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TRANSPORTATION ENERGY CONSERVATION IN PUERTO RICO:
POTENTIAL, APPROACH METHODOLOGY AND PROSPECT TO 1985

BY

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ABBREVIATIONS AND ACRONYMS

b	barrel
B	billion
CY	calendar year
d	(per) day
f/e	fuel economy
FY	fiscal year
g; gal.	gallon [3.78 litres]
l	litre [.265 gal.]
km	kilometer [.62 mi.]
M	million
Mbd	million barrels per day
mi.	mile [1.6 km]
mpg	miles per gallon
mph	miles per hour
PCI	per capita income
PVTS	private vehicle transportation system
TDTE	total direct transportation energy
TEC	transportation energy conservation
TSM	transportation system management
VMT	vehicle miles travelled
yr	year

Occasionally used other abbreviations are explained in the text.

NARRATIVE SUMMARY

The potential for energy savings in transportation in Puerto Rico, already shown in a previous study (Energy conservation in transportation in Puerto Rico: A policy study, CEER X-32, 1978) has further increased. The transportation share in the total energy budget grew from less than 28% in 1979 to 32.5% in 1981. While the total energy consumption was dropping by some 10%, transportation energy was decreasing by less than 4%. Official figures tended to distort the real average consumption per vehicle: the total number of active vehicles was overstated by perhaps as much as 15%; the fuel consumption was understated by more than 7% because the statistics showed only gasoline consumption, not also diesel fuel used in transportation (pages 4-7, 61-64).

Together with secondary energy expenditures incident to transportation (such as losses in refining and distribution, construction and maintenance of roads, public services, and rehabilitation of accident damages to persons and property), the transportation sector used in the fiscal year 1981 over 27 million barrels of fuel, more than 52% of all the energy used in Puerto Rico. 90% of the directly used fuel was burned by passenger vehicles, 83% of them private, 66% in urban traffic. Driving other than to job, school or essential shopping represented about 40% of all trips, that is almost one-half of all private auto travel. Consumption of energy in transportation in Puerto Rico was on several accounts relatively much higher than in the United States as a whole (pages 13-23).

Wide margins for fuel economies exist in such areas as the maintenance of vehicles and roads; more controlled use of power equipment (such as aircooling); traffic engineering and enforcement; driving style and behavior; driver demand (vehicle occupancy, length and consolidation of trips, reduction of nonessential driving) and, of course, improved public transportation. Several recent estimates have confirmed a tentative figure proposed in the 1978 study: that up to 50% of fuel could be saved in Puerto Rico without substantially affecting private mobility. In 1981, this would have reduced the cost of the imported petroleum by some \$290 million; this amount represents almost 40% of the cost of crude which PREPA uses to generate all the electricity for Puerto Rico in a year, if the average daily bill is \$2 million (pages 12, 21-25).

A public policy of systematic transportation energy conservation (TEC) could be implemented on the basis of alternative scenarios, that is various

combinations and sequences of measures calculated to achieve predetermined targets (percentages of past consumption or quantities of petroleum) in specific future years. This study provides an inventory of possible measures, scenario structures and levels, and a shorthand code for easier handling of the many variables. It also identifies the more than a dozen government agencies that would have to coordinate their efforts in implementing the chosen scenario. Their activities would be guided by agency task sheets, that is subscenarios arranged in the perspective of organizational implementation rather than the total TEC targets (pages 26-35).

To illustrate the methodology, data are analyzed and arranged in a model scenario for one major category of TEC measures--fuel conservation through speed control. The analysis shows the inseparable relations between speed (too fast, too slow, erratic), energy consumption, accident rates and driving while intoxicated. Other major categories are transportation system management (which includes construction/maintenance, traffic engineering and control, collective transportation), TEC related to vehicle equipment and maintenance, and cost-conditioned driver demand and behavior. The essential information and methodology is ready for concrete, detailed elaboration whenever there is public interest and will (pages 38-48).

At the present, the decisional and implementation environment is unfavorable and worsening. The rapid transit option, alive until 1980, has been lost for at least a decade. Vested interests are strong. Private vehicle transportation is heavily publicly subsidized because of low highway user costs. The average motorist is, in fact, losing substantially more than he gains, because of poor road maintenance, inadequate traffic engineering and token enforcement; but he does not know it. Improvements cost money. An adjustment of the gasoline tax to compensate for inflation since 1974 would raise it by 10¢ a gallon, generating an income of > \$65 million (based on 1981 gasoline consumption). Systematic driver information and prudent behavior would permit an average fuel economy of 20% per vehicle. The tax could thus be raised by additional 29¢ a gallon (which is 20% of the present pump price) without increasing the total yearly gasoline bill of careful, law-abiding drivers. Even with the decreasing consumption, the government would collect on the order of \$250 million a year. This would go a long way also toward improvements in public transportation and the beginning of a mass rail transit for the 1990s. The easing fuel cost situation, which should facilitate some such course of action spread

over a couple of years, paradoxically further reduces the pressure to take any meaningful systematic measures (pages 50-56).

The expectation to 1985, the time span of this study, is for the "worst case" scenario. Some gradual decrease of fuel consumption will come only through automatic factors and technical fixes, such as the continuing switch to new, more efficient, cars, mileage-increasing gasoline and motor oil additives, the spreading information about individual TEC opportunities and, perhaps substantially, the decrease of federal transfer payments channeled into private transportation expenses. Alternate fuels may make a fractional difference; but a more extensive use of some of them, for example liquid petroleum gases (propane, etc.), would substantially increase traffic risks unless all truckers could be trained and made to avoid abrasive driving.

Among the more affirmative actions that would greatly increase TEC are: return to traffic enforcement levels which prevailed still some 5-10 years ago; a revised, energy-conscious traffic code; flow-improving engineering, as well as several other simple administrative measures. The initial payoff of practically any set of such affirmative actions is obviously very extensive. The passive crisis scenario will not cause the system to collapse, but will induce ad hoc, spontaneous and disorderly adjustments at great human, social and economic cost (pages 56-60).

1. INTRODUCTION

1.1 Objective

In a policy study of energy conservation in transportation in Puerto Rico, which the Center for Energy and Environment Research conducted in 1977-1978, it was concluded that the main transportation energy indicators and accounts in Puerto Rico were significantly higher in comparison with the United States as a whole; that they provided substantial margins for energy conservation; and that particularly the data concerning the private vehicle transportation sector should be further developed to provide a base for projections, goals and policies directed at transportation energy conservation (24.33; see also Table 2.)

The present study is a first effort in this direction. On the basis of consumption data and trends, and the analysis of various combinations of possible approaches, techniques and preconditions for success, the study seeks (i) to identify and define the apparent potential for transportation energy conservation (TEC), in terms of both specific fuel-economy targets and of systems; (ii) to estimate the real prospect for public and private decisions favoring TEC in the immediate future. A consolidated list of recommendations is presented. Elements of and direction for a more detailed follow-up are listed and outlined.

1.2 Scope and focus

There are several reasons for a cautious, limited approach at this time, such as:

- The seemingly unlimited faith of energy and transportation planners in quantified simulation, which dominated in the 1970s, has given way to a more balanced quantitative-qualitative policy analysis. It has been recognized that "much of the predictive power of any methodology is provided by the credibility of the...assumptions underlying it" (84,xiii); and that "a large margin of absolute error is always to be expected...the calculation [is satisfactory if] it will highlight if one option is approximately 2X or 3X as expensive over twenty years as another option"(113,8).

- The most specific caveat is provided by an attempt at energy scenarios for Puerto Rico, including transportation energy (121). The committee of the National Academy of Sciences which authored this report could,

indeed, not foresee the 1980-81 changes in such basic parameters as fuel supply, cost and federal regulatory policies--and much less the effects of reaganomics on mass transit planning in Puerto Rico. These changes substantially affected the premises of the present study and forced major midcourse adjustments. However, the NAS report, at least in the parts dealing with transportation, raises the question of "credibility of... assumptions" and ends up with an apparently "large margin of error" indeed. For example, gasoline consumption in the base year (1977) is understated by 15.7% ("almost 13Mb" instead of the correct figure of 15.3Mb). The low figure serves as a base for projections to 1985, as well as to year 2000. As to 1985, the expectation that gasoline consumption would by then drop back to 1977 levels, might possibly materialize already in 1982-83, although the rate of decrease of consumption has hovered around 2.5%/year, rather than the 10% predicted by the NAS report on basis of smaller increases in gasoline-pump prices. Other concrete references to the report's data, assumptions and proposals are made below as warranted.

- The performance and priorities of the government of Puerto Rico in the field of transportation in general, and of energy conservation in particular. As perceived here, these factors favor an open policy approach rather than more or less rigid scenarios based on too many uncertain variables and speculative assumptions. The situation would, of course, change as soon as the decision makers showed interest in the development and evaluation of concrete policy options and alternative scenarios to implement them.

1.3 Policy methodology

No matter what the particular thrust or scope may be, an exercise in the evaluation of prospects and in scenario construction is always a particular form of policy research and development. Environmental impact assessment offers an example. Its policy nature is no more in question (75;26); yet, it is nothing else but an evaluation of the impact scenario (or alternative scenarios) constructed from information about the planned action.

A few brief comments on the methodology, as related to the present study, may prevent some misunderstandings, both by officials and by other readers. As has been pointed out elsewhere (25,29-30), decision

makers tend to mistrust or ignore policy analysis. They seem to feel that it restricts their decisional freedom. This is no doubt true when independent policy R & D results in recommendations contrary to a politically preferred course of action which the analysis revealed as based on faulty or incomplete data, or on an inadequate (if any) examination of possible alternatives. However, on a more detached reflection, it is difficult not to recognize that the policy method provides a base for improved decision making, even under the normal--rather than exceptional--conditions of great uncertainty. The reason is inherent in the first characteristic of genuine policy development: all the available relevant information is collected and analyzed together. This improves the definition of the problem; missing data are often spotted (thus, also, gauging the degree of reliability); and a broader base for comprehensive evaluation of possible solutions, constraints, etc. is created. Even at its minimum level of effectiveness, policy analysis at least raises red flags where otherwise decisions would be made on often fragmentary and overoptimistic technoeconomic considerations, without any suspicion about the excessive external (social and environmental) cost.

At its best, the policy method functions as applied social system analysis (25,1). It is likely to identify approaches to problems which reinforce the primary objective and make it more cost-effective or otherwise attractive to decision makers because of beneficial secondary fallout. One example of such a system approach is the analysis later in this study (secs. 4.2f. of an apparently narrow and straightforward relation between fuel economy and speed, set in the broader context of causes and effects. These include drunken driving, high-risk driver groups and vehicles, accident cost and prevention, traffic engineering, management and enforcement, revised licencing and renewal requirements, adequate insurance and, of course, also the problem of too slow speed as the cause of unnecessary fuel consumption (including by other drivers) and of accidents. The simple relation between speed and energy conservation begins to look quite formidable in this set of secondary data; they, in turn, represent an empirical base for the reconsideration of major portions of the Traffic Code and of enforcement capabilities and procedures.

On a more mundane level of the millions of individual decisions whose sum total is the waste or conservation of fuel, policy analysis does not, or should not, aim at telling anybody, for instance, how much pleasure driving he can or cannot do. The objective and task are rather analytical: to collect and interpret data which may indicate

(i) that the cost of private vehicle transportation is highly subsidized and therefore not real; (ii) that when the market mechanism and/or the government catch up with this situation, the scope of individual choice is likely to be sensibly affected; (iii) what kinds of choices and trade-offs, depending on individual values and intelligence, may still afford some measure of personal freedom in moving around; and (iv) how the transportation system and needs might be restructured in an anticipatory way to make any future adjustments to critical changes in the present situation less harsh and costly.

This is all an analytical exercise. It becomes prescriptive--forcing you and me to act or not to act in a certain way--only when the policy analysis and recommendations become an authoritative decision. Its implementation is then no more a policy or a scenario; it becomes an obligatory set of law rules, procedures, administrative measures, prices and tax rates, incentives and disincentives, designed to balance transportation fuel supply and demand within the framework of needs and capacity.

1.4 Adequacy of the data base.

Policy analysis for decision making aims not at mathematical precision, but at highly aggregated data or, where necessary, at approximations without serious distortion. Technical data, no matter how hard and apparently complete, do not decisions make, nor should they, at least not in social problem solving (25,21-23). But the policy method is very sensitive to what may be called the coefficient of confidence. Aggregation, generalization, interpolation and estimate are all legitimate ways of generating policy data for decision making. But, obviously, the quality of the end product depends here, as anywhere, on the quality of the raw material: the reasonable completeness, consistency and reliability of the primary data base.

The uncertainty and incompleteness of baseline and current data in transportation and transportation-related energy consumption is notorious (33). It was commented upon in specific relation to Puerto Rico in the 1978 study (24,18). The problem continues. As the following several examples show, the statistics also tend to be biased in the direction of understating the real dimensions of transportation energy consumption in Puerto Rico, with the inevitable effect on priorities and decisions.

1.41 Number of active vehicles. Official statistics appear to have consistently overstated since 1979 the total of active vehicles. In FY'80, when the official number was 1.15 M, the active fleet was closer to 970,000, a difference of approximately 15.5%. A vehicle is not dropped from the active roster if its licence is not renewed by the end of the given fiscal year. The owner may be absent and will renew the licence when he returns. Or the vehicle may be temporarily deactivated and will be relicenced when back in service. Only when a licence is not renewed for two consecutive years is the vehicle taken off the active list. For this reason, the number of active vehicles in a given year must be estimated. The accuracy of this estimate depends on the use of a realistic so-called scrappage rate, that is the approximate percentage of vehicles that have been wrecked, abandoned, dismantled or otherwise permanently deactivated during the preceding year. The official figure seems to be the result of arbitrary estimates of the scrappage rate, after the 8% rate, generally used in the United States, was abandoned several years ago. And yet, it seems to be relatively easy to estimate fairly accurately the current scrappage rate on basis of the verified and averaged numbers for the preceding two or three years. As the estimate for any given year is verified against the actual number of not relicenced vehicles, the new number is factored into the "trend" rate for the purpose of the next estimate. The rounded trend rate established for Puerto Rico by this system is 7.5%. This is the base for the estimate of 970,000 active vehicles in FY 1980. The graphic illustration of the vagaries of the present system, a proposed equation for calculating the scrappage rate and an update note are in the Appendix.

1.42 Total direct transportation energy (TDTE). Direct transportation energy is the fuel used by the vehicle engine and equipment (such as power steering, air conditioning or freight lifting). Two major fuels are consumed in land transportation: gasoline and distillate fuel oil (diesel). Only the gasoline account is separate. It is this total that is officially considered to be the amount of energy consumed by motor vehicles. Diesel oil consumption (1.75Mb in 1979) is statistically included in "Total fuel consumption," not disaggregated by sectors such as transportation, industry, agriculture, etc. (55, Table III). It is impossible to state with any degree of precision just how much diesel is used in transportation and should be routinely added to the amount of gasoline to obtain the TDTE account.

Substantial number of heavy trucks and tractor-trailers, some 6 % of all vehicles in Puerto Rico, used diesel fuel. In the 1978 study, the transportation of freight was assigned, in the absence of any data, a hypothetical fuel consumption factor of 2.5, the factor for the passenger fleet being 1.0. This took into account also such elements as visibly inadequate engine maintenance of many trucks, overloading, and the state of roads other than toll roads, then only partly open (24,32). The NAS study arrives at a figure of 11% for freight (121, Table 23; 60, Fig. 3), without an indication of sources or method. Neither of the two calculations/estimates provides a viable base for the estimate of diesel consumption in transportation. Several new calculations were therefore performed using the following data and factors:

- The proportion of heavy trucks in the total motor vehicles in Puerto Rico is .32 of that of the fifty U.S. states (7% against 21.6%).
- Diesel represents 24% of the total U.S. truck consumption (18,1-12), which amounts to 12.2% of total U.S. transportation energy (Id., Fig. 1.2, 1.3).
- The average ratio of industrial to transportation use of diesel in the U.S., 1977 to 1979, was 1:2.2 (83, II, Table 27).
- 1.75Mb of diesel were consumed in Puerto Rico in 1979.
- The following factors were considered insignificant for the purpose of the present calculations and extrapolations:
 - The U.S. figures include diesel used by railroads and waterway transportation.
 - The use of diesel in agriculture is not disaggregated either in the U.S. or in the Puerto Rico data.
 - The growing, but still very small, number of other than freight vehicles in Puerto Rico using diesel fuel; and of freight vehicles using propane.

The various calculations of the share of diesel in the total transportation energy in Puerto Rico ranged from 4.7% to 7.8%. The rounded average of 6% is considered to be a reasonable conservative projection. This figure represented in the last several years an average of about 2% of all energy used in Puerto Rico. It must be added to the gasoline figures to obtain the real share of direct transportation energy in the total energy budget in Puerto Rico. (See Figure 2 on page 15).

1.43 Indirect (secondary) transportation energy. Transportation consumes also a substantial amount of energy incidentally, indirectly. This so-called secondary energy was already analyzed in the previous study (24,40, Fig. 3) in the following categories:

- Gasoline: Production. Distribution. Evaporation
- Vehicles: Transport. Sale. Maintenance. Tires. Parking and garaging. Administration of the transportation system.
- Infrastructure: Construction. Maintenance.
- Accidents: Emergency treatment and hospitalization. Repair of damage to vehicles and property (public, private).

A coefficient of .66 (meaning that if direct energy is 1.0, the total transportation energy is estimated to be 1.66) was used. This coefficient was derived from United States data (39;73). A 10% margin of uncertainty was assumed. Since the direct transportation energy in 1977 was 30% of the total energy consumed in Puerto Rico, the total transportation-related energy was estimated to be $30\% \times 1.66$, that is 50%. Even with the 10% margin of error factored in, the total amounted to at least 48%. This meant that transportation in Puerto Rico used directly and indirectly about as much energy as all the other sectors together (after their transportation-related energy use, mostly electricity, had been discounted). Subsequent U.S. estimates have been generally in the same range (85, 1-9), especially if the substantial accident account was added--emergency wards and rehabilitation therapies being among the most energy-intensive operations in contemporary hospitals. The TECNET (Transportation Energy Conservation Network) study, prepared for the U.S. Department of Energy, is supportive even without any correction. It concluded that in the base year 1971, "the amount of fuel consumed indirectly by transportation [was] 47% as large as the energy consumed directly by vehicles. Over time, the significance of the indirect component increases" (33,4). An average increase of one percentage point a year would have brought the coefficient of indirect energy to .57 in 1981, for a total transportation energy of 1.57. This happens to be the figure arrived at quite independently (and using a different methodology) in a study of energy consumption and efficiency of 53 sectors of the Puerto Rican economy (58).

Coefficient 1.57 means that 57% must be added to the total direct transportation energy in order to estimate the total (direct and

secondary) energy used in relation to transportation. This total ranges between 47.1% and 50.7% in Puerto Rico in the last three years, very close to the tentative gross estimate made in 1978. It appears safe to use in the future a coefficient 1.6 (TDTE being 1.0) to estimate the total transportation energy in Puerto Rico in a given period.

It is true that the indirect energy account includes many industry, construction and service activities which are presumably targets for improved energy efficiency in their proper sectors. Several others are, however, direct candidates for transportation energy conservation. To cite but two examples: (i) Poor road surface and tire-burning acceleration represent a substantial increase in tire wear. It takes seven gallons of crude to manufacture an average tire. (ii) Service stations account for 36.5% of the estimated five percent of loss of hydrocarbons by evaporation. A good seal at the interface of the pump nozzle and the vehicle fillneck saves 90% of this loss (111). That amounts to saving more than 1.5% of all the gasoline pumped in Puerto Rico in FY 1981--over 10 million gallons.

Indirect energy related to rubrics "Construction" and "Accidents" should also be taken into account in any longer-term scenario. The former, because new infrastructure construction should be weighted against the opportunities of no-construction transportation system improvements, considering the whole energy cost; the importance of the latter must be related to the relatively high accident rate in Puerto Rico, some 1.7 times higher than in the United States as a whole.

1.44 Other missing data. It is widely recognized that the ultimate key to transportation energy conservation is the owner-driver of private automobile. Fuel consumption depends on demand and on driving style. There are sufficient data on demand (number and purpose of trips, their length, vehicle occupancy rate). There are no transportation-related data on driving style and the factors which condition it, such as applied intelligence, training, education (discipline, courtesy, civic responsibility), mental competence and psychological state; data on age and sex are largely available only in the context of accidents and drinking statistics. Traffic behavior pattern of the driving public as a whole is apparently quite different from other geographic areas with comparable traffic structure and density. One indicator is the relatively high accident rate, as well as the number of vehicles with signs of having been

involved in minor PDO (property-damage-only) accidents, not reflected in the statistics. But there is no way to tell with any reasonable accuracy how numerous is the group whose driving style tends to characterize the vehicular traffic as a whole. It may well be a minority. Here it is only important to note that, whether their behavior is outside of law and reason, or whether they are simply unaware, a great number of drivers in Puerto Rico behave in a fashion grossly wasteful of energy.

As a practical matter, this study approaches driver behavior primarily in relation to (i) substantially improved enforcement of existing laws, (ii) adjustments of the price of private driving so it would reflect the real user cost, (iii) the possibility of relating law enforcement and cost to improved conservation knowledge and behavior (not rush from one stop light to another or try to beat them; switch on air conditioning only when necessary; etc.). This focus is determined by the perception of the present and foreseeable government interests and capabilities. It does not imply that nothing more could or should be done. For instance, the vehicular traffic laws and driver licencing procedures are now exclusively focused on the "rules of the road" and, less effectively, on traffic safety. The law would be greatly improved if it were made consistently energy-conscious. High traffic-risk groups, such as males under 25 years of age (and to a lesser, but still important degree, under 35 years) are now identified on the basis of accident rates and insurance claims. But the more basic collective characteristic of such groups is an excessive energy use because of speeding and aggressive highway behavior, whether they have accidents or not.

In the context of adequate data, under discussion here, any more drastic measures directed at private drivers would probably require that existing statistics be more specifically related to driver behavior and that new data--especially quantifications of particular types of traffic behavior based on reliable samples--be developed for the purpose of legislative and enforcement justification against genuine or spurious challenges.

1.45 Conclusions. A conscious and systematic effort to correct the pervasive weakness in transportation and energy-related statistics in Puerto Rico is called for. It may require a central validation process. Such a process may not only improve the quality of the statistical series, but also be more cost efficient, as it would eliminate much effort which appears to be duplicated.

Such discrepancies as exist in the estimates of the active vehicle fleet (plus 15% or more) and of the energy it consumes (minus 6% or more) should be corrected without delay. Overestimating the number of vehicles has been, indeed, the practice of highway-promoting agencies. The figures of the Federal Highway Administration were found to be 12-13% too high (18, 5-26). The improvement in statistics which happened when the Energy Information Administration was formed within the U.S. Department of Energy in 1977, showed that gasoline consumption, as calculated previously on basis of aggregated industry figures, overstated the national vehicle/gallons average by more than 100 gallons/vehicle in 1975 (87, March 1981, p.17). An error like that is very relevant to Puerto Rico. As compared with the originally reported U.S. figure of 816 gals, Puerto Rico's per vehicle consumption of 775 was well below the national average (24, 35). However, in comparison with the corrected figure of 712 gallons, Puerto Rico was 8.8% above this average--an indicator which might have given pause to decision makers.

The preceding evaluation of the existing data base in no way implies that there is not enough information available for the purpose of forward-looking transportation-energy planning and cost/benefit analysis. Even extensive changes in government policies for the coming years can be easily justified with the help of existing data. Methods of policy analysis (see 1.3 above) and of "sketch planning" (e.g., 112, 1-3, 4), which do not require costly data generation and processing, are well developed for the present needs.

least a decade. The system focus in this study is consequently limited to the possibilities of energy conservation within the existing transportation system and its improvements.

2.2 Energy imports and uses

Figure 1 shows the imports and uses of energy in Puerto Rico since the base year 1974. TDTE (total direct transportation energy) is plotted in on basis of the conservative estimate of additional 6% of diesel consumed in a given year.

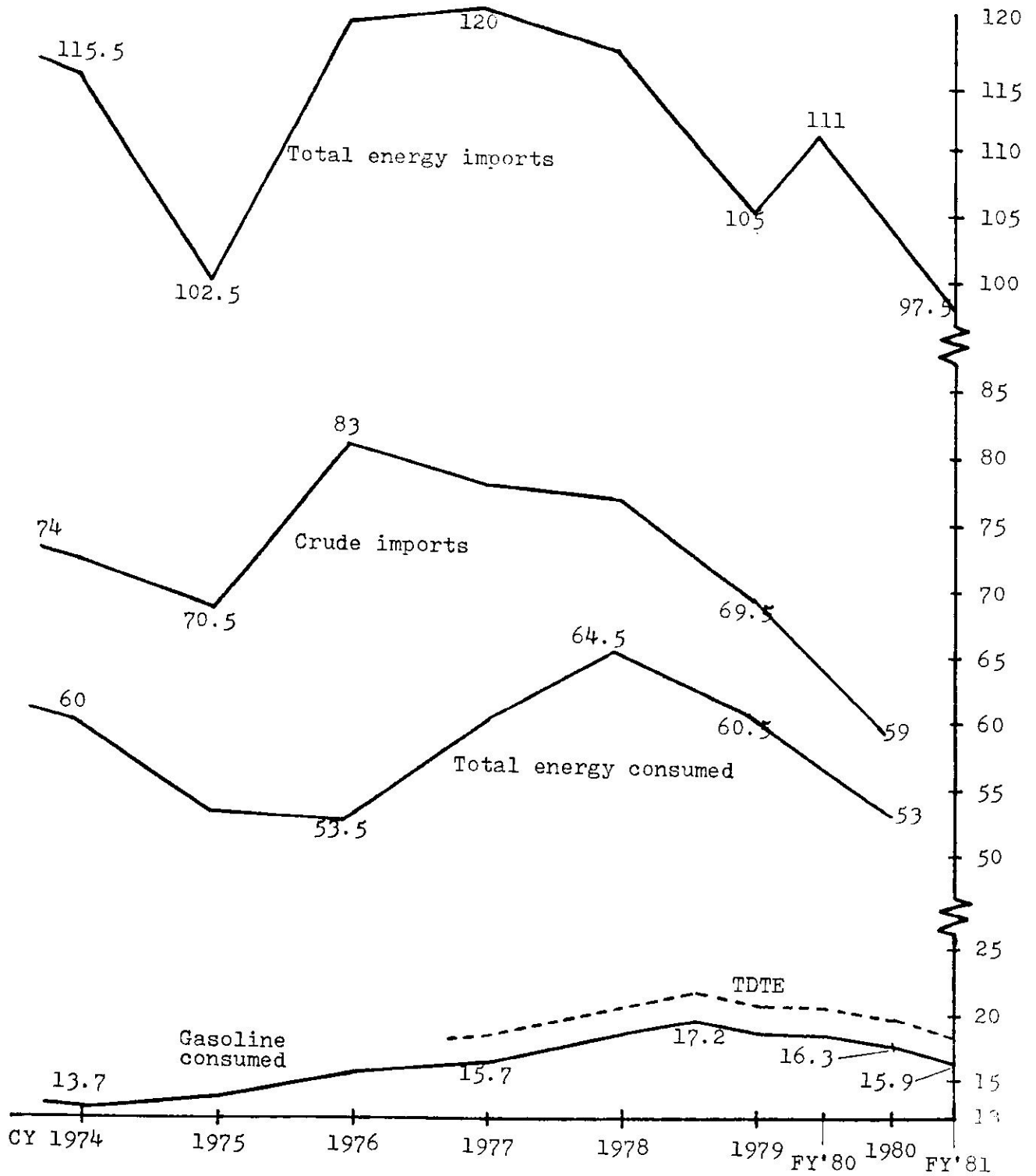
The figures for gasoline consumption are often given in millions of gallons per year; in Figure 3, they are given for Puerto Rico in millions of gallons per day (Mgd), to facilitate plotting in comparison with U.S. consumption (in Mbd). The following formulas permit a quick calculation of one value using another:

$$\begin{aligned} \text{Mg/yr} &= \text{Mb/yr} \times 42 \\ \text{Mgd} &= \text{Mb/yr} \div 8.7 \\ \text{Mb/yr} &= \text{Mgd} \times 8.7 \end{aligned}$$

For example, the last available figure for gasoline consumption, 15.9 Mb/FY'81, translates into an average daily consumption of 1.83 Mg.

If the total value of imports into Puerto Rico in FY 1981 was \$ 3.3 billion, the total energy consumed was worth about \$ 1.8 billion, and transportation energy cost about \$ 575 million.

Figure 1. ENERGY IMPORTS AND USES IN PUERTO RICO
(Millions of barrels per calendar year)



2. THE POTENTIAL FOR TRANSPORTATION ENERGY CONSERVATION IN PUERTO RICO

2.1 Policy baselines

The 1978 study concluded that wide margins for transportation energy conservation (TEC) existed in Puerto Rico. It proposed the following four policy baselines for the purpose of planning and implementation:

- I. Transportation in Puerto Rico consumes directly and indirectly about as much energy as all the other sectors put together. This share of transportation energy in the total energy budget may be as much 10% higher than in the United States as a whole. [A recalculation based on 1979 data indicates that this relative share may be in Puerto Rico about three times as high as was roughly estimated in 1977. See Table 1, item 4.]
- II. All the safe essential mobility of persons could be satisfied with as little as 50% of the current direct transportation energy in Puerto Rico, with adequate maintenance of engines, vehicles and roads, with reduced use and acquisition of convenience power equipment for automobiles, with reduction of driver demand (short trips, low occupancy, nonessential driving), and with the upgrading of overall driver behavior to the standards of the traffic code and of common sense.
- III. The private vehicle transportation sector is highly publicly subsidized. That means that the users of automobiles do not pay the full economic cost of gasoline, highway use, parking, and that they are also subsidized on a number of other accounts.
- IV. Transportation energy conservation cannot be effectively implemented outside an adequate transportation system management (TSM), in the broad sense of integrating transportation planning and management with the whole social and resource system. This will also reduce the social and environmental cost (that is adverse impacts on public and environmental health, land use and environmental esthetics) which must be assumed to be equal in magnitude to the energy and economic costs of automobile-based transportation.

The quantitative dimensions of Baselines I and II, relevant to TEC, are illustrated by the various figures and tables in the following sections. Baselines III and IV are discussed in ch. 4 and 5. The formulation of Baseline IV, cited above from the 1978 study (24,64), was influenced by the then still active planning of a transit system for San Juan, organized around a major rail component (see also 23, advocating light rail against a partially subterranean heavy-rail system) and the implicit possibilities of major improvements in the quality of the urban environment. This opportunity has been allowed to become a victim of changes in federal urban mass transit policies and is, in all likelihood, dead for at

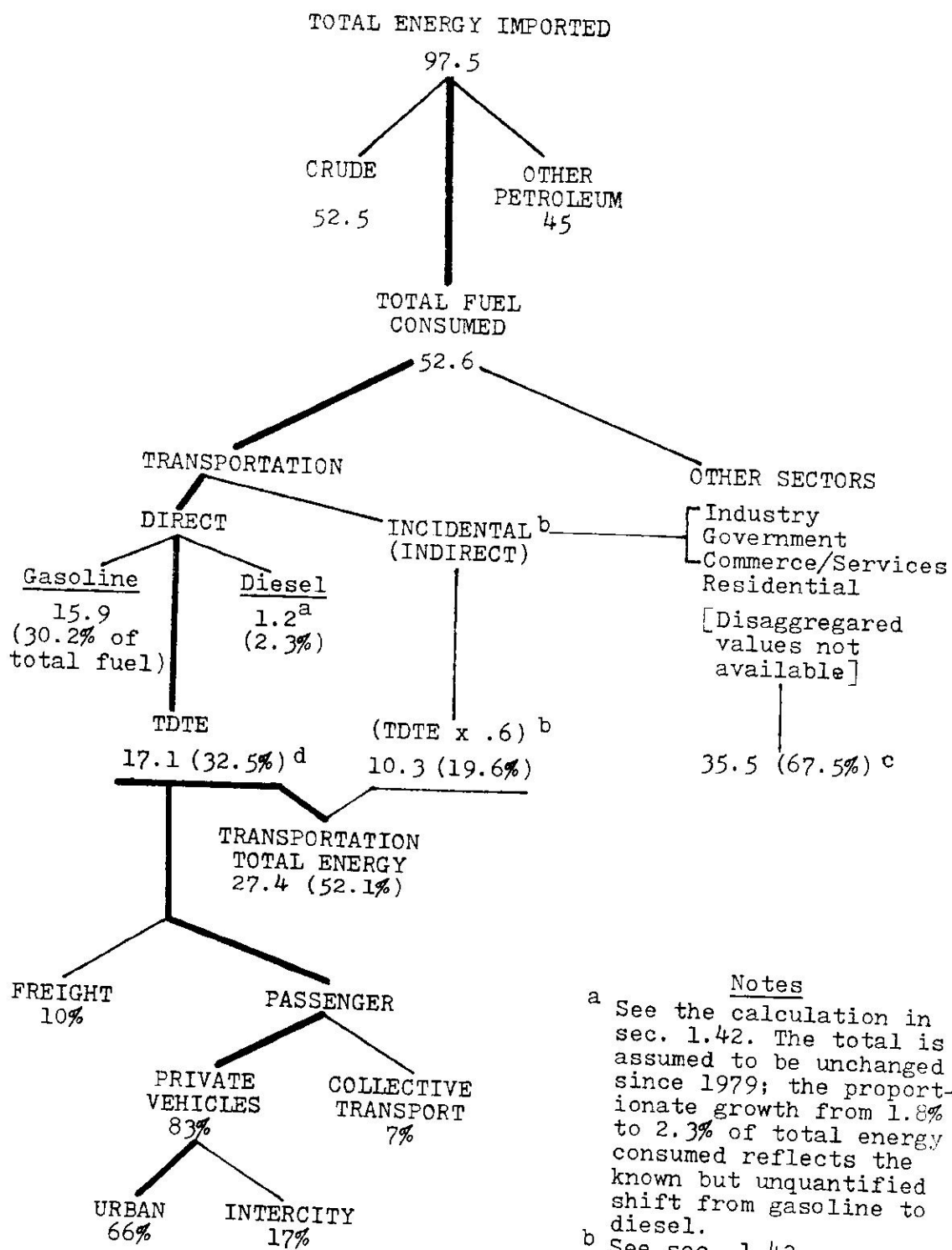
Figure 2 shows the disposition of the energy imported in FY 1981, with emphasis on the transportation sector. The heavy line connects the magnitudes which should control transportation energy conservation policies and actions. The about two-thirds of total transportation energy spent in urban driving represent about 11.5Mb, that is some 22% of the total energy consumption in Puerto Rico in 1980-81. At least 70% of this fuel consumption must be assigned to metropolitan San Juan. That represents more than 15% of the total energy consumption on the Island, despite the fact that according to a 1977 survey by the Department of Transportation and Public Works, based on a fairly reliable sample of 1600 respondents, almost 30% of families in metropolitan San Juan were still carless. (The 1980 census data are not available at this time. The proportion of carless families in comparable metropolitan areas in continental United States is 17.5%. The overall national percentage is 15.3 [95b]).

2.3 Past and present consumption trends

Figure 3 on page 17 compares the cost of imported crude, the pump prices of gasoline and the average daily gasoline consumption, in millions of gallons (Mg) in Puerto Rico and in millions of barrels (Mb) for the rest of the United States. (Puerto Rico figures in U.S. statistics only as an importer--that is, reexporter--of energy in the form of refined petroleum products.) The figure contains all the essential information. It needs only a few interpretative comments:

- The 1976 rise in gasoline consumption in Puerto Rico, the highest in U.S., is attributable to the growth of the number of vehicles, from 82,000 new registrations in FY 1976 to 110,000 in FY 1977. The continuing rapid increase in consumption from 1977 through mid-1979 was, however, out of proportion to the increase in vehicle population. It can be explained only by more driving--vehicle-miles per car (VMT). This was the case also in the United States as a whole in 1977-78. The conclusion that the added portion of VMT in the United States was in the category of discretionary (nonessential) driving seems to be supported by the sharp drop in this category, some 13% in FY 1980, largely in response to the price increase of gasoline and a temporary scarcity in 1979.
- The great increase in gasoline consumption in the U.S. (1974-78) and in Puerto Rico (1975-79) corresponded to a period when the pump prices rose only at the current inflation rate. In fact, crude was in mid-1978, at

Figure 2. ENERGY DISPOSITION TREE (FY'81 in Mb)



- Notes
- a See the calculation in sec. 1.42. The total is assumed to be unchanged since 1979; the proportionate growth from 1.8% to 2.3% of total energy consumed reflects the known but unquantified shift from gasoline to diesel.
 - b See sec. 1.43
 - c This total includes indirect transportation energy
 - d See note * on page 16

\$14/barrel, cheaper than in 1976 at \$13.60/barrel.

- Gasoline consumption peaked in Puerto Rico some 6-8 months later than in the United States. A partial explanation may be found in the fact that there was no gasoline shortage in Puerto Rico (although it was predicted for mid-1979), whereas parts of the United States suffered shortages due to distribution problems and refinery policies aimed at the availability of sufficient stocks of heating oil for the 1979-80 winter. The absence of this problem may exert a subtle but real influence on conservation policies and awareness in Puerto Rico.

- Both in the upward and downward portions of the graph, gasoline consumption in Puerto Rico exceeded relatively that in the United States. Thus the 1975 to 1979 increase in Puerto Rico was almost 28%; in the United States (1974-78) it was 15.5%. The consumption drop 1979-1981 has been in the United States over 1.0 Mbd, or 13.6%; in Puerto Rico it has been only .15 Mgd, or 7.6%. This amounts to only 56% of the decrease rate in the United States. As the monthly consumption figures show, there was no sharp drop in discretionary VMT in Puerto Rico. The two high monthly consumption periods, which correspond to the summer and winter holiday/vacation months, have continued relatively unchanged.

- The result of these trends is the growing proportion of transportation energy in the total energy budget in Puerto Rico. As Figure 2 shows, gasoline consumption in FY 1981 represented over 30% of total energy; it was under 28% in 1979. With the addition of diesel consumption, the total transportation energy in Puerto Rico has grown to 32.5% of the whole yearly energy consumption. * In the United States, on the contrary, the latest aggregate figures (87,22) showed that energy consumption in transportation was dropping 3% faster than the total national energy consumption.

2.4 Comparative interpretation

The relative dimensions of energy consumption in transportation in Puerto Rico, and the implicit potential for conservation, can be further illustrated by the comparisons presented in Table 1 on page 18.

* According to final official figures for CY 1980 (50,18), the gasoline consumption of 16.3Mb represented 30.8% of the total energy consumed, 52.9Mb. Adding 2% on account of diesel (1.2Mb) gives a total of 32.8%; almost one-third of all energy was directly consumed in transportation.

Figure 3. GASOLINE PRICE AND CONSUMPTION
(United States and Puerto Rico)

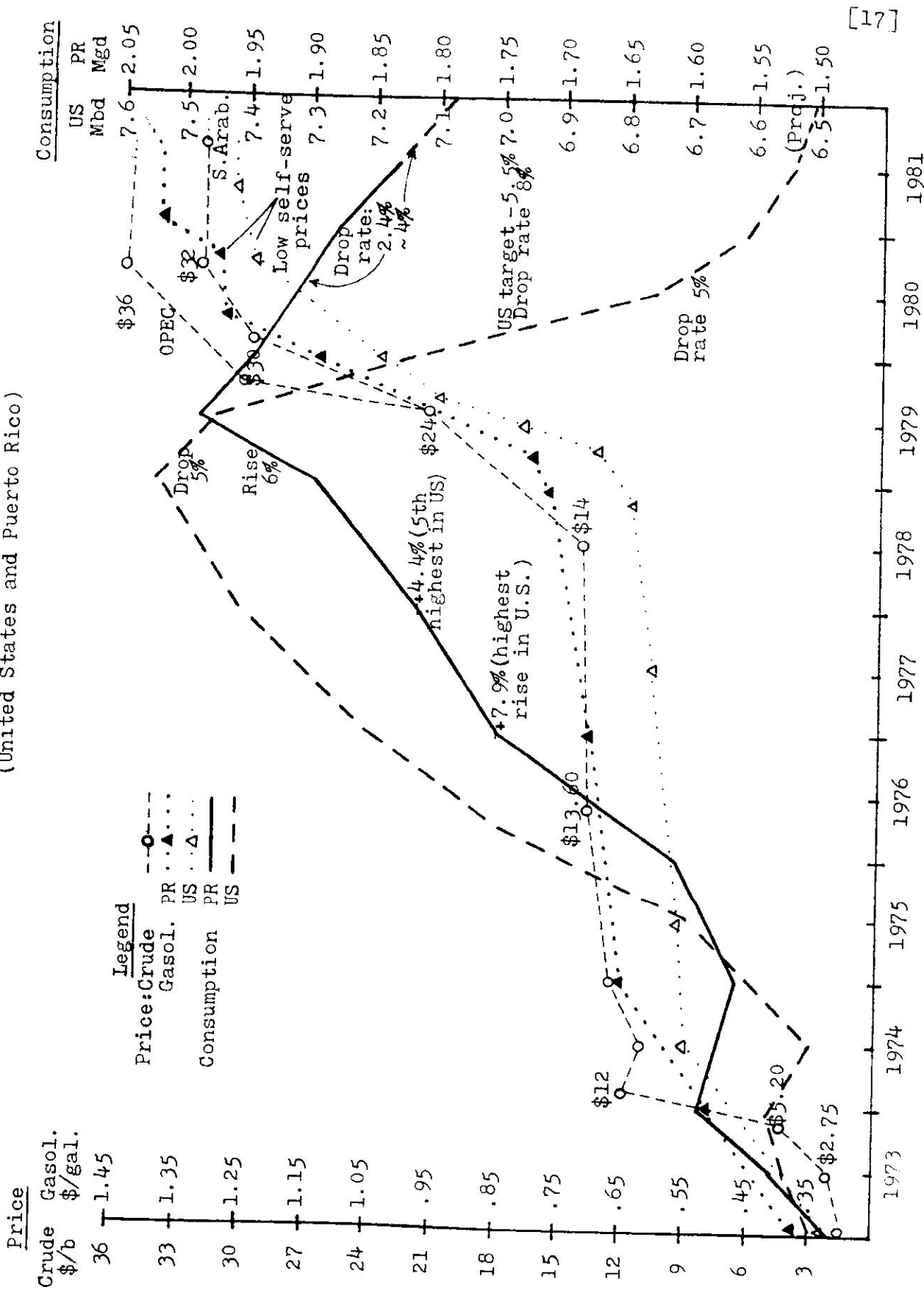


Table 1

Comparative dimensions of transportation energy consumption

(1979)	All U.S. (except where specified otherwise)	Puerto Rico
1. Petroleum share in total energy	47.5%	98.85% (1978-80)
2. Highway-mode transportation	74 %	Almost 100% ^{a/}
3. Petroleum share in TDTE	53 %	100%
4. Transportation share of total energy	25% (direct) 15% (indirect) 40% (1980)	32.5% (direct) ^{b/} 19.5% (indirect) 52 % (FY 1981)
5. Item 4: Ratios	1.0	Direct: 1.28 Total : 1.30 (U.S.+30%)
6. Passenger to freight vehicles	4:1	13:1 ^{c/}
7. Per capita gasoline consumption (gal/day)	1.4 (W.Europe 0.3) (Japan 0.2) ^{d/}	0.62 (45% of U.S., >200% of W.Eur. >300% of Japan)
8. Per capita gasoline to per cap. income (PCI)	Gasol. 496 gal. PCI \$6400	225 gal. \$ 2400 (U.S.+ 17.4%) ^{e/}
9. State gasoline consumption to PCI	Mississippi: Gasol. 3.57 Mgd PCI \$4530 (lowest in U.S.)	1.95Mgd \$2400 (Miss. + 3.2%) ^{e/}
10. Fuel consumption per vehicle to PCI (U.S.)	745 gal. \$6400	750 gal. \$2400 (U.S. x 2.7) ^{e/}

Notes

^a Minus the quantitatively insignificant share of energy consumption by ferries, domestic air travel and pipelines.

^b See Figure 2.

^c Passenger vehicles include "público" sedans and vans, as well as the almost 100,000 LDTs ("camionetas" and other light trucks used mostly for private transportation).

^d New York Times, 16 Sept. 1979, Sec. 3.

^e These figures mean that consumption in Puerto Rico, if proportionate to PCI, would be 17.4% and 3.2% less respectively, or 2.7 times smaller.

Items 7 and 10 in the preceding table acquire additional dimensions when combined with other data. Thus the relatively small per capita gasoline consumption in Puerto Rico is in line with the relative population/vehicle ratio, 3.3:1 in Puerto Rico, 1.4:1 in the U.S. This relative parity is confirmed by figures on per-vehicle fuel consumption (item 10). However, while the P.R. consumption is close to the U.S. average, the area of Puerto Rico, about 100 times 35 miles, is not close to the national average, but rather 48th in size among 51 state units. This is another indicator of the high transportation energy consumption in Puerto Rico. For instance, it was calculated that the 1978 fuel consumption represented some 9 billion VMT. The distance around the Island is about 300 miles. The vehicle mileage represented an average of 32 trips around Puerto Rico for each of the 935,000 vehicles active in 1978.

The interest of the comparisons based on PCI lies in that they show the extent to which private vehicle transportation has been allowed--if not also actively nudged--to become a real or felt necessity almost irrespective of economic level. Some additional comments may be helpful:

- First, the comparison in item 9 of the table--that gasoline consumption in Puerto Rico in 1979 exceeded by 3.2% that of Mississippi, if compared in terms of PCI--coincides interestingly with another figure arrived at by a completely different methodology. In the voluntary state gasoline conservation targets promulgated by the federal Department of Energy, Puerto Rico was requested to conserve in 1980 13.7% of gasoline, the second highest target in the U.S. (Alaska was highest with -16%). Mississippi's target was -10%. Added to the 3.2% calculated above, it would target Puerto Rico at -13.2%--almost identical with the DOE request of 13.7%.
- There is a partial explanation of the real need for the high private vehicle mileage. It is the great amount of commuting to work which resulted from certain aspects of economic development planning. A 1974 study (41,6,A1-4) found that in 54 of 78 municipalities, more than 50% of labor commuted in (while the rest of the labor force was resident). In 13 municipalities, more than 50% residents commuted out to work and more than 50% of the labor force commuted in. In two instances (Cataño and Carolina, both at the edges of metropolitan San Juan), the rates of out-commuters were as high as 63.8% and 65.6% respectively; the in-commuters accounted for 50.5% and 68.7% of the total local labor force. The fuel cost of this exceptionally high mobility was roughly estimated at 20% of the total fuel

consumption. The study suggested that the intercity collective taxi system ("público") be expanded and that its service level and public image be improved. But the major reason for commuting in low-occupancy private vehicles was then, and is still, the convenience at relatively low cost, both in fuel and in highway user costs. For instance, the toll collection on expressways is too low to cover even the annual payments of principal and interest on the borrowed funds. Such economics invite unnecessary driving in all categories. The making of 140-mile round trips (at speeds exceeding the posted limit, thus further increasing fuel consumption) to see a movie in San Juan a few weeks earlier than in the local theater, was documented already in the 1978 study (24, 51). A more recent example is the revelation in legislative hearings that unlicensed street food vendors commute to San Juan over the same or comparable round-trip distances (59, 10 Oct. 1981).

▪ There still remains the question of economics. Considering the low level of "labor participation" (the official percentage is in the low 40s, some 45-50% below the U.S. national level) and the large numbers of welfare participants, where does the money for all this driving come from? Two major sources suggest themselves, in addition to a sufficient taxable income:

(i) the extensive underground economy, estimated to be in the \$3 billion-a-year range (59, Sept. 1981); (ii) the about equal yearly amount of federal programs and transfer payments. Of this money, particularly the food coupons (approximately one-third of the total, or \$1 billion) have become to an important extent a second currency which found its way also into the transportation sector. This aspect of transportation economics in Puerto Rico not only increases energy consumption because of the number of vehicles; it also causes fuel penalties on account of the relative age and the minimum maintenance of the economically marginal portion of the fleet.

2.5 Major TEC categories and targets

Table 2 lists the major categories of fuel penalties (that is, consumption that can be eliminated or reduced) and the corresponding transportation energy conservation potential for Puerto Rico. The contemporary data and estimates differ very little from the 1973-78 information (24, 43-54), extracted and reconciled from some twenty sources. Additional more recent reference is (18; 42; 53; 7; 78; 86; 91; 92; 98; 101; 102; 66; 67).

Table 2. Summary of the categories and estimated potential for transportation energy conservation in Puerto Rico

CAUSES OF FUEL PENALTIES	POTENTIAL TEC IN %	COMMENTS
MAINTENANCE		
<u>Vehicles</u>		
Tune-up	10-15) E.g., a new set of spark plugs, 3.5%.) The cumulative estimates range from) <u>15% to 25%</u>)
New filter	25	
Adjust idling	2	
Lubricants	2.5-5	
Tires: Type	2.5-5	Radial ply tires, as compared with bias ply tires. The rolling resistance of bias belted tires is somewhere in the middle. The upper value corresponds to tires inflated to maximum recommended PSI (27-29 in 1980)
Tires: Inflation	1.5-6	
Front-train alignment		Cumulative maximum value corresponding to optimum tire quality, maintenance and alignment averages <u>10%</u>
<u>Infrastructure</u>	25	This is probably a too conservative increase from the 1978 estimate of 22.5%, because of the massive deterioration of roads in Puerto Rico. Drivers use up to 56% more fuel when driving on substandard roads "due to loss of traction and uneven power flow through the drive train because of vibration" (66).
POWER EQUIPMENT		
Automatic transmission	15	EPA 1981 tests range from 7 to 19%. Exurban driving averages 1.5% less. Weight adds 1% to all values. This is the fuel penalty in urban hot-weather operation. Added weight represent 2%. A cut-off device during acceleration can reduce fuel consumption by as much as 45% (01,69). (Weight) (Operation)
Aircooling	20	
Other power convenience equipm't	1.5 1	
Vehicle getting 10 mpg more	18	
TRAFFIC		
Flow	10	<u>Representative parameters</u> (+ = increase in fuel economy; - = fuel penalty) • One-way street, +12% • Steady flow @ 25mph vs. "normal" stop-and-go traffic (or congested, slowed-down traffic @ ϕ 10mph), +40% • Right-turn-on-red, +2%

(Table 2 cont'd)

<u>Causes of fuel penalties</u>	<u>Potential TEC in %</u>	<u>Comments</u>
<p>TRAFFIC Flow (cont'd)</p> <p>Enforcement</p>	20	<p>[Parameters]</p> <ul style="list-style-type: none"> . Two slowdowns from 40mph over one mile, and reacceleration (due to not synchronized traffic lights), -16% . Two stops and restarts under same conditions, -32% . 50mph in 35-40mph zone, -7% . 70mph in 50mph zone, -25% . Acceleration to "beat" a traffic light or to pass another vehicle at a speed above urban 35-40mph limit, -20% each time. If the violator has to stop at the next traffic light, the fuel lost in stopping and consumed in reacceleration is another -25%, for a total -45%. . Entering an intersection on "yellow" and blocking the "green" cross-traffic; each 10 vehicles idling 1 minute equal one vehicle travelling 2.5mi @ 15mpg, 3.75mi @ 25mpg.
<p>DRIVER</p> <p><u>Style/Behavior</u></p> <p>Following simple rules of economic driving</p> <p>Driving w/in speed limits</p> <p>Excess weight</p>	<p>15(minim.)</p> <p>27.5</p> <p>1 (ea. 50 kg)</p>	<p>According to actually carried out pilot programs, this figure applies to any driver instructed in proper acceleration, smooth driving manoeuvres and anticipation of stops and slowdowns. The economy of fleet drivers can be improved up to 20% (102). Urban braking is estimated to use up one-third of acceleration energy. The potential is higher in the case of erratic/aggressive drivers. Each "rabbit" start wastes 15% fuel as compared with normal brisk acceleration. *</p> <p>See the enforcement parameters above. Base estimates: -7% for 60% of urban VMT; -15% for 40% intercity VMT (passengers and freight). 70% drivers violate speed limits in the U.S.; the hard core (multiple speeding arrests) is estimated at 3.5%, i.e. 5 million (102). Truck fuel penalty is calculated at ϕ -2.2% for each 1 mph over 55mph. (91).</p> <p>Reference is to unnecessary objects permanently carried in the vehicle.</p>

*These and other percentages were measured with the help of equipment which can be installed in any car. A "cruise control" (governor) gave a minimum 5% fuel economy at steady highway speed of 55mph. "Manifold vacuum gauge" improved urban consumption by average of 9 to 14%, but as much as 24% in some cases, by helping to keep light, steady foot on the accelerator. It demonstrated the benefits of deceleration (coasting) versus braking (7;81, Oct.1980).

(Table 2 cont'd)

<u>Causes of fuel penalties</u>	<u>Potential TEC in %</u>	<u>Comments</u>
DRIVER <u>Style/Behavior</u> (cont'd) Unnecessary idling		Defined as letting the engine run for more than 30 secs. when stopped for other purpose than a traffic light. Estimated consumption is 60% of typical urban driving; or .25 to .4 mile for each minute of idling, depending on vehicle mpg and tuning.
<u>Demand</u> Vehicle occupancy (all trips) Short trips Trip purpose <u>Essential:</u> . to work . to school . to shop (consolidated) . medical-dental <u>Non-essential/discretionary</u> . other family business . social . recreational	20 10 25	<p>The 20% f/e results from an increase in average occupancy for work trips from 1.6 to 1.9; that means, for each 10 vehicles, to reduce <u>single</u>-occupant vehicles from 6 to 4, and increase <u>double-</u> and <u>triple</u> occupant vehicles from 2 to 3 each, for a total of 19 persons in 10 vehicles.</p> <p>If a vehicle needs to be used at all, the consolidation of four 1-mile trips into one 4-mile trip increases fuel economy between 2 and 2.5 times, depending on the number and length of stops. (A one-mile trip is only .5 mile there and back; and it may be shorter on foot, depending on the pedestrian vs. traffic layout).</p> <p>This non-pleasure category totals only 50% of private auto travel (home-based, meaning starting at home and returning there directly, and non-home based). These 50% represent 40% of all such trips, the rest being made by some other mode (bus, public, bicycle or just plain walking). The fuel economy potential coincides with the categories "Vehicle occupancy" and "Short trips" above, in addition to a shift to public transportation, as much as available.</p> <p>U.S. estimates are from 35% upward. The P.R. total for home- and non-home-based trips is probably closer to 40% on basis of the following data and empirical observations:</p> <ul style="list-style-type: none"> . Regular gasoline consumption increase by as much as 15% during two yearly holiday/vacation periods (summer, Christmas). . City and intercity traffic density outside the daily peaks for essential travel. . Intercity traffic on weekends. <p>This discretionary driving represents about 50% of all private auto travel.</p>

2.6 A summary evaluation

The importance of the estimates of TEC potential in the preceding table does not primarily lie in their numerical values. Some of these values are difficult to express with sufficient confidence, given the present state of data and art. Other potentials are knowingly understated in the table. An example is the 10% assigned to "Essential trips" because of the lack of public transportation and to, so far, apparent unpreparedness of employers, public and private, to organize vanpooling on a scale that would make a difference. Still other potential economies, though real and substantial, are not inherent in transportation as such, but in the priorities and attitudes of the police. U.S. data support the empirical hunch that the hard core of willful, systematic traffic violators in Puerto Rico is relatively small. The great majority of other lawless drivers follow the example of those who are "getting away with it." Thus a return to "normal" enforcement would probably have a quick multiplier effect. But the decisions necessary to mobilize this TEC potential make it proportionately more difficult. Only strong and determined governments dare to tackle the effects of the social Gresham Law.

For these and other related reasons, the principal value of the estimated fuel conservation potentials is not in any exact numbers, but rather is to be found in two other aspects of the table:

- (i) It suggests the comparative orders of magnitude and the relative pay-offs of various energy conservation actions.
- (ii) It disaggregates as well as confirms the global conclusions expressed in policy baselines I and II, cited at the beginning of this chapter (sec. 2.1).

The 1978 estimate of a conservation potential of 50% of "current direct transportation energy", while providing "all the essential safe mobility" in Puerto Rico, was admittedly heuristic, that is, designed to stimulate more intensive analysis and precise enumeration by technical specialists (24,53,65-66). Even without this follow up, it must be assumed that the very tentative original estimate is now confirmed and supported by the inventory in Table 2 (which is simply an updated synopsis of the original data). For instance, the following fuel economies add up to 50%:

More careful vehicle maintenance and driving	25%
Increased occupancy (work trips)	5%
Selective airconditioning	5%
Reduction of discretionary driving	10%
Other (traffic management & enforcement)	5%
	50%

These are very conservative estimates. The 15% estimate on account of unnecessary driving and failure to form carpools, was made by the former director of the Office of Energy in July 1979. Several incidental counts during the morning rush hour (0730-0830) showed that almost one-half of the passenger vehicles had their airconditioning on. The list above does not include such substantial fuel saving measures as better road maintenance; other items from Table 2 could be added or substituted.

The 50% estimate has been subsequently also supported by:

(i) a number of general and specific studies of energy futures, all of them emphasizing conservation as source of energy, and identifying transportation as the principal conservation target, specifically also with reference to Puerto Rico (121);

(ii) concrete, quantified demonstrations of the extensive fuel economies that can be achieved by relatively simple improvements in maintenance, driving style and awareness (102);

(iii) the increasing recognition that, beside massive technical fixes such as CAFE--the corporate average fuel economy standards mandated by the Energy Conservation Policy Act of 1975 [27.5mpg for 1985 models]--substantial fuel savings can result from the sum total of separately insignificant conservation practices. For example, one million minutes of unnecessary idling (equivalent to one minute idling by every vehicle in Puerto Rico), due to poor timing of traffic signals and to carelessness of drivers, represents about 17,500 gallons of gasoline or the yearly mileage of 35 cars (335,000 miles), worth \$ 26,000 (at \$1.50/gal). This amount of fuel is lost by idling several times over every day in San Juan.

(iv) Recent global estimates of possible fuel economies, published in information material by the U.S. and P.R. governments (78,53), range from 30% to 50%, depending on the age and efficiency of the vehicle and on the engagement of the driver. The individual concern and attention are becoming more critical as the federal technical fixes (e.g., CAFE) may be postponed or made less effective.

(v) Still another similar estimate (40-60% saving) comes from an urban planner (J.E.Gibson, Designing the new city [1977], quoted in The Futurist, Feb. 1979, page 61.

3. SCENARIO ANALYSIS AND CONSTRUCTION: AVAILABLE CONCEPTS AND TECHNIQUES

3.1 Synopsis

The preceding Table 2 represents an inventory of the various causes of fuel penalties and of the corresponding estimates of potential for transportation energy conservation. Although it was shown to be sufficient for the purpose of a rudimentary but significant global estimate, this is only the first stage of scenario making.

The actual implementation of planned fuel conservation requires more than a classified diagnosis of what causes fuel waste. Drivers must be made to act so as to conserve. No other mechanism comes even close to the effectiveness of the cost of driving that hurts. In that sense, TEC is the function of various incentives and disincentives. Some of them are outside the control of the government, such as the cost of crude, refining and distribution of motor fuels. Others can be controlled by the government: gasoline tax; excise tax and/or licence fees directed against fuel wasting vehicles or accessory equipment; parking fees and tolls on low-occupancy vehicles entering congested areas.

Another group of TEC-promoting measures and actions falls under the headings traffic system management and enforcement. The various cost-oriented and management/enforcement measures also need to be inventoried and evaluated for the purpose of TCE scenarios.

Finally, it is necessary to put together and analyze various possible combinations of measures, the identification and quantification of specific conservation targets, the possible priorities, sequences, levels of intensity, and time horizons and limits. The concepts and methods related to the second- and third-stage scenario inventories are explained and illustrated in the following sections.

3.2 Inventory of TEC-promoting measures.

One of the better examples of such an inventory appears in a 1979 study by the congressional Office of Technology Assessment (74,116-117). Entitled the "Petroleum conservation case," it lists the following measures and policy options:

1. Highway construction: decline by 40% by the year 2000.
2. Mass transit: substantially increased [federal] funding (capital investment, operations).

3. Mandatory fuel economy: 33mpg by 1990, 40 mpg by 2000
4. Speed: Rigid enforcement of 55mph
5. Safety [accident prevention]
6. Technology: 25% more diesel cars by 1985; 60% more by 2000
7. Taxes: Gas guzzler ban/tax
High gasoline tax
Efficiency incentive tax
Annual VMT tax
8. National I/M [inspection and maintenance] program
9. Improvement of traffic flow
10. Carpooling promotion
11. Auto use controls
12. Subsidized telecommunication networks [to substitute for auto travel]
13. Public education and appeals.

The list contained also the deregulation of fuel prices, which was mandated by legislation as of 30 September 1981, and actually was implemented early in 1981. The list also makes it possible to see how extensively--though not necessarily forever--some of the most effective TEC measures were reduced or blunted on the federal level, that is, for all practical purposes, removed from the state-level conservation repertory.

A simpler inventory of measures was proposed in the federal Department of Energy's project of "productive conservation in urban transportation" (79, Dec. 1979):

- . Enhance group travel
- . Set specific fuel-economy targets (10, 20, 30%)
- . Reduction of number and length of trips (promotion of home work, with the help of communication technology)
- . Reduction of energy intensity (change of travel mode [car to transit, etc.], staggered hours lessening traffic congestion)
- . Grouping of policy and technology elements to reinforce each other.

Elsewhere, the "techniques for reducing in-use automotive fuel consumption" were conceptualized in three categories (101,88):

1. Modification of the vehicle;
2. modification of traffic flow;
3. modification of driver behavior.

The minimum conservation program proposed in 1979 by the Puerto Rico Office of Energy contained the following measures:

- . Intermediate [peripheral] parking, to continue work trips in vanpools
- . Red-turn-on-right (the law was passed in 1977)
- . Improved traffic engineering, including traffic lights activated by traffic flow
- . Improved public transportation (buses, publicos)
- . Changes in excise tax and licence fees to reduce the import of big and medium-size models.

The last measure was intended to produce about 55% of the expected 5-6% of transportation energy conservation in 1980. As Figure 3 (page 17 above) shows, the effective drop in gasoline use in 1980 was less than 3%.

3.3 Reference inventory for Puerto Rico

In comparison with these and other references, the most complete and specific inventory of TEC-promoting measures is the one summarized in Table 2 above, based on the 1978 policy study. The various measures can be aggregated and graphically ordered as shown in Figure 4 on the opposite page.

The figure brings out again inevitably the predominant role the driver plays in an effective conservation effort. Of the three categories of "modifications" cited above from the DOT study, "vehicle" corresponds to "technical innovation" (left top of the "spoke wheel"); "traffic flow" corresponds to "TSM/Road maintenance" (right top); "driver" corresponds to all the remaining categories, with "cost" being the major incentive/disincentive.

Even the initial disaggregation of the category "cost" in the demand-related column (left bottom) indicates the variety of levels and functions of cost. It also implies that not all of them are equally effective or easy to implement. Table 3 on page 30 shows a possible ranking of various measures using the criterion of difficulty. Difficulty is the function of the degree of decisional discretion, that is collective and individual human control over the various TEC measures. It has been most frequently assumed in transportation energy analysis that, in view of the difficulties related to individual discretion, only "automatic" technical fixes ought to be relied upon for TEC. Such an assumption extensively reduces the scope of possible action. It is not an adequate policy premise if the tasks of policy analysis for decision making include the prevention of future mobility crises.

Figure 4.

Major groups of fuel-economy and TEC-promoting measures

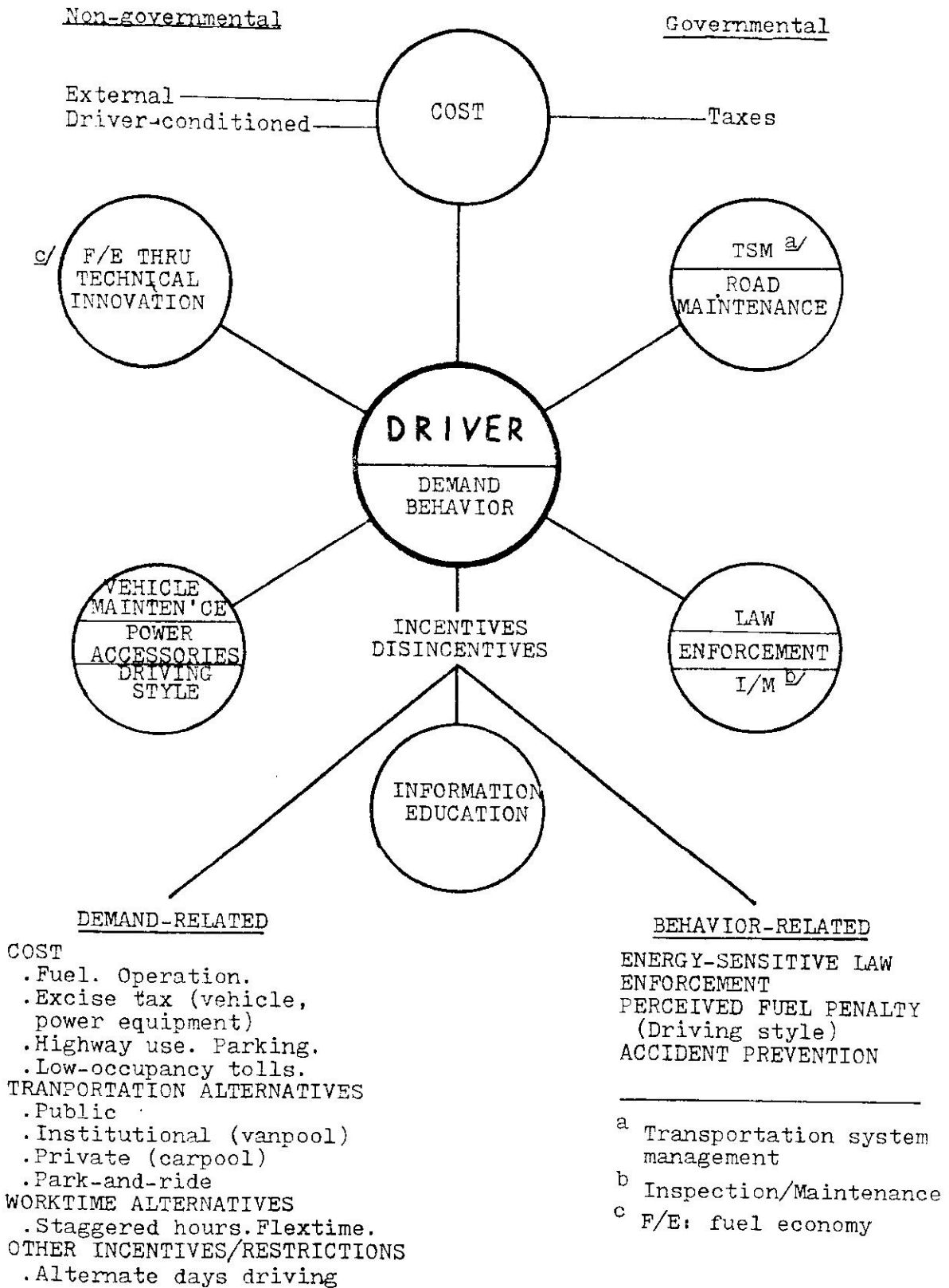


Table 3

TEC measures ranked according to assumed difficulty
in enactment and implementation

- A. AUTOMATIC FIXES [External/Federal]
- I. Cost of imported energy
 - II. Federal laws and regulations
 - III. Innovation (e.g., federally mandated fuel economy for new cars)
- B. DISCRETIONAL FIXES [State government; subject to political decision making and related pressures]
- I. Technical-management
 1. Infrastructure
 - . Maintenance
 - . Non-construction improvement
 - . Construction
 2. Traffic engineering
 3. Comprehensive inspection/maintenance (mechanical-emissions-fuel economy)
 4. Transportation/mobility alternatives
 5. Worktime alternatives
 6. Government vanpooling (supported by withholding of parking privileges or by high parking cost)
 - II. Legal-administrative
 1. Traffic control
 - . Energy-conscious traffic code
 - . Enforcement
 - . Traffic
 - . Parking restrictions
 2. Fiscal incentives/disincentives
 3. Travel restrictions other than by cost/taxes (e.g., alternate-days driving)
- C. DISCRETIONAL BEHAVIOR [Total or substantial individual control]
1. Individual f/e measures
 - a) Vehicle maintenance
 - b) Reduced use of energy-intensive convenience equipment
 - c) Reduced vehicle mileage
 - d) Travel during less congested periods
 2. Increased vehicle occupancy for work travel (carpooling)
 3. Decreased nonessential/pleasure travel
 4. Alternatives to private vehicle

3.4 Structure of alternative scenarios

The final phase in scenario making is the selection and combination, or alternative combinations, of the available elements, using one or more of the following criteria.

3.41 Combining measures and sequences. What combination(s) is(are) possible, practical? How much fuel is it likely to save?

The rudimentary scenario in sec. 2.6 above is an example.

3.42 Quantified fuel targets. What percentage of past fuel consumption or absolute quantity (Mg) can be, should be, conserved? What measures would achieve it?

Assuming that the conservation plan proposed by the P.R. Office of Energy for 1980 (49) attempted to comply with the then minimum federal target of 5%, the scenario quoted in sec. 3.2 (page 27) would be an example.

3.43 Combined approach. What combined measures and at what level of intensity would be necessary to achieve alternative numerical conservation targets in a given year (e.g., 7%, 10%, 15%) or in a sequence of years (30% the first year; additional 10% the second year; additional 5% in the third year)?

3.44 Alternative levels of intensity or assumptions. Finally, alternative scenarios can be developed by postulating various possible/desirable levels of conservation effort and intensity, of time frames and limits, of inevitable/tolerable impacts.

This structure is illustrated, for example, by the alternative scenarios developed for the study of U.S. energy demand and conservation to year 2010 by the Committee on Nuclear and Alternative Energy Systems of the National Academy of Sciences (120). The various scenarios are described in terms of the following energy conservation policies:

- A - Very aggressive; deliberately arrived at reduced demand requiring some life-style changes
- B - Aggressive; aimed at maximum efficiency plus minor life-style changes
- C - Moderate; slowly incorporates more measures to increase efficiency
- D - Same as C, but 3 percent average annual GNP growth
- E - Unchanged; present policies continue

The difference between A and E is 16 quads Btu (or 161%) in the transportation sector, 77 quads (or 132.5%) in total energy projections. The assumed cost of energy is four times higher under A than under E.

3.5 Possible scenario structure and levels for Puerto Rico

The following four levels of possible TEC effort and of the corresponding policies, planning and programs were tentatively defined in the early stages of this study (Fall 1979):

- SCENARIO I. Unchanged policies: minimum or passive response to price changes and federal mandatory standards; minimum improvements in infrastructure and public transportation; token information/education actions; waiting for the crisis to come.
- II. Improved government performance: no real changes in policy, law and regulations, management and existing institutions, some effort to respond beyond the minimum; return to enforcement levels of 5-10 years ago.
- III. Moderate and incremental policy and performance changes: gradual removal of the public subsidies of private-vehicle transportation; increase of gasoline tax beyond the inflation factor; active promotion of vanpools and carpools; the beginning of real transit (bus and/or rail on separate guideways); changes in law and institutions; continuous explanation of individual conservation measures that can offset cost increases.
- IV. Activist TEC policies: the most rapid feasible implementation of the various measures tabulated in Table 2 above.

3.6 Codification. Agency Task Sheets.

3.61 The purpose of codification. Detailed elaboration of alternative scenarios requires that many variables, possible groupings, alternative quantified conservation targets (percentages, cardinal numbers), lead times, agency tasks and rates of implementation be handled. On the level of magnitude represented by Puerto Rico, this can be done without electronic data processing. But some simplified method for easy manipulation of the variables--especially the development and comparison of heuristic flow charts--is required when the time horizon is more distant than in the present study, or with regard to those scenario levels which require a sustained system approach. The latter is the case of SCEN III and SCEN IV as defined above (although they are obviously not realizable within the 1981-85 span).

The following simple codification scheme was designed and pretested in the course of this study. It is included here for the sake of completeness and as a point of departure for a possible follow up.

3.62 Proposed scheme. The complex of variables was organized on the following levels, with letter or number codes assigned as is indicated below.

- Major groups:
- A - Administrative implementation, regulations, institutional coordination and changes. Enforcement.
 - C - Cost to driver other than F (cost of vehicle, operation, maintenance)
 - D - Driver demand and behavior
 - E - Education and information (Driver demand and behavior modification other than through A, C, F, I, L and V-type measures)
 - F - Fiscal/cost measures and controls: Fuel-economy oriented incentives/disincentives. Fund raising for transportation-related government activities (A, E, I, L, R and T)
 - I - Innovation (f/e-enhancing technical fixes, e.g. speed governors; new/improved transport modes)
 - L - Legislation
 - R - Road [transportation infrastructure] maintenance and improvement
 - T - Transportation system management
 - V - Vehicle fuel economy, equipment, maintenance

Subgroups (types of measures or behavior):

Group codes with arabic numbers attached. For example: T1, T2, T3, etc. signify various aspects of traffic system management. Further breakdown into more specific categories or measures is achieved by means of adding numbers or low-case letters: if T3 is public transportation, then T3b is buses, T3p is "públicos" (urban feeder and intercity system can be distinguished as T3pu and T3pi), T3t is transit (separate guideways for buses or rail).

Combinations (groups, measures, agency responsibilities): e.g.,

- LF - Legislation necessary to enact a fiscal measure
- FV - Excise tax favoring fuel-efficient vehicles
- LT - Legislation aimed at traffic management (energy-sensitive traffic code); LTa - administrative/regulatory measures to implement LT; LTa3 - changes in licencing of professional drivers.

Quantified targets: expressed by percentage or quantity following the coded measure. E.g.,

LD1/27.5% [speed limit enforcement]

DE2/20% [instruction of fleet drivers in simple rules of economic driving]

Target years: Y is the target year. The lead time in years is expressed as Y-1, etc. Thus, e.g.

Y-3 - enactment of enabling legislation and regulations
 Y-2 - administrative preparations, budgeting, etc.
 Y-1 - implementation begins; public information/education
 Y - the measure is implemented and effective
 [Y+1 - monitoring and adjustments]

3.63 Agency Task Sheets. Under the system approach which is implicit (and is further elaborated and illustrated in the next chapter), the scenarios group the measures and actions in function of the targets or other desired results, not by implementation sectors or agencies. However, for the purpose of implementation, the existing agency structure must be used unless and until it can be adjusted as energy management and conservation might indicate. The scenario "systems" must be therefore broken down into agency-by-agency subscenarios, here styled Agency Task Sheets (ATS). The function and structure of the ATSS is summarized here for the sake of completeness and as a possible base for follow up.

Purpose. Each ATS defines and explains the rationale, alternatives and the individual or cumulative effects of each proposed f/e measure; technical questions of timing, sequences and interactions with other related measures; and the anticipated difficulties of political, socio-psychological and managerial nature.

Form and language. ATSS aim at middle-level administrators and program managers, on two assumptions: (i) that it is their information and attitude that most immediately determines what in fact happens, (ii) that they are the source of data and concepts for higher level policy decisions.

Addressee agencies. These would be, in the alphabetic order of codes:

ACAA - Obligatory liability insurance (participation in accident prevention and driver education)
CSP - Public Service Commission (regulation of trucks, publicos, taxis)
DACO - Price control (gasoline, parking, interest charges on car loans)
DIP - Public instruction (young-driver education; information of parents through their school children)
FED - Federal agencies (with specific sub-identifications)

- HAC - Treasury (excise taxes on gasoline, vehicles, equipment; traffic fines)
- LEG - Legislature (various commissions: Transportation and public works; Resources; Socio-economic; Health and environmental quality; Treasury; Education; Consumer Affairs--representing the broad support system effective TEC would require)
- PLAN - Planning Board
- POL - Traffic police and support (e.g., computerized driver records)
- PROE - Office of Energy
- TOP / AC: road construction and maintenance; traffic engineering
 AMA: San Juan bus system
 MVB: Motor vehicle records, driver licencing
 PLN: Transportation planning (transit)
- TSC - Traffic Safety Commission
- VAR - Other jurisdictions, appropriately identified, until given separate codes.

Feedback function. The proper sequence in any major detailed scenario building effort would require three principal steps:

- (i) Draft model scenarios;
- (ii) Transformation into ATSS (subscenarios) and field testing in the agencies;
- (iii) Finetuning of the scenarios with the help of feedback from the real-life users.

4. THE NEED FOR SYSTEM APPROACH

4.1 Recent developments in transportation planning

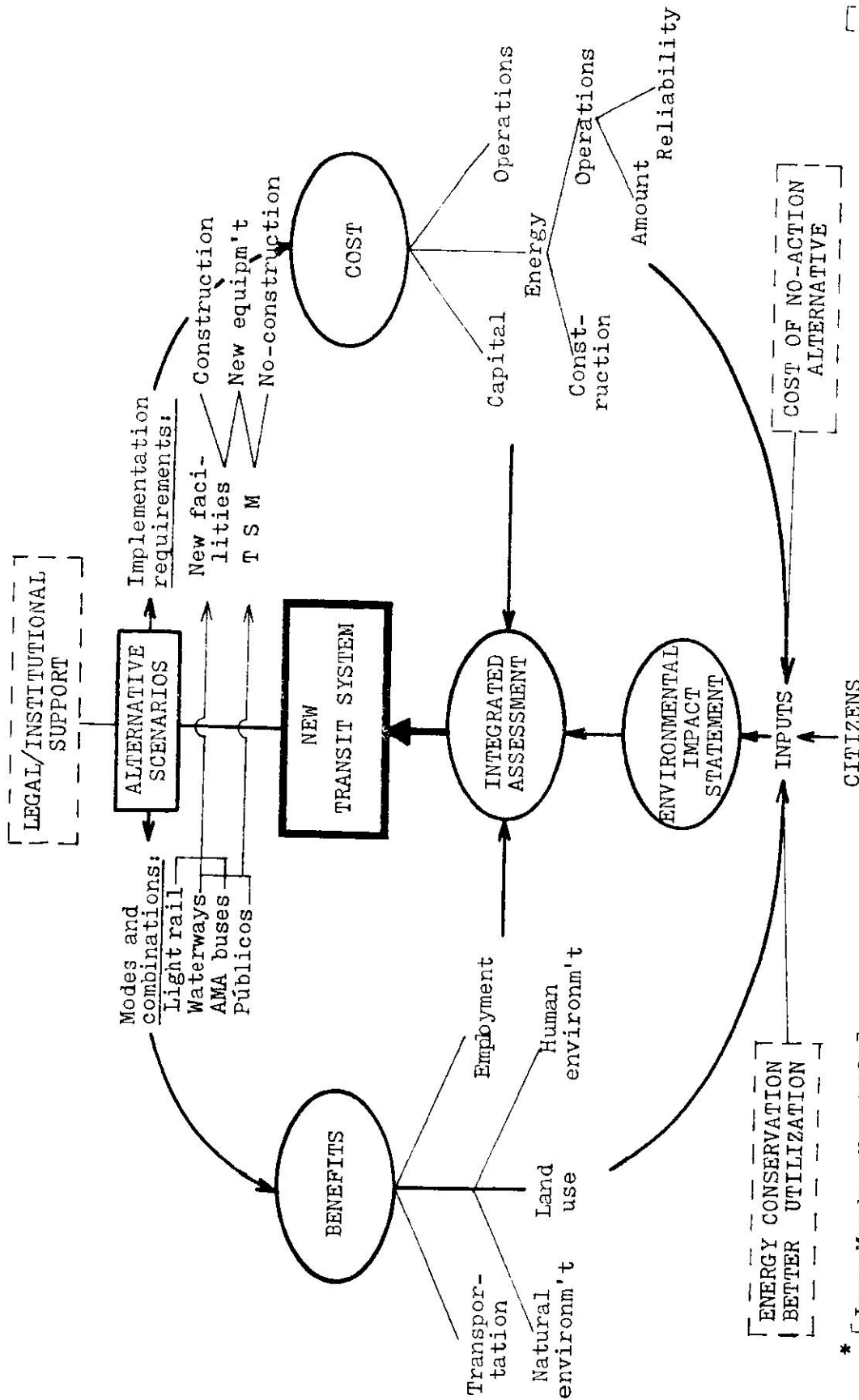
Technical analysis and planning have traditionally tended toward reductionism and sectoral perspective. Presented as a superior, problem-oriented way, this "engineering approach" (20) at best solved one problem without regard to--or even awareness of--other existing or potential problems. Even if planning was systemic in the technoeconomic sense (22), it concentrated on one-half of the real system, neglecting the other. If our problems, many of which can be traced back to the limited and skewed planning vision, are not worse, the reason is that the real-world systems are in fact very complex human ecosystems (21) with all the adaptability and resilience of natural ecosystems. Much that has happened in response to new changing circumstances was due to the automatic built-in socio-economic mechanisms. We have managed not because of the oversimplified schemes of government planners and decision makers, but in spite and outside of them. We need to build this system dimension into our thinking and decision making. The natural adaptation is better than no adaptation. The limitations of human-political wisdom are such that we must rely on the inherent capacity of systems to bounce back. But the new equilibria established in spite of errors and lack of foresight are never at the level or in the form which would result from willed, comprehensive policies. Just think of the difference in our transportation, energy and environment if 20% of the \$550 million, spent on highway construction in 1969-1972, had gone into the beginnings of an effective rail-bus transit in San Juan and on the island. The ideas (e.g., TUSCA) were there.

It was the premise that transportation planning and management is--ought to be--just a specific example of ecomanagement, that guided the 1977 analysis and critique of the ongoing "Metro" planning for San Juan (21). It emphasized the relations between transportation needs on the one hand, and energy, air quality and urban human environment on the other. Under the color of the mandatory environmental impact assessment, this became in 1980 the direction of a new planning stage (see Figure 5, where the group "Cost" represents the bulk of technoeconomic planning; under the limited traditional approach, recommendations based on these parameters would connect directly with the decision on the new system, short-circuiting all the other loops, or at best going through a formalistic, after-the-decision, environmental impact "analysis"). Since this was the

Figure 5

TRANSPORTATION SYSTEM PLANNING FOR SAN JUAN, P.R.

(Scope chart)*



* [Jaro Mayda. Nov.1980]

first really systemic effort in the history of planning and decision making in Puerto Rico--not only in the transportation field--it is particularly regrettable that it was allowed to become a victim of changes in federal policies and funding. It should be reinstated in its full intended scope as early as possible. The "cost of no-action alternative", though not quantified, are obviously very substantial.

4.2 System analysis in policy and scenario development: Example of fuel conservation through speed control.

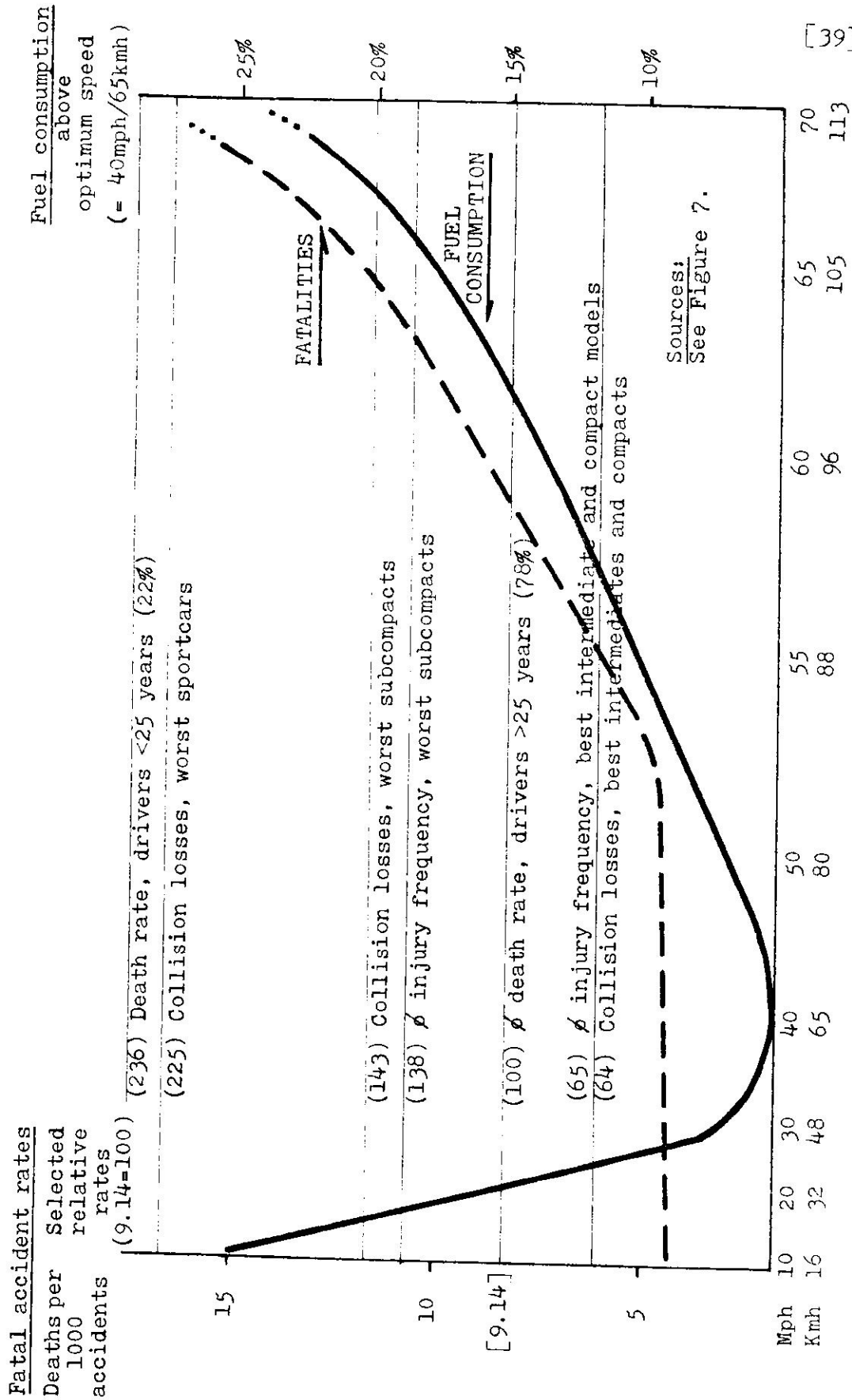
In the specific context of TEC, Baseline IV cited in sec. 2.1, corresponded to similar system considerations. Policy planning elsewhere has moved in the same direction in the last few years (2; 10; 31; 35; 40; 77; 79; et al.). At its low reaches, transportation system management (TSM) is essentially a set of separate programs and actions with some effort at coordination. Combining TEC with air quality is very recent (10); yet emission control tuning represents some 75% of the total fuel economy achievable through engine maintenance (101). Two TSM levels are obviously necessary: (i) Transportation system planning (as discussed above) and (ii) Transportation system management in the narrow, operational sense. The following set of figures and tables is an exercise in analyzing a very specific TEC management problem--the reduction of fuel consumption through speed control--in its system framework. It shows the difference between the policies, justification of the control measures, and the effectiveness of such an approach as compared with single-track approaches to TEC through traffic control and speed limit enforcement based only on traffic-code "rules of the road."

Figure 6 on the opposite page features the TEC-related components of the system in question (except driving while intoxicated; see Figure 7 for this parameter). * The whole system is schematized on page 40.

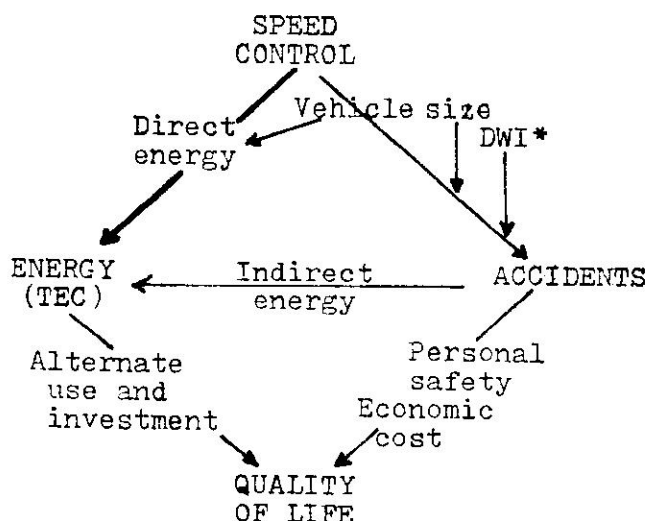
* Figure 6 uses the speed of 40mph as the average base value. The most fuel-efficient steady speed varies in fact from about 35mph to about 45mph, according to the size and power of the automobile. Experimental vehicles have shown even more dramatic increase in fuel consumption than that shown in Fig. 6. Viking IV, which averaged 87.5mpg during a cross-country rally (Bellingham WA to Washington DC), achieved best fuel economy, 103mpg, at 35mph; at 40mpg consumption increased already by 12.2%; at 70mph it was 38.8% more (Popular Science, January 1982, page 80).

Figure 6

COMPARISON OF SPEED, FUEL CONSUMPTION, FATALITIES
 AGE OF DRIVERS AND SIZE OF PASSENGER VEHICLES IN ACCIDENTS
 (U.S. national figures)



[Continued from
page 38]



*Driving while
intoxicated

4.3 Interpretation of Figures 6 and 7.

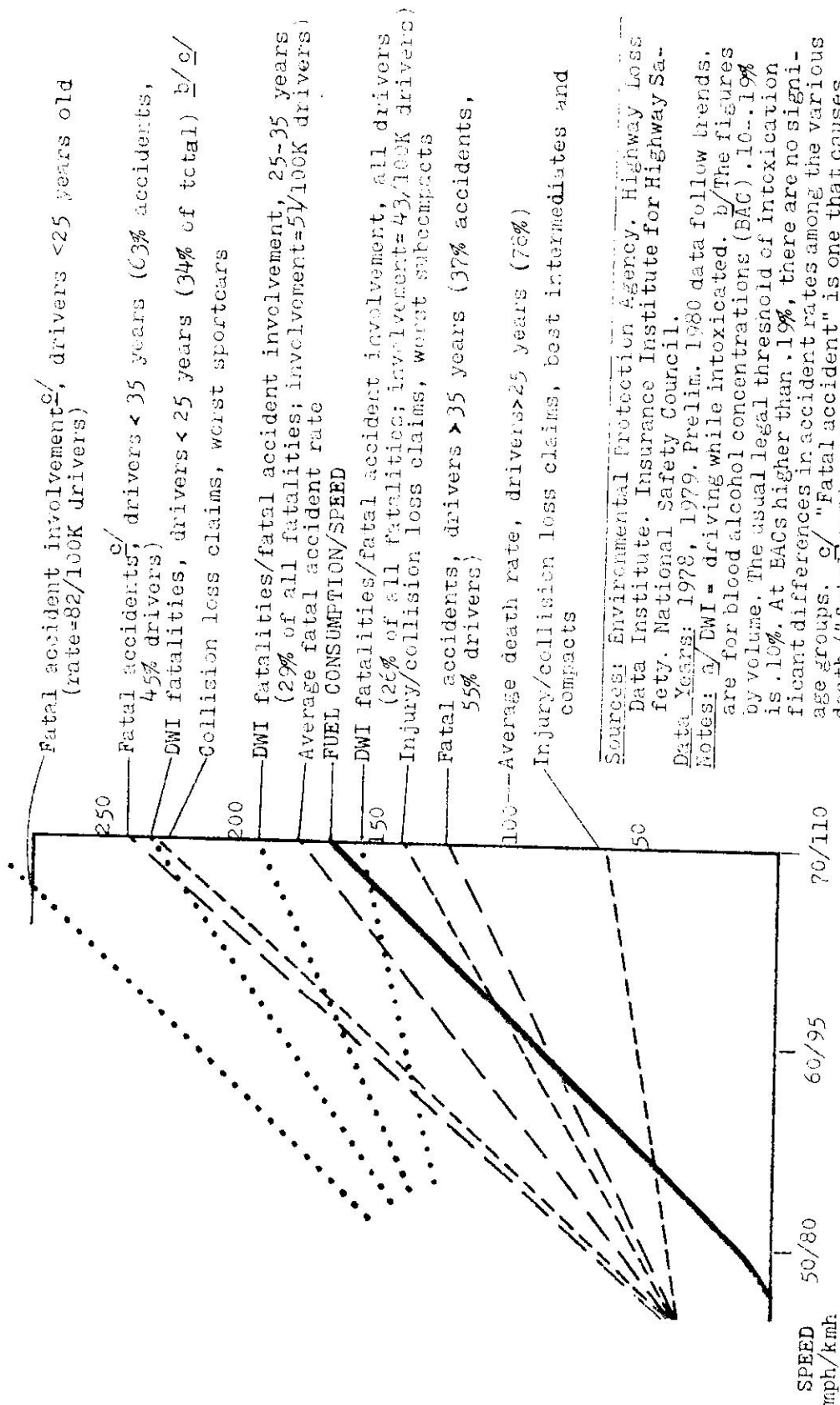
The implications of U.S. national figures are even more significant for Puerto Rico, due to the substantially higher accident rates in all categories, as well as the faster growing fleet of subcompacts--especially models with the worst collision safety record.

4.31 The speed factor.

Figure 6 shows why low speed is also a proper target for TEC through traffic rules, engineering and management. Policy analysis and decision making concerning high speed are more complex. There is an almost linear relation between fuel diseconomy and the average rate of fatal accidents. This rate grows exponentially when low driver age, DWI and their combinations are factored in. It is paradoxical that a change in the fleet composition--the rapidly growing share of small passenger cars--desirable from the viewpoint of fuel economy, is adding a serious accident factor. In addition, the very fuel economy of small cars may be a disincentive when it comes to driving at slower, fuel-saving speeds. These complex interrelationships, simply expressed in the schematic figure above, represent but one example of the insights not readily available through single-issue analysis. The resulting traffic management mandate then reflects the several dimensions and brings them into a common focus. TEC requires a shift to smaller/lighter passenger vehicles. It should be fostered directly through excise tax, indirectly through gasoline tax. But this policy also

Figure 7

CONCEPTUALIZED SYNOPSIS OF FIGURE 6 (50-70MPH SEGMENT)
(with DWI-related data approximately plotted in) 2/



Sources: Environmental Protection Agency, Highway Loss Data Institute, Insurance Institute for Highway Safety, National Safety Council.
 Data Years: 1978, 1979, Prelim. 1980 data follow trends.
 Notes: a/ DWI = driving while intoxicated. b/ The figures are for blood alcohol concentrations (BAC). 10-.19% by volume. The usual legal threshold of intoxication is .10%. At BACs higher than .19%, there are no significant differences in accident rates among the various age groups. c/ "Fatal accident" is one that causes death ("fatality") within one year; but the "involvement" rate is higher, averaging 130 fatal accidents per 100 driver fatalities.

increases the governments responsibility for the prevention of the more severe traffic risks. These must be controled at their origin: excessive speed and other traffic violationsthat cause collisions between vehicles of increasingly disparate size and weight, particularly freight and passenger vehicles. Additional statistical data illustrate the last point as well as other aspects of Figure 7.

4.32 Vehicle size. The most critical data are these:

- The proportion of compacts and subcompacts in the total fleet in Puerto Rico is about two-thirds--almost 50% higher than the U.S.national ratio.
- Cumulative data on 99% of all accidents (the U.S. Fatality Accident Reporting System) established already in 1975 that the fatality rate of subcompacts was 1.93 that of full-size cars. According to 1979 data, 85% fatalities occurred in small cars that crashed with bigger cars; in crashes between small cars and truck 97% fatalities occurred in small cars.
- Tractor-trailers represented only 0.9% of the fleet, but were involved in 8.5% of the fatal accidents. The fatality risk of truck drivers was relatively low, even in collisions with other trucks. Of a total of 4624 fatalities involving trucks (U.S., 1979), less that 7% (322) were truck drivers.

4.33 Fatal accident rate grows proportionately with speed beginning at about 50mph/80kmh. The average U.S. ratio of fatal accidents to all accidents is 1:470; at speeds above 65mph it is about seven times higher, 1:67. An analysis of 270,000 accidents (North Carolina, 1973) showed a fatality rate 15 times higher at speeds above 50mph (28% of all accidents) as compared with accident speeds below 30mph (45% of all accidents).

4.34 Drivers below 25 years of age have a death rate 2.36 times higher than drivers 25 years old or older. Males below the age of 25 have almost twice the accident rate of females in the same age group (but also account for about twice the VMTs-95a). Drivers 35 years or younger are involved in 36% more fatal accidents than those older than 35. The age separation line of 35 years also corresponds to a sharp bend in the DWI-related curves.

4.35 Driving while intoxicated. There are interesting relationships between DWI, age and accident involvement, with important implications for possible policy and law changes with regard to licencing (and suspension) of young drivers. For instance, the overall ratio of driver/vehicle involvement in fatal accidents is 1.3 (meaning that about 77% of drivers in such accidents are killed). However, the ratio corresponding to drivers younger that 25 years, is 2.4. That means that young drivers kill 85% more occupants of the vehicles in collision, while they themselves

survive, than drivers over 25. (In comparison with the 35-and-older group, the rate is 100% higher, that is about double.) The relation to DWI is illustrated by these figures: the percentage of DWI drivers under 25 years in all accidents (figures for fatal accidents alone are not available) is 36%, as compared to 25% in the 25-34 years group, and an average of 10% for drivers 35 years and older. That means that 3.6 times more young drivers involved in accidents are intoxicated, as compared with drivers over 35. The statistically unavailable connection to fatal accidents is implicit in the fact that DWI is responsible for more than one-half of fatal accidents overall; and that drivers in the 20-24 years group (12% of all drivers) were involved in 21% of fatal accidents in 1979, i.e. 75% more than corresponded to their number. It has been suggested that "young drivers are [possibly] less able to drive adequately after drinking" (28, 42, 52, 54; see also reference * on page 45).

4.4 The corresponding scenario model

The following set of tables shows the development of a concrete scenario based on Figures 6 and 7.

4.41 is a comprehensive policy analysis which integrates the controlling data and parameters in Figures 6 and 7 with other previously cited and supporting data and parameters.

4.42 is a conceptual model which organizes the policy data for the purpose of their transformation into a scenario.

4.43 is the possible scenario matrix, the base for detailed recommendations of measures, combinations, sequences, time frames and f/e estimates, as well as institutional responsibilities and coordination.

POLICY ANALYSIS

PRIMARY OBJECTIVE

Speed control at the slow and the fast extremes is an important source of fuel economy and, therefore, one of the principal TEC targets.

DIRECT IMPLEMENTATION MEASURES

Slow speeds: Traffic engineering and management.
Driver education and awareness.
Supporting legal/regulatory.

Fast speeds: Speed limit setting, considering also the f/e parameters.
Speed limit enforcement.

NEED FOR SYSTEM APPROACH

Premises: In addition to fuel diseconomy, fast speeds cause four-fifths of severe/fatal accidents.
Young age and intoxication are the principal cause of accident causing speeds.
In the absence of other braking factors (very high fuel cost; stringent traffic controls), the improved f/e of new, smaller cars could act as a disincentive to driving at more economic speeds.
Small cars suffer disproportionately in collisions with bigger vehicles.
Trucks have an overall record of higher-than-average negligent/reckless driving.
Slow speeds and excessive idling (60 seconds idling = .4 mile driving @ $\bar{\phi}$ 35mph) are the source of also another externality: the impact of the increased fuel consumption on urban air quality.

Conclusions:

The primary objective of fuel economy needs to be analyzed and attacked within the whole set of factors and parameters.

Three major categories are involved and need to be balanced:

- . Technical fixes: improvements of f/e (decreased vehicle weight; better engines and transmissions; aerodynamics, tires, etc.) independent of driver behavior;
- . Economic fixes (gas-pump prices; taxes, disincentives), indirectly affecting driver behavior
- . Direct control of driver behavior (human/social "fixes")

POLICY ANALYSIS (continued)BENEFITS OF
SYSTEM APPROACH

The resulting incidental benefits are secondary to the main TEC objective, but important on their own--mainly the reduction of the human and economic costs of severe accidents.

The mutual reinforcement of the primary objective and the "secondary" control measures, and the total resulting pay-off, should foster positive decision making and implementation.

PUERTO RICO:
ADDITIONAL
REINFORCING
ARGUMENT

All other data and factors being comparable with those in Figure 7, based on U.S. as a whole (age factor, DWI, proportionate growth of small car fleet, truck accident ratios--see additional references in Notes*), PUERTO RICO HAS SUBSTANTIALLY HIGHER ACCIDENT RATES;

FATALITIES PER VEHICLES REGISTERED	= U.S. x 1.75
FATALITIES PER TOTAL ACCIDENTS	= U.S. x 2.7
INJURIES PER TOTAL ACCIDENTS	= U.S. x 5.9

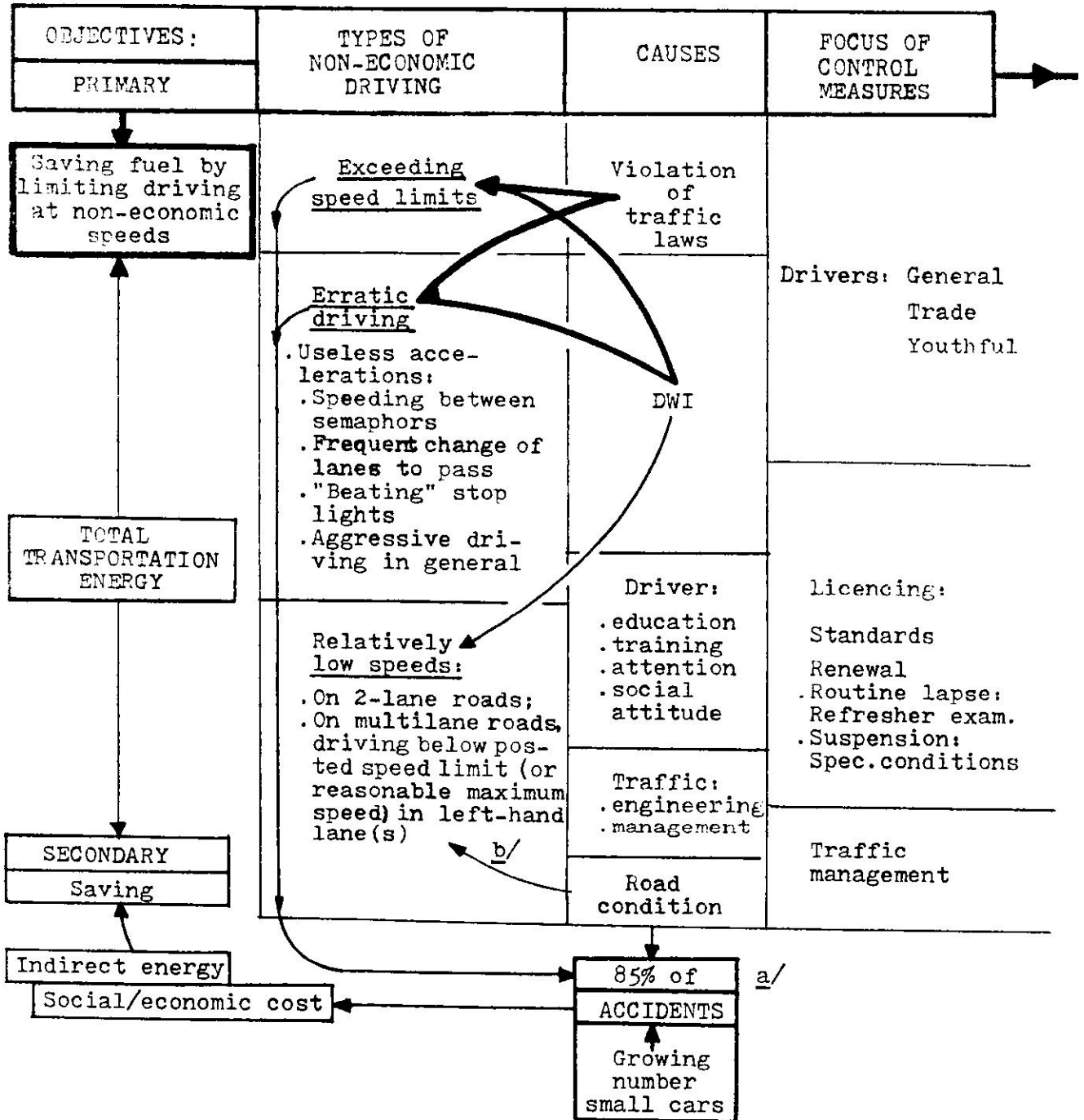
A composite picture of a typical fatal accident in P.R., as culled from police records cited in the daily press (1979-80), includes some or all of these characteristics:

- . Unlicensed driver
- . Age below 25 (often below 20)
- . Excessive speed
- . Early morning hours of Saturday/Sunday (probability of DWI)
- . Veers into the opposite lane, causes head-on crash
- . Kills people in the other vehicle
- . No information available on charges against the apparently liable driver

*Notes: DWI: South Carolina Commission on Alcohol and Drug Abuse, "Alcohol and fatal accidents in S.S., 1975-77," cited by the National Safety Council, 1979, as the controlling U.S. study. Per capita alcohol consumption in P.R. and the U.S. is approximately equal. Truck accidents: Listed as the top issue for government safety regulations (special licencing and controls) in NTPSC, National transportation policies through the year 2000 (1979), pp. 48,239. Driver age. Frequent calls for raising minimum age to 18. Some car rental companies have begun to require minimum age 21 (in mid-1980).

1.12

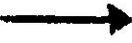





CONCEPTUAL MODEL



a/ Only 15% accidents or less are ascribed to mechanical defects.
 b/ Possible contributory factor; better surface in left lane.

4.43

SCENARIO MATRIX

 MAJOR CATEGORIES OF CONTROL MEASURES	INDIVIDUAL MEASURES	ESTIMATED F/E	AGENCY RESPONSIBILITIES AND INTERACTION
	[See the following text]		
 SYSTEMATIC ENFORCEMENT OF PRESENT TRAFFIC LAW			
 ADMINISTRATIVE SUPPORT ACTIVITIES			
 ENACTMENT OF A NEW ENERGY-SENSITIVE VEHICULAR TRAFFIC CODE			
			
 PUBLIC INFORMATION AND CONTINUING EDUCATION			

4.44 Comments. The next step would be to enumerate the various discrete measures under the several major categories, code them for easier handling, and estimate their direct effect on fuel economy or their influence (indirect effect) on other conservation measures.

Comparable scenario matrixes could be developed with the help of the same methodology with regard to such other TEC measures as are listed or implicit in Tables 2 and 3 (pages 21-23 and 30 above). These measures tend to fall into three major categories. The elaboration of the full alternate scenarios could thus proceed on the basis of the following four matrixes:

- A. Fuel conservation through speed control (the policy analysis and conceptual model for which is developed above);
- B. Transportation system management (TSM in the narrow sense, see 4.2 above);
- C. Fuel economy related to vehicle equipment and maintenance; and
- D. Cost-conditioned driver demand and behavior.

Several considerations add up to the conclusion that instead of an exercise in detailed scenario construction conducted in an implementation vacuum, it is more useful at this time to offer an illustrative open-ended list of measures from all the four categories. The selection of the items for this consolidated list has been determined by the extent to which this sample could illuminate the opportunities for TEC improvements between now and 1985 on the level of SCENARIO II (sec. 3.5).

The major consideration for this approach has been stated at the outset of this study (sec. 1.2): "The performance and priorities of the government of Puerto Rico in the field of transportation in general, and of energy conservation in particular...favor an open policy approach rather than more or less rigid scenarios based on too many uncertain variables and speculative assumptions. The situation would, of course, change as soon as the decision makers showed interest in the development and evaluation of concrete policy options and alternative scenarios."

As Table 2 shows, the initial payoff of practically any set of simple actions is patently very extensive. The prime purpose of the policy method as applied in this study (the introductory explanation is in secs 1.2 and 1.3) is precisely to provide a base for the selection, as well as the progressively more detailed (including quantifications) analysis of the various concrete decisional options as they may become feasible. The

TEC monitoring curve over the first 18-24 months of application would show the real effectiveness of the various measures, as compared with the initial expectations. This would be the base for further, progressively selected and detailed strategies.

A subsidiary set of considerations is technical. Despite the apparently continuing faith of many practitioners in the magic of absolute numbers arranged in neat columns, there has been a growing number of disappointments in various fields, from economics to environmental assessment to energy projections. Experience has often shown the uselessness of efforts to arrive at exact quantifications valid beyond the following six to twelve months. Even computers can not simulate beyond the quality of the raw data they are fed. (Many of the data for Puerto Rico are insufficient or lacking, including such first parameters as the number of active vehicles or of diesel consumption in transportation in a given year; secs 1.41 and 1.42; but see also the summary conclusions in sec. 1.45, last paragraph.)

Advanced quantitative analysis has begun to learn from this experience. The latest prediction of crude oil price for 1985 ranges from \$37/b (the contemporaneous average price) to \$50/b, a margin of 35%. The estimates of an underlying parameter, the predicted U.S. economic growth during the four years in question, have a range of 40%.* It is difficult to draw a clear line of distinction between such gross estimates and the order-of-magnitude numerical base of policy analysis. Except for explicit methodology, the two appear practically identical.

* Energy projections to the Year 2000. Division of Analytical Services, U.S. Department of Energy. September 1981.

5. THE PROSPECT

5.1 The decisional and implementation environment

The decisional and implementation environment in Puerto Rico is unfavorable to any meaningful, systematic transportation energy conservation. Anything significant that may appreciably reduce the excessive fuel wastage in the next several years will be the result of more or less automatic adjustments of the system to external crisis factors, not of any deliberate sustained government policies and actions.

5.11 The worsening situation. The basis and frame of reference for an effective TEC has, in fact, worsened even since this study was first tentatively designed in mid-1979. At least four major areas or factors can be pointed out:

(i) The loss of the rapid transit option. The importance of rail transit lies not so much only in direct TEC, but in the viable alternative it provides to much commuting (jobs, school) as well as some discretionary driving. If properly designed (as was, for example, proposed in 1977: 23) it also physically controls private vehicle traffic and provides a major opportunity for the improvement of land use and the human urban environment. The light-rail concept was, in fact, the main component of several leading options in the last effort to put the San Juan "Metro" on track (see sec. 4.1 and Fig. 5, pages 36-38). Even with the dubious original heavy-rail design (1967; see 20), and despite the rejection of two private construction offers, San Juan was in the mid-1970s still one of the primary candidates for a federal grant. It could make a much better case than such cities as Denver, Miami or Atlanta where new federally supported systems were approved. The opportunity was aborted in favor of an all-bus alternative which was then not implemented. New-construction costs skyrocketed in the meantime.

The major consequences are not only those related to TEC, nor even the social considerations--there are still close to 30% families in San Juan who depend entirely on public transportation. Rather, the most worrisome consequence is the drastic reduction and qualitative change of available options. The "Agua y Guagua" project is admittedly not a rapid transit, but only an incremental improvement of the present system. Even that is unlikely to be in operation before the late 1980s. Any major improvement of public transportation in the metropolitan area, even without the rail compo-

ment, would require separate guideways for buses on the express trunk lines, plus an elaborate integrated feeder system of small buses and publicos. Considering the lead time, cost, life expectancy and already tested new technologies (trolley buses without an overhead wire, but recharging every 5-6 miles for about 90 seconds by running through a catenary segment like that needed for light rail), the differences between this system and that worked on in 1980 are not very significant.

On the other hand, the cost of the no-action alternative, completely overlooked in present decision making, is staggering. The most obvious, though not the only aspect is the fact that the present bus/publico system could simply not handle even the minimum essential transportation requirements in the case of any prolonged scarcity of gasoline. It is of little comfort to know that the same is true of several major metropolitan areas in the United States.

(ii) Traffic lawlessness. Compliance with traffic laws was linked to TEC particularly in Table 2, Figure 6 and the related text. Over the last several years, enforcement has dropped down to a level on which it has virtually no meaningful relation to the need for control required by the principle of public order, not to speak of the additional energy saving dimension. Yet, even erratic token enforcement seemed to have measurable effects. The following figures, related to speed enforcement on the two toll roads (PR 52, Expreso Las Americas, and PR 22, Expreso De Diego) and on the rural collector roads which also have a posted 55 mph limit, illustrate the point:

- The average number of speed citations on PR 52 and PR 22 in the calendar years 1980 and 1981 was 21,500 a year. An average 70,000 vehicles enter the toll roads each day. Monitoring has shown that over 25% of them exceed 55 mph. This amounts to some 6.5 million vehicle trips/year during which the speed limit is exceeded. The 21,500 citations thus amount to some .355% of the total of violations. Thus it can be said that the enforcement is merely token.
- The collector roads (e.g., PR 30, Caguas-Humacao; major segments of PR 2, Ponce-Mayaguez; etc.) have a traffic density, as measured by vehicle miles travelled (VMT) almost three times that of the toll roads (73.5% of the combined total); but only some 39.5% of the total speed citations were issued on these roads (an average of 14,000 per year during FY 1980 and 1981). This represents a 50% better rate of enforcement on toll roads in terms of absolute numbers of citations.
- The severity of violations was appreciably higher on the collector roads: 12% more drivers exceeded 55 mph, as compared with the toll roads; almost twice as many drivers exceeded 65 mph; and the top 15% speedsters traveled at an average 2.3 mph faster.

Speed was monitored during day hours. It does not reflect drunken speeding which occurs mostly during evening and night hours. Citations are issued on a 24-hour basis. On the basis of this comparison, the rate of citations, particularly on the collector roads, may appear to be even less adequate.

(iii) Decreasing skill, caution and discipline of the average driver.

The pool of educated drivers, regularly using their intelligence when they drive, appears to have been stabilized at some absolute number many years ago, while the total driving population has grown by several hundred thousand. The practical collapse of regular traffic enforcement has not only eliminated the constraints on naturally aggressive and undisciplined, mostly young drivers, but has also produced a completely new phenomenon: the middle-class grandmother deliberately speeding through a stop light with a station wagon full of school children--future young drivers--cheering her on, if not also making threatening gestures at other drivers who barely managed not to get hit. This is not the kind of driving population naturally inclined toward reasonably disciplined and intelligent driving style which alone could conserve as much as 20% fuel for the same total mileage driven. Only enforcement and high enough cost (that is, gasoline tax) could begin to have any effect on TEC. Meanwhile, if the federal food money comes in a block grant and is distributed in cash, this will mean more money also for gasoline (not only \$7 in cash for a \$10 food coupon) and without even a shade of illegality.

(iv) The relative decrease of motor fuel cost. The price of gasoline has been stable or even slightly decreasing in the course of the last 12 to 18 months. Even stable price means a decrease in the real cost, since inflation has been running at around 10% during this period. Although this is most likely a temporary phenomenon, it sends totally wrong signals to most drivers, at least as far as TEC is concerned.

5.12 Record of official TEC actions. Even the little that has been achieved shows how much could be done.

The record with respect to the 1979 conservation program (listed on page 27 above) is as follows:

- A park-and-ride pilot program ended when the federal grant ran out. A público-express buses system Carolina-San Juan lasted only a short time. At the present time, only two industrial enterprises on the island have regular vanpool service for their employees.

- The "red-turn-on-right" law was passed two years before the 1979 conservation program. Although the yield is relatively modest, even this potential is not being achieved for two main reasons: (i) lack of funds for the necessary geometric changes to provide a free lane for right turn only; (ii) ignorance on the part of drivers, as well as institutional managers. For example, simple surface markings at three exits from the Rio Piedras campus of the University would provide free turning lanes; in their absence, hundreds of cars waste fuel every day idling behind the first car which must wait for the traffic light.
- The system of traffic lights activated by traffic flow was installed at the Expreso Norte (Baldorioty de Castro) avenue. This is a major achievement due to the past difficulties with the underground sensors. It has had measurable TEC impact. But much remains to be done elsewhere.
- Public transportation has not been palpably improved.
- While there has been a major shift to small cars (which is probably the one factor which has caused whatever reduction in fuel consumption occurred--see Figures 1 and 3), it was not due to the reformed excise tax.

In addition, the government has conducted since the fall of 1980 regular car care clinics as a part of a "three-year program designed to help motorists reduce fuel consumption and cost by providing advice and technical assistance on automobile maintenance and driving habits, facts to be considered in choosing a new car, and planning efficient use of the automobile to avoid unnecessary trips." Based on the number of pamphlets distributed in shopping centers, schools, municipal centers and private enterprises (which guaranteed the attendance of at least 50 persons for one day), it was estimated that some 200,000 persons participated during the first 12 months. Additional impact through spoken word was assumed. On the level of 200,000 conscious participants, the program would have reached less than 20% of licenced drivers. Despite the comprehensive description, the initial program was limited to fuel conservation through better vehicle maintenance. Waste through indiscriminate equipment use (for example, the use of airconditioning without respect to the temperature or exceptional safety precautions; or the failure to adjust airconditioning for the most economic performance when using it to reduce drag at a steady expressway speed) or through uneconomic driving style was not included in the program. It may be added in the future.

5.13 Institutional and other major obstacles to effective TEC. These factors, most of them dealt with in detail in the previous studies (23 to 25), are briefly discussed here to complete the perspective and to add some fresh information.

(i) Lack of an institutional focus for policy development and implementation in the field of transportation energy.

(ii) Major gap between available empirical and analytical knowledge and the public capabilities to receive and apply it.

(iii) Other political and executive priorities, partly contemporary (changes in federal grant policies), partly projected to 1984.

(iv) Strong vested interests. The private vehicle transportation sector (PVTS) is relatively stronger in Puerto Rico as compared with the U.S. as a whole. The 83% of transportation energy it consumes is about 30% more than the corresponding U.S. share. It has generated a powerful economic "motor-vehicle complex." Such a complex represented 23% of GNP in the U.S. in 1980. No such global figure is at hand for Puerto Rico, but sectoral figures imply the size. Thus, the value of gasoline used in FY 1981 was \$575M, 60% of it supplied by an ailing major refinery for which this was the only reliable source of income. The outstanding loans in the motor vehicle sector were almost \$600M; the outstanding instalment debt by buyers was approaching \$500M (P.R. Treasury report, 31 March 1981).* In a legislative report on lobbying, prepared in 1978, auto manufacturers and distributors, auto finance companies and gasoline station operators were listed as the three most intensive lobbying groups.

(v) Transportation welfare system. As was pointed out in detail in the previous studies (23, 35-38; 24, 57-60), PVTS in Puerto Rico is highly publicly subsidized. This fact was considered important enough to TEC to represent one of the four policy baselines (item III, cited on page 11 above; only the price of fuel before tax has risen to its real market level since January 1981, when the price equalization system--the averaging of the prices of domestic and imported crude petroleum--was abolished in the U.S.) The result has been, in fact, a massive welfare system in favor of private automobile owners. It has, for example, created unfair competition for public transportation the cost of which depends also on raising salaries.

* This sector received an unprecedented boost in the new regulations governing the investment in Puerto Rico of the so-called "936" companies (tax-exempt subsidiaries of U.S. companies). The only exception from the principle that the investment must be in productive sectors was made in favor of financing automobile purchase loans.

With regard to highway user cost, the tolls on PR 52 and 22 would have to be raised by 50% to cover the full cost, including the debt service. (This would come to slightly over \$2 for the whole length of the Las Americas expressway--within \$.12 of the heuristic calculation based on a user-cost analysis made for urban expressways in the U.S.; see 24, 60, note.) With this increase, the total toll income would rise to \$33M a year; the direct benefits to the driver--savings on fuel, oil, tire wear, maintenance, vehicle depreciation, travel time; lesser accident rate; convenience and comfort--were calculated several years ago at \$80M a year; by now the total must be well over \$100M a year. With reference to the whole road system in Puerto Rico, the user cost was estimated to be 25% less than the average user cost in the U.S. It was then (1978), based on the total of excise taxes (vehicles, gasoline, licences), an average of \$233/vehicle/year. The amount rose to \$258 in 1979, but dropped to \$236 by 1981. The gasoline tax has remained at 16 ¢ since 1974. It represented then about 47% of the pump price of \$.50/gal. At the present average price of \$1.45/g the tax represents only 12.5%. If it had kept pace with inflation, it would amount in 1981 to some 26 ¢ per gallon; at the percentage level at which it was enacted in 1974, the tax would be now about 68 ¢ per gallon. (Even this amount would still be in the lower range worldwide; gasoline taxes range between \$1.50 and \$2.25/gal. in many countries in Europe as well as in the Third World.) As distinguished from the toll roads, the cost-benefit ratio for the general highway user in Puerto Rico is strongly negative. The average driver spends \$950/year on gasoline. The latest studies (66, 67) show that even on "fair" pavement (as distinguished from "very good" or "good"), the average fuel consumption increases by about 35% on account of lost traction, uneven power flow through the drive train due to vibrations, and the need to periodically slow down and reaccelerate. On substandard pavement, which is now common on Puerto Rican highways, the loss can increase to well over 50%. Taking the conservative lower figure of 35% fuel loss, the increased cost to the average driver in Puerto Rico is \$330/year. That does not include such items as the more rapid wear of tires, damage to the drive train, shock absorbers, etc. A 10¢ increase in gasoline tax (representing only adjustment for inflation) would cost the average driver \$67.50 a year, but would yield \$67.5M for road maintenance, traffic engineering and enforcement, and leave a substantial sum for incremental improvement of public transportation. If the toll road users were charged the full cost, it would add another \$11M to government income;

and it would put an end to an irrational welfare-within-welfare system. At the present, the uncollected margin of the toll road debt service cost is paid from the gasoline tax: the toll road users benefit at the cost of all road users. The road maintenance cost is covered from the general fund: automobile drivers benefit at the cost of all tax payers. Even if all this money comes eventually largely from the same pockets, it has created distorted cost perceptions which are a great obstacle to any reform.

(vi) Finally, there are two unfavorable psychologically legacies from the past. One is the exacerbated dependence on federal funding. This was already critically analyzed in the 1977 study (23, 3-9). The Agua-Guagua project is still expected to be financed by 80 % federal and 20% matching state funds. The other is the continued emphasis on supply-side solutions (new energy sources), rather than on a balanced approach which includes demand controls, that is conservation. Although the old economic growth model has not been valid for quite some time, it is deeply ingrained in political thinking and in the expectations of the consumer society. It is also more attractive to do prestige studies about energy sources for the next century than to insist that drivers should not spend more than ten gallons of gasoline a week--and, in fact, make it difficult for them to do so.

5.2. Implications for realistic expectations.

5.21 The "crisis scenario" which was tentatively defined at the beginning of this study (Fall 1979; see page 32, Scenario I. above), played in part, turned out worse for the rest. The elements of the present scenario are:

- Rapid rail transit for San Juan was lost.
- No bus-based mass transit is considered. In fact, the almost \$4M a year federal subsidy (about one-third of the operational cost) for the present bus service will be withdrawn beginning with FY1983, and will have to be absorbed by the state government which already subsidizes the bus authority by another about \$4M. No substantial expansion or improvement can be expected.
- The "publico" system is effective, but is completely gasoline-dependent,* inadequately regulated and supervised, and has been able to resist integration with the buses.
- The public policy has not only accepted the excessive reliance on private vehicle transportation, but has provided an unprecedented incentive (see the note on page 54). The external costs of this course of action (see sec. 2.1, IV. on page 11), practically irreversible and contrary to any conceivable long-term transportation

* [The note is on next page]

policy, are being ignored.

- Having cast the transportation lot with private automobile, the government is unwilling to face the cost of this system in terms of infrastructure, maintenance, traffic engineering and a minimum public order, not to speak of excise taxes which would actively promote conservation and provide funds for major improvements. **
- Saving anything--water, electricity, money, gasoline--is not an integral part of the social ethic. It can be induced, as it was in the case of electricity, only by adequate cost disincentive.

5.22 The expectation. As far as public decision making and actions are concerned, the prospect is for the "worst case" as defined in the crisis scenario: "minimum or passive response...; waiting for the crisis to come."

Any improvement of the transportation system sufficient to make it operate in a manner which would contribute to TEC would require substantial additional funds. These are neither sought internally nor forthcoming from the outside.

5.23 Conservation through automatic factors and technical fixes.

The public position means that there will be no deliberate effort to foster systematic TEC. It does not mean that the small gradual reduction of fuel consumption will not continue. The following automatic factors and technical fixes are likely to contribute:

- Continued switch to small, fuel-efficient cars. Since about 90% of new vehicles introduced to Puerto Rico are non-U.S., any relaxation in CAFE (the obligatory federal standards under which new U.S.-made cars must reach an average fuel efficiency of at least 27.7 mpg by 1985) would not considerably affect the situation here.
- Progressive decrease of federal transfer payments (welfare funds) will reduce, perhaps quite substantially, the total mileage driven by cutting pleasure driving and increasing vehicle occupancy for essential trips.

* The closing of CORCO's refinery, announced in February 1982, shows how the island supply is vulnerable even if the contemporary glut of fuel will not cause shortage of imported gasoline in a foreseeable future.

** An increase in gasoline excise tax, considered since the beginning of 1981, was presented to the Legislature in February 1982. The proposed increase by 5¢/gal. does not even adjust the rate for inflation since 1974 (see page 55 above). An announcement of an adequate tax increase to be implemented in instalments and then pegged to the gasoline price as a percentage (a practice adopted by several states and in force in various European countries) has apparently never been considered. Yet, the continuing price stability, if not slight decrease, makes the present time particularly favorable for the much more substantial needed tax increase. See also below, sec. 5.3, (ii).

- Information concerning factors which substantially affect fuel consumption is likely to spread and show up in the equipment of new cars (about one-half of subcompacts sold in the U.S. comes now with manual gearshift and without airconditioning--a substantial change as compared with two years ago) and in maintenance and operation. To promote this trend through systematic public information is probably the most cost-effective action except price disincentives. Effective TEC is the total of countless decisions and actions by individual drivers; most modest improvements of fuel economy on the individual level become very significant statistical totals. Much improved performance and coordination of the public information services of all the agencies involved (see pages 34-35 above) would be necessary to get this message across.
- Engineering fixes: mileage increasing gasoline additives and motor oils; up-shifting dashboard signals for most efficient acceleration, etc.
- Alternative fuels: gasohol, methanol, LPGs (propane, etc.). These may have at best a very small fractional effect in the foreseeable future. In addition, LPGs are most suitable for use by commercial vehicles and fleets. It is being stressed in technical literature that the use of LPGs requires "many more precautions than in the normal use and handling of gasoline; drivers must be trained to avoid 'abrasive' driving." A great deal of training would be necessary, considering the widely noticed driving style of many Puerto Rican truck drivers.
- The electric-hybrid vehicle, a good candidate for the fleets of such enterprises as the telephone company or the water and electric authorities, or for use within closed compounds (slow speed, short distances, frequent stops), began to be tested for use in Puerto Rico, but the project depended completely on federal funds. These were also terminated.

5.3 More advanced affirmative TEC actions.

To do anything better than to repair broken roads and rely on automatic fixes for some fuel conservation would require that transportation in Puerto Rico be put on a self-sustaining basis. That means that primarily the private sector (but also trucking) would have to pay the full highway user costs.

This is not as difficult as it may look. But it would require a massive effort on the highest levels of the government to explain to private drivers

(i) that they are in fact losing, by a wide margin, under the present "welfare" system (see page 55);

(ii) that and how they can compensate for even major tax increases by more careful and discriminate driving. It has been shown by practical testing that any average driver can save 20% fuel by following a few simple rules (which, by accident, also contribute to public safety and courtesy).

Since 20% of the current cost of gasoline is about 29¢ per gallon, the tax could be progressively increased to 45¢/gal., rather than the presently proposed 21¢, without any effect on the total yearly gasoline bill. At the 45¢ level, the tax would still be low in comparative terms, and it would reduce gasoline consumption perhaps even by more than 20%. Taking the 1981 consumption of 655M gal. as a base, even the decreasing consumption would yield at 600M gal. about \$270M yearly; at 550M gal. it would amount to \$247.5M.

Very sensible improvements would, in fact, cost much less because the various services suffer at the present time only of lack of qualified personnel and relatively minor material supplies. This is true in particular of two services the increased efficiency of which would make great difference also with regard to TEC.

One is the traffic police, at times with fewer than 300 patrol cars covering the whole island. Many severe fuel penalties among those listed on page 22 above are also violations of the traffic code in force. Merely the return to the mediocre enforcement levels of 5-10 years ago would represent substantial contribution to TEC. It should be determined why the system of citizen denunciations of major traffic violations not observed by the police, instituted some 12 years ago, did not function; it should be properly reformed and launched. Although it would be a great improvement if the police went by the law as it is, a revised traffic code would facilitate the job by (i) incorporating technical considerations relevant to the present conditions, (ii) making the fines adequate to the enforcement needs, (iii) facilitating temporary or permanent removal from the highways of chronic repeaters and dangerous drivers. The traffic law revision prepared in 1978-79 (and not enacted as of this time) was merely a consolidation of the existing statutes. It was inadequate in the terms outlined above; it was completely blind as far as TEC is concerned.

The other service is traffic engineering. Besides the obviously needed geometric changes, traffic flow could be greatly enhanced by careful revision of existing traffic light series (even without the advanced technology used on Expresso Norte); shift of stop lights to intermittent red/yellow signals, with a switch back to standard signaling during heavy traffic hours where necessary (which means that many signals could remain on the intermittent mode permanently); change of all possible "Stop" signals to "Yield", which is the way they function in fact; removal of all nuisance

signaling (e.g. left-turn arrows; these should be replaced wherever feasible by intermittent stop-and-go signals), and perhaps still other measures. Drivers should be encouraged to suggest possible flow improvements.

Simple interagency agreements and administrative actions could bring about many measures making traffic more legal and therefore favoring TEC. For example:

- The problem of running red lights (see the fuel diseconomy estimates on page 22) is that many drivers do not obey--or even know--that the yellow-light signal requires the driver to slow down to stop. The law gives the driver too much discretion. Traffic engineers have dignified it in the concept of the so-called "dilemma zone." Most drivers face in fact no dilemma. They simply charge forward. Until a solution is worked out which is appropriate both technically and legally, a simple expedient could be worked out between traffic engineers and police, and given adequate publicity: a yellow line, painted at the proper distance from the intersection would eliminate the "dilemma" and advise the driver that, if he already crossed it when the yellow signal comes on, he can proceed; if he did not, he must stop.
- Until a functioning computer memory can quickly identify repeated violations, TOP, the police and the courts could establish a system of punching a hole in the vehicle or driver licence whenever a moving violation is established either by paying the fine or by conviction in court.
- The very fuel-costly heavy rush-hour traffic can be diluted by generalizing the system of flexible working hours throughout the government.
- Effective enforcement of illegal parking (self-liquidating through the fines and towing away charges) and a tax on legal parking fees in congested areas would greatly contribute to improved traffic flow (not to speak of pedestrians).
- Through a simple administrative decision, knowledge of basic principles related to TEC through driving style could be added to the requirements for learner permits, driver licences and their renovation.
- Last but not least, an extensive urban "público" system in San Juan, less crowded (enforced maximum occupancy) and operating longer hours, would provide the fuel-efficient flexibility and decentralized private initiative the public buses cannot provide. However, it would have to be planned and coordinated, not just allowed to spring up and then legalized ex post.

Tables 2 and 3 (pages 21f. and 30 above) provide the elements and justification for numerous other measures and combined subscenarios of an orderly and deliberate nature. To follow--that is, to let happen--the crisis scenario will not lead to a collapse of the system. It merely invites ad hoc, mostly spontaneous and disorderly adjustments at considerable human, social and economic cost.

APPENDIX

Note on the calculation of scrappage rate
as the base for estimating the current active fleet in Puerto Rico

Scrappage rate is the percentage of motor vehicles discarded in a year. An 8% rate has been used in the U.S. national statistics. In the absence of more precise different figures in Puerto Rico, the 8% rate was used to estimate the active fleet in a given year, between 1971 and 1977.

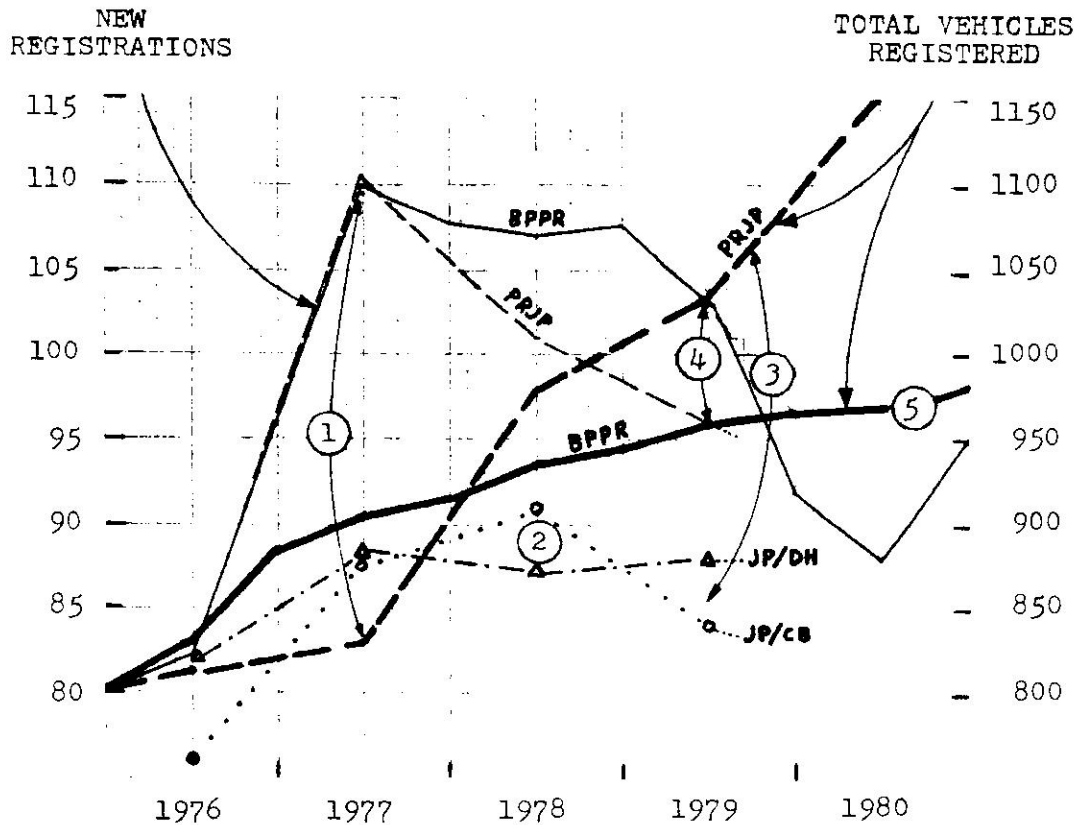
It has been the practice of the Bureau of Motor Vehicles (BMV) to consider a vehicle active unless its licence is not renewed on two consecutive occasions. (Even then a vehicle remains in the register for additional five years.) This means that all vehicles discarded during a given year are included in the total active vehicles until next 30 June. Some vehicles not renewed at end of the preceding FY may be activated when their owner returns to Puerto Rico, or when they are repaired/rebuilt. Experience of several years could produce an "expectancy rate" for this relatively small group. The key to a reliable estimate of the whole really active fleet is a reasonable accurate estimate of scrappage.

In 1978, the official scrappage rate estimate was raised to 10%, without any explicit or obvious rationale. When it appeared to result in a too low total of active vehicles, the rate was discretionally lowered to 5% in 1979. This is apparently the rate used in the 1980 estimate. *

The following Figure 8 shows the recent history of vehicle registration figures in Puerto Rico.

* On the basis of a preliminary draft of this Appendix, BMV began in 1981 to use the rounded trend rate of 7.5%. The "recalculated" total for FY 1980 of 1.133M vehicles, and the estimate of 1.144M for FY 1981 are, however, still some 15% too high. To arrive at the correct figures, it would be necessary to go back at least to 1976 and calculate from then on, adjusting the trend rate as proposed in the formula on page 63 below.

FIG. 8. VEHICLE REGISTRATION (P.R.)
(000)



Legend

PRJP Puerto Rico Planning Board
 JP/DH P.R. Treasury via PRJP
 JP/CB U.S. Census Bureau via PRJP
 BPPR Banco Popular de P.R., "Progress in Puerto Rico" (quarterly) and other consolidated figures
 Δ---Δ Vehicles imported (new and used)
 o...o Vehicles taxed (import excise tax)

Comments

- ① Note the discrepancy between new registrations and the increase in total vehicles registered.
- ② Vehicles taxed > vehicles imported (by some 40,000)
- ③ Comparing the rate of imports and of taxed vehicles with the official estimate of the total fleet, the gap marked as
- ④ would represent most of that part of the total fleet that was reactivated (i.e., repaired or rebuilt) after an at least two-year lapse in active registration. See the comment on page 64, top.
- ⑤ The estimate using scrappage trend rate (next page) is only 5,000 vehicles (+0.52%) higher than the BPPR figure of 969,500 (FY'80). In CY'80, the "S" calculation is only 3000 vehicles lower than the BPPR figure of 978,000, for a total margin of error ± 0.8%.

The following formula was developed using the conflicting available data, with the assumption that by calculating every year the scrappage rate for the preceding year, it might be possible to develop a trend rate which would allow reasonably reliable current estimates and projections.

If vehicles become inactive after failing to reregister for two consecutive years, the scrappage rate and the estimated state of the active fleet can be determined as follows:

$$S_y = (R_{y-1} + N_y) - R_y$$

$$A = (R_{y-1} + N_y) - \phi S$$

Where S = scrappage rate
 ϕS = scrappage trend rate (i.e. the average of several previous years, corrected to reflect new parameters, e.g. increase in old vehicles being rebuilt and re-activated after a registration lapse)
 R = total vehicles in the register
 A = total active fleet
 N = total new registrations
 y = the year being calculated (consequently, y-1 is the preceding year).

Thus, for example (in thousands of vehicles)

$$S_{78} = (901 + 108) - 934 = 75 = 7.43\% \text{ (of 901)}$$

For 1979, the rate is 7.51%. The official figures for 1977 show only 4.75% rate; however, if the trend of FY 1977 to 1979 is projected backwards, the rate is 7.58%; if the 1976-1977 trend in vehicle imports is similarly projected, the rate is 6.63%.

Using a rounded trend rate of 7.5%, the estimated number of scrapped vehicles in FY 1980 would be 72 (960 x 7.5%). The estimated total active fleet would then be:

$$A_{80} = (960 + 87) - 72 = 975,000 \text{ vehicles}$$

Adding a purely hypothetical 25,000 vehicles as having been re-activated during FY 1980, after not being active for more than two years, the maximum estimate total of active vehicles is 1,000,000. This is 150,000 less than the official estimate. In order to arrive at this estimate of 1,150,000 active vehicles, it would be necessary to assume that the scrappage rate was only 5% in FY 1979, and 2.7% in FY 1980, that is about 65% and 35% respectively of the historical rate. To justify the official esti-

mate, it would be necessary to substantiate that between 35 and 40,000 vehicles were reactivated in 1979 after being out of circulation for over two years; and that the number for 1980 was between 70 and 75,000. *

Too high official estimates of active cars are apparently not unusual. The 1980 estimate in Puerto Rico would be 15% or more above the corrected trend estimate. In United State as a whole, an overestimate of 12.8% was found in 1977, comparing Federal Highway Administration data with those developed at DOT Transportation Research Center (116, S3-12). Difference estimated two years later was "up to 12%" (18, 5-26)

* The estimated average life expectancy (that is, the age which one-half of the vehicles of a given year reach or exceed) of cars and light trucks was typically calculated to be 10 years or 100,000 miles (18, 2-20, based on U.S. statistics 1966-77). Recently it has been raised to 125,000 by some analysts (e.g., 72, 5) and up to 18.5 years (the advertised life expectancy of a high-quality midsize European car). The longer vehicle life may require major repairs in the final years. These are unlikely to deactivate the vehicle for more than two consecutive years, except in some unusual cases.

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