a poor state of repair, consists of the following trunk or main lines:

1. Puntarenas (Pacific) to San Jose
2. San Jose to Limon (Atlantic)
3. Rio Frito to Siquirres
4. Ferrocarriles del Sur.

Exhibit 1.a

PROVINCES
(7 Provinces)

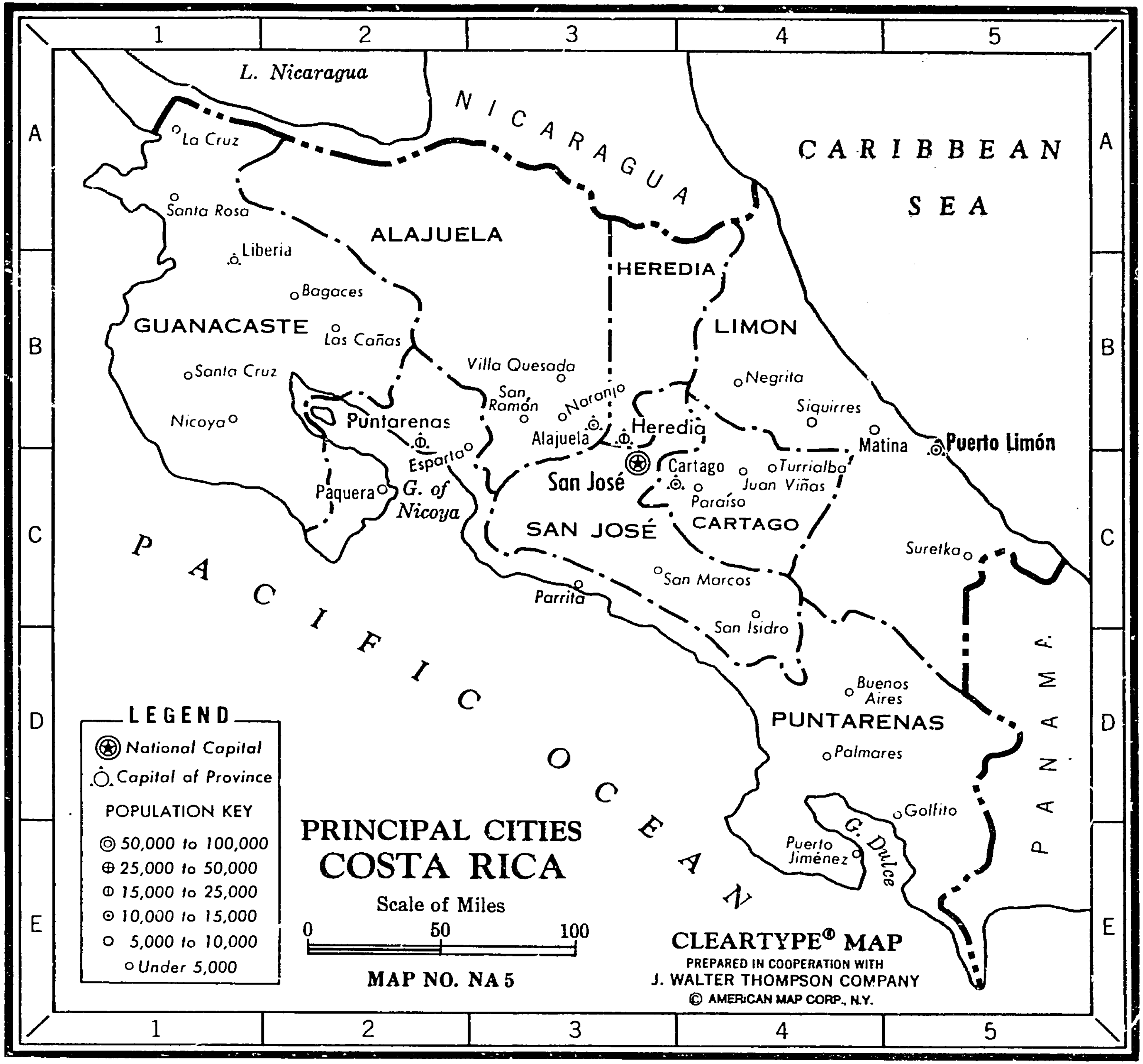
Name of province followed by population in thousands, to nearest thousand, then location on map.

Alajuela, 149.	A- 2
Cartago, 101.	C- 3
Guanacaste, 88.	B- 1
Heredia, 52.	B- 3
Limon, 41.	B- 4
Puntarenas, 88.	D- 4
San José, 282.	C- 3
Total Costa Rica	**801.**

CITIES

Name of city followed by population in thousands, to nearest thousand, then location on map.

Alajuela, 14.	B- 3
Bagaces, 4.	B- 2
Buenos Aires, 2.	D- 4
Cartago, 12.	C- 4
Esparta, 3.	B- 3
Golfito, 4.	D- 5
Heredia, 17.	B- 3
Juan Viñas,	C- 4
La Cruz, 4.	A- 1
Las Cañas, 1.	B- 2
Liberia, 3.	B- 1
Matina, 5.	B- 4
Naranjo, 2.	B- 3
Negrita,	B- 4
Nicoya, 2.	B- 1
Palmares,	D- 4
Paquera, 5.	C- 2
Paraiso, 1.	C- 4
Parrita, 3.	C- 3
Puerto Jiménez, 1.	E- 4
Puerto Limón, 11.	B- 5
Puntarenas, 24.	B- 2
San Isidro,	C- 4
San José, 150.	C- 3
San Marcos,	C- 3
San Ramón, 4.	B- 3
Santa Cruz, 2.	B- 1
Santa Rosa, 1.	A- 1
Siquirres,	B- 4
Suretka,	C- 5
Turrialba,	C- 4
Villa Quesada, 2.	B- 3



COSTA RICA

Exhibit 1.b

Movement of Passengers and Goods by Mode of Transportation

	1980	1985	1990	1995
A. Millions of passenger kilometers per day				
Private auto	4.00	4.40	5.37	6.70
Bus	6.20	8.80	9.85	12.28
Rail	0.14	0.18	0.23	0.29
Air	0.05	0.05	0.06	0.08
Total	**10.45**	**12.71**	**15.51**	**19.35**
B. Millions of ton-kilometers of freight per year				
Highway	664	974	1,162	1,375
Rail	160	233	353	416
Pipeline	75	97	122	154
Total	**899**	**1,304**	**1,637**	**1,945**

SOURCE: Plan Nacional de Transporte Volume 1 (December 1981).

The first three lines (513.75 km in all) and their 159.15 km of feeder lines into the banana plantations are government-owned and -operated by FECOSA (Ferrocarriles de Costa Rica S.A.). The fourth line (162 km) is currently privately operated. In 1988, however, this line plus its 84 km of feeder lines into the banana plantations of Palmar Sur and Coto Colorado will come under government ownership. The Rio Frito-to-Siquirres trunk line and its continuation (via its connection to the San Jose-to-Limon line) serve as the trunk for eight banana lines. The Estrella line is another major banana line running south (50 km) along the coast from Limon.

At present, only the Puntarenas-to-San Jose and Rio Frito-to-Limon sections of line are electrified. All lines are 3'6" gauge single tracks, with few sidings.

In 1982, the entire rail system was credited with only 145.19 million ton-kilometers of freight and 90.5 million passenger-kilometers. Since August 1983, FECOSA has operated the system as a set of mixed freight and passenger lines. The mix was necessitated by a dramatic shift in the mode used to transport bananas. Previously, 80 percent of the bananas were moved by rail; since 1983, 80 percent are moved by truck. The change, occasioned by frequent derailments and poor rail service, and made possible by a large-scale shift to containers on trucks, has placed FECOSA in considerable financial difficulty.

OTHER TRANSPORTATION MODES

Petroleum Pipeline

The only freight of any significance not moved by truck or rail is petroleum, which is pumped inland along a 162-km pipeline from the RECOPE refinery at Moin (on the Atlantic coast adjacent to Limon) to terminals at El Alto, La Garita, and San Jose.

Container Ports

Approximately 85 percent of Costa Rica's exports leave the country via its ports; four-fifths of these exports are loaded at Limon on the Caribbean Sea, with most of the remainder using the Pacific ports of Caldera/Puntarenas and Golfito. Increasingly, the ports handle container traffic, using a crane to lift containers from trucks or flat rail cars. Most of the goods entering the ports are bound for the San Jose region, with customs checks either at port or an initial destination inland. A recently opened cargo terminal to the northwest of San Jose, near Alajuela, is intended as a major collection/consolidation/break-bulk/distribution point and customs clearing house for the nation's imports and exports. There are plans to develop the terminal area for both truck and rail use, at an estimated cost of $2.5 million.

Other Modes

Water and air transport in Costa Rica -- internal and coastal shipping and internal and international air transport -- are relatively minor components of the system. Rural roads are usually preferred to navigable rivers, although a fairly active coastal shipping trade exists along the Pacific.

Costa Rica currently has 124 airports or landing fields spread evenly across the country, and reached by a small fleet of 26-seat AVIO CAR C-212 and 30-seat DC-3 light aircraft operated by the national airline LACSA. About 110,000 passengers use this service annually. Four of these airports (Juan Santamaria and Tobias Bolanos in the Central Valley, Liberia in the northwest, and Limon on the Atlantic coast) are designated as international fields.

The Costa Rican transportation sector is a mixture of public and private organizations, ranging from the railroads -- which will soon be wholly government-owned -- to truck-freight -- where there is no significant government activity. In between are buses and taxis; the government plays a major role in supplying vehicles, setting fares, and, in the case of buses, determining and assigning concessions for routes. The government's indirect influence is broad, including the supply and pricing of fuels, construction and maintenance of the road network, establishment of tariffs and import duties on transportation equipment, and other regulatory functions.

THE PUBLIC SECTOR

The government of Costa Rica plays an important role in both the regulation and supply of transportation services. Government agencies are involved not only in the construction and maintenance of roads, registration of vehicles, and enforcement of traffic laws, but in the provision of bus, taxi, and rail service (we did not specifically investigate the government's role in air transport). Through ownership of the petroleum monopoly, it is also directly responsible for supplying transportation fuels. Thus, the government is able to influence the efficiency of the vehicle stock and its operation and to create programs for switching from imported petroleum to domestically produced energy sources.

The Ministerio de Obras Publicas y Transporte (MOPT) has primary responsibility for the transportation sector, with broad planning duties for all modes. With respect to highways, MOPT is responsible for road construction and maintenance, and for vehicle registration and regulation. Within MOPT, the Direccion General de Transporte Automotivo is responsible for vehicle inspection. However, there is only one inspection station in Costa Rica, and it checks only a limited number of automobiles. According to the MOPT officials we interviewed, trucks are not checked at all, and for all practical purposes, there is no vehicle inspection program.

Buses and taxis. TRANSMESA is a state company formed in 1976 to provide buses for public transportation. Its most important function is to import buses and resell them to concessioners (bus owners with the right to operate over a certain route). The buses are sold at one-third cost, with no down payment and a 6-year loan at 12-percent interest. TRANSMESA is thus indirectly subsidizing bus fares by lowering the cost to purchase buses. TRANSMESA does not set the fares, however, which are reportedly so low that on 30-40 percent of the routes, the operators cannot recover costs. Recently, TRANSMESA was also made responsible for buying taxis for Costa Rica. Taxi operators must pay full price for their vehicles, but are exempt from import duties.

Together, buses and taxis account for approximately 15 percent of total highway energy use. Given its role as the supplier of all buses and taxis, TRANSMESA is in an ideal position to influence the fuel efficiency of these vehicles. However, design specifications for 100 bus chassis and 300 taxis that TRANSMESA is now buying do not even mention fuel efficiency.

The purchase of parts and supplies for maintenance and repair may provide another opportunity to encourage energy efficient practices. In the past, TRANSMESA has supplied operators with some replacement parts, but not tires. It now intends to import radial tires for intercity buses, using bias ply tires for intracity operations.

TRANSMESA operates a bus garage, but has no "clean room" facility for preventive maintenance of diesel injectors and pumps. The World Bank (January 1984) recommended that assistance be provided to TRANSMESA to construct such a facility. However, the fact that the individual owner-operators, not TRANSMESA, are responsible for bus maintenance represents a potential stumbling block to a preventive maintenance program. Moreover, owner-operators are unlikely to be able to afford more than corrective maintenance.

Railroads. Railroads are the responsibility of the Direccion de Ferrocarriles -- a planning and regulatory agency under MOPT -- but are operated by FECOSA, a government-owned company. The privately-owned Ferrocarriles del Sur will come under FECOSA in 1988. The government apparently assumed ownership of the railroads after private owners in effect "abandoned" them because they were chronically losing money.

Transportation fuels. Transportation fuels, with the exception of electricity use by FECOSA, are supplied by RECOPE, the government-owned petroleum monopoly. Government control of the prices, quantity, and quality of transportation fuels is an important factor, as alcohol or gasohol blends could replace some of the petroleum used in the sector.

The government also wields considerable influence over the transportation sector through taxes and import duties. Import duties range from 30-40 percent for trucks and buses to over 350 percent for certain automobiles. Taxes and subsidies are used by RECOPE to create a fuel price structure. Until December 1980, diesel fuel sold for half or less than half the price of gasoline. In 1981, diesel prices were raised to two-thirds of the gasoline price and now stand at about 80 percent of gasoline's price. The prices of both fuels are now well above world market price.

THE PRIVATE SECTOR

There are three basic categories of private sector groups in Costa Rica's transportation industry: (1) transportation companies, (2) cooperatives, and (3) individual owner-operators. Cooperatives are most prevalent in taxi and bus transportation, while all three are important in trucking.

Cooperatives are voluntary organizations of individuals who join together to gain economies of scale in purchasing replacement parts to facilitate recordkeeping, management, maintenance and repair, and to augment their influence. Cooperatives undoubtedly play an important role in helping individuals deal with the government, especially taxi and bus drivers who must deal with public-sector agencies to obtain a concession or even buy a vehicle. Cooperatives may be small or large. COOPETICO, for example, claims to represent a majority of all taxi drivers in Costa Rica. In San Jose, where there are about 1,500 taxis, COOPETICO has about 900 members.

In some instances, transportation cooperatives have joined together to form larger organizations. One example is COTRACOOP, a consortium of bus cooperatives owning a total of 102 buses operating in the San Jose area. Each cooperative has a representative on COTRACOOP's board of directors. The consortium acts as an intermediary between the government and bus patrons to ensure adequate service. Its stated objective is to provide service at the lowest possible cost. COTRACOOP is able to make use of the "Law of Cooperatives," which provides a waiver of taxes for cooperatives.

COTRACOOP is large enough to operate its own maintenance facility as a benefit to its members. With 10-15 mechanics, maintenance can be carried out on four buses at a time. The consortium does some engine overhauls and even some preventive maintenance, consisting of tests of steering, brakes, tire pressure, and the electrical system. However, it lacks equipment to do much of the necessary preventive maintenance, such as wheel alignment or anything requiring a hydraulic lift. Moreover, it has no clean room facility and thus cannot carry out effective maintenance of pumps and injectors. Occasionally, COTRACOOP goes to commercial shops to have overhauls done, but not preventive maintenance of pumps and injectors, which is too expensive.

Major private companies and privately organized cooperatives dominate the trucking industry, with no apparent direct role for the government. GASH, one of a few large trucking firms in Costa Rica, is privately owned and operated and has a fleet of 56 tractors and 75 trailers. It operates primarily between San Jose and Limon, and San Jose and Calderas. GASH has contracts with three container firms, including SEALAND. In the SEALAND agreement, which is typical, SEALAND provides both the container and trailer chassis, contracting with GASH to transport the full container to San Jose from Limon and bring it back empty. GASH charges a round-trip tariff for this service, so it has no incentive to try to reduce empty backhauls.

GASH has its own maintenance shop in which most repairs and maintenance are carried out. It does not repair injectors, but sends them out to local shops that specialize in such repairs. According to a GASH representative, there are about 20 local firms capable of doing repairs on injectors and fuel pumps. We visited one shop where injector and pump maintenance were carried out and found that the necessary equipment was available but that strict "clean room" conditions were not maintained. Nonetheless, clients of such shops seem to have a uniformly high opinion of the quality of the mechanics and the repair work done by private shops in Costa Rica.

UNITRACSA, an organization of truckers, is neither a cooperative nor a company. Although it is made up of individual owners like a cooperative, it insists that it is a union of truckers, not a cooperative. UNITRACSA's primary purpose is to serve as an intermediary between truckers and shippers (customers). It provides working capital to finance trips as well as administrative services such as accounting and insurance. Members typically own two to five trucks; the union claims a total of 120 tractors. About 75 percent of UNITRACSA's business is between San Jose and Limon, with most of the rest between San Jose and Calderas.

Most of the major transportation companies, cooperatives, and unions are apparently members of the Camara Nacional de Transportes, a voluntary private-sector organization. Although the Camara has been in existence for 35 years, it only began to include freight transporters on April 9, 1984. It seems to be an important group, broadly representing the private sector, whose participation in energy planning for the transportation sector would appear to be essential for the success of any conservation efforts.

TRENDS

In 1982, energy use in Costa Rica's transportation sector amounted to 15,118 terajoules (TJ), according to estimates by RECOPE (see Exhibit 2.a). This use was 48 percent of total secondary energy consumption (electricity, natural gas and gas liquids, petroleum products, alcohol, and charcoal) and 24 percent of total primary and secondary energy use (also includes wood and vegetable residues). Diesel fuel accounted for 63 percent of all energy used in the transportation sector. Gasoline accounted for 32 percent, jet fuel for 4 percent, and alcohol, electricity, and residual for the remaining 1 percent (see Exhibit 2.b and 2.c). Preliminary figures for 1983 indicate a similar pattern.

The use of energy in the transportation sector grew at an annual rate of 10.3 percent annually from 1965 to 1973, and 8.2 percent annually from 1973 to 1979, but declined at an average annual rate of 8.4 percent from 1979 to 1983 (see Exhibits 2.d and 2.e). Diesel fuel use grew most rapidly, accounting for 74 percent of the total increase in transportation energy use between 1965 and 1982.

These fuel consumption statistics are apparently based on RECOPE's customer sales data. As a result, they should be reasonably accurate. We were not able to find out precisely how RECOPE classifies buyers by end-use category or how it compiles fuel use statistics. It would be appropriate for the Direccion Sectorial de Energia (DSE) to determine how the data are compiled, establish their validity and accuracy, and document the data.

MODAL PATTERNS OF ENERGY USE

The availability and reliability of energy use data vary across transportation modes. Railroads account for all electricity use in the transportation sector and minor amounts of diesel fuel and gasoline. Total rail operations used 186 TJ of diesel fuel, 6 TJ of gasoline, and about 1 TJ of gasohol in 1982, which translates into 2 percent of total diesel use and 1 percent of gasoline use. Aircraft account for all transportation use of jet fuel. The highway mode, however, dominates with a 93-percent share of total sectoral energy use (see Exhibit 2.f). Because of this fact, transportation energy conservation policy for Costa Rica must focus on the highway mode.

Exhibit 2.a

Transportation Energy Use by Mode and Fuel Type in 1982 (TJ)

	Air	Rail[1]	Highway[2]	Marine[3]	Total
Diesel	--	186	9,316	2	9,504
Aviation gasoline	188	--	--		188
Gasoline	--	6	4,684	--	4,690
Jet fuel	674	--	--		674
Alcohol	--	1	28	--	29
Fuel oil	--	--	--	8	8
Electricity	--	25	--		25
Total	**862**	**218**	**14,028**	**10**	**15,118**

[1]Includes only FECOSA's operations for liquid fuels.
[2]For diesel, gasoline, and gasohol calculated as a residual by subtracting other uses from total. May therefore include small amounts of marine diesel use, and diesel use by Southern railway operations. Also may include diesel use by agricultural and construction equipment.
[3]Includes only operations of the Tempisque Ferry which is believed by RECOPE to be the major marine fuel user. Sales to foreign vessels, fishing boats, etc. are not included. All fuel oil reported as consumed in the transportation sector was assumed to have been used as boiler fuel in marine vessels.

SOURCE: RECOPE.

Exhibit 2.b

Sectoral Use of Secondary Energy
Costa Rica 1982

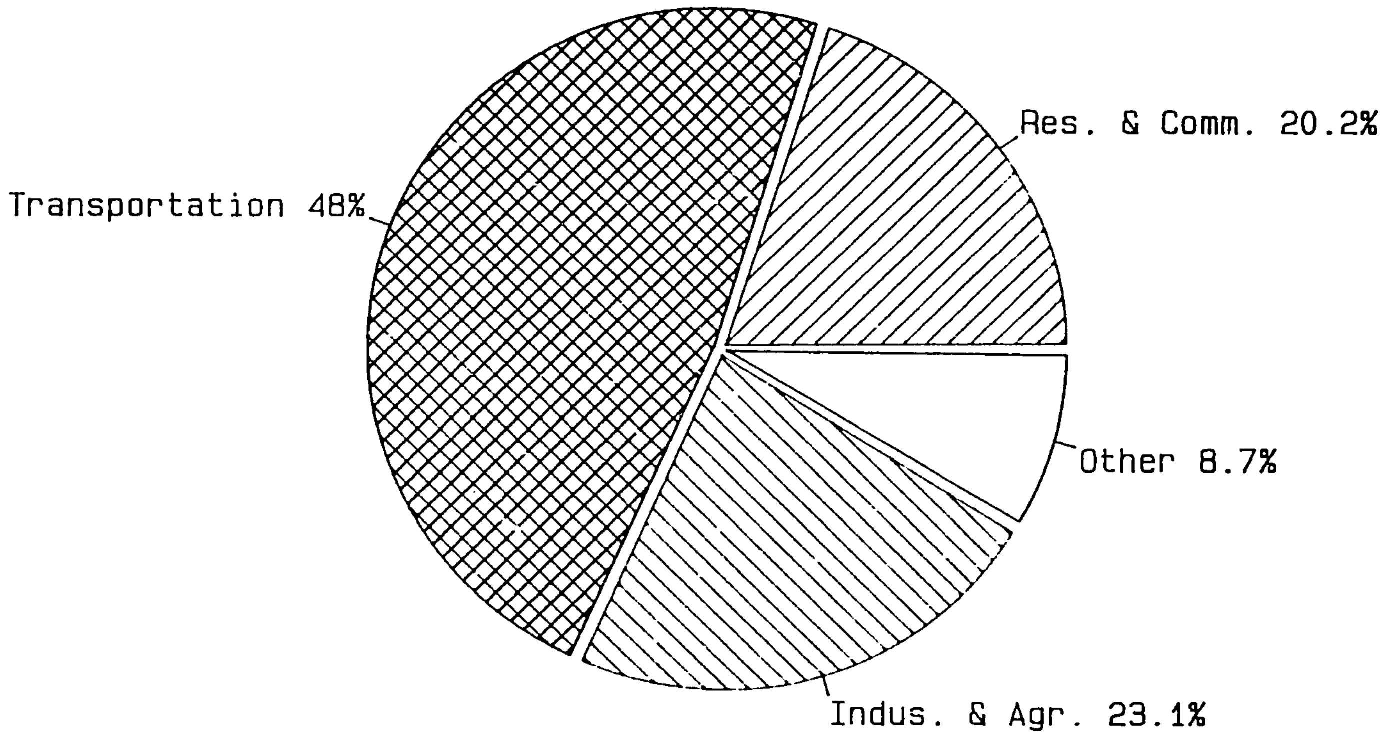


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Exhibit 2.c

Transportation Fuel Use
Costa Rica 1983

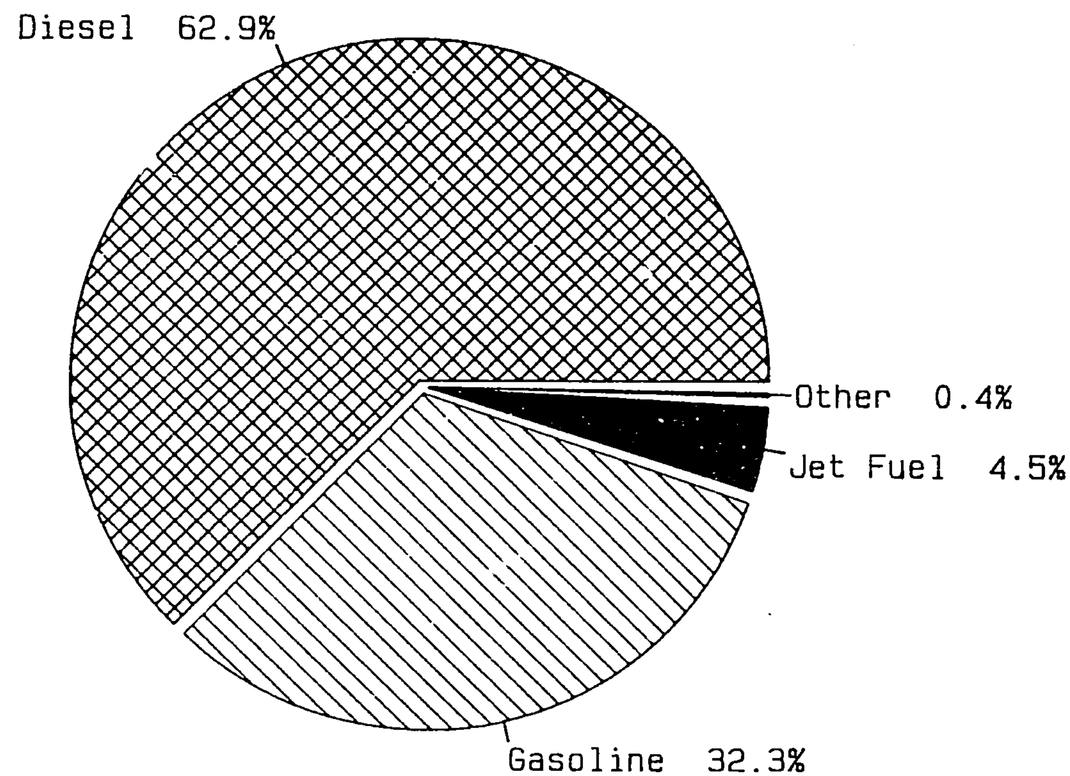

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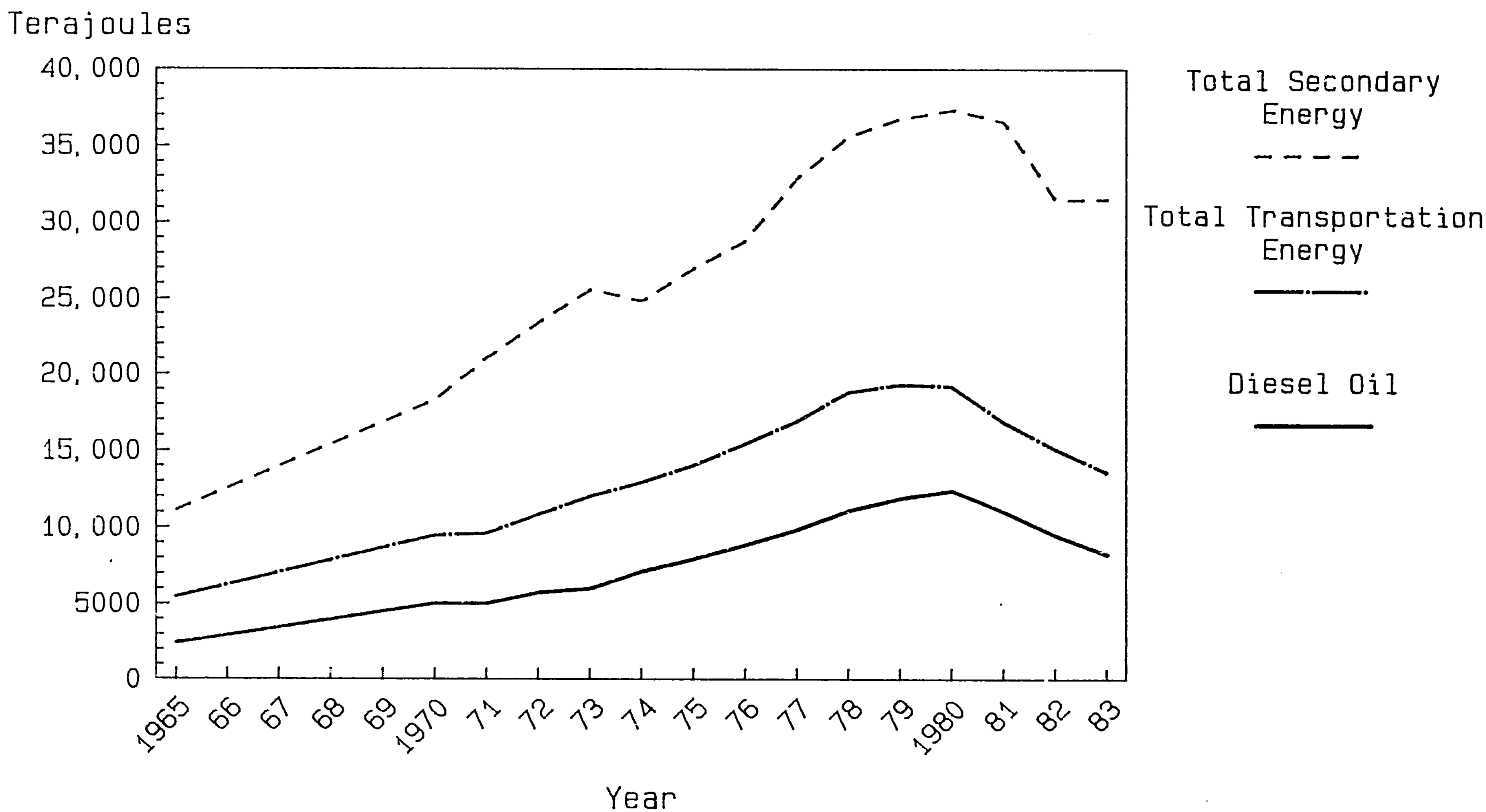
Exhibit 2.d

Transportation Energy Use in Costa Rica



Source: Secretaria Ejecutiva de Planificacion, Sectorial de Energia, Republica de Costa Rica, August 1981

Exhibit 2.e

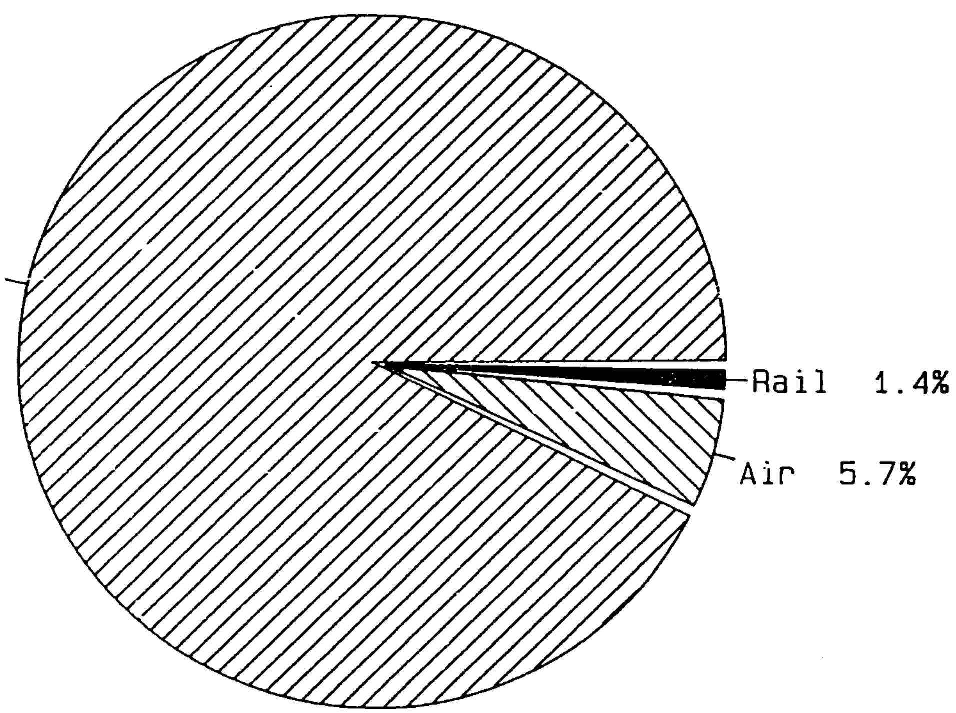
Energy Use in the Transport Sector by Fuel Type (TJ)

		Electricity	Gasoline	Jet fuel	Diesel oil	Fuel oil	Alcohol	Total
1983	Transport	42	4,727	553	8,261	8	13	13,604
	Total (preliminary)	7,988	5,049	1,122	11,313	4,329	13	31,560
1982	Transport	25	4,873	674	9,504	8	29	15,118
	Total	7,457	4,878	1,131	10,715	5,330	29	31,498
1981	Transport	42	5,053	708	11,045	0	33	16,881
	Total	7,628	5,053	1,247	13,092	7,394	33	36,538
1980	Transport	29	5,803	938	12,435	0	0	19,205
	Total	7,072	5,811	1,813	14,173	6,422	0	37,347
1979	Transport	38	6,439	921	11,953	0	0	19,351
	Total	6,452	6,439	1,959	13,636	6,230	0	36,793
1978	Transport	33	6,862	812	11,154	0	0	18,861
	Total	6,074	6,862	1,917	13,419	5,375	0	35,657
1977	Transport	38	6,285	703	9,914	0	0	16,940
	Total	5,493	6,289	1,582	12,255	5,434	0	32,917
1976	Transport	38	5,991	557	8,897	0	0	15,483
	Total	5,141	5,991	1,453	10,262	4,417	0	28,860
1975	Transport	33	5,606	444	7,988	0	0	14,072
	Total	4,765	5,610	1,239	9,387	4,417	0	27,018
1974	Transport	33	5,355	410	7,172	0	0	12,970
	Total	4,564	5,355	1,197	8,198	4,086	0	24,857
1973	Transport	38	5,577	398	6,041	0	0	12,054
	Total	4,191	5,577	1,323	8,490	4,212	0	25,605
1972	Transport	42	4,819	230	5,782	0	0	10,873
	Total	3,965	4,823	1,130	7,742	3,655	0	23,425
1971	Transport	42	4,283	285	5,037	0	0	9,646
	Total	3,592	4,287	1,176	6,925	3,731	0	21,055
1970	Transport	42	4,120	285	5,066	0	0	9,512
	Total	3,199	4,120	1,105	5,765	3,157	0	18,329
1965	Transport	38	2,842	193	2,420	0	0	5,493
	Total	2,018	2,842	695	3,166	1,645	0	11,149

SOURCE: Secretaria Ejecutiva de Planificacion, Sectorial de Energia, "Anuario Estadistico del Sector Energia, Año 1980," and supplementary tables, Republica de Costa Rica, August 1981.

Exhibit 2.f

Modal Shares of Transportation Energy Use
Costa Rica 1982



Highway Energy Use

Since the highway mode accounts for nearly all the energy used in the transportation sector, more detail on this mode is needed. We obtained our highway energy use estimate of 14,028 TJ by subtracting incomplete esitmates of other modes' energy use by fuel type from the reported total sales by fuel type to the transportation sector. We based our estimate on certain assumptions, which need to be verified. We assumed that aviation gasoline sales **are** included in total transportation sector gasoline sales. In addition, it is likely that gasoline and diesel fuel use by off-road agricultural and construction equipment is included in the totals for transportation diesel and gasoline sales.

The only direct source of information on energy use by type of highway vehicle is data on taxi and bus energy use provided by TRANSMESA. Other estimates have been derived by multiplying the number of registered vehicles of each type by crude estimates of average annual usage and fuel consumption rates:

Fuel use = (no. of vehicles) x (annual kms/vehicle) x (liters/100 km).

MOPT keeps records on the number of vehicles registered by type of vehicle and fuel type (see Exhibit 2.g). At least two attempts have been made to use these data to estimate fuel consumption by vehicle type. The most recent, prepared by MOPT, is represented in Exhibit 2.h. The chief shortcoming of this method is that the annual use and average fuel efficiency data for most vehicle types are no better than educated guesses. If the estimates are carefully made, they should be accurate to roughly ±33 percent. While this is a very broad range, it can at least indicate which energy users are the large ones and which the small ones. Data from a similar table prepared for 1981 are shown in summary form in Exhibit 2.i. In that year, heavy vehicles were clearly the big energy users. Roughly half of highway energy use was attributed to trucks, buses, and special vehicles, with trucks capturing about a 30-percent share of the total.

Light vehicles were second in importance, claiming nearly 40 percent of highway energy use. Together, pickup trucks and automobiles/station wagons account equally for about one-fourth of total highway energy use. Jeeps and taxis claim about 5-percent each, while medium-weight trucks and microbuses together account for about 10 percent of highway energy use.

Because, as these estimates indicate, highway energy use is dispersed among different vehicle types, it is not possible to introduce simple sweeping conservation measures. Instead, a diversified approach targeting all vehicle types and user groups will be required to achieve significant energy savings.

Finally, there are two major problems with the data presented in Exhibit 2.h. First, they do not match fuel sales to the transportation sector as reported by RECOPE. As Exhibit 2.j demonstrates, highway diesel use is

Exhibit 2.g

Motor Vehicles in Circulation According to Category of Service and Type, April 1984

Passenger	101,533	(48%)		
Automobile			58,710	(28%)
Station wagon			12,561	(6%)
Jeep			30,262	(14%)
Cargo	62,579	(29%)		
Pick-up			44,851	(21%)
Panel van			5,578	(3%)
Truck				
Tractor			1,904	(1%)
Other			8,342	(4%)
Buses	3,320	(2%)		
Microbus			387	(0%)
Bus			2,933	(1%)
Taxi	1,792	(1%)		
Motorcycles and mopeds	32,724	(15%)		
Motorcycles			28,413	(13%)
Mopeds			4,311	(2%)
Special Equipment	10,890	(5%)		
Agricultural			7,729	(4%)
Non-agricultural			3,161	(1%)
Total	**212,838**			

SOURCE: MOPT.

Exhibit 2.h

Estimated Average Annual Consumption of Fuel by Vehicle Type in 1983

Type of vehicle	Number of vehicles		Consumption (liters/km)[1]		Annual travel (km)[2]		Total consumption (liters/year)		Percent	
	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline
Automobile	1,148	55,666	0.088	0.115	11,000	7,000	1,111,264	44,811,130	0.36	30.92
Pick-up	16,549	27,730	0.104	0.135	13,000	9,000	22,374,248	33,691,950	7.25	23.25
Panel	169	5,364	0.104	0.135	12,000	9,000	210,912	6,517,260	0.07	4.50
Jeep	15,479	13,693	0.100	0.130	12,000	9,000	18,574,800	16,028,810	6.02	11.06
Station wagon	123	12,053	0.092	0.120	10,000	7,000	113,160	10,124,520	0.04	6.99
Truck	10,312	1,319	0.366	0.475	41,000	30,000	154,741,872	18,795,750	50.12	12.97
Special equipment	9,731	324	0.700	0.910	7,000	5,000	47,681,900	1,474,200	15.44	1.02
Microbus	115	257	0.220	0.280	100,000	80,000	2,530,000	5,750,800	0.82	3.97
Bus	2,722	146	0.233	0.300	57,000	35,000	36,150,882	1,533,000	11.71	1.06
Taxi	1,384	395	0.172	0.224	106,000	70,000	25,233,089	6,193,000	8.17	4.27
Total	**57,732**	**116,947**					**308,722,126 (11,218.96 TJ)**	**114,927,020 (4,733.32 TJ)**		

Sales of diesel to transport sector reported by RECOPE 1983 = 8,361 TJ.
Sales of gasoline to transport sector reported by RECOPE 1983 = 4,727 TJ.

[1]Data on consumption per kilometer were estimated using engineering curves for speed versus velocity for various sized vehicles in the United States and do not necessarily represent actual conditions in Costa Rica.

[2]Estimated.

SOURCE: MOPT, Department of Economic Studies, General Planning.

Exhibit 2.i

Highway Vehicle Consumption by Vehicle Type, 1981

	Consumption (TJ)		Percent	
Light vehicles		7,126.3		38.5
Automobile/station wagon	2,243.6		12.1	
Jeep	1,211.0		6.6	
Taxi	1,024.8		5.5	
Moto	3.5		0.0	
Pick-up	2,387.0		12.9	
Panel	256.4		1.4	
Medium vehicles		2,068.4		11.2
Microbus	493.4		2.7	
Medium truck	1,575.0		8.5	
Heavy vehicles		9,290.5		50.3
Heavy truck	5,478.0		29.6	
Bus	1,883.5		10.2	
Special vehicles	1,929.0		10.4	
	18,485.2		**99.9**[1]	**100.1**

[1]Does not add to 100.0 due to rounding.

SOURCE: Table provided by Ing. Alexandra Hernandez Carrillo of Direccion Sectorial de Energia, original source not known.

Exhibit 2.j

Comparison of Estimated Highway and Reported Transportation Sector Diesel and Gasoline Use (Terajoules)

	1981		1983	
	Estimated highway	**RECOPE total (% difference)**	**Estimated highway**	**RECOPE total (% difference)**
Gasoline	5,513	5,053 (+9.1%)	4,733	4,727 (+0.1%)
Diesel	12,973	11,045 (+17.5%)	11,219	8,261 (+35.8%)

considerably overestimated. The difference ranges from 18 percent in 1981 to 36 percent in 1983, even before removing non-highway diesel use from the RECOPE estimate. The increased gap between estimates and actual consumption is directly attributable to the assumption that vehicle use is constant. In fact, commercial vehicle use has probably declined sharply as a result of the country's economic crisis.

Second, assumptions about fuel efficiencies and annual usage are generally no better than rough guesses, undocumented and unverified. Certain individual items of data are known to be substantially in error. For example, Exhibit 2.h reports taxi fuel efficiencies of 0.172 liters/km for diesel and 0.224 liters/km for gasoline. However, we obtained much lower estimates from COOPETICO, the country's major taxi cooperative, and from the National Chamber of Transporters -- 0.146 liters/km for diesel and 0.154 liters/km for gasoline. Exhibit 2.h reports an estimated fuel efficiency for diesel heavy trucks of 0.366 liters/km. However, estimates obtained from a major trucking firm (GASH) and a major truck operators' (Unitracsa) were around 6 km/gallon, or 0.631 liters/km, for their tractor trailers. The bus efficiency estimates that we obtained were within the 2.25-2.8 km/liter range, or about 0.4 liters/km, much higher than the estimates used in Exhibit 2.h.

Still another set of estimates was obtained from TRANSMESA for buses and taxis (see Exhibit 2.k). These data contradict the MOPT vehicle registration data as well as the fuel efficiency and annual usage data. Estimated taxi fuel consumption is less than half that shown by MOPT, despite the fact that MOPT shows 10 percent more taxis. Moreover, although TRANSMESA shows nearly 30 percent fewer buses, its estimate of bus fuel use is 25 percent higher than that of MOPT because of a much higher rate of fuel use per kilometer.

All of this serves to emphasize the shortcomings of such a method of estimating fuel use. Errors may be present in the estimation of stock as well as vehicle use and efficiency, about which there is little direct information. Until these questions are resolved, the available data should be used only to indicate the general magnitude of energy use by type of vehicle. Nonetheless, the order of priority should be trucks, light duty private vehicles, buses, and then taxis.

HIGHWAY VEHICLE STOCK: STRUCTURE, PURCHASES, AND EFFICIENCY

Improving the efficiency of the vehicle stock is a longer-term energy conservation strategy that must be considered in any transportation energy conservation program. Unlike maintenance and operating strategies, the improvement of vehicle efficiency will conserve energy despite changes in fuel prices or consumer attitudes. What is more, its effects will last for 10 years or more. The potential to improve the efficiency of the vehicle stock in Costa Rica appears to be substantial, but it is difficult to quantify because detailed data on the existing fleet structure are not available. However, the results of our interviews, together with passing observations

Exhibit 2.k

Estimates of Bus and Taxi Operations, Efficiencies, and Fuel Use According to TRANSMESA

Vehicle type	Number	Efficiency (l/km)	Average (kms/yr)	Annual fuel use (liters)
Buses				
San Jose	540	0.3721	49,159	9,877,715
Rest	1,440	0.4505	55,952	37,594,621
Total	**1,980**	**0.4316**	**55,554**	**47,472,336**
Taxis				
San Jose	1,120	0.1000	87,000	9,744,000
Rest	492	0.1310	50,220	3,236,779
Single taxis	38	0.1052	73,344	293,200
Total	**1,650**	**0.1062**	**75,718**	**13,273,979**

SOURCE: Lic. William Cubillo, Director, Direccion General Estudios Tecnicos, Ministerio de Obras Publicas Y Transportes, San Jose, Costa Rica, June 5, 1984.

of the vehicle stock and knowledge of its composition by vehicle type and engine size by number of cylinders (see Exhibit 2.1), suggest that efficiency improvements on the order of 25-50 percent should be attainable for light duty vehicles. The light vehicle fleet contains almost no minicars (less than four cylinders), but has a large number of four cylinder engines, along with some six and eight cylinder engine vehicles.

Since 1980, the introduction of new vehicles into Costa Rica has all but stopped (see Exhibit 2.m), partly as a result of higher import duties for larger automobiles but mainly because of the economic crisis. The assembly of automobiles in Costa Rica accounted for almost one-third of all introductions into the country in 1977. Domestic production, which stopped in 1982 because of the economic crisis, could provide an opportunity to supply the most energy efficient vehicles possible to Costa Rican consumers if it were resumed.

Exhibit 2.1

Vehicles in Circulation by Number of Cylinders
(Believed to be 1983 data)

	Number of cylinders									
	1-3		4		6		8		Unknown & other	
	Diesel	**Gasoline**	**Diesel**	**Gasoline**	**Diesel**	**Gasoline**	**Diesel**	**Gasoline**	**Diesel**	**Gasoline**
Automobile and station wagon	7	773	830	49,194	139	5,166	29	1,695	284	949
Pick-up and panel trucks	11	284	10,876	27,194	4,320	2,023	418	448	205	1,997
Jeeps	7	982	13,766	7,228	461	3,277	6	883	101	324
Taxis	0	0	1,366	372	33	10	0	0	5	0
Trucks	13	95	2,740	973	7,305	317	609	89	1,002	216
Buses	1	0	518	46	1,950	78	335	38	249	19
Total	**39**	**2,134**	**30,096**	**85,007**	**14,208**	**10,871**	**1,397**	**3,153**	**1,846**	**3,505**

SOURCE: Direccion General de Planificacion del MOPT.

hibit 2.m

pports of New Vehicles 1975-1982

	Finished vehicles						
AÑO	Automobiles[1]	Cargo[2]	Jeep	Buses[3]	Equipment[4]	Motorcycles[5]	Total
975	415	4,302	273	395	589	2,426	8,400
976	374	5,227	205	277	768	3,529	10,380
977	1,462	7,615	16[illegible]	423	714	5,583	15,964
978	817	9,973	314	572	751	5,575	18,002
1979[6]	4,508	10,053	1,612	297	948	6,431	23,849
980	2,019	5,473	772	783	515	4,340	13,902
1981	577	2,736	322	400	187	2,553	6,775
982	244	72	72	333	63	314	1,098

Includes automobiles and station wagons.
Includes light and heavy cargo vehicles: panel vans, pickup trucks, trucks of all types and chassis with motor.
Includes all types of motor vehicles for commercial transport of persons and the chassis without motors.
Comprised of tractors and like equipment for agricultural farms.
Includes motorcycles and mopeds.
Preliminary data.

OURCE: MOPT.

Exhibit 2.m (continued)

Imports of New Vehicles 1975-1982

	Vehicles for assembly					
AÑO	**Automobiles[1]**	**Cargo[2]**	**Jeep[3]**	**Buses[4]**	**Motorcycles[5]**	**Total**
1975	1,140	983	1,919	9	156	4,207
1976	1,496	1,263	2,099	35	122	5,015
1977	2,110	1,194	3,618	--	105	7,027
1978	2,707	1,078	3,200	1	108	7,094
1979	3,318	951	1,500	5	4	5,778
1980	4,496	412	1,211	1	553	6,673
1981	3,201	--	48	--	176	3,425
1982	--	--	--	--	--	--

[1]Includes automobiles and station wagons.
[2]Includes light and heavy cargo vehicles: panel vans, pickup trucks, trucks of all types and chassis with motor.
[3]Includes all types of motor vehicles for commercial transport of persons and the chassis without motors.
[4]Comprised of tractors and like equipment for agricultural farms.
[5]Includes motorcycles and mopeds.

SOURCE: MOPT.

The efficiency of energy use (services produced/energy input) can be improved by more efficient operation of existing vehicles or by changing the composition of the stock so that it consists of more efficient vehicles. In Costa Rica, significant opportunities exist for energy conservation via both short-term operational improvements and the long-term improvement of the vehicle stock. Below, the need for awareness of the effect of vehicle operation and maintenance on fuel efficiency is discussed, followed by an examination of actions the government can take to improve vehicle efficiency.

ENERGY CONSERVATION INFORMATION, EDUCATION, AND DEMONSTRATIONS

We found vehicle owners and operators to be generally unaware of the effect of vehicle characteristics, vehicle maintenance, and driver behavior on energy efficiency. Neither truck, bus, nor taxi operators were aware, for example, that radial tires saved fuel. Time and again we were told that neither special lubricants nor special additives were used to counteract sulfur, reduce wear, or save fuel. We were also told by more than one source that it was a frequent practice to remove the thermostat in trucks and buses that overheated so that the engine would run cooler.

Moreover, basic engineering factors that affect vehicle fuel economy -- such as the fact that fuel economy is generally reduced by 1 percent for each 9°F that an engine is below fully warmed-up operating temperature -- are apparently not widely understood. We asked nearly everyone we spoke to for their suggestions on how to improve energy efficiency. Only occasionally were well-known conservation actions mentioned. The exceptions were driver training and improved maintenance, which were mentioned several times. There seems to be widespread support for driver training as a means of reducing operating costs.

Finally, there is no general source of information on vehicle fuel economy to assist car buyers in making a rational choice. We believe that a government information program designed to tell private individuals, transportation companies, and operators of government vehicles how to achieve maximum fuel efficiency through vehicle purchase, maintenance, and operation should be a cornerstone of transportation energy conservation policy.

The government should develop a comprehensive information program that includes the following three components:

1. Fuel economy information
2. Energy conservation awareness
3. Fuel economy demonstrations.

The chief obstacle to the success of a conservation program is the lack of financial resources on the part of transport companies. Many operators say that because of Costa Rica's economic crisis, they are unable to do any preventive maintenance or to cover depreciation costs of their equipment. At present, only short-run marginal costs are being covered, which will make it extremely difficult for commercial transporters to adopt any conservation action that does not have an extremely low cost or a payback of a few months or less, unless outside financial assistance is available. These considerations must be kept in mind in designing driver training and information programs.

Fuel Economy Information

To make rational trade-offs between fuel economy, purchase price, and other vehicle attributes, consumers need a reliable source of fuel efficiency information that constitutes a consistent basis for comparison among vehicles. Vehicles may already have been subjected to international fuel economy tests (such as the various DIN cycles). If not, manufacturers marketing vehicles in Costa Rica could be required by the government to supply the standard test cycle fuel economy data for each vehicle. We are not suggesting, however, that the Costa Rican government begin a full-scale fuel economy testing program.

Once obtained, the information should be made readily available to the public, by such means as product labels, pamphlets, and newspapers.

Energy Conservation Awareness

The energy efficiency of a fleet of vehicles can be affected significantly by the way it is maintained and operated. Estimates of potential savings range from 5-percent upward, depending on the condition of the vehicle. Conservation actions that vehicle owners and operators can take to improve energy efficiency include:

- Energy conserving maintenance (e.g., tune-ups, oil and air filter changes, wheel alignment, brake adjustment)
- Maintaining correct tire inflation pressure
- Using radial tires
- Eliminating unnecessary vehicle weight
- Purchasing efficient vehicles
- Using fuel efficient equipment rather than fuel consumptive optional equipment
- Driving in a fuel-efficient manner

- Driving at efficient speeds
- Ridesharing.

Some of the conservation activities that seem appropriate for Costa Rica are provided in Exhibit 3.a. Energy savings estimates taken from the literature are provided for illustration; actual savings would depend on the specific features of each activity.

Information programs should be aimed at specific transportation groups, including the following:

- General vehicle-owning public
- Bus cooperatives and private owners
- Taxi cooperatives and private owners
- Trucking companies, truck cooperatives, and private owners.

Programs designed to assist commercial transporters (bus, taxi, truck) should be developed in cooperation with the appropriate private-sector organizations. In this way, organizations such as the National Chamber of Transporters, major trucking firms such as GASH, and major trucking organizations such as UNITRACSA can be involved in the design and implementation of truck fuel economy programs. In our interviews with these organizations, we found a high level of interest in fuel efficiency information and a willingness to insist that operators learn about fuel efficiency.

The TRANSMESA representative we spoke to recommended that drivers be trained to adjust to traffic and road conditions in order to conserve fuel. GASH's general manager said that, in his opinion, driver training would be the most important factor in fuel economy. He noted that GASH had previously brought in an outside lecturer to train drivers in operating the vehicles, and said that this should be done for fuel economy. UNITRACSA officials also endorsed better driver training as a means to improve fuel efficiency. They said that a great deal of fuel was wasted through bad driving habits and pointed out that the training course to obtain a trucker's license does not cover fuel economy. In fact, they observed, there is no driver training course for fuel economy. These officials believed there might be some resistance from drivers, but they pointed out that drivers could be obliged to participate. COTRACOOP, the large bus cooperative, also cited driver training as a top priority for improving fuel economy and added that it does not now offer any formal driver training.

Professional driver training programs should cover the following topics:

- The effect of driver behavior on fuel consumption, and the further benefits of fuel-efficient driving (greater safety, reduced fatigue)
- An understanding by the driver of the mechanical principles of his vehicle and thus the causes of fuel waste

Exhibit 3.a

Energy Conservation Opportunities for Road Vehicles in Costa Rica

	Estimated[1] fuel saving (%)
Driver training	
Improve driving behavior	6.0
Operations	
Clearing house for return loads	
Reduce vehicle weight	
Improve air intake and exhaust equipment	0.5
Recycle oil for diesel fuel extender	
Suggestion plans	
Maintenance	
Tune engine regularly	1.5
Maintain engine regularly	
Check wheel alignment regularly	
Maintain proper tire pressure	4.0
Over-inflate tires	
Use proper lubricants	0.5
Use lubricant additives to reduce friction	2.0
Adjust governor for maximum fuel efficiency	
Maintain correct coolant temperature	
Equipment	
Use radial tires	3.0
Improve air intake and exhaust equipment	
Systems	
Rotating vehicle "holidays" by licence plate number	
Stagger work hours	
Operate express buses	
Operate alternative higher-grade bus service	
Collect fares outside bus	
Adjust off-peak schedules	
Permit right turn on red	
Demand-actuated traffic signals	
Share taxis	
More taxi stands	
All urban traffic flow improvement	3.0
Road conditions	
Improve roads (3% for medium to good surface improvement)	
Combined savings	**18.9**

[1]Based on literature.

- A demonstration of the effect of speed on fuel consumption
- The concept of a fuel-efficient range of engine operation, and the use of instruments that assist in maintaining operation within this range
- The importance of properly breaking in a new vehicle and of preventive maintenance.

Professional drivers can be trained by means of classroom instruction combined with instruments installed in the truck cab. Also, they can be provided with incentives that will reward fuel-efficient driving on a continuing basis.

Cooperatives, firms, and unions could be invaluable partners in a government-initiated driver energy conservation program. These organizations are keenly aware of the economic benefits of reducing fuel consumption. Cost breakdowns based on actual operations of GASH and UNITRACSA show that fuel accounts for 30-40 percent of operating costs (see Exhibit 3.b). COTRACOOP officers indicated that their fuel costs represent 40 percent of their members' operating costs.

Fuel Economy Demonstrations

In addition to the information and education efforts, it would be extremely useful to conduct demonstrations as a means of convincing vehicle owners and operators that energy efficient practices will work and be cost-effective in Costa Rica.

For example, a demonstration program could be organized to prove the fuel savings that can be obtained by using radial tires. While radial tires have gained broad acceptance worldwide, most such tires in Costa Rica were supplied as original equipment on imported cars. Because there is no longer any local car assembly, however, the number of radial tires in use is gradually increasing as new imports enter the vehicle stock. Nonetheless, the durability of radial tires (double that of bias ply tires) is the feature emphasized in sales, while the fuel efficiency aspect is ignored. Few drivers and operators are aware that radial tires are more fuel efficient, and even the manager of Quiros y Cia., a major tire distributor, did not know of this feature.

Officials of Firestone, the only tire manufacturer in Costa Rica, said that steel-belted radial tires were unsuitable for the country's rough road conditions, and the company thus produces textile radial tires (for passenger cars only). Firestone will soon introduce steel-belted radial tires, however, largely to meet foreign competition. Another obstacle to the use of radial tires is their cost. Potential buyers perceive a cost different of about 60 percent, but we found that radial tires are only 25 percent more expensive than bias ply tires in Costa Rica. Some bus and taxi operators in Costa Rica report good experience with steel-belted radial tires, but have not evaluated the effect on fuel efficiency. Truck operators expressed a belief that radials were too delicate for rough Costa Rican roads, and others mentioned that radials could not be retreaded, which was a necessity. In fact, we found that the commercial Bandag (TM) retreading process was available.

Exhibit 3.b

Truck-Freight Operating Cost Structures

GASH

Category	Percent
Fuel	39.3
Maintenance	17.5
Administration	11.6
Depreciation	11.3
Salaries	6.5
Tires	3.4
Insurance	2.6
Lubricants	1.8
Other	6.0

UNITRACSA

Category	Percent
Fuel	34.0
Tires	25.0
Depreciation	13.0
Salary	3.0
Other	24.0

VEHICLE STOCK EFFICIENCY IMPROVEMENT

Providing individual consumers with the information necessary to discriminate between efficient and inefficient vehicles will make a significant contribution to improving vehicle fuel economy over the long run. There are also direct actions that the government of Costa Rica can take to create a more energy-efficient vehicle stock. The government owns a significant number of vehicles itself, and more importantly, a government agency -- TRANSMESA -- has sole responsibility for buying all buses and taxis. TRANSMESA can thus directly determine the efficiencies of the taxi and bus fleets. The government also imposes substantial taxes and import duties on motor vehicles, such as the 200-percent duty on automobiles with engines over 1,200 cc. There appear to be major loopholes, however, and it is not clear that the present tax structure is efficient. A study to rationalize vehicle taxes and duties could develop more effective incentives to improve vehicle efficiencies.

Government and Institutional Vehicle Purchases

In Costa Rica, government agencies own 3,677 vehicles and large institutions own an additional 3,519 (see Exhibit 3.c). Seventy-five percent of the institutional vehicles are held by six institutions. In addition, the nearly 12,000 taxis and buses account for 7 percent of Costa Rica's 169,000 highway vehicles (excluding motorcycles). Furthermore, taxis and buses consume disproportionately large shares of fuel because of their intensive use. All government agencies and large institutions should be required to adopt purchasing practices that will increase the fuel efficiency of their vehicle stocks.

TRANSMESA offers a unique opportunity to conserve energy through the purchase of more efficient vehicles, as it is responsible for writing specifications for and effecting the purchase of all taxis and buses. Current specifications call for buses with larger engines than those now in operation and taxis with diesel engines of at least 2,200 cc and five-passenger capacity. In our interviews, however, taxi cooperative managers said that vehicles with capacities of less than five passengers would be adequate for virtually all missions and that 1,500-1,800 cc engines would more than suffice. Taxis with 2,200 cc engines achieve efficiencies no better than 11 liters/100 km, according to taxi cooperative records. This rate could be reduced by one-third through the use of a more fuel-efficient vehicle, as shown in Exhibit 3.d. The calculations, although crude, indicate that savings on the order of five million liters annually could eventually be achieved.

The case of buses is more complex. Most buses have been purchased as chassis, with the coachwork being done in Costa Rica. Moreover, Mr. Uri Migdal, an engineering advisor to TRANSMESA, maintains, and the union of bus cooperatives COTRACOOP agrees, that in many applications a larger bus engine would conserve energy by allowing a heavily loaded bus to operate in higher gears and at lower engine loading. This contention may be true, even though smaller engines generally consume less fuel, because operation in higher gears is more efficient than in lower gears and engine efficiency generally decreases with increasing RPM above about 1,000-

Exhibit 3.c

Government and Institutional Vehicles (1984)

Institution	Total vehicles
Government vehicles	
Hacienda	169
Trabajo	47
Economia	21
Salud	51
Policia	347
Transporte	1,452
Relaciones Exteriores	70
Educacion	51
Seguridad Publica	341
Presidencia	55
Cultura Juventud Y Deportes	123
Justicia	99
Agricultura	911
Total	**3,677**
Institutional vehicles	
Banco Anglo Costarricense	31
Banco Central de Costa Rica	29
Banco Credito Agricola de Cartago	12
Banco de Costa Rica	63
Banco Nacional de Costa Rica	60
Banco Popular Y Desarrollo Com.	1
Comison Nal. de Prest. Para La E.	1
Instituto de Fomento Y Ases. Munic.	21
Instituto Nac. de Fom. Cooperativo	23
Instituto Nacional de Seguros	272
Instituto Nacional de Produccion	153
Empresa Serv. Publicos He.	19
Instituto Cos. Acued. Alcantarillados	380
Instituto Cost. de Electricidad	1,346
Inst. Cost. de Puertos Del Pacifico	21
Inst. Nacional de Vivienda Y Urb.	37
Junta Adm. Serv. Elect. de Cartago	42
Junta Adm. Portua. Y Desa Economico	44

Exhibit 3.c (continued)

Government and Institutional Vehicles (1984)

Institution	Total vehicles
Institutional vehicles (continued)	
Caja Cost. de Seguro a Social	328
Comision Nac. De Asunto In.	4
Consejo Nac. de Invest. Cientifica	7
Consejo Nac. de Rectore	1
Consejo Nac. Rehabilitacion Y Educ.	1
Editorial Costarica	4
Instituto Cost. Invest. Ensen. Nut.	8
Instituto Costarricense de Turismo	14
Instituto Mixto de Ayuda Social	76
Instituto Nacional de Aprendizaje	88
Instituto de Tierras Y Colonizacion	11
Instituto Technologico de Costa Rica	38
Junta Adm. Direc. Nac. de Comunicacion	15
Ministerio de Gobernacion	4
Junta Pensiones Jubilaciones Del Magis.	1
Junta de Proteccion Social de San Jose	9
Junta de Proteccion Social de San Jose	5
Oficina Del Cafe	31
Oficina Del Cafe	1
Oficina Nac. de Semillas	6
Patronato Nacional de La Infancia	38
Serv. Nac. de Aguas Subterraneas	29
Ser. Nac. de Electricidad	20
Universidad de Costa Rica	158
Universidad Estatal A Distancia	23
Universidad Nacional	44
Total	**3,519**

SOURCE: DSE.

Exhibit 3.d

Estimated Long-Run Energy Savings
of More Efficient Taxis

Number of taxis	1,650	SOURCE: TRANSMESA, 1984
Annual km/taxi	76,000	SOURCE: TRANSMESA, 1984
Efficiency (1/100 km)[1]	10.52	SOURCE: TRANSMESA, 1984

Total fuel use:

1,650 x (76,000 ÷ 100) x 10.52 = 13.2 million liters

By changing over to, for example, diesel VW Rabbits or Nissan Sentras at 5.01 1/100 km and 4.70 1/100 km (based on U.S. EPA city cycle, 1984) considerable savings would result. These efficiencies are discounted by multiplication by 1.25 to account for lower actual efficiency than on the test cycle.

Total new fleet fuel use:

1,650 x (76,000 ÷ 100) x 5.01 x 1.25 = 7.9 million liters

Total savings = 5.3 million liters, or 40 percent

[1] Interviews with taxi cooperatives and operators indicate that a range of 11-16 1/100 km is more realistic. MOPT used 17 1/100 km in their calculations.

1,500 RPM. Further study is thus needed to determine whether large bus engines would, in fact, save or waste fuel.

As best we could determine, there are no efficiency standards for vehicle purchases by the government or national institutions. Moreover, such vehicles are apparently exempt from the import duties and taxes, which would tend to discourage the purchase and ownership of large vehicles. However, we saw no evidence that government vehicles were generally larger or less efficient than other vehicles. Nonetheless, we believe that the government and major vehicle-owning institutions could easily improve the efficiency of their fleets by 25 percent or more. Through a study of vehicle composition and capacity requirements, the degree of fuel efficiency improvement could be determined.

TAXES AND IMPORT DUTIES TO ENCOURAGE OWNERSHIP OF EFFICIENT VEHICLES

Current import duties on motor vehicles are extremely high for automobiles and light trucks with engine sizes greater than 1,200 cc (see Exhibit 3.e). A surtax of 200 percent of list price is levied on automobiles, jeeps, and pickups with engines over 1,200 cc, while the surtax on engines under 1,200 is only 10 percent. Other taxes (ad-valorem, economic stabilization, and selective consumption) on automobiles, jeeps, and pickups amount to well over 150 percent of list price, while for trucks and buses, only ad-valorem (15 and 22 percent, respectively) and sales taxes (10 percent) apply. The far lower taxes on buses have greatly increased the popularity of microbuses as household vehicles. On used vehicles that are imported, taxes and duties are applied to the depreciated price of the vehicle, which is calculated primarily as a function of the vehicle's age but may also be adjusted by customs according to its state of repair. Used vehicles already in the country are not subject to these taxes, but all vehicles must pay an annual ownership tax. The tax is now a flat rate for each vehicle type, but we are told that the MOPT intends to make the tax a function of vehicle size as soon as it is able to maintain registration databases with the necessary information.

Clearly, there is already a strong disincentive for buying new light vehicles (except microvans) with large engines. In fact, it is difficult to imagine anyone paying taxes of 300-400 percent. Not surprisingly, very few vehicles have been imported in recent years (see Exhibit 2.m). There are loopholes, however, including buying used vehicles imported by people or agencies that are exempt from the duties, or importing used junkers and repairing them in the country. As an energy efficiency policy, the tax structure is crude, at best. A more efficient system could more closely reflect the economic costs of vehicle, fuel, and parts import.

ROAD CONDITIONS

The poor condition of much of the Costa Rican road network affects fuel economy through increased vehicle maintenance requirements, reduced road speeds, greater rolling resistance, and increased changes in momentum. Roads in poor condition are estimated to increase fuel consumption by 30 percent compared with roads in good condition. Few roads in Costa Rica are in good condition.

Exhibit 3.e

New Vehicles Import Duties

Type	Automobiles[1]	Jeep, pickup	Truck	Bus
Hospital	3%	3%		
Stabilization	30%	30%		
Selective consumption	70%	70%		
Sales	10%	10%	10%	10%
Surtax				
greater than 1,200 cc	200%	200%	10%	
less than 1,200 cc	10%			
Consular	1%	1%		
Emergency law	1%	1%		
By kilogram of weight		₡23		
less than 800 cc	₡79			
up to 1,200 cc	₡92			
greater than 1,200 cc	₡1			

[1]Includes taxis.

All calculated on the value of the vehicle with an exchange rate of 44 colones per dollar.

SOURCE: Principal customs official, Ministry of Finance.

In addition, the reduced road speeds diminish the fuel conservation benefits of measures such as engine maintenance, fan clutches, speed governors, and radial tires, and the poor road surfaces prevent consistent operation of engines in the most efficient speed range.

While many factors contribute to the deterioration of roads, by far the most important is usage by vehicles whose axle loadings exceed the design limits of the pavement. Restriction of heavy vehicles from roads not designed for them, tighter control of vehicle weights, and a vigorous road maintenance program, including prioritized repair of potholes, are required to overcome this barrier to better fuel economy.

IN-COUNTRY VEHICLE ASSEMBLY

With the exception of buses, no vehicles are now being assembled in Costa Rica. However, before the economic crisis, in-country vehicle assembly supplied up to one-third of the additions to the vehicle stock. If resumption of in-country vehicle assembly is considered in the future, the fuel efficiency of the vehicles to be produced should be given high priority.

RECOMMENDATIONS

1. We recommend that the Direccion Sectorial de Energia publish fuel economy information for light duty vehicles (automobiles, vans, and light trucks). It would be best to begin with an evaluation of existing sources of fuel economy information and a determination of the most appropriate available measures. New and, to the extent possible, used vehicles should be included. It would be desirable to require new and used vehicle dealers to label all vehicles with this fuel economy estimate. Pamphlets containing all fuel economy estimates could be published and made generally available to car buyers.

2. There seemed to be unanimous agreement among the transport groups interviewed that driver training for energy and cost efficient practices would be beneficial. Therefore, we recommend a program to train Costa Rican instructors, who in turn will teach energy efficient operation to vehicle owners and operators. It is important to involve the transportation sector organizations in the design and implementation of the program as early as possible.

3. Three demonstration programs aimed at large taxi, bus, and truck cooperatives, unions, and firms and using low-cost conservation techniques would be highly desirable. The cooperation and possibly the collaboration of the National Chamber of Transporters in this effort could be invaluable.

4. We recommend that government and other major vehicle-owning institutions develop plans for purchasing new vehicles that will result in fleet efficiency improvements of at least 25 percent.

5. TRANSMESA should undertake an analysis of bus and taxi vehicle specifications with the goal of incorporating fuel economy into its purchasing specifications. An efficiency improvement of at least one-third should be possible for taxis.

6. A study of vehicle taxes and import duties should be undertaken to determine economically efficient tax and duty schedules that will discourage the importation of inefficient light duty vehicles. The study should also address the distribution of charges among taxes, duties, annual ownership fees, and fuel taxes.

7. A study of the benefits and costs of improving the conditions of streets and roads in Costa Rica should be undertaken. Special attention should be given to: (a) quantifying energy savings, including direct fuel use and the energy required for road repair; (b) prioritizing road repairs on the basis of benefits and costs; and (c) defining vehicle use restrictions to keep the pavement in good condition.

In Costa Rica, fuel quality and vehicle maintenance appear to be inextricably linked. Poor quality fuel can lead to increased engine wear, smoke problems, reduced fuel efficiency, and a greater need for maintenance because of the effect on pumps, filters, and injectors. The only way out of this trap is to ensure that fuel is of acceptable quality. Pushing ahead with a program of improved maintenance will surely fail if the quality of the fuel is poor.

FUEL QUALITY

Almost all fuel users (truck, bus, and taxi operators) complained that the diesel fuel distributed in Costa Rica is of poor quality. According to some, this problem dates from 1974, when the state petroleum monopoly RECOPE was established. They claim that water, sediment, and sulfur (sometimes exceeding 1 percent) in the fuel increases the need for engine maintenance, causes engine wear, reduces fuel efficiency, and increases air pollution.

The question of fuel quality was raised with the RECOPE Director of Quality Control, who conceded that in the past there had been individual cases of contaminated fuel being released for distribution owing to operational errors. He then described corrective actions that have recently been taken, or are planned, to ensure the good quality of the fuel, including a test of crude prior to release for shipment, tests at key points in the production and distribution processes, and installation of filters in the tank loading racks (sintered bronze, washable, 10-12 microns). We asked whether the sulfur content of RECOPE's diesel fuel was high and were told that the standard for imported fuels required less than 1-percent sulfur and that domestically refined diesel has about 0.5-percent sulfur. The standard for fuels sold in Costa Rica is 0.9 percent by weight, almost twice the SAE U.S. standard of 0.5 percent (Society of Automotive Engineers, 1983).

We also asked whether RECOPE had special refinery equipment (e.g., hydrotreating) for removing sulfur from crude and were told it had none. The current sulfur content of crudes entering RECOPE's refinery stream is high, as shown in Exhibit 4.a. However, it is not possible to deduce with certainty the sulfur content of distillates produced from these crudes.

The National Chamber of Transporters asserted that poor quality diesel fuel was their number one problem. When asked for recommendations on how to improve fuel efficiency, a TRANSMESA official put improved fuel quality at the top of the list, and increased maintenance at the bottom. TRANSMESA's maintenance expert, a strong proponent of better maintenance, said that the need for maintenance would be reduced if fuel quality were improved. He added that bad fuels, both gasoline and diesel, are largely responsible for the pollution in San Jose. Officials of

Exhibit 4.a

Crude Petroleum Imported by RECOPE

Type	Percent of imports	Sulfur content (by weight)*
Itsmo (Mexican light crude)	70	1.5%
Lagotreco (Venezuelan light crude)	26	1.2%
Tia Juana (Venezuelan heavy crude)	4	2.7%

*Crudes are classified by sulfur content as follows: sweet, less than 0.5 percent; medium-sulfur, 0.5-1.0 percent; high-sulfur, in excess of 1.0 percent sulfur by weight.

SOURCE: Information supplied by engineer Navarro Plantel of Limon by telephone, June 1984, to engineer Alexandra Hernandez, DSE.

UNITRACSA reported that the quality of diesel fuel in Costa Rica was terrible. In their opinion, it is the principal factor in the deterioration of diesel engines. They believe it harms injection pumps, injectors, cylinders, turbochargers, and filters. They also blame the fuel for smoking problems. One major diesel repair business we visited reported that diesel fuel tested in its laboratory had a sulfur content of around 1 percent. According to the test engineer, the proper acid-counteracting crankcase oil additive was not available in Costa Rica. He believed that the increased wear resulting from the high-sulfur fuel and lack of additives reduced engine life by up to 50 percent. This engineer did not agree, however, that fuel quality was the cause of high levels of smoke, pointing to increased wear or improper injection settings as more likely causes. Officials of COTRACOOP (the consortium of bus cooperatives) agreed that smoking was the result of poor maintenance rather than poor fuel quality. Finally, one repair shop expressed the belief that the fuel was adulterated in filling stations and not of poor quality to begin with.

The effects of poor diesel fuel quality include: fouling of filter mechanisms and passages in the fuel injection system (sediment); improper combustion (water); wear of valves, valve seats, cylinders, and piston rings (sulfur); and poor atomization (high viscosity). Incomplete combustion -- which may be caused by injection system malfunction or engine overload -- results in the black smoke discharge frequently seen along Costa Rican roads. Poor atomization, caused by overly viscous fuel, can also cause black smoke. In addition, nozzle (spray tip) deposits result in black smoke. White smoke, on the other hand, may indicate compression loss resulting from engine wear.

It is important to determine whether fuel quality is, in fact, a major problem in Costa Rica. If the quality is generally poor, it may be possible to take corrective actions that will provide short-term improvements in fuel economy. Moreover, provision of an adequate level of fuel quality is an essential prerequisite to an efficient engine maintenance improvement program.

VEHICLE MAINTENANCE

As a result of the current recession in Costa Rica, vehicle owners and operators have reduced their maintenance expenditures to a minimum (oil and filter changes only) and as a rule perform only **corrective** maintenance. Such maintenance, together with longer service life (owing to a rapid escalation of vehicle replacement costs), results in a large number of vehicles operating in sub-standard condition.

Two recent reports by the Ministry of Public Works and Transportation describe the condition of the truck and bus fleets. A check of 500 trucks at four principal weigh stations indicated that 54.6 percent required repairs, 8.1 percent of them urgently. A similar examination of the bus fleet revealed that 10.8 percent of the vehicles were in poor mechanical condition. According to the Israeli bus technician who is assisting the metropolitan bus authority (TRANSMESA), maintenance of buses has deteriorated to a point where some buses are unsafe to operate. Regulations require an annual vehicle inspection in state-operated facilities, but the requirement is reported to be largely ignored.

The management of COOPETICO, the large taxi cooperative, said that the fleet was in poor mechanical condition and that a great many taxis are out of service. They observed that maintenance was not good and that there was a shortage of spare parts for their vehicles, most of which are 7 or more years old. Except for oil and filter changes and lubrication, they do not carry out preventive maintenance. They believe that mechanics in Costa Rica are generally good and very resourceful, yet they are reluctant to use commercial repair shops because of the high cost. UNITRACSA (a truck operators' cooperative) officials echoed this, noting that they believed better maintenance would improve their fuel economy but that they simply could not afford it. The National Chamber of Transporters concurred, saying that they carry out only corrective maintenance on urban buses. They believe that there is a need for more and better-trained mechanics.

Good commercial maintenance facilities were seen at MATRA, a distributor of Mack and Hino trucks, and at Taller Vargas Matamoros, a precision grinding shop that rebuilds parts for engines of all types and applications. While MATRA's diesel injection system rebuiding shop lacked clean room conditions, interviews with transportation managers and vehicle maintenance professionals indicated that there are three or four good diesel fuel system repair shops in San Jose. The telephone book yellow pages list eight shops in this specialty.

In addition to lack of capital, ignorance of energy efficiency principles contributes to poor maintenance practices. For example, interviews with UNITRACSA and with MATRA revealed that it was common practice to permanently remove thermostats from engines that were overheating. The result -- operation of the engine with coolant temperature below design level -- wastes fuel.

THE WORLD BANK PROPOSAL FOR BUS MAINTENANCE

The World Bank has proposed that MOPT establish -- through TRANSMESA -- a preventive maintenance program for buses, which consume approximately 10 percent of all energy used in the transportation sector in Costa Rica. Phase 1 of the proposal involves developing a program plan. Phase 2 calls for the construction or modification of a maintenance building with clean rooms, pump and injector test stands, the establishment of a spare parts inventory, and the training of personnel, all to be carried out by TRANSMESA. The objective is to increase bus fuel efficiencies from the present range of 2.4-2.7 km/liter (5.6-6.4 mpg) to 4-5 km/liter (9.4-11.8 mpg). Transit buses in the United States (which are generally larger and more powerful) average 3.5 mpg (1.5 km/liter) and intercity buses average 5.95 mpg (2.5 km/liter). Although the efficiencies of Costa Rican buses vary greatly, depending on the equipment and operating conditions, there is little evidence that they are grossly inefficient.

Nonetheless, improved bus maintenance would be desirable, but there is some question as to whether TRANSMESA is the appropriate organization to provide such maintenance. We asked COTRACOOP and the National Chamber of Transporters about the World Bank proposal. COTRACOOP officials wondered why TRANSMESA, which operates no buses, should have a maintenance facility. They added that if TRANSMESA could operate one at low cost, it would be acceptable to them; otherwise, they would rather do it themselves. The Chamber of Transporters was far more negative. It said that if TRANSMESA did set up such a facility, no one would use it because maintenance would take a month and cost too much, and the bus would not be fixed properly.

Although TRANSMESA supplies buses to operators, it does not own or operate buses or determine bus routes. Consequently, it may not be the appropriate agency to provide bus maintenance. Based on our interviews, it appears that problems with inadequate bus maintenance derive from its relatively high cost, from inadequate profits in the bus business, and from shortages of trained mechanics and necessary facilities. Because TRANSMESA heavily subsidizes the purchase of buses, it might be justified in subsidizing the proper maintenance of the buses so that they do not depreciate at an accelerated rate and have to be replaced sooner. However, we believe alternatives should be explored before committing funds to a TRANSMESA-operated facility.

RECOMMENDATIONS

Fuel Quality

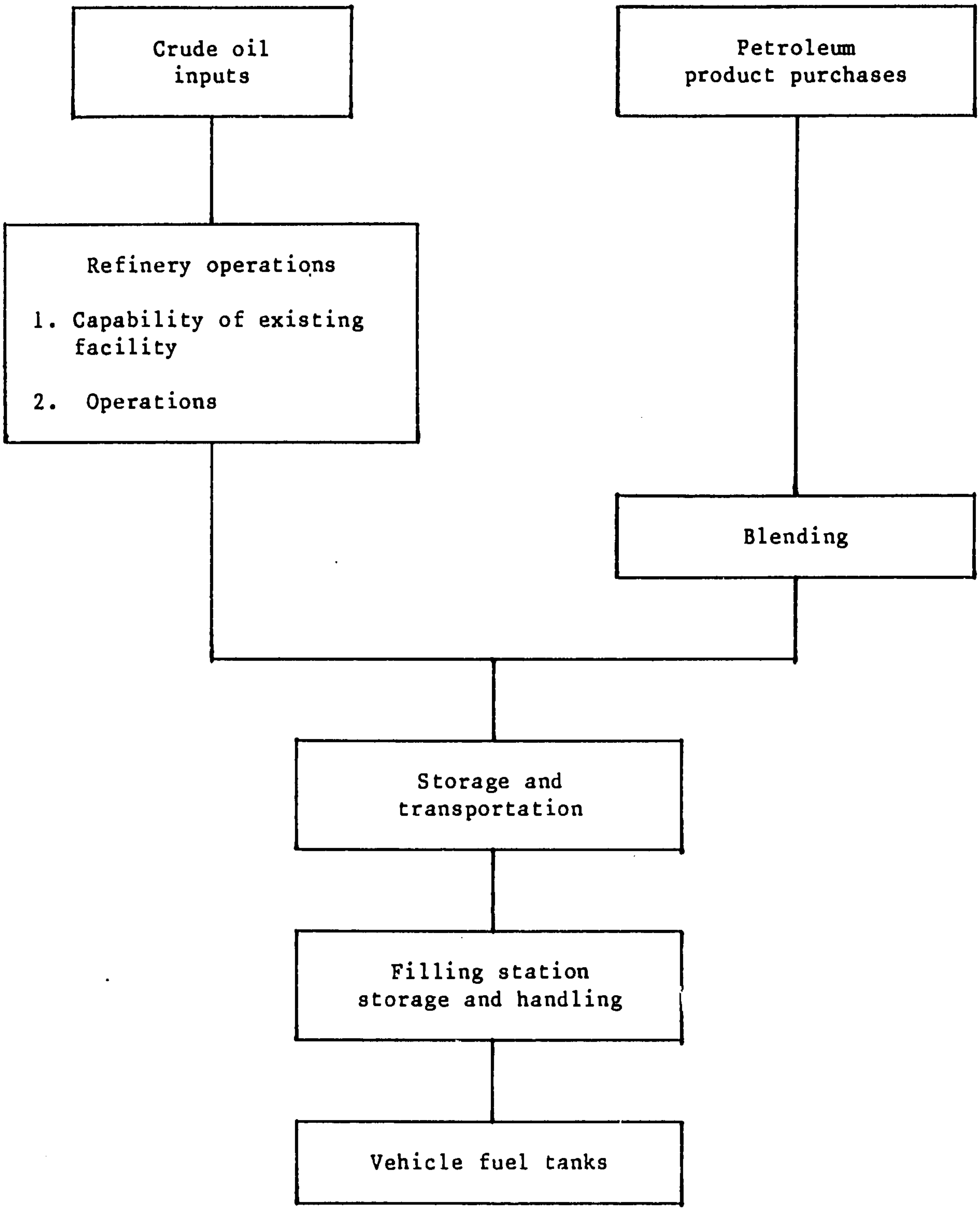
We believe that a thorough study of transportation fuel quality is needed, as evidence indicates that a serious problem may exist. We suggest that a group, composed of representatives of the private transportation sector as well as the government, be established to oversee a study on transportation fuel quality. For example, one representative each from RECOPE and DSE might adequately represent the government's interest. A few representatives of trucking cooperatives, trucking companies, bus cooperatives, taxi cooperatives, and the general public would complete the group. The study itself should be carried out by individuals who are unbiased experts in the refining and distribution of transportation fuels and in automotive engineering, particularly fuels and lubricants. USAID could play a key role by providing financial support for expert assistance in designing and carrying out the study.

The study design must include all phases of fuel production and handling, from crude oil inputs and product purchases to the fuel tanks of vehicles themselves (see Exhibit 4.b). The quality of crude oil inputs, the ability of RECOPE's existing refinery to make satisfactory transportation fuels from these inputs, and the adequacy and appropriateness of refinery operations, including blending, must be determined. Then, the quality of fuel outputs from the refinery and direct imports must be established. Finally, each phase of transportation, storage, and handling -- from refinery tank farm to pipeline, local tank farm, local distribution, filling station storage, and on-board vehicle storage -- should be investigated for possible contamination, adulteration, or deterioration. Since the petroleum product stream may vary in quality over time, the study should determine whether quality controls are adequate over the longer term.

The study must not only identify problems, but offer solutions to whatever problems may be found. For example: Should RECOPE use different crudes? Should its refinery be upgraded? Should the specifications of imported fuels be tightened?

Exhibit 4.b

Key Elements of an Investigation
of Transportation Fuel Quality



Should special fuel or lubricant additives be used? Should filling station tanks be replaced, regularly cleaned, or inspected? The final product of the study must be a definitive statement on fuel quality and, if necessary, a feasible plan to ensure adequate quality for transportation fuels (and lubricants) in Costa Rica.

This study can be designed to serve two purposes simultaneously. A previous gasohol program had serious problems related to fuel quality and use. As a result, there is a need to study the refining and distribution system with reference to the possible production and sale of gasohol. An examination of the quality of transportation fuel and of gasohol could thus be efficiently combined.

Improved Maintenance

We are convinced of the need for improved maintenance of diesel-powered vehicles in Costa Rica. Even if the quality of the diesel fuel is satisfactory, the problem of adequate maintenance is a difficult one. It is one thing for an organization to establish a maintenance program for its own vehicles, as was apparently envisioned by the World Bank in its proposal for a TRANSMESA maintenance facility. However, if the government deals only with its own vehicles, it can have little impact on bus fuel consumption.

Individual owners and operators appear to have every incentive to properly maintain their vehicles, but do not do so for two reasons: they cannot afford to, and they may be unaware of the full benefits of proper maintenance. Because of the economic recession in Costa Rica, there is now a temporary oversupply of freight vehicles. As a result, truck tariffs have been driven down to the point where they cover only short-run marginal costs; there is no allowance for preventive maintenance and depreciation of the equipment. Thus, most truck operators will be unable to afford adequate preventive maintenance until the economy recovers. If operators could be convinced that the improvement in fuel economy would more than pay for the cost of maintaining injectors, pumps, and filters, there is every reason to believe that they would carry out preventive maintenance.

The fares paid to bus and taxi operators are regulated, and we were told by both TRANSMESA and bus operators that these fares are insufficient to cover proper vehicle maintenance. Either the fares must be raised, the government must subsidize maintenance, or the government must demonstrate that reduced operating costs will more than pay for proper maintenance.

The promotion of improved maintenance is complicated, however, by the perception of owners that poor quality fuel causes engine fouling and increased wear, resulting in smoking and poor fuel economy.

The government has an important role to play in all of these problems. First, only the government can ensure adequate quality fuel to the transportation sector, since it owns the petroleum monopoly. Second, where government-regulated fares do not allow for preventive maintenance, the government has a clear responsibility to take some action: raise fares; subsidize maintenance; demonstrate that proper maintenance is cost-effective. In the trucking sector, where a competitive market prevails, it is in the country's best interest for the government to demonstrate the cost-effectiveness of proper maintenance, if possible. However, the government also has the option of enforcing adequate maintenance by requiring vehicles to pass an inspection designed to ensure their efficient operating condition. Such a requirement would effectively raise the short-run marginal cost of operating a truck, prompting a rise in truck tariffs to cover this increase.

We recommend that the government study the following options for improving vehicle maintenance:

1. Instituting mandatory annual vehicle inspections for efficiency as well as safety

2. Subsidizing certain maintenance for trucks, buses, and taxis, or any one of these

3. Raising bus and taxi fares to enable owners to afford proper maintenance

4. Conducting maintenance demonstration programs in collaboration with private operators to prove that maintenance aimed at increasing fuel efficiency is cost-effective.

Based on the results of the study, the government should act to reduce fuel consumption and prolong the life of the vehicle stock by improving vehicle maintenance.

Costa Rica has two locally produced energy resources that could provide transportation energy: electricity and alcohol. Current electric generating capacity far exceeds demand -- 719 MW capacity versus 420 MW peak demand.* Moreover, the price of electricity is quite low (currently $0.04 U.S./kWh), although it should be raised to $0.05 U.S./kWh to cover expenses and return on investment.** The use of electricity should be seriously investigated in two areas: as part of the effort to upgrade rail feeder lines to banana plantations, and for the electrification of urban mass transit in the San Jose area.

ALCOHOL AS A MOTOR FUEL

The use of alcohol as a transport fuel may be an economically attractive option. Several alternatives are available for the use of the excess sugar now produced: it could be sold at low world market prices (about one-third of the U.S. quota price), converted to alcohol and sold to the United States under favorable Caribbean Basin Initiative prices (about $1.50/gallon), or substituted for gasoline in the form of gasohol. A fourth alternative -- making use of ethanol's octane-enhancing properties -- could be cost-effective and eliminate lead from motor vehicle emissions.

Surplus sugar production in Costa Rica in 1984 once again raised the question of producing alcohol as a fuel for motor vehicles. The internal demand for sugar in Costa Rica is 120,000 tonnes (metric tons) per year. In addition, Costa Rica has a quota for export to the United States of 60,000 tonnes; this sugar is sold at the very favorable price of U.S. $21.50 per 100 pounds. In 1984, an excess of 30,000 tonnes of sugar was produced, and the next harvest is expected to produce an even greater surplus. Production that exceeds internal demand plus the U.S. quota is considered surplus because of the structure of prices faced by sugar producers. While the U.S. quota price is $21.50/100 pounds, the world open market price is only $7.90/100 pounds. Cane growers are fearful that in the face of this price discrepancy, the U.S. quota price will eventually be lowered.

Costa Rica apparently has sufficient surplus sugar cane and adequate idle distillery capacity to supply more than enough alcohol for a well-designed gasohol

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*World Bank, Costa Rica: Issues and Options in the Energy Sector, January 1984, p. 21.

**World Bank, Costa Rica: Issues and Options in the Energy Sector, January 1984, p. 40.

program. Costa Rica presently devotes about 50,000 hectares of land to sugar cane production. A yield of 80 tonnes of sugar cane per hectare would provide an estimated 4 million tonnes of sugar cane per year.* According to the FAO Production Yearbook, about 2.5 million tonnes of sugar cane were produced in 1980 and 1981. In 1979, 2.6 million tonnes of cane provided 204,000 tonnes of sugar, or 12.75 tonnes of cane per tonne of sugar. Thus, a 30,000-tonne surplus of raw sugar is equivalent to 380,000 tonnes of surplus cane. Assuming a yield of 56.7 liters of anhydrous alcohol per tonne of sugar cane, Costa Rica could produce nearly 22 million liters per year -- 15 percent of annual gasoline consumption in the country.

The sugar producers' organization (CATSA) already has an idle facility for producing ethanol. The plant has two distillation units, each with a capacity of 120,000 liters per day. Operating an estimated 100 days during harvest periods, the distillery could produce:

$$2 \times (120{,}000 \text{ liters/day}) \times (100 \text{ days/year}) = 24 \text{ million liters/year.}$$

If operations could be stretched out over the entire year, only one unit would need to be used.

CATSA apparently believes that ethanol could be sold directly to the United States under the Caribbean Basin Initiative's program at the favorable price of $1.50/gallon. The industry seems to be faced with three options for using the sugar surplus:

1. Sell the sugar at the world market price of $7.90/100 pounds

2. Convert the sugar to ethanol and sell to the United States at $1.50/gallon

3. Convert the sugar to ethanol and blend with gasoline.

Total revenues from 22 million liters of ethanol at the CBI price of $1.50/gallon would be:

$$((24 \times 10^6 \text{ liters}) \times (\$1.50/\text{gallon}))/(3.785 \text{ liters/gallon}) = \$8.72 \times 10^6.$$

The value of the sugar itself at the world market price of $7.90/100 pounds is:

$$(30{,}000 \times 10^3 \text{ kilograms}) \times (2.2 \text{ pounds/kilogram}) \times (\$0.079/\text{pound}) = \$5.2 \times 10^6.$$

Selling ethanol to the United States would clearly generate more revenue. However, the profitability of each option depends on production costs. According to Mr.

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*Vedova, Mario A., "Production of Alcohol Fuel in Costa Rica: Appraisal and Perspectives," April 1981.

Javier Gonzalez of DSE, production costs for ethanol would be \$1.30/gallon. Unfortunately, we do not know how this cost was arrived at and in particular what value, if any, was assigned to the sugar or to the sunk costs in the distillery. As a result, it is not possible to determine which option is most profitable. Nevertheless, based on the above figures and setting foreign exchange issues aside for the moment, it is clearly not profitable to replace \$0.87/gallon gasoline with \$1.30/gallon ethanol.

A fourth alternative -- using ethanol not only as a substitute for gasoline but also as an octane enhancer -- has not yet been explored.

Studies in the United States indicate that research octane increases about 0.4 points for every 1 percent ethanol added to regular gasoline (see Exhibit 5.a). It should be possible to optimize the process of producing gasohol by mixing lower octane, and thus cheaper, regular gasoline with ethanol in percentages that minimize total production costs. The following hypothetical example illustrates the principle:

In the United States in 1983, leaded premium gasoline sold for \$1.42/gallon compared with \$1.22/gallon for leaded regular gasoline. The difference in research octane numbers for these grades in the United States is typically 7-8 points, or about 2.5¢ per point per gallon. If we assume that we could reduce the cost of regular gasoline in Costa Rica by 10¢ per gallon, from \$0.87 to \$0.77, by lowering the octane requirement by four points, then we could regain the four octane points by adding 10 percent ethanol, an amount equivalent to adding 2-3 cc of tetraethyl lead per gallon. Assuming that the ethanol cost \$1.30/gallon to produce, the total production cost of the 10-percent ethanol gasohol per gallon would be:

$$(\$1.30)\ .1 + (\$0.87 - \$0.10)\ .9 = \$0.82.$$

In this example, the value of ethanol as an octane enhancer would be \$1.80/gallon, compared with its value of \$0.87/gallon as a simple substitute for gasoline:

$$(\$1.80)\ .1 + (\$0.87 - \$0.10)\ .9 = \$0.87.$$

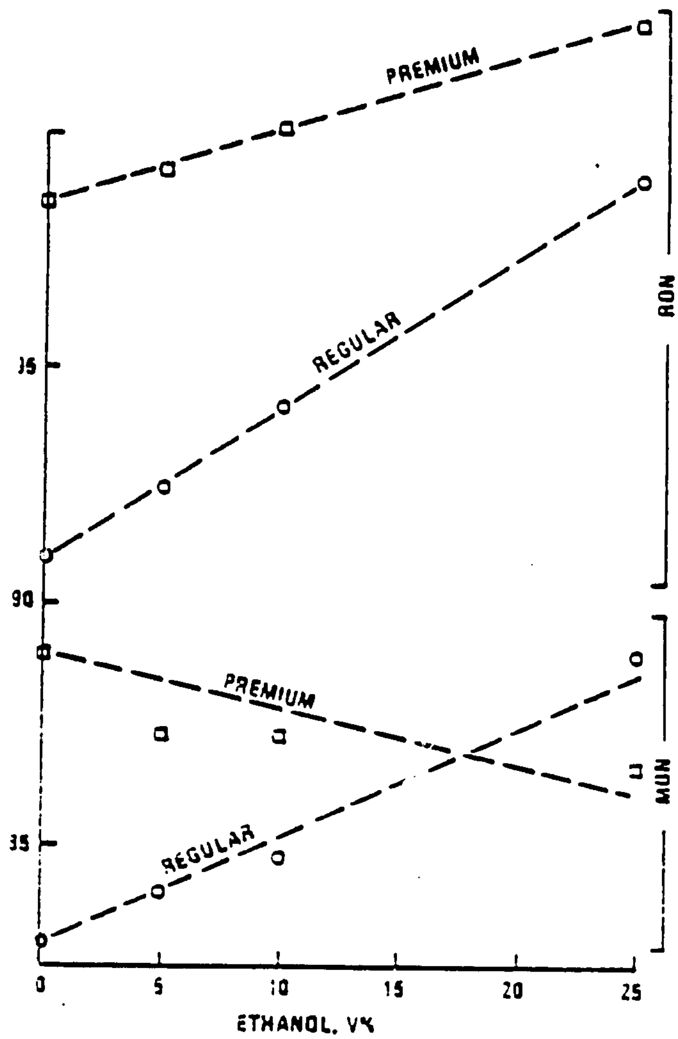
The total economic value of 22 million liters of ethanol would thus be \$10.5 million.

This example, at best, is a crude illustration. The optimization of refinery operations and fuel purchases to use ethanol in Costa Rica would require a thorough analysis of the specific situation. Nevertheless, the potential exists to greatly enhance the value of ethanol produced in Costa Rica by integrating the blending into total refinery operations and fuel purchases to minimize costs. An additional benefit would be the virtual elimination of tetraethyl lead from gasoline, which could substantially benefit the health of Costa Ricans.

Costa Rica's previous experience with an experimental 20-percent ethanol blend was poor. Severe problems apparently arose because sludge and sediment in storage tanks and vehicle tanks were dissolved by the ethanol and carried into the fuel system, fouling it, because consumers were not advised to clean fuel tanks, replace

Exhibit 5.a

Effect of ethanol addition on RON and MON of premium and regular gasoline.



Source: U.S. Department of Energy, 1978.

fuel filters, and reset spark timing to take best advantage of the gasohol, and because water contaminated the mixture during storage. The first two problems could be addressed by using a blend with a lower percentage of ethanol. The water contamination problem would be exacerbated, however, as gasohol's tolerance for water -- before phase separation occurs -- decreases with a decrease in the percentage of alcohol in the mixture (see Exhibit 5.b). A solution to this problem will have to be found if any gasohol program is to succeed.

RAIL ELECTRIFICATION

San Jose Metropolitan Area Urban Transit

Over the past few years, the MOPT has been studying the possibility of introducing an electrically driven transit system to serve commuters in the San Jose metropolitan area. The aim is to reduce urban traffic congestion and at the same time substitute domestically generated electrical energy for imported diesel fuel. Electrification would also reduce diesel-generated pollution.

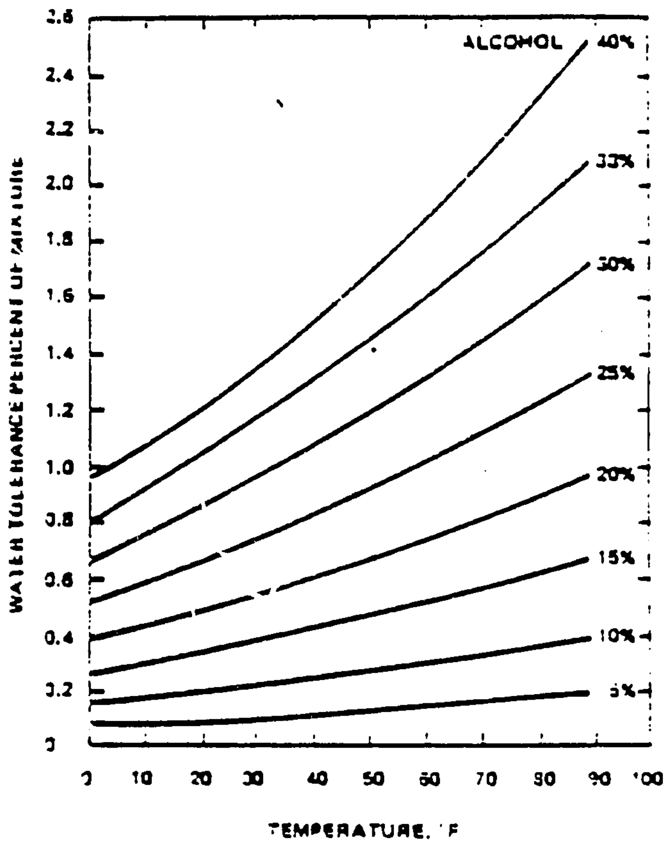
The MOPT is actively considering a project to build a 40-km modern light rail transit (LRT) system that would eventually serve the four radial corridor routes of Tibus-Paso Ancho, Moriavia-Matillo, Curridabat-Pavas, and Desamparados-Uruca (see Exhibits 5.c and 5.d). The cost of the total system has been estimated at $600 million. A more modest 12-km line linking Curridabat to the east and Pavas in the western suburbs of the San Jose urban area has been estimated to cost $50 to $60 million. Current passenger demand along this route is only on the order of 5,000-6,000 passengers per peak hour in one direction. However, an overly optimistic estimate of 16,000-18,000 passengers per peak hour is being suggested for 1990. As noted by the World Bank (1984), LRT systems are usually designed for peak hour capacities of 18,000-24,000 passengers one way. It is questionable whether such levels of patronage can be generated along the corridors in question, given the relatively even population density within the urban part of Costa Rica's Central Valley.

An interesting alternative to LRT, and one deserving of further study, is the use of electrified trolley buses, possibly by conversion of some of the existing bus fleet. Such a system would eliminate the capital expense involved in laying track. In addition, trolleys have maneuverability in traffic that a rail system does not. Moreover, the trolley bus system offers greater route flexibility at a lower cost. However, to operate trolleys effectively, restrictions on automobile use, notably parking, will be required along those routes used by public transport vehicles. Current evidence suggests that enforcement of traffic laws such as these in San Jose may prove to be a problem.

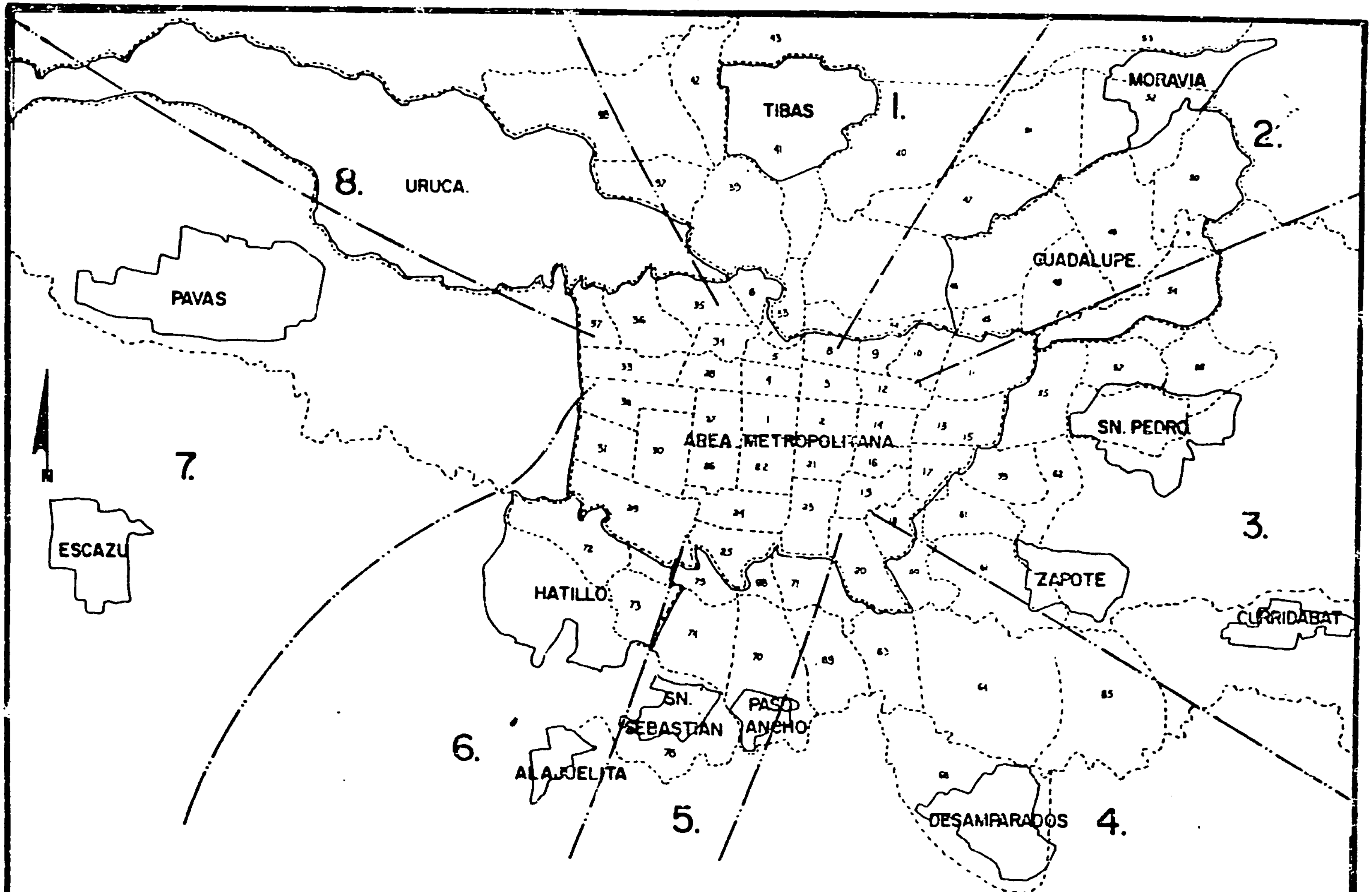
Even with a comprehensive electrified LRT or trolley bus system in operation on the major commuter corridors shown in Exhibit 5.d, we estimate that only 63 percent of all transit riders would have ready access to the routes. The remaining riders would have to use the diesel bus system. It is thus desirable that MOPT consider the electrification of urban transit in the wider context of a multi-modal urban public transportation system management program. A major aspect of this program

Exhibit 5.b

Water tolerance of ethanol gasoline blends.



Source: U.S. Department of Energy, 1978.

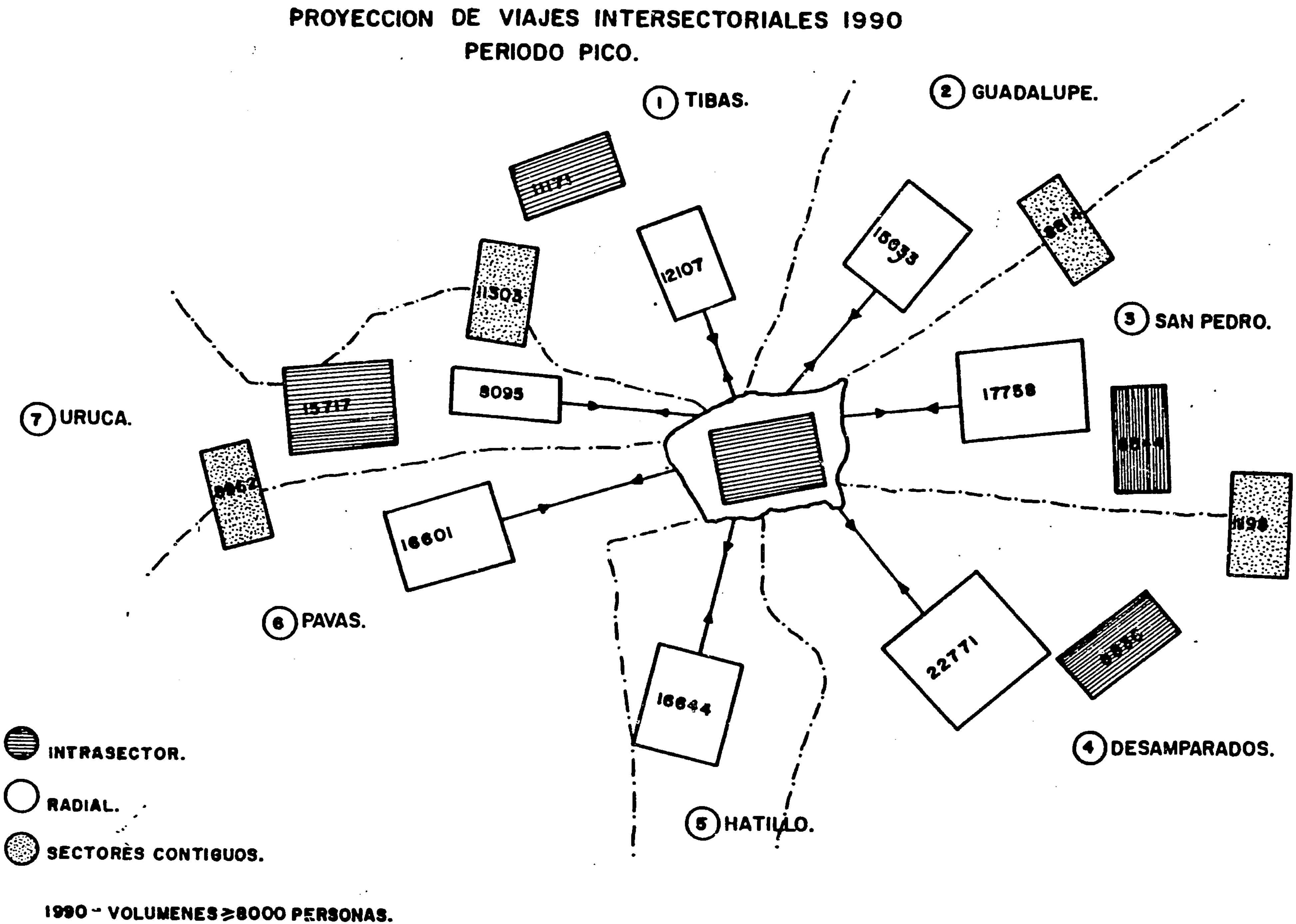


AREA DE ESTUDIO.

ZONAS Y SECTORES.

FIGURA 3.2.I.

Exhibit 5.d Projected 1990 Peak Period (2 hour) Transit Demand for the Metropolitan Area



should be the rationalization of existing autobus routes. A systemwide analysis of the most economic and energy-efficient mode/routing operation is necessary. The study of electrification as a separate modal issue introduces the problem of replacing modal (energy and/or cost) efficiency with route-based inefficiency. The aim of an electrified -- or any other -- transit system should be to minimize duplication of effort along routes. The introduction of a fixed-route LRT system, for instance, would have to be accompanied by careful consideration of existing bus route disruption and its effects on passengers who are not located in the major commuter corridors.

We thus recommend that the potential savings from a (computer-aided) bus routing and vehicle scheduling program be quantified as an integral part of the evaluation of urban mass transit electrification. Such an evaluation is particularly relevant to the San Jose bus system, whose routes have developed on a line-by-line, demand-responsive basis over recent years. The MOPT is the logical agency to carry out a systemwide analysis, as it has good data on bus companies' routes, schedules, and passenger volumes that are documented on a regular (monthly) basis.

Rehabilitation and Electrification of the Railways

The Costa Rican government faces two major investment decisions with respect to the future of its rail system:

1. Whether to rehabilitate and electrify the La Junta to Alajuela sector (124 km) of the country's interoceanic Pacific-Atlantic trunk line, at a cost of $52 million

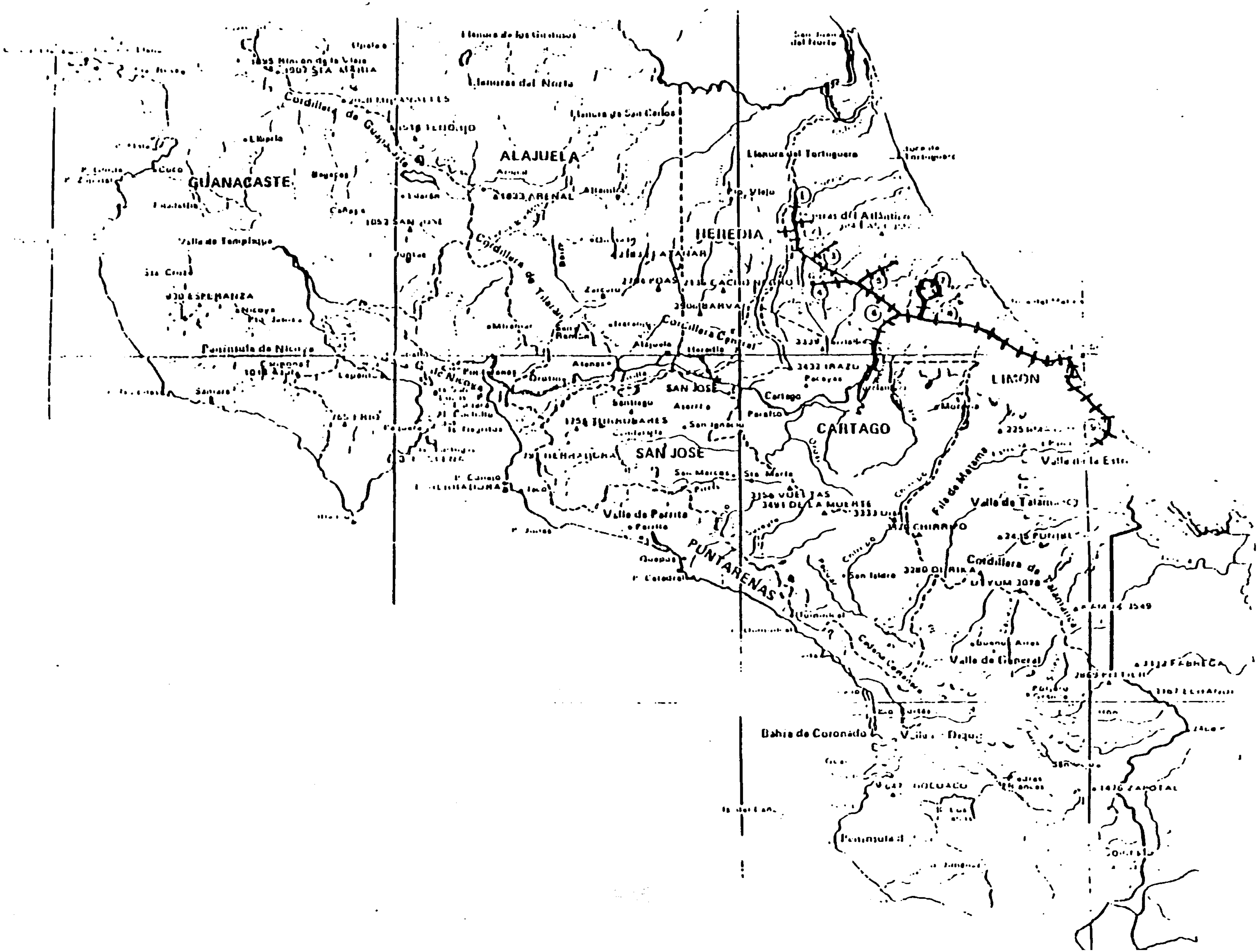
2. Whether to rehabilitate and electrify the 159.15 km of banana branch lines that currently act as feeders to the recently electrified and upgraded Rio Frito-to-Limon (Atlantic) trunk line, at a cost of $40 million.

In both cases, electrification costs would be about one-fifth to one-quarter of the rehabilitation costs. Electrification should be carried out if the extensive -- and expensive -- rehabilitation required of the badly maintained lines is decided upon.

All feeder lines are single track, and their condition is classed by the Direccion de Ferrocarriles as "poor" to "very bad." Only the recently electrified Rio Frito-to-Limon line is in acceptable operating condition. Both the banana feeder lines and the La Junta-to-Alajuela section of track are non-electrified and in a very poor state of repair. The length and electrification status of the nation's rail lines are shown in Exhibit 5.e.

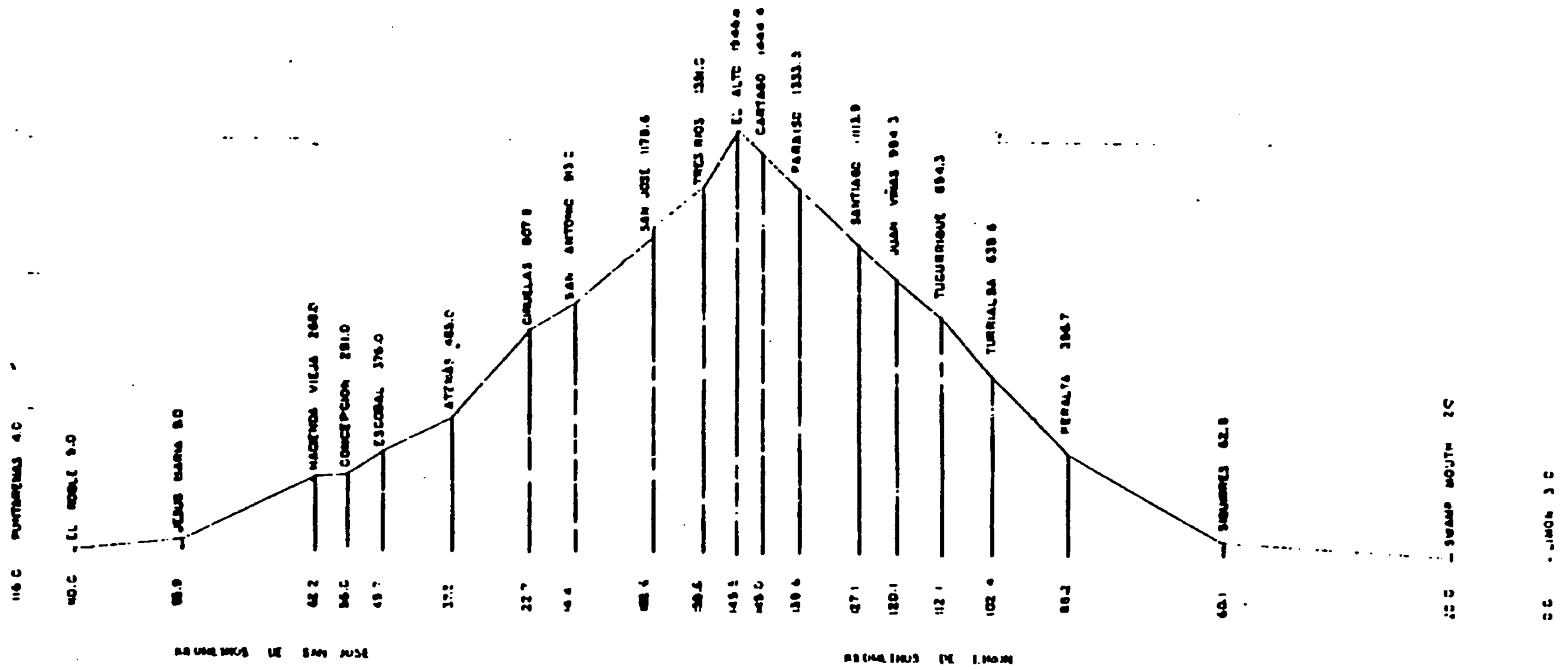
Transoceanic Trunk Lines

The grade profile for the complete Puntarenas-to-Limon rail line operated by FECOSA is shown in Exhibit 5.f. Because of the very steep grades (as high as 3.3



GUANACASTE
ALAJUELA
HEREDIA
SAN JOSE
CARTAGO
LIMON
PUNTARENAS
Cordillera de Guanacaste
Cordillera de Tilarán
Cordillera Central
Cordillera de Talamanca
Llanuras del Norte
Llanura de San Carlos
Llanura del Tortuguero
Valle de Tempisque
Peninsula de Nicoya
Golfo de Nicoya
Valle de Parrita
Valle de General
Valle de Talamanca
Fila de Matama
Bahia de Coronado
1756 TURRUBARES
3432 IRAZU
San Jose
Alajuela
Heredia
Cartago
Quepos

Exhibit 5.f Grade Profile for the Puntarenas to Limon Rail Trunk Line



percent on the Tres Rios-to-El Alto section) and associated sharp bends in the track, along with the current state of poor maintenance, a journey from San Jose to Puerto Limon (168 km) takes 8 hours. In contrast, the same journey on the current two-lane road takes 4½ hours, and the new highway (which has a third, climbing lane for heavy truck traffic on the steepest sections) will reduce this travel time to about 3 hours. A purely economic analysis of the situation suggests a move to road transport. Transoceanic freight is likely to be insufficient to justify the rail line's rehabilitation costs, estimated at $52 million ($10.5 million for electrification). The 1981 Plan Nacional de Transporte, for example, projects only 1.8 million tonnes/year in interoceanic trade by the year 2000, and even this scenario seems optimistic. With only three operational sidings along this single-track line, an economically justifiable freight capacity is also questionable. Passenger travel along even an upgraded and electrified line would also be rather limited in either direction. No major towns are on the route, and service now requires frequent stops for a handful of passengers at each station. Given the current economic crisis facing Costa Rica, the cost of serving these passengers is high.

The complete abandonment of this section of the rail line, of course, raises social issues that cannot be dealt with fully in this report. As well as the loss of rail access for those passengers who live along the line (and often have no other easy means of access to the Central Valley area), there is the issue of union labor's response to a proposed line closure.

At the time of writing, word was received in Costa Rica that the West German government had offered to lend $23 million toward the repair and upgrading of publicly owned rail stock. While the details of the offer are not known at this time, we recommend that the Costa Rican government consider carefully the wisdom of perpetuating an inefficient service by upgrading it at high cost to serve relatively few passengers as opposed to using available funds to enhance the rolling stock on the ailing but economically more justifiable Pacific coast (electrified) or Atlantic coast and banana feeder lines (with their much greater revenue-generating potential). At the time of writing, FECOSA is said to be losing 1 million colones ($23,000) per day (the difference between revenues and operating costs). In the context of the costs, the energy that could be saved through electrification of the trunk lines is a relatively minor factor in the decisions that need to be made.

The Banana Feeder Lines

The MOPT, Direccion Ferrocarriles, and FECOSA are jointly considering the upgrading and electrification of nine operational rail feeder lines attached to the recently upgraded and electrified Rio Frito-to-Limon main banana freight line. Since 1981, these lines have been run by FECOSA. At present, the electrically driven locomotives have to push diesel locomotives along the trunk line to the feeder lines. Until 1983, 80 percent of the bananas collected and shipped from these farms and farm cooperatives moved to the port by rail. Since then, however, the situation has changed drastically, with 80 percent of the bananas now moved by container truck and only 20 percent by rail. The major reasons for this shift were the rapidly deteriorating rail feeder lines, with derailments a serious problem, and a move to containerized road transport in place of the old, wooden-sided banana trucks. To add to the truckers' advantage, the already completed section of the new San Jose-to-Limon highway parallels much of the existing Rio Frito-to-Limon rail line.

Four options are available to the government with respect to the banana feeder lines:

1. Abandon the rail feeder lines in favor of truck transport

2. Carry out minimum maintenance of the feeder lines and continue to use non-electrified, diesel-consuming trains

3. Rehabilitate and electrify all the feeder lines to match the conditions and operations of the main line

4. Rehabilitate and electrify a subset of the feeder lines.

The rates of diesel fuel use and electricity use by selected rail and truck routes, including the truck and feeder banana routes used by both modes of transportation, are shown in Exhibit 5.g. We estimate that if an entire annual banana harvest of 704,100 tonnes (see Exhibit 5.h) were moved by truck alone, it would require $1,295,000 of imported diesel fuel (at $0.90 per gallon), compared with $149,000 of imported fuel to run the existing diesel electric locomotives (moving 100 percent of the harvest), plus $375,000 (or 3.97 million kilowatt-hours at $0.04 per kilowatt-hour) for main line electric locomotive use. Whether such fuel savings can be made will depend on the future of FECOSA, which in turn depends heavily on the banana freight trade for its economic viability.

To carry out the appropriate benefit-cost analysis, detailed operating cost data need to be collected and made available by FECOSA. The Direccion de Ferrocarriles is the appropriate planning advisory agency to carry out such an analysis, and there are indicators that it will soon be undertaken. Available rail rehabilitation and electrification cost estimates are shown in Exhibit 5.i. A realistic estimate for rehabilitating and electrifying the system is $39.75 million, or $200,000 per kilometer to repair the lines and $50,000 per km to electrify them. Without the appropriate rail operation and maintenance information, no definite conclusions can be reached on the economic feasibility of feeder line rehabilitation and electrification.

The issue can be viewed in two ways: the economics of rail versus truck, and rail costs versus rail revenues. To compete economically with truck transport, we estimate that the rail system would have to be able to move an annual banana crop of 704,100 tonnes at or near a cost of $3.182 million. This figure is based on an estimated annual operational cost of $1.937 million to make an estimated 31,080 truck deliveries (see the line-by-line analysis in Exhibit 5.h and 5.j), plus a $1.655 million annual gravel road resurfacing cost (at $10,300 per km, according to MOPT).

xhibit 5.g

nergy Consumption Rates Per Kilometer by
ail and Truck and Truck Freight Modes

	Percent grade	Weight (tons/train)	Average speed (kph)	Consumption Electricity (kWh/km)	Consumption Diesel (liters/km)
. Rail line					
an Cristobal-Limon	0.5	180	50	16.25	
unatarenas-San Jose	2.5	240	30	16.89	
strello branch line	1.5	500	15		13.30
ther banana feeders	0.0-0.5	400	15		4.38
an Jose-Siquirres	3.0	250	25		5.40
. Truck route					
unatarenas-San Jose					1.40
iquirres-San Jose (all five axle trucks)					0.54
anana feeders					0.75
iquirres-Limon					0.60

OURCE: Ministerio de Industria, Energia y Minas.

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Exhibit 5.h

Potential Annual Diesel Fuel Use on Banana Feeder System

Feeder line	**Thousands of tonnes per year**	**Number of truck deliveries per year**	**Number of trains per year**	**Total annual truck diesel use (thousand gallons)**	**Annual rail diesel use (thousand gallons)**
Estrella	214.8	10,740	1,193	451	106.0
Ticaban	148.8	7,440	827	305	11.0
Trancari	74.2	3,960	440	182	12.0
America	7.2	360	40	11	10.3(?)
Rio Frito	86.4	4,320	480	209	12.0
Rio Jimenez	20.4	1,020	114	36	2.0
Monte Verde	26.4	1,320	147	42	4.0
Roxana	38.4	1,920	214	72	4.0
Indiana	62.1	3,105	345	131	17.0
Total	**704.1**	**31,080**	**3,912**	**1,439**	**161.3**

Exhibit 5.i

Rehabilitation and Electrification Cost Estimates for Banana Feeder Lines (All figures for 159.15 km of track)

	Million $
A. Track, damage, and bridge repair costs	
Minimum upkeep[1]	5.166
Estimate 1[1]	15.608
Estimate 2[2]	16.551
Estimate 3[3]	29.268
Estimate 4[4]	19.098-38.026
B. Electrification costs	
Estimate 1[1]	3.066
Estimate 2[2]	7.958
Estimate 3[3]	7.317

[1]Source: MOPT-FECOSA-Direccion de Ferrocarriles (1984); see references 2 and 5.

[2]Source: MOPT-reference.

[3]Source: See interview notes, Direccion de Ferrocarriles.

[4]Source: World Bank, op. cit. (= typical cost range reported by similar studies in the developing nations).

Exhibit 5.j

Banana Line Rehabilitation and Repair Costs[1]
(Millions of U.S. dollars)

Feeder line	Length (km)	Average speed	Distance to Limon	Average monthly tonnage (thousand tonnes)	Minimum cost cost	Track and drainage reconstruction cost	Electrification cost	Bridge repair cost
Estrella	50.7	20	0.0	17.9	1.848	3.076	1.084	0.310
Ticaban	7.0	10	110.0	12.4	0.225	0.356	0.135	0.030
Trincari	14.4	10	106.1	6.6	0.499	0.809	0.279	0.047
America	3.0	5	71.0	0.6	0.110	0.150	0.058	--
Rio Frito	15.0	10	113.2	7.2	0.331	0.960	6.290	--
Rio Jimenez	11.0	10	80.2	1.7	0.406	0.548	0.198	0.076
Monte Verde	14.8	10	59.5	2.2	0.506	0.828	0.285	0.033
Roxana	10.0	10	93.1	3.2	0.278	0.512	0.194	--
Incliana	28.0	10	60.0	5.1	0.947	1.582	0.542	0.095
Total*	**159.15**			**56.9**	**5.166**	**8.820**	**3.066**	**0.591**

*Rounding errors exist.

[1]All costs converted to U.S. dollars at 43.5 colones to the dollar.

SOURCE: Derived from references 2 and 6.

From a rail cost versus rail revenue standpoint, we were told that the loss of much of the banana freight to the trucking industry was costing FECOSA about $460,000 a month, or $5.52 million a year (about two-thirds of its current operating deficit). To recapture this trade, through line rehabilitation and electrification, and to retain it, FECOSA should keep its annual operating costs well below this figure.

Other benefits from a return to the rail mode, not quantifiable at this time, include the reduction in damage caused the bananas when moved by good rail versus truck, and the relative ease with which containers on rail flat cars can be loaded into ships by the single crane in operation at Limon. In contrast, it is more time-consuming to back individual container trucks into and out of position. Yet another benefit is the improvement in revenue and service quality that would occur on these lines.

We recommend that MOPT, FECOSA, and the Direccion de Ferrocarriles pay careful attention when deriving the costs involved in improving the lines and maintaining and running a good quality freight service along them. From the standpoint of long-term energy planning, electrification of these rail lines is desirable, but only if FECOSA can become an efficient railway based on the re-won banana freight trade.

RECOMMENDATIONS

1. The Direccion Sectorial de Energia has already prepared an outline of a study of gasohol production in Costa Rica that raises a wide array of questions. We recommend that this study be undertaken, but that it concentrate on the use of ethanol as an integral part of the production of gasoline motor fuel with the aim of minimizing total costs. This study should have the active participation of RECOPE, and should involve experts in refinery operations with experience in using ethanol as an octane booster. It is quite possible that such an approach would lead to a profitable and stable long-term market for ethanol produced from sugar cane, as well as possible significant environmental benefits from reduced lead pollution.

2. A study of fuel quality, focusing on diesel fuel, has been proposed. We recommend that gasoline quality also be studied, with a view to identifying potential problems for a 10-percent ethanol and gasohol blend. Such a study would focus on potential sources of contamination by water or other substances that might be dissolved by the ethanol and, as a result, act to foul engines. Solutions to any problems identified should be proposed, and their costs estimated.

3. The MOPT is considering plans for a single-line light rail transit service in San Jose. We believe that a system of trolley buses equipped with rubber tires is more likely to be a cost-effective means of substituting electricity for diesel fuel. It would avoid the cost of laying track, and entail the conversion of existing buses

rather than the purchase of new rail cars. Commuter travel demand in San Jose does not appear to be well suited to LRT because of the lack of sufficiently high volume corridors. USAID could assist MOPT by supporting an alternative study of the cost and feasibility of an electric trolley bus system in San Jose. Such a study should be multimodal, recognizing that a flexible-route, diesel-powered bus system will still be required to supplement the fixed-route trolley system. A reason why such a system has not been adequately studied may be the lack of an external sponsor, willing to provide financing, and the fact that the French have apparently taken a keen interest in the LRT option. USAID should consider whether financing can be found for a trolley bus system if it proves to be the best option.

4. In our opinion, it is extremely unlikely that rehabilitation of the transoceanic trunk line could be justified economically or as part of a fuel-switching program.

5. Rehabilitation of the banana feeder lines, on the other hand, might be essential to the survival of Costa Rica's rail system. Two facts need to be established. First, it must be determined whether the rail system could recapture and successfully serve the banana traffic. Unless it can do so, there is no point in investing millions of dollars in the rail lines. Second, better estimates of the costs of rehabilitating, electrifying, and maintaining the improved lines should be derived. From the standpoint of long-term energy and transportation planning, electrification of these lines is desirable, but only if FECOSA can become an efficient railway based on the re-won banana trade.

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