

CER - X-32 ENERGY CONSERVATION IN TRANSPORTATION IN PUERTO RICO POLICY STUDY

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ENERGY CONSERVATION IN TRANSPORTATION IN PUERTO RICO: A POLICY STUDY

By Jaro Mayda

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FOREWORD AND SUMMARY

ABBREVIATIONS, ACRONYMS, TERMS OF ART

INTRODUCTION

Prefatory remarks

1.2 Working thesis

1.3 Focus and method

DATA BASE

2.1 Present transportation system: Structure and operation

2.11 Vehicle population

- 2.2 Structure and state of the fleet
 - 2.13 Transportation network
 - 2.14 Traffic intensity and vehicle occupancy
 - 2.15 Trip purpose
 - 2.16 Collective transportation
 - 2.17 Transportation of freight
 - 2.18 The human element
- 2.2 Energy demand: Macroanalysis
 - 2.21 Direct energy
 - 2.22 Indirect energy
 - 2.23 Overview: First policy baseline
- 2.3 Energy demand: Microanalysis
 - 2.31 Age and maintenance of the fleet
 - 2.32 Roads and traffic management
 - 2.33 Tires and proper alignment of wheels
 - 2.34 Convenience power equipment
 - 2.35 Nonessential driving
 - 2.36 Driving habits in general
 - 2.37 Speeding
 - 2.38 Tax-free gasoline
 - 2.39 Summary: Second policy baseline

BASIC COST/BENEFIT ANALYSIS

- 6.0 Introduction
 - 3.1 The auto owner's costs
 - 3.2 The full economic cost

- Gasoline: base price
- Gasoline: tax
- Highway use
- Transportation cost as a function of the consumer price index
- Parking subsidies
- Parking Violations
- Miscellaneous

3.3 Third policy baseline... 39

3.3 The full social costs

- Air quality
- Other sources of environmental pollution
- Congestion
- Noise and vibration
- Accidents
- Land use

3.4 Summary: Fourth policy baseline... 63

POLICY DEVELOPMENT: BASES AND SOME RECOMMENDATIONS

4.1 The policy baselines... 64

4.2 Collective development of a policy model... 65

4.3 Some directions and recommendations... 66

4.4 TE as a function of total transportation policy and management... 66

4.5 A first list of integrated criteria and indicators... 67

4.6 Near-term TEC policies and measures... 68

4.7 Setting a limit on energy consumption in transportation... 68

4.8 Positive restraints on PYES... 70

4.9 Shift to rail as the dominant mode of travel... 70

4.10 Adequate TSH... 71

4.11 Law, Institutions, information, education... 72

APPENDICES

A. Extracts from San Juan Transit

B. Bibliography: List of sources cited and consulted

FIGURES AND TABLES

Figure 1. Disaggregation of the total energy demand and transportation consumption: United States... 31

Figure 2. Same for Puerto Rico... 32

Figure 3. Components of a model of total energy consumption related to transportation in Puerto Rico... 40

Table 1. Summary of the categories and estimated potential for transportation energy conservation in Puerto Rico... 50

FOREWORD AND SUMMARY

Use and waste of energy in transportation in Puerto Rico is such a negative and complex social event that it is particularly suited for a major exercise in policy research and development for decision making. Such an effort must be collective and should aim at both specific recommendations.

Recommendations and time tables, and an improvement of the methodology used to analyze the real systemic nature of important social and resource problems so as to enhance public decision making. The present study is an initial effort to apply social system analysis to transportation energy conservation, in order to prepare the ground for a team effort of transportation and energy specialists, regional planners, policy analysts, generalists, and government administrators—with additional inputs from commerce, industry, and the community at large. The task of this study has been to inventory the principal factors and inputs in the field of transportation energy demand and possible conservation, estimate their magnitudes and relations, and arrange them in a tentative but reasoned pattern—whereas before there were only scattered data, technical studies with a limited focus, sectoral programs and decisions, and vague impressions about the serviceability, impacts, and social value of the product. It needs to be also noted that this is a technical study addressed primarily to specialists. This explains the compressed form and style designed to facilitate rapid scanning and reference. It also explains the extensive use of abbreviations and acronyms. These are listed for reference following this foreword and summary. The preceding table of contents gives a reasonably detailed idea about the structure of the study and the progression of analysis and application. The data are analyzed in a policy perspective, that is with emphasis on their order of magnitude; their relation to the whole system; and a cost/benefit analysis which expresses the whole energetic, economic, and social-environmental cost of the present transportation system in Puerto Rico, dominated by private motor vehicles used with no concern for energy efficiency. The principal conclusions are expressed in four policy baselines.

I. Transportation energy consumption is usually expressed only in terms of direct...

Consumption includes gasoline and oil. This account represents upwards of 30% of the total energy budget in Puerto Rico in a given year. However, a great deal of energy is consumed indirectly for transportation purposes. This includes losses in gasoline refinement, distribution, evaporation; manufacturing, transport, sale, maintenance, repairs, parking, garaging, administrative and enforcement services to vehicles; construction and maintenance of roads and other infrastructure; and repair of accident damage to persons, vehicles and public property. When the applicable amounts are estimated and totaled, Puerto Rico consumes some additional 20% of indirect transportation energy. As a result, transportation consumes directly or indirectly about one-half of the total yearly energy. This is as much as all the other sectors together: residential and municipal, light and heavy industry, commerce, communications and services. Upwards of 80% of the transportation energy is consumed by private automobiles (Figure 3). With adequate maintenance of engines, vehicles and roads, and the acquisition of power equipment, reduction of driver demand (short trips, low occupancy, nonessential driving) and upgrading of overall driver behavior to the standards of the traffic code and common sense, all the safe essential mobility of persons in Puerto Rico could be satisfied with as little as 50% of the present total direct transportation energy (Table 1).

III. The private-vehicle transportation system is highly publicly subsidized. This means that the users of automobiles do not pay the full economic cost of gasoline, highway use and parking, and that they are also subsidized on a number of other accounts (section 3.2).

IV. Transportation energy conservation cannot be effectively implemented outside an adequate transportation system management. This is the integration of transportation planning and management with the whole social and resource system. The present lack of such a system management creates problems.

Adverse impacts on public and environmental health, land use and aesthetics must be assumed to be equal in magnitude to the energy and economic cost of automobile-based transportation. It is expected that detailed quantification and fine-tuning of the underlying model, which this analysis attempts to stimulate and facilitate, will result in some adjustments, but that it will not affect the involved orders of magnitude which determine the longer-term policy options and decisions.

The need for fairly rapid changes in the whole transportation system is imperative. No effective transportation energy conservation is considered possible without them. Technical fixes are not sufficient because the problem of energy conservation is a problem of decisions about energy use. Thus, it is primarily a human, social and therefore political problem. Some directions for more detailed policy research and development are indicated in the last section 4.3, with regard to energy conservation and transportation management, basic guidelines for future policies, near-term energy conservation measures, the possible approaches to the limitation of total energy consumption in transportation, the shift to rail as the dominant mode of essential travel, and a review of the present status and plans for transportation system management in the light of energy, enforcement and future transit requirements. Occasional specific reference is included also in this section to indicate the wealth of information and know-how available to the decision makers through further policy research and development. Some defects of the present implementation system are also illustrated (section 4.38) with the suggestion that this should be the subject of a whole separate study and analysis. The contemporary revision of the Traffic Code and the forthcoming reorganization of the executive branch represent two opportunities to improve the implementation system. Education is also mentioned with regard to the study topic, as well as the

Widespread experience shows that driver education is ineffective where it is not reinforced by economic and enforcement factors.

REFERENCE #5: REMOTE ABBREVIATIONS, ACRONYMS, TERMS OF ART

Barrel (42 gallons)
Billion cost/benefit [analysis]
Central business district
Traffic checkpoint at the limit of an area
Consumer price index
U.S. Department of Energy
U.S. Department of Transportation
P.R. Department of Transportation and Public Works
U.S. Environmental Protection Agency

U.S. Energy Research and Development Agency (now DOE)
Fuel economy
Federal Energy Agency (now DOE)
Federal Highway Administration (part of DOT)
Motor vehicle population; total of vehicles which serve a specific purpose
Heavy rail [transit], also referred to as Inspection/Maintenance
Input/output [analysis]
Thousand
Kilometer (.62 mile)
Light rail transit
Million [million gallon]
Mile (1.6 km) per gallon per hour
No date
U.S. National Highway Traffic Safety Administration (part of DOT)
Operation/maintenance [cost]
Property-damage-only [accident]
Group of vehicles traveling together, such as from one traffic light to the next
Passenger miles traveled
Private-vehicle transportation system

Traffic checkpoint within an area
San Juan Metropolitan Area
Total direct transportation energy
Transportation energy conservation
Intensive transportation of passengers on separate guideways which increase speed, capacity, and safety. (Alternatives "express" and "rapid")
Transportation system management
U.S. Urban Mass Transit Administration (part of DOT)
Vehicle miles [traveled]

1. INTRODUCTION

This study was designed and begun in April 1977 as part of the endeavor of the Center for Energy and Environment Research to develop and apply methodologies for the analysis of social factors and interactions related to energy and the environment. The problem of energy conservation in such a massive social event as transportation involves a

The text deals with a particularly complex and intensive mix of technical, human, and environmental factors and mutual impacts. It is suited as a topic for a policy study on both substantive and methodological grounds. In terms of substance, there is a great need and opportunity to reduce the existing waste of energy in transportation in Puerto Rico. In terms of methodology, any contemporary social policy analysis must ultimately address itself to the presently weakest link in public decision making: the tenuous, undeveloped relation between the real nature of major problems - they are without exception complex systems of resource uses and abuses - and the capacity for applied social system analysis, as a state of mind, as an analytical-technical instrument, and as an operational frame of reference. The topical and highly visible nature of

energy uses and abuses in transportation in Puerto Rico provides therefore a concrete and particularly relevant setting for a policy exercise which aims not only at a set of specific recommendations, but also at a contribution to the improvement of policy development and decision making, with reference to priorities and time horizons that correspond to the nature and magnitude of the problems rather than to other, shorter-term considerations. The working thesis of this study is stated in greater detail in section 1.2, the focus and methodology are elaborated in section 1.3. Chapters 2 to 4 contain the substance in the following sequence: Chapter 2 organizes the relevant available data with regard to the structure, operation, and energy demand of the present transportation system. The analysis of the aggregate and the disaggregated energy demand is expressed in the first two policy baselines. Chapter 3 analyzes the system with regard to cost and benefit - the car owner's, the full economic cost, and the full social cost. This C/B analysis yields two additional policy baselines. Chapter 4 synthesizes and interprets these bases as a starting point for the development of a

This text presents a comprehensive and refined model of Transportation Energy Conservation (TEC) and Transportation System Management (TSM). It also outlines some directions, assumptions, and recommendations for this task. The task of collecting and organizing sufficient empirical data for policy development was hindered by the well-known deficiencies in Puerto Rican statistics. Instead of finding all or most of the necessary information in a form suitable for policy analysis, considerable search, comparisons, and pocket calculator operations were required to develop the data and reconcile them. This general problem was described in a recent report, also in the field of transportation, as follows: "The analytic effort was unnecessarily complicated by the dispersion of the basic data and the incompatibility of the statistical series. Considerable but necessary time was spent on structuring the problem and determining how the compiled data should be utilized..." (12, ch.II, IV). However, why should the transportation sector have foolproof data on, for example, the number of motor vehicles actually in use, when the health department (with a much longer statistical tradition and experience) was reported to have last counted hospital beds in Puerto Rico in 1952 (M6, 3 August 1978)? Or when a federal official provided us with information that seemed dubious, was checked out with a local radio-television station, and turned out to be completely incorrect? On the other hand, unlike technical-engineering studies, the importance of data in relation to a social policy study lies less in their serial completeness and decimal-point precision than in providing a sufficient basis for order-of-magnitude estimates and for detecting trends through longitudinal comparisons. Moreover, some characteristics of the private-vehicle-transportation system in Puerto Rico appear similar to the PVTS sector in the mainland United States, suggesting that critical interpolations from there are possible and legitimate.

The text should not be overlooked either. Statisticians anywhere will collect and organize information in their way if the users--planners, policy analysts, political and operational decision makers--do not provide them with some other, more appropriate conceptual matrix. Analytical studies should generate the need for new data and for new patterns of organizing them, not merely use the existing information and complain about it. With the exception of a few references that could be incorporated into the typescript while it was being readied, the general cut-off point for data is May 1978.

A spin-off product of this study was an extended policy memorandum on the San Juan Transits Outline of a policy analysis for decision making, prepared in September and October 1977.

Relevant excerpts from this memorandum are incorporated in the present study: the table of contents and a detailed summary can be found in Appendix A.

1.2 Working thesis

If "energy conservation is a national imperative and has become a major factor in transportation decision-making" (U.S. Secretary of Transportation, 17 September 1975), the need and the potential for conservation are even greater in Puerto Rico than in the rest of the United States. According to a study based on 1972 data, Puerto Rico had one of the highest rates of energy consumption in the world, in terms of both productivity, as measured by gross national product per person, and of intensity, that is the amount of energy used per square mile (55). The development of energy-intensive industries since the 1950s was a partial explanation. But a great deal of energy was wasted due to construction practices, unsuitable designs and standards requiring intensive air conditioning and space lighting, as well as simply wasteful habits of consumers, favored until recently by low basic costs and a regressive rate structure. Puerto Rico depends on petroleum for over 99% of its energy. Internal transportation in Puerto Rico depends almost entirely on gasoline-powered vehicles.

Vehicles consume directly about 30 per cent of the total energy budget. By contrast, the United States relied on petroleum for one-half or less of its energy needs (46 per cent in 1972), with the remainder coming from natural gas, coal, hydro- and nuclear power. Transportation used about 25 per cent of the petroleum, which represented, in terms of the 1972 data, only 11.5% of the total energy. This is in comparison with the 30% direct consumption in Puerto Rico, which is entirely petroleum-based.

According to another calculation, the approximately 600 million gallons of gasoline used in Puerto Rico in 1972 represented five times the United States consumption per square mile in the same year. This was approximately double the ratio between the Puerto Rican and the United States overall energy consumptions per square mile. In other words, the transportation sector in Puerto Rico used twice as much energy compared to the overall energy budget than the transportation sector in the United States.

This estimate is of the same order of magnitude as that cited above, arrived at from different data and through a different calculation. Thus, there is an ample margin for transportation energy conservation (TEC) in Puerto Rico. In fact, this study concludes that as much as 50 per cent of gasoline can be conserved in transportation in Puerto Rico without any reduction of necessary driving.

Apart from the considerable additional benefits this would bring to environmental resources and the human ecosystem as a whole (these are elaborated below, especially in sections 2.25 and 3.3), there is a clear and urgent energetic and economic need to move rapidly toward effective TEC policies and measures in Puerto Rico.

The principal reasons are these:

- The substantial dependence of Puerto Rico on OPEC crude.
- The present situation in transportation energy in the United States is a glut of gasoline at a price which is about one-third of the average in other major Western countries. This is partly accidental.

Dental aberration, the overproduction in 1977 of home-heating oil, with gasoline actually being a byproduct, is certainly a temporary phenomenon. However, it comes at a high cost: the relative decline in the United States' economic power and the value of the dollar is primarily attributed to the massive trade deficits resulting from OPEC crude imports--\$42 billion (B) in 1977, as compared to a \$48 billion general trade surplus, resulting in a trade deficit of \$38 billion. Puerto Rico, to begin with, doesn't have a general surplus in its socioeconomic accounts. In fact, the 105 million barrels (MBBL) of crude and naphtha imported in 1976 cost more than the total amount of the government budget for that year.

It's widely expected that by mid-1980s at the latest, the Western world will face another critical situation in terms of petroleum-derived energy. A less optimistic estimate suggests that the "oil crunch" might arrive "perhaps in 2-3 years" (bk, 28 November 1976 and 16 April 1978). A succinct summary of future projections, released in September 1977 by the World Energy Conference, stated that "oil supply will fall short of our needs in 15 to 30 years...if tremendous fields are discovered and unexpectedly double our reserves...that would delay the peak for only perhaps 15 years" (142. [October 1977], 246-50).

Under these circumstances, the discovery of petroleum reserves off the north coast of Puerto Rico (the exploration is set to begin in 1979) would only delay difficult fundamental decisions. For instance, the Prudhoe Bay field in Alaska, the largest ever discovered in North America, amounts to a 25-year supply at the current rate of consumption. Even if the drilling in the Atlantic Ocean off the New Jersey coast meets the most optimistic estimates, it will only fulfill total U.S. oil needs for about three months and natural gas demand for five months (JMB, 1 May 1978).

The lead times involved in the development and implementation of policies--technical and, especially, social--in a field as complex as transportation are considerable.

Energy timelines are very long. For instance, to make a major light rail transit and the supporting transportation management system operational for metropolitan San Juan would take at least ten years. Of course, another oil embargo, gasoline rationing, or a rise in the pump price to the real cost level would do wonders for conservation. However, it would not independently produce a substitute energy-efficient transportation system.

The substantial margin for TEC in Puerto Rico is accompanied by a wide margin for changes and improvements in political decision-making related to transportation. The present transportation system is partly the result of cheap energy, specifically gasoline. The range of 70-76¢/gal. in mid-1978 may represent as little as thirty-five percent of the real cost. The low price results from the inclusion of Puerto Rico in the United States system of averaging the price of domestic and imported crude oil.

However, the transportation system primarily reflects a sequence of government policies and non-policies. These include politically motivated choices, yielding to special interests, eternal studying of alternative transportation modes without taking any effective action, overdependence on the availability of federal funds for local planning, and other factors.

Above all, past policies in transportation in Puerto Rico were characterized by the failure to perceive and plan a coherent system as a function of the whole society, economy, and environment. It's true that the energy cost and fragility of transportation based on gasoline and

other petroleum products could not be noted widely enough before the 1973 price increase to influence public decision-making.

Even such well-known unfavorable impacts of this kind of transportation, such as exorbitant fatality risk (using fixed rail as a base = 1, the fatality risk factor for commercial airliners is about 1.5, for private automobiles about 50) and urban air pollution (up to 80 percent of CO is generated by motor vehicles) were largely ignored as decisional factors.

Assumed that strategic decisions with regard to TEC, as well as their concrete implementation, will be facilitated if the analysis and the resulting recommendations are set in a comprehensive framework of all relevant energy, technological, social, economic, administrative, regulatory, and political/decisional data. A major obstacle to effective TEC is also the widespread public ignorance about the nature and scope of the energy problem, combined with a consumption-oriented value system. In the United States, the first factor was confirmed by a poll taken one year after President Carter's nationally televised energy message (April 1977), 40 per cent of the sample did not even know that the U.S. depended on foreign oil to help to meet its energy needs (248, 1 May 1978). As to the consumption syndrome, U.S. motorists ignoring official pleas burned in June through August 1977 a record 31.586 of gasoline (bk, 2 October 1977), almost 3 per cent above the 1976 level--and despite the greater fuel efficiency of the new cars in the fleet. There is no ground for assuming that public awareness in Puerto Rico is higher. Information and education are therefore critical ingredients of any TEC program which does not rely entirely on rationing and taxing. The conception and implementation of such public education can be only enhanced by perceiving the problem in the broad frame of reference outlined above. (pg 27)

Focus and method: The nature, method, and some limitations of a policy study of TEC in Puerto Rico need to be briefly discussed. First, and by definition, only factors that can influence TEC policy development and decision making in Puerto Rico are analyzed here. Since no automotive research and development, nor production, take place in Puerto Rico, data on the improvement of fuel efficiency through better engine design or the development of alternative power plants (13, 56, etc.), or other technical information of this kind, is of course interesting, but is secondary to other TEC.

Elements and considerations are also in view of the present and the prospective age compositions of the motor vehicle fleet on the island. Secondly, the use of the term policy is far from uniform. The meanings range from goal or norm (speed reduction) to an operational or technical improvement (increased vehicle efficiency; 97, 31-2). Even the widely officially used terminology--"science and technology policy"--is at best ambiguous. Does it refer to policy for the enhancement of science and technology? Policy, in the development of which science and technology data are represented as inputs? The latter meaning would be closer to, although only in part concurrent with, the general technical sense of policy as a discrete, comprehensive analytical base for decision making. This technical meaning is not of recent vintage. With specific reference to environment and resources, it served as a focus for the eco-management conception (52 [1967], 110-M). The principal methodological characteristics of policy research and development in this context were confirmed in the comparative evaluation of 18 regional environmental system management projects sponsored by the U.S. National Science Foundation (137 [1977], i-iv)--most of them originally designed along econometric lines, that is, as quantification and computer processing exercises. Policy research and development require both more and less. On the one hand, decision making cannot wait for

mathematical models. It must take place with the available data; numerical data as far as possible, but also incomplete, uncertain, fuzzy data, interpolated and projected as well as the numbers permit; concepts; values; intuition. In the present state -Page Break- 6 of the art, policy development in any real social situation must proceed predominantly on the basis of qualitative rather than quantified information. On the other hand, the essence of policy research and development, which is the transformation of all the relevant data into reasoned policy options ("decisional vectors"), does not require the

The precision of electronically processed mathematical models is integral in social decision making, even though it is often intuitive in nature. This is especially true when dealing with complex problems that occur at the interface between man and resources. The idea is not to completely automate decision making, but rather to enhance raw political intuition with educated, intuitive decision making. Consequently, there is a need to compile all essential information at the level of order-of-magnitude data or educated estimates, instead of relying solely on some information with decimal-point precision. The main goal is to make approximations without distortion. When empirical data are missing, "sound technical judgment" can help fill in the gaps (122).

This form of policy development initially seems different from conventional "policy making." Every decision, whether public or private, executive, legislative, or judicial, implements a policy with a specific purpose in mind. However, this policy making or application does not usually follow an organic path from the facts, through their analysis/synthesis, to the acceptance of the most favorable or justified option. "Policy making" has often been an ex-post rationalization of a prior decision reached on a less complete and rational basis. In other instances, like many environmental impact statements, the data were amassed but not adequately analyzed and transformed into alternative options deserving the technical designation of policies.

Proper policy research and development, at least at this stage, is more likely to raise questions than provide answers. It can highlight gaps in the data for information generators to address. Competent policy analysts are likely to be generalists or synthesizers, able to look across disciplinary lines from their unique backgrounds. They may challenge the methods used to compile information or suggest alternative problem-solving approaches. Consequently, they may be regarded as "spoilors."

Especially when planning has gone forward on less than all the important considerations, particularly social and environmental ones.

1. "Benefits and costs have been in existence long enough to have created its own momentum." This is why the policy dimension should be an integral part of project design from the beginning. Otherwise, it is likely that the technical positions and political opinions derived from them will harden before they can be evaluated in a comprehensive policy perspective. This could potentially hinder the development of better technoeconomic concepts. For an exemplary case of the San Juan "Metro", see Appendix A.

Even in the exceptional case where the ex-post policy analysis prevails, the wastage of time and resources cannot be repaired. Furthermore, extensive searches in materials produced in North America, Europe, and by international organizations, indicates that the kind of policy research and development outlined above has not been so far applied anywhere in the field of transportation in

general or TEC in particular.

This study must therefore be judged as a tentative effort which had no existing design to follow. While it makes concrete recommendations where they appear possible, its primary purpose is to establish a first conceptual model which would help the technical analysts and sectoral decision makers in the fields of energy and transportation in Puerto Rico to mutually relate their data and perspectives and to integrate them into a progressively complete and sophisticated operational and predictive model.

With such a model available, no separate policy studies will be necessary. The system will function in an environment of direct input from, and communication to and among all the participants--data producers, project designers and planners, policy analysts, decision makers, citizens and users, resource managers, monitoring/feedback systems--facilitated by a common conceptual language and policy principles.

System analysis applied to social resource management becomes a state of mind.

18

2. DATA BASE

2.1 Present Transportation and Operation

2.2.1 Vehicle Population

In mid-1977, there were 630,373 active motor vehicles of all classes in Puerto Rico. This figure is based on registration licenses renewed by June 31, 1977 and on the number of vehicles registered for the first time during the fiscal year 1976-77. The Motor Vehicles Bureau makes several other estimates. For instance, vehicle licenses which were not renewed are still counted for another year and renewal notice is sent out. Only when the license is not renewed for two consecutive years, is the vehicle dropped from the "active" computer program.

On this basis, there were over 1 million vehicles in Puerto Rico in 1977, of which over 290,000 were "not renewed". However, this calculation, with the addition of new registrations, does not add up to 830,373. Nor does the registered/active vehicle ratio of .778, based on a 1971 study, appear correct in 1977.

Accepting the figure of 1 million "registered" vehicles, the real ratio would be closer to .825. Similar estimates of vehicle population in the United States appear equally unreliable when compared with a count as of a certain date, the difference being as much as -12.88% in 1975.

The point is not to dwell on statistical vagaries, but to draw attention to the uncertainty about the rate of scrappage and other factors that are essential for making projections with a tolerable margin of error. In fact, past projections concerning motor vehicle transportation in Puerto Rico have generally not been within this margin--whether they erred on the side of over- or under-estimation.

However, it is not impossible to reconcile the figures and methodologies in short term projections.

Thus, taking the 1977 figure of 830,000, adding the new registrations for the first eight months of FY 1978 and projecting them for the whole year, and utilizing the accepted 8% scrappage rate based on United States data, we arrive at an estimate of 870,000 active motor vehicles.

As of June 31, 1978, the number of active vehicles was within a 1% margin of the Motor Vehicle Bureau's gross estimate that 875K or more registrations would be renewed. This estimate is based on the total of 950K renewal notices sent out on May 7, 1978, and a reasonably probable projection of 110K new registrations in FY 1977. Consequently, the cumulative total of all registered cars would amount to 1,060K, not the bureau's figure of 1,005K.

The total motor vehicle population increased from 248K in 1965 to 774K in 1975, more than tripling. The yearly growth was as much as 70K vehicles (15.28%) in FY 1971. By FY 1976, growth was down to 50K vehicles (a 7.1% increase over the previous year). The growth rate in 1977 was less than 2%, but the 1978 estimate is over 5%.

Even considering the uncertainty inherent in this variable (in the San Juan Metropolitan Area, the increase in motor vehicles fluctuated by a factor of 10 over a five-year period from 1968-69 to 1972-73, and by a factor of 7 from one year to the next), it seems unlikely that the Planning Board and the Department of Transportation and Public Works' projection for a mean vehicle population of 1.1M in 1980 is correct. This projection is cited in resources 12 and 48, based on 1970-75 data, and U.S. national transportation studies (see resources 22, 35).

The person-to-vehicle rate in Puerto Rico increased from 10 in 1965, to 3.7 in 1977. This was below the U.S. figure of 2. However, the vehicle density in Puerto Rico is much higher. In 1974, San Juan, where 40% of households do not own a car, had about 2335 vehicles per square kilometer (6050 vehicles per square mile). This is almost 50% more than the highest urban density in the mainland United States. The overall density in Puerto Rico was 6.3 times higher than in the U.S. These figures have increased since then. The absolute figure for San Juan was 401K vehicles in 1977, slightly under one-half of all vehicles in the territory.

In Puerto Rico, out of the 830K motor vehicles, 660K are classified as private cars. If one includes other sedans and minibuses (taxis, "públicos," government vehicles), and the majority of the 92K so-called pick-ups (classified as "camionetas privadas," private mini-trucks popular due to the reduced 10% import tax but mostly used for personal transportation), the total of motor vehicles other than commercial trucks, trailers, and motorcycles (representing less than 7%), falls between 750K and 75K. This accounts for approximately 92-96% of vehicles used for personal transportation. The number of buses in Puerto Rico is statistically insignificant. This data correlates with earlier findings, which suggested that the growth of private automobiles in Puerto Rico has outpaced that of commercial vehicles (6%). In contrast, in mainland United States, personal vehicles constitute only about 60% of the total.

2.12 Structure and State of the Fleet

In addition to absolute numbers, the composition of the personal vehicle fleet by weight and horsepower (HP), and the ratio of imported to used cars, are of particular interest for transportation energy conservation (TEC). These figures are interconnected in the sense that most used cars imported into Puerto Rico are heavy. In 1977, about 55% of personal vehicles fell into the

"standard" category (3000-4000 lbs); 35% were light (2000-2500 lbs), and 10.58% were heavy. However, if the heavy category is defined as vehicles weighing 4000 lbs or more, there were more than 225K of such vehicles. The "medium-heavy" category (3500-4000 lbs vehicles) comprised over 45% of the total. About 22.5% of the cars imported in 1977 were used. The majority were 3500 lbs or more and had engines of 130HP or more. In the 130HP-or-more bracket, 8 new and 182 used cars were imported in the last quarter of 1977. In the 110HP/<23001bs bracket, 8525 new cars were imported, compared to only 387 used ones. These new, fuel-efficient cars represented about 10% of the total.

The whole fleet at that time was another measure of the state of the fleet from the TEC's standpoint, as indicated by vehicle inspection statistics. The state-level inspection program, which included a superficial check on mechanical safety equipment, resulted in a rejection rate of 30% in 1976. A high percentage of vehicles, 138 in total, were not inspected. It's impossible to estimate how many of these vehicles were active during the inspections, which are spread over the twelve months of each year. However, it is likely that many of the non-inspected active vehicles would have been rejected.

A federally-funded inspection-maintenance (I/M) project in Puerto Rico, which also checked emissions—an important indicator of a vehicle's fuel efficiency—had a rejection rate of 90%. This high rate led to criticisms that the project's criteria were too lax (30, 56).

2.13 Transportation Network

Internal transportation in Puerto Rico depends entirely on roads. Railroads were eliminated in the mid-1950s. Water transportation is minimal—a commuter-ferry line operates in San Juan harbor. The development of the road infrastructure responded to the numerical growth of vehicles, as well as factors such as the Fomento policy of decentralized industrial development and the advent of containerized cargo shipping, most of which enters Puerto Rico through San Juan.

The highway network grew by about 20% from 1965 to 1975, to a total of almost 9,000 km. The surfacing improved from 79% paved in 1965 to 85% in 1975. New construction from 1969-73 cost almost \$550M (equivalent to nearly \$1,000K in 1978 dollars). Most of these funds were provided by the federal government. The Expreso Las Americas (P.R. 52), largely financed by bond issues, cost \$291M to construct. With financing costs of \$396M over thirty years, and an undetermined cost of maintenance, it represents a commitment of funds on the order of two-thirds of the contemporary state government budget, for a highway some 91 km/60 mi long. The expected net revenue in FY 1976 was...

The order of ¥M. The effects of the structure and state of the highway system on TEC, and the planning perspective will be discussed below.

2. Traffic intensity and vehicles. From the standpoint of policy analysis, absolute numerical data about traffic intensity are of interest only in terms of possible controls on further growth and measures to enhance the individual and aggregated fuel efficiency. The feasible controls and measures are discussed below.

The components of the transportation/energy system are so interconnected that measures which

promote fuel-efficient cars also tend to reduce traffic congestion, that is, too high traffic intensity. This is because fuel-efficient cars are generally smaller, thus taking up less highway space. This tends to reduce the severity of congestion--not to mention the fuel wastage and impact on air quality which traffic jams cause.

The capacity of the highway system in and around metropolitan areas in Puerto Rico to handle the traffic requirements is fair to poor, not only in the experience of individual motorists, but also in the judgment of transportation administrators and experts. A scale developed by the Highway Research Board (U.S. National Academy of Science, 1965) rates service on five levels, from A (light, sporadic traffic) to F (bumper-to-bumper traffic with intermittent stoppages). Level C is "normal" traffic, that is the planned flow in terms of numbers and speed.

On this scale, "Las Americas" was expected to have in 1977 still only B/C service level in its 8-lane metropolitan segment; instead, it operated generally between C and D and, at some times, even between D and F. Barbosa Avenue, a 6-lane access corridor to the Hato Rey central district, operated during substantial portions of working days on D and F levels. This and other similar experience in Puerto Rico duplicated the experience in the United States a decade earlier: the Long Island Expressway in New York, planned for peak traffic of 80,000 cars/day in 1970, was

In 1966, Japan had a traffic volume of 140,000 cars/day. Similarly, in Europe, a major exit corridor from Paris, the Autoroute de l'Ouest, was so saturated in 1968 that a routine accident on the outskirts of the city could cause a traffic jam extending 10 km into the center. The First Law of Motodynamics - "If left alone, automobiles always multiply faster than highways and parking lots can be built" - operated everywhere, including Puerto Rico where it was originally proposed (\$2, 66, 199, 209). The rush hour intensity in metropolitan San Juan could also be illustrated by screen-line measurements in the four major boroughs. Of the 24-hour total, 8-9% of traffic moved between 0700 and 0800 hrs, 7-8% between 1600 and 1700, the following hour being only slightly lower. Thus, almost one-quarter of the 24-hour volume moved in fact in three hours. The same 1976 cordon-line (at the limit of the metropolitan area) and screen-line (at selected points within the city) figures indicated relatively low occupancy rates. In Rio Piedras, out of a total of 415K vehicles/week, the private vehicle occupancy was 1.57, all vehicles (including públicos and buses) had an occupancy rate of 1.78. For Santurce, the figures were 400K vehicles, occupancy 1.54/1.56; Bayamon had 164K vehicles, 1.63/1.8; Old San Juan had 85K vehicles, 1.62/2.15. The average was 1.63 for all vehicles at all screen-line points. The cordon-line traffic, in- and outbound, averaged 1.73 at the two busiest points, with a total 2-hour flow of 57K private vehicles. The total traffic at these points was 372K, with an occupancy rate 1.9/4. This probably reflected largely the "plonico" traffic with often 5-6 passengers per car during the 12-day period. The commuter load factor in the United States, comparable with the cordon-line figures above, was 1.6 in 1975 (13%, 37). But it was as little as 1.2 in Nassau County, Long Island (5%) and in California (13, 80). By 1978, the Nassau County rate rose to 1.4 during crises such as gasoline rationing during the second world war.

The California rate was only raised to 1.7. An occupancy rate of 1.2 means that seven out of ten cars carry only the driver--if two of the ten carry two persons and one carries three persons. Empirical observation of the 0800 traffic on Barbosa Avenue indicates an even higher proportion of passengerless cars, despite the higher screen-line average for Rio Piedras. Such a level of use of cars and highways is not only exorbitant energy-wise (an average of 150HP or more to move one person at an average speed of under 10mph), but also in terms of land use. To take two examples,

17% of land in Nassau County is occupied by highways and parking lots; the figure for Los Angeles is close to 40%. The figure for San Juan is not available but is probably comparable. The impact of the present transportation system will be further developed, along with other items, in the section on secondary, indirect transportation energy demand.

2.15 Main Purpose: The cordon- and screen-line figures mentioned above also indicate that the majority of private vehicle trips take place in the San Juan Metropolitan Area (SJMA). This share, and the corresponding travel intensity in the SJMA, is substantially higher than that corresponding to the 51.5% of the island's passenger vehicles registered in San Juan. Trips in private cars grew in the SJMA from 64% of the daily total of 1.53 in 1970 (22, Table III-10) to 82% in 1976 (Zd., ch. III) or 76% in 1977 (246, 4 April 1978). Neither figure was unusual for a metropolitan area with insignificant collective transportation and relatively cheap (in fact, subsidized; see sec. 2.6) private vehicle transportation system (PVTS). To make a geographically distant and culturally different comparison, 87% of all urban trips in Australia were by private vehicle in the early 1970s (93, 261). The 1970 figure for street surface in the SJMA, about 8.5% (71, 25), may provide a reliable estimate base. Not only is it out of date, but it does not include parking. Moreover, the cordon line encompasses...

"Faster, more accurately sold, one can note a strong June subregion, with 308 undeveloped lands governing the streetscape in urbanization within an S98 balance from 25% to 40%. A "guesstimate" based on key factors, the 70K growth in street surface between 1960 and 1970, the undeveloped land and the rate of development (almost 20% from 1960 to 1970), the construction or 'urbanization' of several urban expressways (estimated land use for more than 'acres of land per 1km) and 1x for off-street parking space (including the big new shopping centers), sums up to almost 25%.

2. An urban PVIS has two characteristics that are important from the standpoint of energy conservation: a) Urban trips are relatively short. It was estimated that in 1965 auto trips 4 km/2.5 mi or shorter represented 60% of all urban trips in terms of fuel consumption. Some ten years later, trips shorter than 8 km/5 mi accounted for 15% of all auto mileage in the United States; they consumed over 30% of all auto fuel (86, 10; 132, \$3-33). This was over 50% more fuel than that consumed by all auto trips 60 km/10 mi or longer. Precise data are again lacking, but empirical observation indicates that the situation in urban areas in Puerto Rico is similar. A particularly dramatic, but apparently not untypical, example is provided by the traffic between the faculty residences and the principal campus of the University of Puerto Rico. Many S-shaped trips of more than 1 km are made daily to the overtaxed parking lots inside the campus; the direct walking distance, with no parking problems, is one-half as long. This example also illustrates the second characteristic of urban PTS: non-essential transportation. Transportation studies typically classify trips in the following categories: (1) Home to work (2) Home to shop/personal business (3) Home to school (4) Home to social/recreation (5) Non-home based trips. The division between essential and nonessential trips is not uniform. It is probably fairly close to reality to draw the line as follows: Essential are groups."

(i), (ii), 50% of (414), and 508 of (v). Groups (iv), 50% of (414), and (v) are nonessential. The 50% guess for groups (iii) and (v) can be justified, among other things, by such data as the following:

* Car ownership tends to generate trips and not consolidate two or more purposes or destinations

into one trip. For example, before traffic restraints were instituted in the Singapore CBD in 1975, vehicle-owning households generated 40% more trips per day than households which had to use modes other than a private car (60, 179).

* The Los Angeles Regional Transportation Study (1967) identified 22% of trips as other than home-to-work/school/shop (11, 87), implying these were non-essential shopping and driving-around trips.

* "Family business" trips other than shopping and medical/dental visits were estimated at over 14% of all trips in the United States in 1972 (63, 2-23).

25 * Although the non-home-based group tends to be a catchall, it obviously includes a substantial portion of social/recreational trips. If the formula for the calculation of nonessential trips, as suggested above, is applied to SIMA data, 35.5% of the 1.9M daily person trips (1970 estimate; 21, 21) and over 40% of the 3M daily person trips projected for 1990 (72, Table IIT-10) are nonessential. Despite its highly empirical nature, the estimate is probably rather accurate. It certainly compares with the 1972 federal study cited above (63, citing 102) which arrived at the figure of 36.7% nonessential person trips using a somewhat different method and inputs.

Incidentally, the state of the art can be illustrated by the fact that only a 1970 estimate was available for an update study made in 1975; the second study made in 1976, corrected the trip total from the estimated 1.9M to a "real" 1.53M, but then went on to make probably another exaggerated projection for 1990. In this projection, the number of "other", mostly nonessential trips, is increased by a factor of almost 3.1.

Between 1964 and 1990, there were uncertainties about the absolute numbers of trips, but these did not affect the estimated percentages of nonessential trips. Collective transportation is defined here as the transportation of passengers who pay for their seat ("buses," "publicos") rather than for the vehicle and the driver (taxi). They are not moved on a separate guideway which increases speed, capacity, and safety. The latter type of collective transportation is currently referred to as transit--and if so defined, it does not need attributes such as "mass" or "rapid." Under these terms, a system like the AMA (San Juan Metropolitan Bus Authority) does not qualify as transit. Even where these buses move in separate counter lanes, their average speed is 7 mph (1977). According to RIA's own figures (16 Feb. 1978), the mileage/year has remained unchanged since 1973, at 13.5M mi/ 21.7M km. The number of passengers decreased from 45% to 31.7K (in 1966, the total was 66M). The average passenger cost was 40¢ in 1973, 63¢ in 1977 (the fare remained constant at 10-25¢ in air-conditioned buses on the ground that approximately 95% of bus users had incomes below \$8,000/year/family). Consequently, AIA had a deficit of \$9.5M in 1973, which grew to \$11.2M in 1977. Additional data was found about the SJMA bus system. The system consisted of 52 routes approximately 850 mi/1360 km long (1975).

26. In the same year, it had 390 buses, of which only 290 were in service on a typical day. The rest were immobilized due to mechanical defects or absenteeism of personnel. The ratio of passenger trips per bus mile, steadily decreasing since 1960, was 3.3 in 1973, and 2.6 in 1977. That means that buses for 50 seated passengers carried on average only 2.6 persons. (The data for the total mileage/year, 13.5M mi, differ from data provided by the AMA's accounting office to the Office of Energy--11.7M mi for 1977, a steady decrease from the maximum mileage of 13.9M mi in 1974. The lower bus-mile

The figure still yields a ratio of only 2.95. Contrary to these figures, based on the simple division of the official figures for bus mileage and number of passengers per year, the P.R. Highway Authority estimated the passenger average at 12 persons/bus in 1972. This figure is 3.5 times higher than the actual ratio for that year (3.15), and the Office of Energy correctly considers it dubious (78, 2). If the real ratio or load factor were used to calculate the energy consumption per passenger, it would be substantially higher than the estimated 2,792 BTU based on the 12 passengers/mpg base (78a, 3).

The energy efficiency of the buses, which averaged 5.1mpg from 1970 to 1974, suddenly dropped to 3.95mpg in 1975 and averaged 3.98mpg between 1975 and 1977, a drop of 25%. There is no indication in the available sources as to how much of this drop could be assigned to the higher fuel consumption of new air-conditioned buses. However, the sudden jump of average cost per passenger from 49¢ in 1976 to 63¢ in 1977 cannot be explained in terms of wages or fuel cost. These new buses still operated on the 25¢ fare basis. The loss was 38¢ per passenger trip.

The velocity of express buses in the "exclusive" counter lane, some 21 miles long, was 12mph in 1976; it dropped to below 10mph in 1977 and, if a standard U.S. calculation method was used, the average speed of the whole AMA system was about equal to the speed of the express buses, only 7.2mph. This was, according to AMA technicians, not too different from the average speed in congested U.S. cities; in low-density-traffic cities, the average bus speed was 12-14mph.

The service did not operate on any reliable schedule. The headway between buses (that is the time elapsed between the departure of one bus and the arrival of another on the same route) was as much as 23 minutes. The load factor of 12, used by the Planning Board in the 1974 National Transportation Study, is probably far off because it is based on average weekday occupancy (1975, 3).

"Lenteen Sethe eet" is unclear and may need to be clarified. For comparison, U.S. data (1970) were as follows: 10 gases/vehicle for urban buses, and 2940 BTU per passenger at peak times (120, 5 [Prize et al., 1971]).

During working day hours, private buses served SIMA primarily between Bayamón and Río Piedras, providing the only bus connection between these two major boroughs and the Medical Centers, as well as between Bayamón and Santurce. The ridership, estimated in 1964 at 450,000 passengers/year, dropped to approximately 10,000 by the mid-1970s. Private lines also operated between San Juan and various points on the island. Their share in the total transportation was insignificant.

The service could be illustrated by the length of the San Juan-Mayagüez trip which takes 5 hours, compared with 3 hours for a "público" and under 2 hours for a private car. The decrease in bus ridership (excluding the small fractions for private buses) from the peak of 66 million in 1966 to 35 million in 1977 was 47% - comparable to the estimated overall drop in ridership in the U.S. from 1955-71, which was 52.5% (123, 125).

However, if such an obvious variable as the population increase in the SJMA is taken into account - it went from 542,000 in 1960 to 820,000 in 1970 (51.58) and the growth rate in the 1970s was

projected at approximately 20% (72, Tables II-3, II-H) - the actual drop in the AMA ridership was perhaps as much as 65%, and continuing.

Meanwhile in Nassau County, Long Island, an area comparable physically, if not also socio-economically, the trend reversed in the early 1970s and the bus ridership grew by 278 (from 55 to 70K/day, for a total of more than 20 million/year; 50% revenue came from passenger fare; the 1977 operating deficit was still \$9.6 million; 55, 17).

"Públicos" represented the relatively most efficient component of the collective transportation in Puerto Rico; in fact, they were the only one in the rural areas and in much of the SIMA. They totaled almost 10,000, of which about 2,800 were privately owned (PD license). The rest was largely owned by cooperatives. About 2,000 públicos operated in the SJMA and some 800 operated on

Routes in and out of the SMA, public transport totaled over 150K person trips on an average weekday. Outside of the 6:00 AM to 6:00 PM period, there was little to no service. Despite laws and regulations, the system operated on the basis of generalized routes, without a fixed schedule (except on some long interurban routes by reservation), and on the principle that the vehicle departs only when it is full. However, during busy hours, the waiting time at terminals or along the route rarely exceeded 10-15 minutes. The system was self-supporting on a fare basis comparable with that of the air-conditioned AMA buses in the SJMA. The constant "problems" with the so-called "phantoms" --unlicensed public transport competing with the buses--indicate that at that rate the public transport made a reasonable profit. They also rendered important public services during strikes at the labor-problem-plagued AMA. Contrary to the decrease of AMA ridership, the public ridership increased between 1964 and 1976 by 29% in SIMA, and by 19% on the island as a whole. The net ridership on the island decreased slightly during this period, from 40K to 38K passengers/day. It would not be correct to say that the public transport system was unique to Puerto Rico. For example, Caracas had a very efficient system of "por puesto" (paying for the seat) taxis already in the 1950s. This flexible system of regulated private enterprise--with substantial margins for improvement to make it even more attractive and useful--was one of the cornerstones of future energy-efficient transportation planning. If this evaluation implied a contrast to the bureaucratic, tax-supported, and inefficient bus system, apparently incapable of reform except by way of a complete overhaul, a supportive comment about public collective transportation was made in connection with the smallest component, the San Juan-Cataño ferry. Operated by the Ports Authority, it spent \$1 to transport one passenger paying 10¢ for the crossing. The daily total was some 6,200 passengers.

The text remained practically unchanged from 1961 to 1975. Although the U.S. UNTA granted funds to the government of Puerto Rico to upgrade the ferry system, expectations are that service will continue at about the same level (72, 57,83). The rate structure of the ferry system, which required an intolerably high subsidy of some 90%, was possibly based on a misinterpretation of the AMA statistics.

It is true that the drastic reduction in AMA ridership occurred since 1969 (64K passengers to 47K in 1972); but during these years, private car ownership rose from 260K vehicles to 340K in the SJMA, likely more in response to deliberate government policies than to the fare increase. The fare only doubled (if inflation is taken into account); buses with the original 10 fare remained in service; and the increase in vehicle ridership still left some 43K families in the SJMA without a car, thus

dependent on public transportation.

At a 1.5 occupancy rate, the 60K additional private vehicles accounted for 22.5K passenger trips/year, counting working days only. Crash highway building programs and reduction in vehicle import and registration fees facilitated this switch from public to private transportation.

(Page Break)

To round out the account of collective transportation, it must be mentioned that an undetermined but substantial number of home-to-school trips in the SJMA are made by school buses. On the island, an estimated 156,000 students were going to be transported every day in 35 municipalities in the school year 1977-78, at a cost of over \$9. No data on total mileage or fuel consumption were available.

2.27 Transportation of freight. A comprehensive survey of cargo transportation in Puerto Rico was made in 1976 (12). Although the perspective of this study is regulatory (and in this sense, it complements and updates a 1969 study, 29), many data there are relevant to TE0 analysis, specifically the proportionate consumption of cargo vehicles and the mutual impacts of personal and cargo transportation.

The text has been corrected for grammatical and typographical errors:

With apparent effects also on fuel economy. From the standpoint of TEC policy analysis, these were the main salient characteristics of the cargo transportation system: Of the total cargo which passed through Puerto Rican maritime ports (and that was 99.6% of the grand total, the remaining 0.4% being air freight), 26Mt or 7% consisted of crude and petroleum products, the latter mostly exported. This cargo was moved mostly by pipeline. Of the dry cargo, more than 90% entered and left through San Juan, less than 5% through Ponce and about 2.5% through Mayagüez. The San Juan maritime traffic consisted of 439K lift- or roll on/off vans in 1975, the majority were delivered in the SJMA, but a substantial minority went to various points on the entire island. If cargo vehicles were classified as light (pick ups, panels, light trucks, all 4-wheel types) and heavy (2-axle-6-wheels truck and multi-axle trucks and combinations), then there were 20.4K heavy trucks (2.6%) in the 1975 active vehicle population of 775K. For the purpose of traffic intensity calculations, an average (heavy) truck was estimated to take the space of two standard personal vehicles. (The estimate of 20.4K active trucks out of 22.9K registered would indicate an 11% scrappage rate, compared with the 8% generally assumed for the fleet as a whole.) Of the estimated 1975 total of 7.44B vehicle miles (VM), 820M VM (11%) were assigned to freight. No estimate was available to indicate the ratio between VM traveled within SJMA and those on the island and thus to allow informed speculation about the relative impact of trucks on highway use and the resulting energy account. But, considering the size of the SJMA relative to that of the island, a major portion of the VM must have been driven outside the SJMA. Much more detailed and reliable data would have to be available to afford drawing any inference as to direct fuel consumption based on the information in the preceding item. Data for passenger cars (3500 lbs) and...

Dump truck (15-16,000 lbs) data indicate that fuel consumption is comparable at constant speeds of 10mph and 50mph (15, 17, Fig. 1). For policy development, it's necessary to analyze the impact of urban congestion caused by passenger cars on truck movement and fuel consumption. Additionally, the impact of trucks negotiating gradients at 15-25mph on 50mph-limit two-lane

highways, holding up a platoon of passenger vehicles behind them, must be taken into account.

The maximum intensity of truck entry into the SJMA was measured between 0900 and 1000 in Ponce, and between 0800 and 0900 elsewhere. Out-of-city traffic on a four-lane highway between San Juan and Caguas (4238 vehicles in both directions, between 1600 and 1700) consisted of 8.1% heavy trucks.

For TEC analysis, a 1974 study by the regulatory agency, the P.R. Public Service Commission (6), is likely relevant. The study highlighted the low efficiency of terrestrial freight transportation in Puerto Rico, focusing on the rate structure. However, conclusions on the relative efficiency of light vs. heavy trucks and the high proportion of LTL (Less-than-Truckload) traffic must also be considered in any fuel consumption analysis.

2.18 The Human Element: It doesn't need to be particularly stressed that people are an important element of any transportation system. In relation to TEC, the human element appears to be key. This isn't so much about technological development, but rather the assumption that at any level of transportation technology, the relative energy account is ultimately determined by the demand for private vehicle transportation versus other practical modes, ranging from walking to transit. It's also determined by the usage of cars (intensity of driving, driver behavior, education and discipline, diligence/negligence in vehicle maintenance) and by social controls (policy and planning based on the real systemic nature of the transportation/energy complex, political intelligence and will, rules and enforcement). The human element is listed here only for reference.

Completeness: More detailed analysis and recommendations are developed further in the study.

2.2 1. The Figure 1 below shows the disaggregation of total demand and transportation consumption in the United States (105, ly 12):

Source 2:

C 72 x 10¹⁵ BTU
Time 19.6f- 100% 80.4%

Another calculation of the Total Urban Transport Energy (TUTE) for the United States is 25.9% (63). This estimate is possibly more realistic, especially because of the steady growth in private auto consumption since 1974. Both numbers represent, however, only the direct portion of the total transportation energy, that is fuel, oil and electricity used for propulsion and lubrication. Transportation also requires a substantial indirect energy input (see 2.22 below). The estimates vary from about 50% to 66.5% (63, 5-6). Again, the latter calculation is considered closer to reality.

The total transportation energy use then becomes $19.6/25.38 \times 1.5/1.66 = \text{approx. } 0.98$ of "Total Direct transportation energy.

32 total energy consumed. Sweden, which is considered an energy-efficient country, reported Total Direct Indirect Energy (TDIE) at 17%, indirect transportation energy at 21%--but that includes apparently only manufacture.

Both Sweden and a substantial part of the mainland United States have cold weather during 5-7 months. "Cold" starts of motor vehicles are known to consume disproportionate amounts of fuel. Figure 2 shows comparable data for Puerto Rico (29s, 8j updated). Trucks are classified as heavy (see 2.17 above); arbitrary energy consumption factors are assigned to them as follows: direct consumption equals 2.5 x passenger vehicle; indirect consumption is calculated using a factor of 3.0, largely on account of poor controls on load and the resulting excessive highway wear. Bus Total Operating Revenue Service (TORS) is considered insignificant, for the energy separate listing.

TOTAL ENERGY (62m bbl_petroleum)
0% "BEL OTHER
30% = 100%
70% reference Passenger 25/82. 54 (78 total)

Feet are 5/17. Private Car Collective makes up 92% of the total fleet. Transportation is at 24/808 or 2.56. The incorrect range for the year is 15/208 (equal to 50/66.5% of the total).

Paragraph 23: All the energy accounts are significantly higher in Puerto Rico than in the United States as a whole. The IDME is 20/346 higher, depending on which base figure is used (see Figure 1 and comment).

Total transportation energy, compared on the same basis, is 15/50% higher in Puerto Rico. Private car consumption (using the 63/180 ratio for the relative proportions of private automobiles in the whole fleet; see Figures 1 and 2) is about 21% higher in Puerto Rico.

All these data, and especially those related to the PVT (private vehicle transportation) mode, obviously represent significant margins of apparent energy waste. They need to be disaggregated and reassembled in models sufficiently precise to provide a rigorous base for specific TEC projections, goals, and policies.

As the previous analysis/synthesis shows, TEC policies based only on direct gasoline consumption - these are the data most prominently, if not exclusively used in governmental and public discourse - seriously understates the energy account of the transportation sector. And the higher the ratio of private vehicles in the system, as it is in Puerto Rico, the more serious the understatement.

However, even the addition of the 50 to 66.5% on account of indirect energy does not represent the cumulative total. What needs to be added is a factor which represents the relative wastefulness of the internal combustion engine. This consideration is especially relevant when one considers not only the TEC potential in a system based overwhelmingly on PVT, but also considers the medium- and long-range alternatives of other modes and transportation system mixes.

Energy loss in processing and use is so substantial that not to consider it would greatly distort policy analysis for decision making. The utilization/loss data for Puerto Rico are based on United States data, specifically those for the western states.

The effective use of energy in transportation is 25%, resulting in a loss of 75%. Electrical energy is

35% effective. Although the 65% loss is identified in reference 79 as "loss in the generation process", this total figure aligns with other estimates which calculate loss in generation and distribution of electricity. For example, the U.S. UTA's information sheet on "Energy efficiency of different urban transportation modes," 1976, uses the figure of 59% for generation losses and 8% for distribution losses, totaling 67%. The 75% loss of energy in the transportation sector partly duplicates items included in the figures for indirect energy consumption (such as gasoline refining, evaporation in fuel transportation and sale, etc.). There is apparently no basis for useful estimates here, except for the well-known energy efficiency data of internal combustion engines--usually in the 25% range. Only the 1976 U.S. models were considered "clearly better" than their predecessors in terms of energy efficiency.

Substantial improvements in the energy efficiency of motor vehicles can be expected with the development of new engines, fuels, switch to diesel engines, etc. The SAE Publications in the series exemplified by references 47 to 49s 118: 90, are representative of the vast literature on this topic. Electricity-powered transit already has an energy advantage now, not to mention other advantages discussed below, and the generation efficiency is also expected to be significantly improved. Beyond electricity derived from fossil fuel, there is wind and ocean thermal energy. The integration of these sources with an urban and island-wide rapid rail system must be kept in mind in any future technical and policy analysis.

2.21 Direct energy. Gasoline consumption. The consumption of diesel oil in transportation in Puerto Rico is insignificant (industrial consumption was at the rate of 7-8% of the gasoline total in 1976; ref 82). The total gasoline consumed in FY 197 was 646Wg in transportation (the grand total, including...

Non-transportation consumption was 66Uilg. This represented more than double the 1967 consumption of 316g. The number of motor vehicles grew in the same period 2.64 times. The consumption growth since the 1973 oil embargo and price increase was over 20%, compared with a 22% growth in the number of private vehicles (17% if light trucks are grouped together with passenger vehicles—see the rationale in 2.11 above; and also 22). This latter percentage, probably more realistic, means that gasoline consumption grew faster in recent years than the category of vehicles comprising some 93% of the whole fleet. The year-to-year increase was 2.9% in 1976, and 4.48% in 1977. The first rate of increase was the highest in the U.S.; the second rate was the fifth highest (146, 5 Apr. 1978). The overall demand for gasoline in the U.S. was increasing at the rate of 6.68% in 1977-78. A line must be drawn between engine efficiency and fuel economy, as expressed in mpg. Engine efficiency is a measure of how well the engine converts fuel to useful work. Fuel economy also depends on other variables such as the characteristics of the vehicle, the style of driving, the traffic conditions, etc. (See 126,5)

35 While the indicator of gallons-per-vehicle is about as refined as per capita income, it affords some comparisons. The 1975 average for the U.S. was 816 g/vehicle. The consumption ranged from Wyoming, 996 g/vehicle, to Hawaii, 516 g/vehicle. Puerto Rico's 772 g/vehicle put it below the national average, but above California, 765 g/vehicle, and Florida, 720 g/vehicle. Considering these figures and the relative size of Puerto Rico (48th in terms of area), which means shorter distances, these figures also illustrate the relative traffic density on the island. If other variables are taken into account by comparing the U.S. and Puerto Rico's transportation energy intensity with, for example, Western Germany, the exorbitant consumption is even more dramatic. For a comparable...

In terms of economic and living standards, the United States consumes four times more transportation energy per capita. Since Puerto Rico consumes 25% or more of the total U.S. energy, its energy intensity per capita is at least five times that of Western Germany. Yet, its economy and standard of life are considerably lower. Comparisons are complicated due to inflation and changing dollar values, as well as differing components of a good living standard. However, if we conservatively estimate the West German per capita income as three times that of Puerto Rico, the factor of transportation energy intensity rises to an incredible level. This is in line with the general energy inefficiency in Puerto Rico in relation to GNP.

In addition to the vehicle's weight and power plant, referred to in section 2.12 above, there are other factors related to optional equipment, operations, and maintenance that increase energy consumption far beyond the reasonable minimum needed for safe mobility. Due to their nature, these factors are much more susceptible to reduction or elimination through various measures. Therefore, they constitute the primary target for TEC and are discussed in section 2.3.

Section 2.22 discusses indirect energy. There are four main groups of transportation-related activities which consume significant amounts of energy in addition to TORE:

a) Refining and distribution of gasoline. One calculation arrived at a multiplier of 1.26, meaning refining and distribution of gasoline added 26% to TDTE. Another calculation determined 9.5% of the total U.S. energy budget, or 37.5% of TDTE. The issue of losses through evaporation in the distribution of gasoline, initially highlighted in the mid-1960s as an environmental pollution problem, has recently been publicized due to the high ambient content of

Benzene, a gasoline additive and a suspected carcinogen, is present in gasoline pump areas. Since (63) is an input-output analysis, this fuel loss through evaporation is most likely included.

The group from manufacture to services includes: manufacture, transportation, and sale of motor vehicles; maintenance, repair, parts, tires; parking, garaging, toll collection, insurance (energy expenditures only, not costs). This group should also include the energy cost of traffic and parking enforcement--items that are not expressly mentioned in the various calculations.

The total estimate for group 8) is on the order of 4% of the total energy (equal to 17% TDTE); another estimate is of an additional 3400 BTU/VM (22, 673). At 136,000 BTU/gallon and the national average of 15 miles per gallon at that time, this would add some 37.5% of indirect energy. While these estimates seem to differ by a wide margin, the totals of a) plus b) differ by only 10% Si-64.

This range is confirmed by a third calculation, based on (205. 22). If auto manufacturing figures for 1968 are interpolated into the 1970 series on which the calculation is based (1970 shows a 25% decrease in auto manufacturing energy consumption, probably because of industry recession), the indirect energy sums to 55.6% of TDTE.

Highway construction and maintenance should also include the construction and maintenance of rail transit systems, especially the energy-intensive heavy rail. Some estimates address themselves to this account. The parameters of group c) can be inferred from these data:

A basic estimate for "highway construction" is 1.7% of total energy, or 7% TDTE. This based on 1967 data and 1/0 analysis.

With reference to the controversial planned West Side Highway in New York City, the construction energy for the system (road and transitway, both partly tunneled) was estimated at 74×10^{12} BTU over a period of 10 years, or about one-half of the TDTE for all passenger cars in Manhattan for that period (27, 671).

Another base for

Inference is the construction energy cost for BART (San Francisco "Bay Area Rapid Transit"): of the total energy budget of the system over 50 years of operation, construction was estimated at 1M, propulsion at 40%, and station operation and system maintenance at 16% (105, 22, Table 5). Still another energy cost estimate could be derived from the dollar cost of the upkeep and renovation of the U.S. interstate highway system, put at \$329B for the 1978-1990 period (IMB, 24 July 1978). The relevance of these figures for transportation policy analysis in Puerto Rico is obvious, especially with regard to the deterioration of the existing system and, on the other hand, the construction and maintenance of toll roads, complex tunneled urban interchanges (for example, the planned connection of the Las Americas and De Diego expressways with the Baldorioty de Castro Avenue in the Minillas Center area), as well as the continued official adherence to the "Metro" concept of conventional heavy rail, in the face of a possibly more favorable alternative (see 3.12 below).

4) Energy cost of accidents. This category of indirect energy requirements does not appear to be included in the controlling estimates cited above. It is only marginally mentioned in one source (22) with a non-technical but probable estimate of about 20% of the total auto industry energy being required to repair or replace damaged vehicles. The share of replacement of vehicles would duplicate the particular portion of energy expense in the item production of new vehicles. In addition to the remaining portion of indirect energy on account of repair of accident-damaged vehicles, there are other obvious indirect energy costs caused by accidents: energy costs of funerals, hospitalization and outpatient therapy; repair of damages to public and private property other than vehicles. Data for Puerto Rico are scattered and incomplete but sufficient to indicate the magnitude of this account and lay out the base for more precise estimation.

Enumeration: The energy used by ambulances, tow trucks, and other emergency vehicles is direct energy and thus part of TDTE. The accident statistics show some discrepancies between such agencies as the Department of Transportation's Bureau of Traffic Safety, the Police, and the state Commission for Traffic Safety. The difference is as much as 32,469 accidents (over 40%) between two statistics for 1975. One of the safety agencies announced in its yearly report to the Governor that there was a 36% reduction in the number of accidents when, in fact, there was an increase of almost 6%. The next year (1976), accidents grew by another 6.58%. According to the most reliable count by the Department of Transportation and Public Works, there were approximately 360,000 accidents in Puerto Rico from 1973 to 1977, for a yearly average of 96,000. This total shows the following cumulative ratios:

- Traffic deaths (including pedestrians): 7.5%
- Heavy injuries (standard category A, requiring transportation of the victims from the scene): 13.0%
- Total injuries: 45.0%
- Property damage only: 68.0%

Important considerations for the energy interpretation of these figures would include: one out of nine cars will have a recorded accident in an average year. The energy cost (or even dollar cost) of PDO accidents is virtually impossible to calculate at present. Only accidents worth more than \$200 need to be reported to the police under the law, and not all are. Not all such small damages are repaired, as the state of many cars in the active fleet shows. Only a fraction of private vehicles - in fact, even public carriers - have individual private insurance. The mandatory state insurance (ACCA) does not cover property damage. Even if the net cost of repairs could be learned, it would not be disaggregated in categories appropriate for this analysis. A careful sample survey would be necessary. Almost the same is true about energy estimates of personal death and injury, but the dispersed data on ACCA yearly could be a consideration.

Payments on the energy budgets of such major emergency facilities as the Centro Medico, and longer-term hospitalization and follow-up therapy, could yield reasonable input in the overall energy estimate. On the other hand, monetary estimates of the cost of traffic accidents in Puerto Rico - \$239M in FY 1976, are based on U.S. mainland values and costs, mechanically transferred and therefore, having more of a shock value than analytical value. For instance,

39

the \$100,000 assigned by the U.S. National Safety Council as a loss caused by a traffic death is unrealistic in Puerto Rico where at least one-half of the population lives below the federal poverty line. On the other hand, NSC assigns an average cost per injury of \$3900 (1976); the Insurance Institute for Highway Safety found that in 1974 over 5,300 Americans suffered spinal cord injuries in traffic accidents. Of the less than 3000 survivors, 338 recovered and about 2600 became permanent para- or quadriplegics. The initial hospitalization and lifetime care of the survivors cost about \$250M; the indirect economic cost (including some energy expense) was estimated at \$580M, for a total of \$830M in 1974 (143, 28 February 1974; 28, FY). The first figure, directly relevant to indirect energy estimates, comes to over \$85,000 per car. Data are also lacking for an estimate of the energy budget with regard to the repair of damage to public property caused by traffic accidents. Where the driver can be identified, the police notify the regional director of Transportation and Public Works. The cost is assessed and the driver is made to pay it, in installments corresponding to his economic situation. According to the finance division of the department, the bill is often in the \$1500-2000 range. But the division keeps no statistics on the total of the damage caused and recovered.

2.23 Overview. The preceding inventory of the elements of total energy consumption related to transportation does not pretend to be either complete or refined. Even

This tentative, policy-oriented synthesis implies the following conclusion: The current statistics, which are solely focused on TDTE, vastly underestimate the actual energy cost of transportation in Puerto Rico. Consequently, these statistics do not form a solid foundation for practical energy and social policies. Figure 3 graphically illustrates the components of a comprehensive model of the

transportation energy budget in Puerto Rico. However, it does not attempt to demonstrate the intricacies of the system - a reality that makes the existing IDI data appear overly simplistic.

For instance, tires inflated to a mere 16 lbs., as opposed to the optimal 24 lbs. - a barely noticeable difference - increase direct fuel consumption by lowering the mpg (refer to 2.33 below). Under-inflation can also lead to tire deterioration at a rate 50% higher than normal. This necessitates earlier replacement, and if not replaced, defective tires contribute to over 10% of all U.S. accidents (1.2 - 1.5% per year; 143,31 January 1977). Either scenario leads to additional indirect energy consumption.

To fully understand the system from a preventative standpoint, one must also consider social management factors such as surveillance measures to reduce vandalism of air pumps and regulations ensuring that gasoline retailers maintain their pumps in working condition.

Figure 2 illustrates the total energy costs.

The diagram indicates various aspects of TOTAL TRANSPORTATION ENERGY, including manufacturing, construction, accidents, refining, transportation, sale, maintenance, evaporation, vehicle usage, and infrastructure. It also considers factors such as parking, public garaging, property rules, and compliance.

The broken lines suggest some evident TDTE resulting from transportation-related activities/events, and the multiple within-system effects of a minor factor - the example of under-inflated tires discussed in the preceding text.

The stark conclusion drawn from the inventory and the known or interpolated numbers is as follows...

In Figure 3, it's expressed that Puerto Rico utilizes about half of its total annual energy budget on direct and indirect transportation accounts. At least 80% of this energy (or more than 46,408 of the total energy) is consumed by private vehicles (see Figure 2). These are estimated to make up over one-third of non-residential use (see section 2.15 above).

The upper range of the U.S. coefficient, interpolated in the Puerto Rican model as 208% of Total Direct Transportation Energy (TDTE), is considered more realistic due to several grounds. Firstly, the study from which it is taken is the most comprehensive and recent in the literature. The interpolation is on the conservative side; the order-of-magnitude value used here ("two-thirds") corresponds to a coefficient of .666, while in reference 63, it's closer to .69.

Another estimate of comparable competence, based on E. Hirst's work, is much higher - approximately 100% TDTE or an increased coefficient of 1.0. This is expressed by saying that indirect energy reduces the miles per gallon (mpg) of the motor vehicle fleet to one-half, from the then national average of mpg to mpg.

In other words, applied to Puerto Rican figures, the total transportation energy used in Fiscal Year 1977 would represent the equivalent of approximately 1.3 billion gallons rather than the "official"

figure of 646 million gallons (of gasoline).

The U.S. figures apparently do not include the not negligible indirect energy consumption in column (4) of Figure 3 - Accidents. The only items among the standard components of the indirect transportation energy account, which do not apply to Puerto Rico, are in column (b): manufacture of vehicles, tires, and most parts.

A more refined quantification would therefore require that the energy estimates correspond to the new and used vehicles introduced in Puerto Rico in the given year (the recent average has been >100K), and the imported tires and parts. On the other hand, some parts are produced in Puerto Rico for U.S.-made motor vehicles. Based on these considerations, it appears unlikely that the fine-tuning of the tentative heuristic model in Figure 3 will substantially change the result.

The following text is a revised version of the original text:

This paper establishes a baseline for policy development and decision making in Puerto Rico in the area of this study. Transportation consumes about as much energy as all the other sectors combined: households and government, light and heavy industries, commerce, communications, and services. The share of transportation energy in the total energy budget is significant.

2.2.9 Energy demand Microanalysis: As overwhelming as the preceding conclusion on the total direct and indirect transportation energy demand in Puerto Rico may be, its translation into concrete TEC policies and recommendations requires a more specific determination of the energy minimum necessary for safe essential mobility, given the insufficient collective transportation and the absence of transit. In other words, what are the various categories of transportation energy consumption that could be reduced or eliminated by various operational measures, changes in driver attitude and behavior, and legal/regulatory measures, incentives, and constraints? The identification of these categories and a first estimate of their individual and cumulative impact on TEC is the purpose of the following microanalysis of transportation energy demand in Puerto Rico.

2.3.1 Age and maintenance of the fleet: The age structure of the Puerto Rican fleet, especially the over 90% of private vehicles, apparently does not fit the standard of useful life of a vehicle used by the U.S. EPA--9 years/100,000 mi [160,000 km] (Qu1, 8[1977]29). Neither does, for example, California where the "volumetric decay rate for automobiles" shows that it takes between 11 and 12 years before one-half of any year's vehicles are retired (11, n.p.[63]. There is, however, a sharp increase in retirement from the 10th year on. From the standpoint of fuel economy (f.e.), the age of an automobile represents two possibly unfavorable factors: higher weight and generally less careful maintenance. The contemporary impact of these factors shows in the following figures: the 1977 U.S. model cars.

The text was tested at an average of 18.7 mpg and effectively operated at 17 mpg; however, the entire fleet had an average fuel efficiency of only 13.7 mpg (132, S3-29; 148, 11 April 1977). While the size/weight parameter can only be optimized slowly, as automobiles are replaced with smaller and lighter models over a period of 10 or more years, maintenance can be improved relatively quickly and with a great impact on fuel consumption. An important yardstick of vehicle performance and fuel efficiency is the rate of polluting emissions. Much of the data on fuel efficiency has been collected with primary interest in controlling and reducing emissions. However, a car that exceeds

pollution standards is a car that burns gasoline inefficiently, therefore using more fuel than it should in relation to its performance.

43 The margins for improvement in maintenance can be gleaned from such theses. A sample of 5600 cars tested in 27 different cities in the U.S. showed that 4 out of 5 had some maintenance deficiency which had an adverse effect on fuel efficiency, exhaust emissions, or performance. The U.S. Department of Energy estimated that cars needing a tune-up wasted 375 kg of petroleum per day (___, 18 July 1977). An EPA study, related to a pilot Inspection/Maintenance Program in New Jersey, concluded that "improper adjustments and lack of proper maintenance" were the major reasons for the perceived "shortfall in the Federal motor vehicle control program" and that "the latest technology appears as sensitive as older cars to proper maintenance and adjustment" (22, 24). Visible exhaust is one indicator of a poorly tuned vehicle, with a fuel efficiency penalty of 25%. This was assumed to be the case for one out of every ten vehicles in 1974 (220, 7). Empirical observation indicates a much higher proportion of such vehicles in the Puerto Rican fleet. This state of engine maintenance was also confirmed by the high reject rate (90%) of a temporary Inspection/Maintenance Program which also tested emissions, compared with the standard inspection program in Puerto Rico (since 1969) which records only 30% of vehicles.

Rejects (see 2.12 above). For a comparison, a rejection rate of slightly under 20% in Ohio (including emission testing) was considered too high, and the EPA went to court against the state of Ohio. However, the police issued almost 79,000 citations in the preceding year, 1976 (QU, 30 January 1977, supplemented by EPA, Region V). These data indicate the magnitude of the problem and the margin of opportunity for better maintenance and enforcement in Puerto Rico. The age of the fleet as a factor is probably supported by another comparison with California. In a voluntary I/M program in Riverside, 85k motorists were invited, 50k participated, and of these 17k (about one-third) failed (Que, 24 July 1977). This rate is 50% higher than that recorded in the Cincinnati, Ohio test. The Riverside test took place two years before the Ohio test (1975-1977), which certainly affected the age-efficiency factors. It is also assumed that the Cincinnati fleet is relatively younger. The major elements of maintenance with regard to f. Tune-up include:

- a. Following the manufacturer's specifications (e.g., with regard to correct ignition setting, not 5 degrees off) makes a 3-9% difference in the car's fuel efficiency (220, 7).
- b. Simple exchange of spark plugs improves fuel efficiency by 3.5% (1K, 18 July 1977).
- c. One non-functioning spark plug substantially reduces fuel efficiency.
- d. Proper tune-up of the nation's fleet would improve the overall fuel efficiency by some 11.5%, but some automobiles could improve their fuel efficiency by as much as 50% (Id).
- e. Tuning vehicles every 6k miles, instead of the present average of 12k miles, would represent a saving of 1.58 of the TDTE (62, 2-16).

A particular aspect of tuning is the proper setting of the idling speed of the engine. In urban stop-and-go or jammed traffic, the low average speed combined with high idling speed can burn fuel at a rate comparable with the vehicle travelling at a sustained speed of 65 mph. If the variable of nonessential driving is added, the same situation affecting fuel efficiency.

This can also occur in exurban traffic. On a weekend in April 1978, traffic between the edge of the SJMA and Luquillo Beach and the Fajardo Boat Show was reported to average 12 mph over a stretch of about 20 miles. Inbrication, the use of 10W-K0 oil instead of 30W oil, is reported to have

a significant effect on fuel consumption. The applicability of this data to the relatively uniform temperature in Puerto Rico should be established. A recently developed "uniflow" oil claims a miles-per-gallon improvement ranging from 9.8 to 22.7 per tankful; this would mean an average fuel efficiency improvement of about 48%. A synthesis of various estimates for fuel efficiency improvements through maintenance, as well as on account of other factors discussed in the following sections, appears in Table 1 (pages 53-5 below).

2.32 Roads and Traffic Management. Extensive tests in Pennsylvania showed that it cost an average of 41% more to drive on deteriorated (fair to very poor) pavement because of higher fuel consumption, accelerated tire wear and damage, and greater vehicle wear and damage. The impact on fuel efficiency can be inferred from the fact that fuel accounted for 75% of the total running costs of the test vehicles (101, 7). The state and progressive deterioration of roads in Puerto Rico in the last several years probably increases the fuel consumption penalty.

45 above the Pennsylvania figure, which translates into a 5 mpg loss for an average vehicle (1977 = 17 mpg). Even at an average figure of 20% loss of fuel efficiency due to less than excellent road surface, i.e., a 3.5 mpg loss for the average vehicle, this factor amounts to an astronomical figure. Traffic management consists of engineering, laws, regulations, and enforcement. The low state of the art in all these departments in Puerto Rico is notorious. It is subject to policy analysis and recommendations below—from simple techniques to improve urban traffic flow to information and education of drivers. The magnitude of possible total energy consumption is illustrated by the following sample of data: The reduction of stops—mostly on account of

Faulty timing of traffic lights or oversaturated traffic can increase traffic by 15% during a typical urban 'whip.' This results in a 36% improvement in fuel efficiency (f.e.) (62, 2-21). At an average traffic flow of 25 mph, the fuel saving is 40% compared to a "normal" stop-and-go city traffic (Id., 2-20). In exurban driving, a combination of highway design and poor enforcement that results in steady speeds of 70 mph--such as on the Las Ané- ricas toll road--represent a fuel loss of some 24% when compared with a steady speed of 50 mph, and some 30% in comparison with the most economic steady speed of approximately 40 mph (24).

2.39 Tire and proper alignment of wheels also have significant impacts on f.e. The relative drag of tires has a considerable effect. The coasting distance from 25 mph to a stop is 334 m for bias-ply tires, 360m for radials, and 482 m for a recently introduced "oval" type. Radials, kept inflated to the manufacturer's maximum recommendation, can improve f.e. by about 7% over bias-ply tires. The "oval" model is said to represent an additional 3-8% (US, 10 October 1977) or 7-10% (163, Nov. 1977) improvement over radials--approximately .3 mpg on the average car. Using the WR data for Puerto Rico, this seemingly small f.e. improvement amounts to roughly 240 more miles traveled by the average car annually, using the same amount of gasoline. Proper wheel alignment is also a noticeable factor (2). As with many other factors, improper alignment can indirectly increase energy consumption--through accelerated tire wear and a higher likelihood of accidents if tires are not replaced in time. Another supportive estimate is a 15% fuel penalty at 50 mph cruising over "badly broken and patched asphalt" (268,11).

46 2.94 Convenience power equipment. This category includes four principal types of optional equipment that carry a fuel penalty, on account of added weight and operation. a) Automatic

transmission. Compared to manual gear shifting, automatic transmission reduces f.e. by about 1% due to the added weight, and by 10-15% due to operation.

Consumption with urban driving is less economical. The fuel efficiency of both the manual and automatic systems is being improved. The manual is improving by transitioning from 3 speeds to 4 or 5; the automatic system is seeing similar increases in speeds, with the addition of a switch to infinitely (constantly) variable transmission, and the inclusion of locking torque devices to prevent slippage (56, 294; 4B, 13; 31, 140: Technol. Rev. III-1V/1977). Among the top 31 cars in the 1977 EPA mpg tests, 30 had manual transmission, and one (number 17) had automatic transmission (148, 3 October 1977). Manual transmission appears to have an efficiency edge that even the best improvements in automatic transmissions--80-100% in performance or 15-20% in efficiency--will have difficulty erasing, due to other economic disadvantages of the automatic mode when operated by an average driver. Indeed, the engineering efforts probably respond to the fact that the automatic transmission is more energy efficient than the average-to-poor driver, that makes up the bottom two-thirds of the driving population. With manual transmission, these drivers tend to shift too slowly into higher gears, thereby revving up the engine more than corresponds to the actual speed. However, the same drivers are often equally clumsy with automatic equipment: by not letting off the accelerator, they delay the gear shifting (2). At the same time, they feed the engine more fuel than it can burn. The only way out for the unburned energy is through the tailpipe--an efficiency loss as well as a source of air pollution. The greatest disservice of automatic transmission is probably the fact that many of these energy-wasting drivers would likely not drive at all, or would drive much less, if they had to shift gears manually. In the 1978 tests (1979 models), all the top 10 cars listed in the first press report (UPI, 15 September 1978) had manual transmissions; eight had the standard "European" speed gear shift, two had an improved 5-speed shift.

4) Air conditioning. This option is generally considered the most energy-draining. It increases

The text discusses the consumption of 1-2% due to weight, and 9-20K when operating in an automobile. The higher figure corresponds to urban stop-and-go traffic, which seems to be the prevailing condition when automobile air conditioning is used in Puerto Rico. This has been exacerbated in the last decade by the systematic desertification of urban areas and highway fringes, causing a loss of trees and bushes--the natural air conditioners and purifiers.

However, as explained in the next paragraph, air conditioning is a dubious protection against air pollution in heavily travelled corridors. This is likely the justification in the minds of many drivers, in addition to the safety factor of keeping car windows closed at all times. No data is currently available on how many cars in Puerto Rico have air conditioning. Local industry data indicates that air conditioners are being installed in new small cars and many used cars at a rate of approximately 6000 units per year.

Paradoxically, these units are of the so-called vacuum type which is much cheaper (around \$365), but more effective as a protection against foul air since they only circulate the air inside the vehicle. The factory-installed air conditioners are of the ventilation type; for an average cost of \$900, they not only provide air conditioning, but also force traffic fumes inside the car unless the vent is opened and shut according to the outside environmental conditions. This is probably beyond the attention span of the average user.

Sensitive measurements of traffic CO were made inside a car with only this ventilation open. A small-scale study of bicycling and air pollution by the U.S. Department of Transportation (reported in Science 199, 1187 [1978]) also showed that the control group riding in air-conditioned cars absorbed more CO than the cyclists in hot, polluted Washington air, likely because the latter moved faster through jams. This example takes us back to the fuel efficiency related to idling, and is just one of many illustrations of the systemic interlocking of many of these factors, separated here for the sake of clarity.

Purpose of Analysis: A simulated test with a 1972 standard automobile in Puerto Rico arrived at the figure of 176 (20, 72). This is probably low as compared with real operational conditions, as summarized in the text above.

48) This includes brakes, seats, windows, and roof. This equipment adds up to 2% in weight; the amount of energy used varies with the frequency of use (steering, brakes), as compared with the occasional use of the other options.

4) V8 engine instead of V6 engine: The average performance of standard cars without these power options (and high fuel efficiency) was 23 mpg. With the power equipment of all four categories, it was 16.3 mpg, for a total fuel penalty of 41 (2, 5).

2.35 Nonessential driving: Nonessential trips were already defined and estimated at 35-40% of the total trips in Puerto Rico (see sec. 2.15 above). If we conclude that the vehicle miles traveled (VMT) per household per year vary more with annual income than with any other factor, this would mean that higher-income drivers, who own on average bigger, less energy-efficient cars, do more driving in general and therefore also more nonessential driving. This would tend to increase the energy consumption above the overall estimate based on nonessential travel, putting it somewhere between 40 and 50% of total daily travel energy (TDTE).

Some doubt may have been cast on the income/VMT correlation (132, 3-10) by a mid-1978 survey related to the cost-of-life index in Puerto Rico. It was reported (146, 3 September 1978) that both a typical family close to the poverty line (income of \$6,000/year) and one at the middle-class level (\$26,000/year) spent about \$40 a month on gasoline, which is over 55 gallons at the prevailing average price of \$.725/gallon. However, the higher-income family did at least 450 miles/month of nonessential driving (daily round trip home for lunch, 10 miles each time; and a 60-mile round trip out of town on the weekends), which is over 56% of the total 600 miles (55 gallons at 14.5 mpg). No data were available to calculate the nonessential driving, if any, of the poor family. Another kind of

Energy-expensive and often nonessential driving are usually short trips. The U.S. data may not be entirely applicable without taking the climatic conditions into account. Trips under 5 miles do not normally allow the engine to reach its best operating condition. Conversely, warm-weather driving tends to improve fuel efficiency by as much as 8% (130, 6-7). With specific Puerto Rican data interpolated, the basic fact of severe penalties for short trips is likely to remain unchanged. It was calculated (132, S3-33) that if a car can make 10 trips of 40 miles each, using 25g of gasoline with a fuel efficiency of 16 mpg, the same amount of fuel will be spent on 60 4-mile trips, 90 2-mile trips or 100 1-mile trips. The respective total distances driven are 400, 240, 180 and 100 miles; the shortest trip is four times as energy expensive as the longest.

A special category of nonessential consumption is recreational powerboats. Boat engines and motors are notoriously energy-inefficient. At 6,200 BTU/PA for a recreational boat carrying 4 persons, the energy consumption is four times that of a small car carrying the same number of passengers. It is nine times that needed to transport 1 ton of cargo by water (1, Appendix A; 120, 5). Powerboats are frequently excessively overpowered. The 15-foot lightweight flat-bottom "cruiser," equipped with two outboard motors totaling 170 HP, and observed while it was trailed by a sedan with a 250 HP engine, is an exception. But 75 HP motors on runabouts, where 10-25 HP would be ample, are a rule in Puerto Rico. The tendency to abuse this power and thus to consume even more energy is greater on water than on highways, though the sense of safety because of the free space can be illusory. U.S. Coast Guard statistics show that more than 50% of boating accidents involve vessels less than 20 feet in length, powered by motors of more than 75 HP (144, 22 May 197). The boating Cadillacs commonly have engines of 300 HP or more. Although these are in most cases diesels, the fuel

Consumption is still extraordinary when considered in the whole framework of energy, recreation needs, and social utility.

2.36 Driving habits in general:

A driving style that results in substantial fuel efficiency (not to mention safety and lower polluting emissions) requires nothing more than observing the rules of the road, using common sense, and acting with a modicum of courtesy and discipline. Unfortunately, this kind of driving is almost becoming an exception.

All the transportation and fuel efficiency specialists, since at least the late 1950s, agree on these simple rules:

- Be gentle on the accelerator. Do not practice "rabbit" starts. Once the car moves, it only takes 10 HP to keep it moving. By not pressing hard on the accelerator, you allow the engine to use every drop of fuel effectively.
- Maintain as steady a speed as possible. Adjust your speed to the traffic's density.
- Leave some space ahead of you. Anticipate stops. In tight urban traffic, look two lights ahead. Coast to a red light as soon as you see it. Do not keep running at the same speed and then brake hard. Do not "beat" red lights: you may pass one but still have to stop at the next.
- Do not let your car run when stopped, except at a traffic signal.

A difference of 20% in fuel consumption due to differences in driving style was demonstrated. On the basis of a pilot program of the U.S. Department of Energy (DOE), carried out in Nevada, it was concluded that the fuel efficiency of any driver can be improved "up to 15%" by instructing them on the simple rules of acceleration, stopping, and maintaining a steady driving speed.

In view of the "up to 15%" for the average driver, the 20% figure cited above may be a conservative optimum. Instant fuel consumption meters may be necessary as standard equipment.

To suggest just one more example of the interconnected system nature of these factors and considerations that is vital to an adequate policy development, erratic stop-and-go driving from one traffic light to another is a major source of fuel inefficiency.

The text leads to longer idling times at stop lights where (iii) fuel consumption is a function of proper maintenance (correct setting of minimum idling speed) and (iv) is a major cause of high traffic pollution concentrations. 2.37 Speeding. Driving above posted speed limits or exceeding them for the purpose of passing is so energy costly that it deserves separate listing. At least three factors contribute to speeding: (i) Design speed of roads. For example, while the Las Anfricas toll road has a federal speed limit of 55 mph, its design speed is 70 mph in the northern segment, 60 mph in the central segment (Caguas-Salinas), and 80 mph in the southern segment (Salinas-Ponce). During the National Speed Monitoring Program in 1977, it was found that over 50% of drivers in Puerto Rico exceeded the 55 mph limit; 17.6% exceeded 65 mph. The overall average was 52 mph (the speed limit on most highways in Puerto Rico is 50 mph; some 60 mph signs may have been left by oversight). ERDA began testing similar meters of electricity consumption in households in Washington in 1977.

The invitation to speeding and its acceptance was such that a respected columnist could write after the inauguration of the final segment of Las Anfricas (1M6, 7 Oct. 1977) that "like almost everybody else", he was not observing the speed limit; and predicted that the short travel time from Ponce to San Juan would bring many people "to get in line" on a new popular movie. Calculating this combination of speeding (above 65 mph, plus city driving) and nonessential driving induced by the expressway (130 mi round trip) comes out to some 11 gallons (at 14 mpg, with a 20% fuel penalty for the 65 mph average as compared with a 50 mph average) per car - a considerable energy price to see "Star Wars" perhaps two weeks earlier. Publicized industry acceleration standards are usually expressed by the time needed to accelerate from 0 to 60 mph. The "macho" appeal is measured in tenths of a second. The planned

The new Delorean DMC-12 car has a "0 to 60" performance of about seven and one-half seconds, close to the Porsche 912 (Uit, 18 September 1977). The acceleration capacity goes hand-in-hand with speed performance; hence, the DMC-12 is also "designed for... survivability at an 80-mile-per-hour-plus head-on collision." The more sedate standards of the big auto makers are in the 11-14 seconds range for acceleration. Now, the industry seems to fear that this propaganda may backfire and make the new GM diesel passenger cars "unacceptable" to the consumer, as they take 15 seconds or more to accelerate to 60 mph (U5, 16 May 1977). The related fuel penalties are considerable. If the acceleration performance design were reduced to 17 seconds, 2.5% mpg would be added; a car with a 20 seconds acceleration time would gain 5 mpg (22, 28).

Driver attitude is, of course, the cardinal factor, since the vehicle does not speed without the driver making it. The exponential growth of fuel consumption at speeds above the most energy-efficient steady 35-40 mph is extensively documented (e.g., 19, 20, 126a, b). A table in the latter source shows the following "cruising" performance for a "typical domestic automobile":

22.5" 70" 123"

According to these figures, the fuel consumption penalty at 70 mph is -23.6% as compared with 40 mph; -19.5% as compared with 50 mph. Other data indicate stiffer fuel consumption penalties.

EPA's own penalty figures derived from the table are, in fact, higher: -25% for 70 mph as compared with 50 mph. This would mean a penalty of -30% in comparison with the optimum steady speed of 40 mph, a calculation confirmed in (Zit).

The table also offers an argument in favor of a minimum speed limit of 30-35 mph on exurban primary highways; and it allows another calculation of fuel consumption penalty of urban stop-and-go driving. At 20 mph in urban traffic, the vehicle delivers only 10 mpg, as compared with 16.5 mpg in 20 mph cruising. The penalty is more than -40%. The average speed in congested urban areas,

The text appears to be regarding an analysis of fuel consumption and transportation systems, potentially in Puerto Rico. Below is a revised version:

An entity such as SJMA, is estimated to operate at only 10 mph or less. These figures are in the same range as (63, 2-20), cited in section 2.32 above. A combination of speeding, misuse of acceleration capacity, and erratic driver behavior, such as surpassing the maximum speed limit, also results in heavy fuel penalties. At 50 mph (the maximum speed on most primary roads in Puerto Rico), one speed change (acceleration) per mile can result in a penalty of -25% (126a, 11).

Section 2.38 discusses tax-free gasoline. An analysis of the consumption of tax-free gasoline (24), used mostly, if not exclusively, by government vehicles, shows a surprising increase. In FY 1975, the 11 Mg of this gasoline represented 2% of the total transportation gasoline consumption. In FY 1976, it was 3.98% of the total, and in FY 1977, 29 Mg or 4.5%. It is conceivable that the lower cost (the tax is 16¢ per gallon) makes government users less conscious of consumption. In addition, government cars have to burn more fuel to travel to separate central pumping stations to fill up.

Section 2.99 provides a summary. Figure 1 on the following page synthesizes the inventory of physical, human, and institutional characteristics of the transportation system in Puerto Rico (with emphasis on the predominant private vehicle sector) that increase the direct energy demand beyond the minimum necessary for safe essential mobility. The table presents the corresponding fuel penalty estimates. These are weighted approximate median values derived from the indicated sources, taking into account some special circumstances in Puerto Rico. The table indicates how much transportation energy could be conserved in Puerto Rico without affecting the basic social and economic need for mobility. The sum of the TEC potential represents a second policy baseline: The essential functions of the present (private) transportation system in Puerto Rico could be satisfied with as little as 50% of the current TDTE.

Table 4 details the categories: CAUSE OF ADDITIONAL POTENTIAL FUEL.

This text seems to be scrambled and unclear, possibly a result of OCR scanning errors. It appears to discuss various aspects of vehicle maintenance, fuel consumption, and driving conditions, but the specific information is difficult to discern due to the scrambled words and phrases.

Here's an attempt to reconstruct some of the text, but please note that without the correct context or source material, it's challenging to provide an accurate revision:

"Consideration | Concentration etc. Regarding vehicle MAINTENANCE, one must emphasize the

importance of regular check-ups indicated by the vehicle's age. It's perceived that the state of maintenance greatly affects the specific experimental data.

1. Talking | Specifics
2. Fabrication
3. Roads | Progressive deterioration of roads post-recommendation. Interior estimate: 22.5
4. Tires: type | Inflation
5. Alignment
6. Automatic transmission
7. Air conditioner
8. Power options

For the driver, urban traffic includes flow, traffic control, and occupancy. Speeding and erratic driving should be avoided.

Table 1 - Continued

SUBTOTALS

GRAND TOTAL (rounded) 10.0

EXPERIMENTAL FORMULA FOR THE CALCULATION OF TEC POTENTIAL:

"Essential" fuel consumption: +100

"Real" aggregate fuel penalty: (2) 50% of the grand total: +70 (G1) 75% of non-essential trips: +30
TEC POTENTIAL EQUALS THE AGGREGATE FUEL PENALTY, THAT IS $100 = 50\%$ OF TEC.

Notes: In the manner described at the beginning of this section, fuel consumption is considered. The fuel penalty incurred by one 1972 test car was 424. Not all cars incur all fuel penalties, nor will all of these be eliminated. The 50% figure is, however, considered realistic."

Please provide further information or a clearer version of the text for a more accurate correction.

The estimates in Table 1 only refer to direct energy consumption, and not to indirect consumption due to accidents, where there is a substantial room for improvement in Puerto Rico. This is not only desirable for energy conservation reasons but also for others. Due to the absence of data on fuel consumption of heavy trucks (see 2.11 and 2.2, Fig. 2, above) and their equipment, no attempt is made here to distinguish between total direct transportation energy (TDTE) in the private-passenger and freight sectors. As in Figure 2 above, bus TDTE is insignificant at the level of analysis attempted here. This reference is not to the weight of the vehicle, but to objects stored and "permanently" carried in it.

55

3. COST/BENEFIT ANALYSIS

3.1 The Auto Owner's Cost

The preceding data and analysis show that a) over 90% of transportation in Puerto Rico is by passenger vehicles or their equivalents; b) over 99.5% of these vehicles are privately owned; c) this private vehicle transportation system (PVTS) consumes over 80% of the total direct and indirect transportation energy budget. It is therefore the primary target for total energy consumption (TEC). Unless otherwise indicated, the remainder of this study addresses itself to PVTS.

The principal benefits of owning an automobile are:

- a) The satisfaction of the need for essential mobility, in the absence of an alternative (collective) transportation mode.
- b) Freedom of nonessential mobility.
- c) Status symbol; opportunity for conspicuous consumption.
- d) According to studies in such long-distance commuting areas as, for example, Los Angeles, the satisfaction of a psychological need for privacy and own space in an increasingly crowded and noisy environment.

The cost of owning and operating in 1977 in Puerto Rico, an automobile acquired in 1973 for \$5,000, with an estimated lifetime of 10 years and 100K miles, was calculated at \$0.3218 per mile (including the usual financing cost) (68). This is a substantially higher figure than the various data for the mainland United States (e.g., 44). Even in comparison with the highest-cost area--Boston, \$

\$0.2363 per mile (U4, 18 September 1977). The figure for Puerto Rico is + 36. The Boston figure is so high due to insurance; the Puerto Rico figure is distorted for the same reason. It includes \$1,830 insurance cost over 10 years, whereas the vast majority of auto owners in Puerto Rico have only the obligatory third party liability insurance which would cost them only \$350 over the same period of time. On this basis, the operating cost in Puerto Rico would still be more than 10% above Boston. Considering the high cost of living in Puerto Rico, this is probably a realistic estimate. The cost of car ownership is estimated at more than 20% of personal/family income, as much as 27% in the latest statistic for the U.S. (142, 2 July 1978). These data need to be interpreted for the purpose of TEC analysis. In this perspective, three conclusions are particularly relevant.

First, despite the cost increase, the ownership and operation of an automobile has become progressively cheaper. Although the 1977 figure of 27% represented an increase of 7% over 1976, the share of personal income dedicated to automobiles in 1976 was higher (28.7). Income has grown much faster than prices (147, 31 October 1977). Especially the principal energy parameter, gasoline, has been getting progressively less expensive. The CPI figures show that between 1940 and 1970, all items increased by a factor of 2.8; gasoline only 2.5 (Uj, 1 May 1977). In 1975 dollars, gasoline cost in 1960 \$0.576/gallon, in 1976 (that is after the post-1973 increase) only \$0.558/gallon (135, June 1977).

Second, the present price levels had no appreciable effect on TEC. Both in the U.S. and in Puerto Rico, the transportation sector was the only one in recent years where energy consumption was increasing. In the absence of an effective I/M system and driver information, the relative price increases of gasoline probably had an inverse effect on fuel. Engine maintenance costs were cut, consumption of fuel as the economically cheaper factor was increased.

Increased. Third, the operating cost represents neither the full economic cost (3.2 below), nor the full social cost (3.3 below). The PVIS is heavily subsidized by the public.

3.2 The full economic cost. The component acquisition has relevance for TEC analysis in the sense that fuel consumption is directly affected by the number of cars and the ability to acquire them. Personal/family budgets have shown surprising elasticity in this regard. The facilities for financing, the cost of which are "hidden" or distributed so that they can be met, are probably most responsible. This factor was apparently not sufficiently considered by decision-makers. During the 1969-1972 period, when everything possible was done in highway development and reduction of auto taxes to facilitate the acquisition of automobiles, the widely reported tacit premise was that the private economic capacity will limit the vehicle population to a maximum of 600K. The error in judgment was 240% (1969 = 408K registered vehicles, 1978 = 874K). There are also social implications which will not be further discussed in sec. 3.3. Money spent on an auto, no matter how "inconspicuous," is not available for other family needs. Puerto Rico's rate of private indebtedness is substantially higher than that of the world's foremost credit economy, the United States as a whole.

7 The component operation bears more directly on the question of whether automobile owners in Puerto Rico pay the full economic cost of the PVTS, with implications for TEC suggested below. The following is a list of the principal cost items of operating an automobile, with comments on the real economic cost.

Gasoline: average price. The price of crude imported in Puerto Rico rose by a factor of almost 4.2 between FY 1972 and 1976. The gasoline price rose by only 1.45. This is principally due to the "equalization" of prices between Puerto Rico and the mainland U.S. But the increase in the U.S. gasoline base price in the 1972 to 1976 period was x 1.9, that

The price of gasoline is approximately 5% higher in Puerto Rico. Despite the fact that the absolute prices are higher in Puerto Rico, they increased approximately 31% less than in the U.S. within the last five years.

Regarding gasoline tax, no federal gasoline tax, which is 4 cents per gallon currently, is collected in Puerto Rico. The local state tax remained unchanged at 11 cents per gallon from 1966 to 1974, even though highway investment amounted to \$520K between 1969 and 1972. An increase in tax was considered but not implemented. The tax has been 16 cents per gallon since 1974 and the Consumer Price Index (CPI) has risen over 40 points since then.

To reflect inflation and corresponding increases in average income, the gasoline tax would have to be now in 1978 at 23 cents per gallon. Even at 16 cents in 1977, it was the highest state tax in the U.S. The U.S. gasoline price and tax policy, which Puerto Rico follows, is very low by world standards.

In April 1977, gasoline prices in a representative sample of foreign countries in Europe and the Americas ranged from \$2.13 per gallon in Italy to \$1.04 in Chile, averaging \$1.38. Prices in several countries have risen since then.

When comparing the cost of gasoline to Gross National Product (GNP) as an approximate indicator of the ability to pay, the difference is even more striking. If the U.S. cost per litre is 1.0, then Sweden is 2.41, West Germany is 3.0, Italy is 7.06, and India is 115.3. Even these absolute and

relative prices were considered as not expressing the real cost.

An official report to the Congress on "automotive fuel economy" emphasized that the U.S. and Puerto Rican gasoline prices are suppressed by government control.

As for highway usage, a heuristic calculation based on U.S. and Puerto Rican data indicated that highway users in Puerto Rico pay approximately 258% less than the 8.7% assigned to the average mainland motorist for highway use and maintenance. In fact, highway users in Puerto Rico pay nothing directly for road maintenance. All the gasoline tax revenue is used for construction and maintenance.

Financing of new highways primarily depends on general budgetary allocations. These allocations have decreased from \$15.8M in FY 1972, assigned for the maintenance of 6530 km, to \$13.7M in 1977, for a network of over 7000 km. The maintenance allocation is slated to return to the 1972 level only in 1980, in current, not constant dollars. The accelerated deterioration of the highways and the effects on fuel efficiency were already discussed above in section 2.32. By not being assessed an adequate tax for road maintenance, drivers end up spending more on fuel and vehicle maintenance. Since maintenance costs come from the general budget, non-drivers or occasional highway users pay along with regular users.

Transportation costs as a function of the consumer price index (CPI) fluctuated between 1974 and 1977. The consumer cost of private transportation rose by 30-68%, and public transportation by 41.3% (source: 82, 31 March 1977). When the price of gasoline rose in 1974-75 by 47%, the private transportation cost index (PTCI) rose only by 20%, while the public transportation cost index rose by 278%. These comparisons are rough because public transportation includes wages and other costs which do not factor into the PTCI. However, in absolute terms, public transportation became almost one-third more expensive--an incentive/subsidy in favor of private transportation. The growing deficit of the National Highway Authority (ANA) was also covered from the general budget, paid for by the residents of the whole island, not just San Juan residents whose preference for private transportation contributed to ANA's deficits.

Parking subsidies include: a) No-fee parking on government-owned lots, b) Specific parking space requirements in commercial buildings as a precondition for construction permits, and c) Control of parking prices in privately owned commercial lots, by the Department of Consumer Affairs (DACO). While this may seem to be a laudable policy of consumer protection, it is misguided from a transportation energy perspective. Urban parking space is very costly, and its use should be priced at its real value. The difference between the currently allowed rates and the real cost is significant.

The text represents a margin for potential price increases for operators, as well as a parking tax. More importantly, the tax would serve as a tool for traffic management: it would discourage nonessential trips to expensive parking areas and allow distinctions between commuters and shoppers by making all-day parking substantially more expensive per hour than short-term parking. Similarly, parking during working hours could easily be differentiated from evening or weekend parking which serves non-congested traffic.

9 - Parking violations. The fine of \$7 for on-street or sidewalk parking, combined with mediocre ticketing performance and inadequate tow-away facilities (in 1977, there were 6 trucks in the SJMA

for this purpose, only 4 of which were normally in service) encourages the motorist to take a risk. There is no increase in the fine for repeat offenders. Automobiles cause damage to the sidewalk pavement, according to the director of Public Works for SJMA (146, 24 March 1977). Even the fact that it is possible to pay the fine with a delay of as much as 12 months without any interest or surcharge is a form of subsidy.

Miscellaneous: The following, and perhaps still others, represent an undetermined economic subsidy for the PVIS:

- The yearly cost of license plates is deductible from income tax.
- The Highway Authority bonds are tax-exempt.
- Transportation administration and enforcement costs come from the general budget.
- The cost of repairing damage to public property caused by accidents is only partially recovered.
- The low I/M standards represent an indirect subsidy at the cost of air quality, accidents, and other social costs.

In summary, automobile users do not pay the entire economic cost of their transportation. (Nor do, for that matter, the users of collective transportation, since the bus rates are underpriced and the public vehicles are subsidized on many of the listed accounts along with private vehicles.) As a result, those who drive sparingly also pay a share of the economic cost for those who drive frequently.

Intensively, those who do not own an automobile, which makes up upward of 40% of families in SMA, pay in two ways. First, because a significant amount of public funds must be used to subsidize the private vehicles, instead of services and facilities. Second, because private vehicles not supplemented by adequate collective transportation or transit discriminates against the poor, the aged, and the handicapped for whom public transportation is the only economically feasible means of mobility.

Even on much narrower grounds, it was concluded that "American highway investment in urban areas results in social costs that far exceed the present taxes and charges on American driving." The real cost, expressed in terms of a "toll per unit of driving," is estimated to be an additional 50 cents per gallon of gasoline.

The resulting third policy baseline is that private vehicles, the dominant transportation mode in Puerto Rico, are not only excessive energy consumers, but are also highly publicly subsidized, partly at the cost of those whose mobility depends on public transportation.

3.3 The full social cost. The total economic cost of motor-vehicle transportation is not the total cost. Although the focus and interest of this study is policy for energy conservation, it will be argued below that a more energy-effective system, with a planning horizon of several decades, must be an integral part of a comprehensive vision of the whole society, its energy and environmental resources and prospects--in other words, Puerto Rico viewed as a human ecosystem.

It is therefore convenient at least to list the major interactions between the present transportation system and the human system it serves. In addition to the factors of mobility and energy consumption, the analysis of which has been outlined above, the present private vehicle system

involves a number of other factors and impacts that are not perceived as cost either by those who drive or by the society at large. These include air quality, which is generally considered to be the most serious problem.

"All; 134, 42. The contaminants are principally CO, NO_x, airborne lead, HC. Direct correlations between these substances and environmentally induced cancer and respiratory diseases have been established. The Netstal (Switzerland) study, carried out over a period of 15 years (1958-72), found a ninefold rate of cancer among residents near a local highway, compared with those living 500m or farther away. When calculations were applied to the tolls charged at the Jas Anfri expressway, the cost for the whole would be a significant penalty for overspeeding. However, averaging the fleet equals emissions at \$0.50/gal surcharge, it is only \$1.95. Recent figures released by the highway storm (16, 10 September 1978) illustrate the extent to which congestion can shorten travel time; decrease comfort and total costs almost \$80K in FY. They covered 0% of the about \$20m of the debt but contributed only for that year - which is, in principle, financed from the gasoline figures were possibly released to assuage the expressway users who protested in 1972 against the raise of \$0.40 to \$1.35. But the point is that the \$60K worth of public benefit.

Aromatic HC, measured in tailpipes of passing cars, and in soil and soot around the homes, was identified as the probable cause. The traffic density was measured at 4K to 5K cars/day. It is, according to figures for August 1978, 50K/day on weekdays and 45k/day on weekends on the opened segment of the De Diego expressway in San Juan. The concentrations of contaminants in SJMA were documented in a local study (30). In California, they led to emission standards which exceed substantially the federal norms. In New Jersey, which has the highest rate of environment-caused cancer in the U.S., a pilot I/M program consists of stopping motorists, rapidly measuring their emissions, and giving them a short period of time to tune or repair the vehicle, under considerable penalty. SJMA has at this moment only a mathematical simulation model of air contamination from mobile sources (1971)."

The office of environmental studies for the Highway Authority does not include air pollution in its impact analyses, instead relying on dispersion. The Environmental Quality Board prepared a request for federal funding in 1978 to establish a monitoring network that would collect real data. The Netstal story was also published in the local press on November 2, 1977. The solution to the impact of automobiles on air quality through emission control devices is still a distant and problematic goal. Only 16% of a fleet of about 107 million cars had emission controls installed in the United States in 1977. The effectiveness of the present catalytic converter after 50,000 miles is debatable. The proportion of emission-device-equipped cars in Puerto Rico is smaller. In the absence of regular and strict controls, the device can be disconnected or made non-operational by the use of leaded gasoline or some substitute additives used to boost the octane rating--which is the capacity to accelerate and speed. There are other sources of environmental pollution. One example is the problem of disposing of used lubricating oil. In 1976, there were about 10 million gallons of it in Puerto Rico, representing a disposal problem for around 100 gasoline stations. The seven oil companies that operate gasoline stations were ordered to install disposal tanks. Five complied completely, one partially, and one not at all. This means that a considerable number of gasoline stations in Puerto Rico do not have this means of disposal. It is also unclear what happens with the used oil when the disposal tank is full. Congestion and time spent in travel are also issues. In Caracas, which has traffic density somewhat comparable with San Juan, it's estimated that up to one hour may be lost by travelers every day due to traffic jams. The total was (in 1975) some 1.5

million man-hours/day, with the implied impacts on productivity, physical and mental state. A study by the transportation workers union estimated that bus, jitney ("por-puesto") and taxi drivers used the same amount of time.

The text, after corrections, should read:

The reason for an extra US\$200,000 worth of gasoline monthly, is 1 Mg at the prevailing price of US\$ 0.20 or less per gallon (26, 120). The impact on air quality does not have to be belabored. Pedestrian delay, noise and vibration are both directly correlated with public and mental health parameters. Accidents, this factor was already discussed in 2.22 d) above. In the human ecosystemic perspective, one notable relation is between traffic congestion, accident pattern (both are a function of traffic engineering and enforcement), the mobility of ambulances and the often futile siren noise they make.

Land use:

- Direct use for highways, streets and parking (see also 2.14 above).
- Disruption of construction. Impact of land use decisions on transportation and vice versa. Urban sprawl, location of big shopping centers, the selection of automobile and transit corridors, interact in a synergistic fashion, making many decisions virtually irreversible. The construction of a new shopping center, such as Plaza Carolina, looks quite differently from the viewpoint of the investors and the developers, and from the viewpoint of traffic density in the approach corridors such as the already saturated 65th Infantry avenue, the Loiza Expressway and P.R. 3.
- Impact of large paved areas (highways, parking lots) on flooding, runoff, underground water replenishment, microclimate.
- Decline of public transportation, Interference with energy-effective modes indicated for short trips, such as walking and bicycling.
- Lack of mobility for nondrivers.

Years later, the relationship between such "aesthetics" and air quality and conditioning was already referred to (2.34 b/ above). The preceding is only an illustrative inventory. All the categories could and should be developed into submodels for further policy analysis and synthesis, which is outside the scope of this study. Much data is available or can be developed when the conceptual model is constructed. Some ten years after the concept of external costs was proposed (Itishan et al., 1962-67), energy and transportation specialists insist on the need to "determine and internalize...the entire...'non-dollar' cost to society...the total cost of urban transportation modes" (J, 42-3). The transportation system in Puerto Rico, in this sense, is an urban system.

3-4 Summary: In sum, PVIS in Puerto Rico is not only an excessive energy consumer which does not pay for itself in economic terms, but it also generates social and environmental costs not enumerated in the preceding discussion but extensively and generally documented. Until they are sufficiently quantified for Puerto Rico, these externalities must be assumed to equal in magnitude the energy and economic costs. The first of several causes of the excessive external cost has been the separation of transportation planning and development from the whole social and resource system. The consequent policy baseline is twofold: 1) transportation energy conservation cannot be effectively implemented outside an adequate transportation system management (TSM), the development of such a TSM is not possible unless 2) transportation is perceived and planned as part of the whole human ecosystem, and monitored with reference to an equally holistic cost-benefit

calculus.

4. POLICY DEVELOPMENT BASES AND SOME RECOMMENDATIONS

4.1 The policy baselines: The discussion of transportation energy demand and the cost/benefit analysis of the full economic and social cost of the present transportation system in Puerto Rico--principally its dominant mode, the PVIS-- resulted in the following...

Baselines relevant to the consideration of policies and measures to conserve energy in transportation:

I. Transportation directly and indirectly consumes about as much energy as all other sectors combined. The share of transportation energy in the total energy budget may be as much as 10% higher than in the United States as a whole.

II. All the essential mobility needs of individuals in Puerto Rico could potentially be met with as little as 50% of the current Total Direct Transportation Energy (TDTE). This could be achieved through adequate maintenance of engines, vehicles, and roads, reduced use and acquisition of convenience power equipment, reduction of driver demand (such as short trips, low occupancy, non-essential driving), and upgrading overall driver behavior to meet the standards of the traffic code and common sense.

III. The Puerto Rico Vehicle Inspection System (PVIS) is highly subsidized by the public. This means that automobile users do not bear the full economic cost of gasoline, highway use, parking, and are also subsidized in a number of other ways.

IV. Transportation energy conservation cannot be effectively implemented without adequate transportation system management. This involves the integration of transportation planning and management with the broader social and resource system. This approach could also help reduce the social and environmental costs (including impacts on public and environmental health, land use, and aesthetics) which are assumed to be equal in magnitude to the energy and economic costs of automobile-based transportation.

It is concluded that a detailed quantification and fine-tuning of the conceptual and methodological model that underlies these policy baselines may adjust the implied relations and vectors for the purpose of interim or tactical measures, but it will not affect the orders of magnitude which form the proper base for longer-term policy options and decisions.

65

4.2 Collective development of a policy model.

There is a need for a fairly rapid change in the entire transportation system, as indicated by the numerical and policy data.

Staggering. No effective TEC is considered possible without such change: "The lead times

necessary to achieve anything but band-aid treatment are long. It takes some 10 years from the threshold decision to a full operation of a metropolitan rail and feeder system of the size San Juan needs. The complexity of the system of technical data and elements, of their interrelations and trade-offs; of government processes and financing; of social and economic expectations and vested interests, is mind-boggling. The power of the 'auto-transportation-industry complex' to resist even remedial corrections can be gleaned from the fact that in the 1976 Fortune List of the 500 largest industrial corporations (142, 8 May 1978), there are five gasoline and three auto producers among the ten top U.S. companies; the top nine in the world (by sales) consist of seven refiners and two auto makers (Id., 14 August 1978). According to a leading senator, the three most active lobbies in Puerto Rico in 1977-78 were 1) auto manufacturers and distributors, 2) financing companies, 3) gasoline distributors (46, 7 June 1978). There is a wide consensus that the no-action alternative--that is, the continuation of past and present policies--would lead to a major crisis. Small, incremental changes such as right-turn-on-red, increased excise tax on the heaviest automobiles, small park-and-ride programs, improvement of traffic light timing at a few intersections--create a feeling that something is being done, while in fact they amount to a no-action, when the system is considered. No sufficient technical fixes are available because the problem of energy, general or transportation, is ultimately the problem of decisions about how to use energy. Conservation means such a use that the source of energy is not completely exhausted before other sources and ways of using them can be developed. The latter is technology; the former is a human, social and therefore political problem. It is evident that the useful function of a single policy

The work of an analyst ends when he has inventoried the principal factors and inputs, estimated their magnitudes and relations, and arranged them in a tentative but reasoned pattern. Where there were before only scattered data, technical studies with a limited techno-economic focus, sectoral programs, and decisions, and vague impressions about the serviceability, the impacts and the social value of the product.

From this point on, the development of a policy model based on all the available empirical and decisional data, indicating pragmatic decisional options, priorities and trade-offs, becomes the task of a team of transportation and energy specialists, regional planners, policy analysts and synthesizers, and government administrators. They will be seeking and applying industry, commerce, and community input where indicated.

It would be presumptuous, if not impossible, to try to anticipate the specific results of such a collective exercise, even though a great deal of Puerto Rican and adaptable external data and analysis are available for this purpose. The scope is partially reflected in the appended working bibliography.

Nevertheless, some directions for further policy research and development for the purpose of decision making follow so clearly from the policy baselines that they are at least briefly outlined below.

4.3 Some directions and recommendations.

4.91 TEC as a function of total transportation policy and management.

FIRST RECOMMENDATION: THE CONSIDERATION AND IMPLEMENTATION OF TEC MEASURES OUGHT TO BE INTEGRATED WITH THE OVERALL TRANSPORTATION PLANNING AND SYSTEM MANAGEMENT.

The basis for this recommendation is the close interrelations between the parameters that affect TEC and TSM. Two examples must suffice:

- a) Velocity and fuel economy.
- b) Speeding and erratic driving is a great fuel waster.
- c) Enforcement of the highest speed limit (55 mph) cannot be separate from general enforcement of compliance to the speed limit and discouraging erratic driving (both of them TSM measures), because it is a matter of road behavior.

General. Over 50% of drivers were shown exceeding the maximum 50mph speed on primary roads in Puerto Rico. A more important consequence of the 55 mph limit on federal highways and in foreign countries than TEC has been a dramatic decrease of serious and fatal accidents. The source of TEC is the gradual replacement of heavy automobiles by compact and small models. The proportion is expected to be about 50/50 in 1960. But there is a tradeoff: in a collision with a heavier automobile or truck, the risk of death increases by 75% for the small car passengers, the risk of permanent injury increases proportionately with speed.

(Anystate Insurance Co., Automobile rating program, November 1976) Transit and fuel economy. There is a relatively minor fee, in having an operational transit in addition to other transportation modes. The more important fee, is indirect. It comes from the constraints on PVTs which can be implemented when satisfactory transit is in place. This is more favorable with regard to restraints on PVTs. Since it runs in principle entirely, it forces TSM to implement restraints on PVTs in order to construct around the existing DVIS and has no measures to evaluate values. A favorable concept of transit also enhances two other concerns: urban humanity and the rehabilitation of urban environment. (Appendix A, i, 9)

The second reason for the recommendation discussed in this section is of a decisional nature. Even minor, short-term TEC measures need to be presented to political decision makers in a policy context that makes them appear as orderly and necessary steps in the right direction, rather than only either-or suggestions, the acceptability of which may be determined by considerations extraneous to the real problem.

SECOND RECOMMENDATION: SIMPLE BASIC GUIDELINES FOR FUTURE TRANS-

Transportation energy and development policies ought to be agreed upon and promoted. Even a tentative list for further consideration and elaboration is likely to contain the following criteria and indicators:

- * Transportation energy prospects and constraints
- * Convergence of the principal long-term trends: energy, population, resources, and the related economics

- * Advocates for a policy thinking based on the assumption that severe constraints will prevail in the future over the limitless opportunities that shaped the decisions in the last 25 years in Puerto Rico and much of the world
- * The need for, and content of, long-term policy decisions rather than a series of crisis responses and makeshift solutions
- * Social criteria for transportation system development, rather than merely engineering parameters and economic cost
- * Policy concern about essential mobility with reasonable margins for personal freedom of choice at real economic cost
- * The close relation to and the turn to an ecosystemic civilization which conserves not only transportation energy, but also conserves, reuses and recycles other forms of energy, water, materials and other resources
- * Transportation as a function of the urban habitat: physical enhancement, environmental quality, human and aesthetic improvement, reversal of urban non-planning and of land wastage
- * The economics and institutional aspects of TEC (to be specifically mentioned below).

Already the first San Juan metro study (1964-67), focused on technical planning, urban land use parameters and financing, concluded that the transportation plan "will require pooling of resources and foresightedness to bring about the greatest concerted effort ever undertaken in Puerto Rico by both private and public sectors and the citizens in general." The social dimension of this planning appeared then to be too narrow but was more than the decision-making process could handle. The present gap to be spanned can be inferred from two...

Recent policy documents: The latest Governor's message to the Legislature (February 1978) makes only an incidental reference to transportation with regard to the economics and regulation of the "public" sector. The "energy problem" is dealt with a similar lack of prominence and narrow economic focus. The draft "Plan of Integral Development," prepared by the Planning Board (March 1978), devotes four out of a total of 210 pages to generalities about transportation and energy. The first of six specific transportation objectives is "to develop a vast program of highway construction" to supplement the existing network. Transportation energy conservation is not mentioned or implied.

4.93 Near-term TEC policies and measures. **THIRD RECOMMENDATION: THE SCOPE OF PRESENT AND PROPOSED TEC ACTIVITIES SHOULD BE ENLARGED TO RESPOND TO THE FIRST, SECOND, AND THIRD POLICY BASELINES.** The supportive data and analysis are in sections 2.2, 2.3, and 3.2. They invite further development and refinement. The policies and measures could be conveniently grouped in the following categories: 420 of a total of 1026 column/centimeters, i.e, some 2.4% of the total.

6 © Fiscal/economic © Technical/mechanical (including vehicle and road maintenance and improvement) Planning/management (the bulk of TSH) Legal/regulatory Enforcement/surveillance Driver information/education Improvement in data generation/processing

4.3% Setting a limit on energy consumption in transportation. **FOURTH RECOMMENDATION: TEC POLICY OUGHT TO FOCUS AS SOON AS POSSIBLE ON MEASURES THAT WILL DIRECTLY LIMIT ENERGY AVAILABLE TO PARTS.**

There are at least four possible approaches:

- Ceiling on petroleum imports. This has been implemented in such countries as France and Brazil. It implies implications, ones to plan. The consideration of this alternative would obviously require a review of the outstanding petroleum import and gasoline export commitments of the Puerto Rican refineries.
- Ceiling on gasoline available on the Puerto Rican domestic market.

Editing it,

Evaluating, 2 contingent the longer term constituents and/or 1° possibility of exporting greater quantities of refined gasoline in Puerto Rico. Raising the consumer price of gasoline progressively to its real economic value, establishing a surtax on nonessential gasoline consumption. The last two approaches were tentatively analyzed in San Juan Transit (Appendix A: 3.2, 3.4, 3.8) along the following lines:

- a) Besides scarcity of supply, price is the only variable that can significantly affect gasoline consumption. The elasticity of demand is seen when the cost becomes effective only when it reaches the range of \$1.50 to \$2/gal.
- b) Allowing the gasoline price to raise to this level would cause substantial hardship, not justified in view of the fact that it was government "planning" that created the degree of dependence on essential mobility.
- c) The government has no duty to provide an unlimited supply of gasoline.
- d) A surtax would, in fact, create a double price level: (1) A reasonable allotment of gasoline for essential economic driving (2) Free purchase of additional gasoline at current price plus tax.

If the surtax amounted to 100% of the current price in mid-1978, the total price per gallon of the free gasoline would merely equal the contemporary average price in a great part of the world. There is a similarity between the two-tier gasoline price and the residential electricity rates in Puerto Rico: low consumption is subsidized (as gasoline is subsidized now); consumption above the reasonable minimum of 425kwh per family is charged at full price.

Additional comments are necessary due to developments in the last twelve months. First, the basic price of gasoline will rise within the next years, largely because of the U.S. commitment at the economic summit in Bonn (July 1978) to raise energy prices to their real level by 1981. Second, the surtax is not the same as the U.S. standby

Rationing plan. Rationing absolutely limits the amount of gasoline available. However, it is somewhat similar to the modified rationing discussed in the spring of 1978, that is, the freedom of car owners who do not use their ration to sell it at a higher price to others. The surtax proposal for Puerto Rico was motivated by the need to generate funds for transit. The Schlesinger "white market" concept turns non-consumption into private profit enterprises.

Positive restraints on personal vehicles (PVs) are necessary. FUTURE RECOMMENDATION:

ENERGY PRICE AS THE KEY TO TECHNOLOGY MUST BE ACCOMPANIED BY OTHER MEASURES SUCH AS WITHDRAWAL OF "HIDDEN" SUBSIDIES OF PVs. Price is the key, but not the only one. Observation of the Tokyo transportation system, subsequent to the preparation of the report on San Juan Transit, established a surprising tenacity of PVs in the face of:

1. One of the most extensive, efficient, and reasonably attractive combined urban/exurban rapid rail systems in the world.
2. The price of gasoline of \$1.68/gal. in 1977 dollars, \$2.28 in mid-1978 dollars.
3. Uncomfortable traffic density and congestion, despite an elaborate network of urban toll expressways.

The conclusion must be that in addition to gasoline price and the availability of transit, positive steps to restrain PVs must be undertaken. In Puerto Rico, a substantial restraint would probably result from withdrawing the various subsidies enjoyed by PVs and putting it progressively on equal footing with other transportation modes. That presupposes the next policy direction.

Before going to the next point, it should be noted that the preceding concentration on PVs corresponds to the numerical preponderance and dominance of this sector and to the resulting potential for technology and energy conservation (TEC). It does not imply that the collective and freight transportation sectors operate economically and should not be monitored and analyzed for possible TEC gains.

Shift to rail as the dominant mode of essential travel. SIXTH RECOMMENDATION: THE PRINCIPAL FACTORS THAT

Impeded in the past, a favorable decision in the matter of rapid rail transportation for San Juan and islandwide ought to be analyzed to facilitate future decision making. Reference is made to the relation between rail transit and TEO, touched upon in 4.31 b) above. The concept is to eventually substitute rail transit for PVES as the dominant mode for essential travel. The following premises need to be verified:

- a) The past "Metro" planning was conventional, misled, and requires dramatic conceptual innovations.
- b) It was not pragmatic enough in terms of cost, equipment, and simple, adequate technology needed to serve transit needs in the available economic and social framework. It was therefore too expensive.
- c) "Metro" (heavy rail) is costly; economically, the new system for overseas is budgeted at US\$10 per mile; the cars proposed for the San Juan "Metro" were the most expensive Boeing model, costing \$560k each in 1975.
- d) "Metro" type transit is also costly in construction energy and environmental impacts during the construction phase.
- e) ERE is the mode indicated for San Juan as well as islandwide.

Although economic cost was always cited as the principal obstacle, at least three bids by private enterprises to construct rail transit in San Juan and on the island were turned down. Bus is not a practical long-term alternative for rail, even if it operates on separate guideways (Appendix A: 1.2). Rail transit as a substitute mode for commuting and other essential travel is a medium-term project, but the long lead time requires that the threshold decisions and commitments be made early

(Appendix A: 6.).

4.37 Adequate 15x SEVENTH RECOMMENDATION: The existing TSM plans ought to be thoroughly revised in the light of energy, enforcement, and future transit requirements, and implemented as soon as possible.

2 The existing TSM plan for SJMA (75) needs to be revised and broadened.

a) TSM is an essential factor in the effort to conserve.

Transportation energy. TSM is not only an engineering enterprise but also enforcement. Traffic lights are meaningless if they are ignored. Traffic jams are caused or aggravated by intersections blocked by drivers who entered the area without having a clear exit in their direction. Most often, these drivers enter after the green light had switched to amber. Traffic engineering would be to clearly advise the driver that unless he has crossed a yellow line before the amber signal came on, he must stop. However, this would be a waste of paint without enforcement and a sufficient fine for violation.

Finally, efficiency, in the sense of the best use of what is available and of gradual improvement, is an absolute precondition for satisfactory functioning of the feeder system of buses, vans, public transports, park-and-ride lots, etc., on which rail transit depends. As with transit planning, traffic engineering in Puerto Rico has been plagued by a tendency to rely on overly complicated and costly technologies (e.g., underground sensors to activate traffic lights, which tend to break down after a while), instead of simple techniques such as advising the driver by means of a small sign at what steady speed he ought to travel to make the next light. This tends to be cheaper and more adequate than six different timed programs for various traffic densities, which are out of order most of the time.

TSM should also be coordinated with all the other planning, maintenance, enforcement, and public safety factors needed to foster low-energy mobility such as walking and bicycling. Laws, institutions, information, and education are crucial. The best policies for TEC and transportation in general are useless unless reflected in law, institutional implementation and enforcement, information access and utilization, and continuous education of all the actors. This implementation system is a subject for a separate study and analysis. Only some current reference is made here: The Traffic Code (Ley de Vehículos y Tránsito), now being revised, does not reflect TEC concerns and needs.

The text is not an adequate philosophy of penalties. It ought to be rewritten in this respect. The status and personnel of the traffic police (as of November 1976) represent 5.26% of all policemen, and 7.28% of all police employees. There is no separate organization status as it had in the past. This is severely out of line with the size and needs of the transportation system.

The philosophy of enforcement is selective so that the police commanders determine in fact which law or laws (including noise, littering, etc.) will be enforced at what time. The recent internal reorganization of the DIOP is a step in the right direction. But, this is only one agency involved. The TEC and 75M are also involved but depend heavily on the integration of policies and programs between DPCP, Office of Energy, Environmental Quality Board, Planning Board, Police Department, Public Service Commission, Department of Consumer Affairs, Public Instruction and

perhaps still other agencies.

If the forthcoming reorganization of the executive branch is intended to be more than a mere nominal simplification of the government's organogram, it should examine the deep structures of major social problems and issues, and shape the institutions accordingly. The transportation, energy and management field is a strong candidate for this kind of analysis/synthesis.

The inadequacy of the information system for policy analysis was mentioned at the outset of this study. There is much more information and know-how in Puerto Rico than has been effectively used in past decision making. When education is mentioned in connection with transportation, the meaning is usually limited to the basic knowledge of driving and of the rules of the road. Even in this narrow sense, a great deal remains to be done.

The driving practice of a considerable portion of drivers indicates deficient training and testing on both accounts. The authorities do not inform drivers adequately about new rules. For instance, the new law extending the right-turn-on-red privilege (implemented in August 1977) was in effect at 80% of intersections.

Intersections one year later; however, a substantial portion of drivers either did not know about it or abused it to turn left. A "campaign" was only planned in mid-1976.

Information about TEC should be included in drivers' tests. Drivers should be periodically retested when their license expires. Public service time on radio and television stations, some 12% of total broadcasting time, should be effectively used to enhance TEC.

Contrary to the belief in the effectiveness of driver education, it has been shown time and time again that educational efforts, which are not reinforced by economic incentives and police enforcement, are wasted. In a recent California experiment, 100 drivers were saturated with leaflets, tips, and how-to-do information. Six months later, the rate of traffic violations and accidents in this group were the same as in an uneducated control group (106, 2 April 1978). In a federally sponsored study (132; 83-34), information on energy conservation was found to be the least effective of four approaches. "Exhortation/prompting" was the second to last in effectiveness. Economic motivation was the most effective approach.

Aside from its continuity, education in the field of transportation, and TEC in particular, is probably most useful when it is not considered as a sector or element, but as a dimension and a transmission belt of applied knowledge, from the decision-makers, through the administrators and technicians, to the individual motor vehicle operators.

APPENDIX A. SAN JUAN TRANSIT OUTLINE OF A POLICY ANALYSIS FOR DECISION MAKING By Jaro MAYDA

The author is Professor of Law and Public Policy at the University of Puerto Rico, Rio Piedras Campus 00931, and Principal Investigator in this current study of Energy Conservation in Transportation in Puerto Rico (Center for Energy & Environment Research/U.P.R). This memorandum, derived from the broader study, is made available in a preliminary and separate form to provide a specific policy focus on the San Juan Transit.

"Planning, in view of decisions on the concept which need to be made in the near future. The analysis and conclusions reflect the best present judgment of the author on the basis of data available to him. They do not express any position of the CER. October 1977.

Appendix 1-2

AUTHOR'S NOTE

The designation of this paper as merely a working draft is not excessively modest. It was prepared for reasons and under time constraints that are explained in the text. In its form, it is a rush job with only rudimentary random editing. Hopefully, the concepts and analysis are presented in a clear and helpful fashion. This rapid mobilization of the substance was possible because the San Juan transit problem is conceived in this analysis as a particular problem of allocation and management of the total resources-human, energy, environmental, economic-in other words, an economic management problem susceptible of being attacked by the particular kind of system analysis/synthesis which is the methodology of economic management. In this framework, the scattered pieces soon fall in place enough to make possible the threshold decision. The ball is then back in the technical planners' court. While the typescript was being readied, the American Public Transit Association met in Atlanta. Statements made there by federal and state officials confirmed the policy premise summarized in Section 2.2 below.

Appendix A-3

SUMMARY

This memorandum draws attention to the policy defects of past planning and cost-benefit analysis related to the San Juan Transit (832). It assumes that the next round of competition for federal funds will take place at the beginning of FY 1979. Very early decisions in principle are necessary to meet this deadline with a competitive revised proposal. The state funding commitment must be accompanied by other advance steps related to Transportation System Management. There appears to be a substantial convergence between the most pragmatic concept of the SJT and the present federal funding practices."

The "Metro" alternatives of 1976 are analyzed under the assumption that the simpler, more innovative, and cost-effective the SUP will be, the more positive social cost-benefit ratio it will achieve, and the higher the probability of funding. The social accounting includes not only technical and operational factors such as speed and capacity, but also considerations of energy efficiency, land use economy, air quality, safety, and long-range flexibility. To enhance both the economic feasibility and the social balance of the project, an innovative approach to the dominant mode and its interface with the private vehicle transportation sector is unavoidable. The concept which appears best justified in terms of a synthesis of the various policy considerations is proposed for technical and economic reevaluation. It is a modified Poly-Modal Alternative, organized around Light Rail Transit, with predominant at-grade guideway, no subway sections, and operating in a pedestrian environment along the "Spine" -- the Old San Juan to Rio Piedras corridor. Supportive concepts, incentives, and disincentives are exemplified. The available data are considered

sufficient to justify an intuitive strategic decision with a time horizon well into the 21st century.

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Appendix A-4 REPEATEDLY USED ABBREVIATIONS

- Advanced Bus alternative [San Juan]
- Metropolitan Bus Authority
- Billion, Bayamon Crescent alternative alignment
- British Thermal Unit
- Heavy Rail
- Improved Bus alternative
- Light Rail Transit
- Light Rail Vehicle
- Mile, Miles per gallon
- North-South alternative alignment
- Poly-Modal Alternative
- Poly-Nodal System
- Passenger miles traveled
- Private vehicle transportation system (on Right-of-way)
- San Juan Metropolitan Area
- San Juan Transit
- Transportation System Management
- U.S. Department of Transportation
- Urban Mass Transit Authority

"The Spine" is the Old San Juan - Santurce - Rio Piedras segment of the BC or the MMA alignments.

Page Break

Appendix A5, TABLE

TABLE OF CONTENTS, WITH SECTION SUMMARIES

Planning any transportation system is not primarily a techno-economic problem, but a complex interrelated process of decision making about, and management of, human, social, and environmental resources. The policy analysis in this memorandum aims at supplementing the technical submodel of the SJ7 with considerations derived from a broader social model. The limited function of such an exercise is to raise questions at the technical end, and to stimulate the process toward a timely and justifiable go-ahead decision.

1.1 Basic propositions concerning oriented transportation planning in Puerto Rico are listed.

2. FOCUS OF AND WITHIN ORIENTED POLICY ANALYSIS...2

3. FEDERAL FUNDING ENVIRONMENT AND TIMETABLE...4

A threshold policy question as to whether exclusive state-level funding of SJF could or should be considered is posed, based on some comparative data about allocation of capital funds in the transportation sector and on the possibility of constraints which federal funding might impose on the most cost-effective procurement of equipment for the SJ7. The memorandum is, however, based on the general assumption that federal funding will and should be sought.

2.1 Positive exclusive state...

Appendix A-6 plan for SJ7 ready at the beginning of federal FY1979

2.22 The federal "new look" for transit is in accord with the real needs and means of Puerto Rico.

2.23 The better the SJT plans reflect reality.

3. WHAT NEEDS TO BE CONSIDERED AND DONE...6

The pragmatic posture of the present administration and the technical groundwork are favorable. The state funds raised through a partial diversion of auto-related revenues (which amounted to a total of \$8690 in the last five years), combined with a surtax on excess gasoline consumption, modeled on the two-tier rate structure for residential electricity consumption. The surtax is judged to be a priority mechanism because of its multiple beneficial impacts on...

'The entire transportation system, beyond the initial financing of the SJ%. To enhance the probability of federal funding, certain steps towards TSI/TIP are necessary. This includes:

1. Assigning to the state a portion of the total state revenues from automobiles.
2. Revision of the auto excise tax.
3. Shifting of the corresponding portion of the gasoline tax revenues from highways to transit.
4. Applying a surtax on excessive gasoline use, to be earmarked for public transportation either directly or through the general fund.

In Appendix A-7, vehicle-related revenue needs to be considered in its implementation, which could affect the overall cost.

Institutional changes need to accompany national planning. Some of these actions will initiate reports for the system in Puerto Rico, with the SJ%.

The implementation of policy recommendations concerning the concept and findings is necessary. The usage of gasoline surtax will be a substantial initial source of revenue for the public transportation funding, but will decrease in proportion to its full beneficial impact.

The gasoline surtax will not affect the essential functioning of the present system. It should therefore not be mistaken for a disincentive directed at the existing system.

A simple, efficient, economical, and competitive public transportation concept, which could be favored for federal funding, requires a fresh, innovative approach.

In the latest consulting study, the bus alternatives are not capable of solving the transit problems beyond 1990. The total cost of bus transportation is higher than that of rail, and bus transit cannot have the necessary beneficial impact on the urban environment. The rail and mixed options appear to be more viable.

The concept of operating almost entirely at grade level - creating a pedestrian-friendly environment throughout the length of Ponce de Leon Avenue from San Juan to Rio Piedras - is proposed as a feasible, economically viable solution.

The text appears to concern urban development and public transportation opportunities, possibly in San Juan. Here's a possible revision, although some parts may need more context to clarify:

"There are considerable opportunities for private-sector urban and social enhancements. Other opportunities that such total 'racist planning' affords--such as the transformation of Old San Juan into a pedestrian city, and a waterway from Old San Juan to North Catalina--are suggested. Aspects of a decision in favor of the 'new South' concept are discussed. A 'Metro' study suggests alternative southward routes, with a circuit feeder system primarily serving as an AMA improvement. Unrealistic capital cost estimates and quick saturation are noted, with later conversion to light rail possible.

The bus option is more costly to operate and maintenance is estimated to be expensive. Bus service is deemed inadequate to permit effective disincentives directed at private vehicles. Other unfavorable factors for buses include energy consumption, air pollution, ambient noise, and accident costs.

Technical data is the best criteria for cost-benefit analysis with private transportation projections. Conventional design and assumptions, construction time and disruption are all taken into account. Balanced and open-ended recommendations are made. Reasons why 'Metro '76,' as presently conceived, is not feasible are discussed.

Technological design is deemed unnecessary and too costly for Puerto Rico, and to win federal support.

Appendix A-9 highlights the insufficient calculated impact on urban and human environments and energy efficiency. It corresponds to transportation innovations. Other considerations include right-of-way, construction costs, visual controls, cost of cars, and the need for climate control.

The Utah Transit Authority's conclusions are presented. Light rail is seen as an instrument for environmental reconstruction and enhancement. Figures 1, 2 and 3, related to sections are also included.

A 'heroic' decision to ban auto traffic is supported by overwhelming arguments. These include transit economics, routine engineering solutions, enhancement of retail business, easy pedestrian mobility, and the possibility to supplement access and mobility with bikeways. Combining the new transport renovation and enhancement is also suggested."

"29 Hello, I'm Juan. In-place improvement of the 'Martin Poffa' vector coordinated with a San Juan to North Carolina waterway transit, extending to Lofea, Grande, and Aquillo. The Rio Piedras central business district: SAN JUAN TRANSIT: PRESUPPOSITIONS OF ACCEPTANCE AND SUCCESSFUL OPERATION...

32 Several prejudices need to be faced: The transfer to the LRT of the "poor-man" of trolleys through unwarranted historical/economic linkage with the old San Juan to Rio Piedras tramway. Erroneous impressions of decision makers that any human-operated system must be inferior and that only an automated subway can function well. "A planning complex arises about the obligatory operations deficit of any new transits. The State's interference with the PYIS has been satisfactorily addressed.

Although no immediate decisions are called for, the following hypothesis should be analyzed: that the PYIS is a highly publicly subsidized system; and that, if allowed to compete on economically equal terms, the SUP might require only minor disincentives directed at the private automobile.

5-1 Discussing the WP's creative retrenchment. Feasibility of human efficiency, The operations deficit complex. 5.2 The interface with SNPS... 1... Ok

5.3 BOS in Puerto Rico is a highly subsidized transportation system--which is also discriminatory against the poor and non-owners of automobiles.

5.4 Some examples of subsidies are listed. Gasoline base price. Gasoline tax. Transportation costs. Higher way user charges than in the mainland U.S. Parking subsidies. Non-enforcement of parking violations.

5.5 The value of these policy generalizations...

6. CONCLUSION

The decision about San Juan Transit cannot be based on engineering and economic data alone. When the whole transportation and social model is considered within the indicated time frame of several decades, the data base and the policy vectors become so complex, that the decision on the principle must be intuitive. The empirical and..."

Analytical data available are considered sufficient to make an informed, intuitive decision now.

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