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ENERGY CONSERVATION IN TRANSPORTATION IN PUERTO RICO

POLICY STUDY

by

Jaro Meyda

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(September 1978)

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Center for Energy and Brvironment Research of

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FOREWORD AND SUMMARY

Use and waste of energy in transportation in Puerto Rico is such a nageive and complex social event that it is particularly suited for a major exercise in policy research and developrent for decision making. Such an effort must be collective and should aim at both specific recomnendations and tine tables, and an improvenent of the methodology used to analyse the real systemic nature of important social and resource problos so as to enhance public decision making related to ther

The present etudy ie an initial effort to apply social system ana~lysis to transportation energy conservation, in order to prepare the ground for a team effort of transportation and energy specialists, regional planners, policy analysts and generalists, and government adminis-?trators--with additional inputs from conmerce, industry and the community ?at large. The task of this study has been to ifventory the principal factors and inputs in the field of transportation energy demand and possible conservation, estinate their magnitudes and relations, and arrange ?thom in a tentative but reasoned pattern--where there were before only

0 many scattered data, technical studies with a Limited focus, sectoral prograns and decisions, and vague impressions about the serviceability, ?the impacts and the social value of the product.

Tt needs to be alec noted that this is a technical study addressed primarily to specialists. This explains the compressed form and stylé designed to facilitate rapid scanning and reference. Tt also explains ?the extensive ue of abbreviations and acronyms. These are listed for reference following this foreword and summary.

The preceding table of contents gives a reasonably detailed ide about the structure of the study and the progression of analysis and application. The data are analysed in a policy perspective, that is with emphasis on their order of magnitude; their relation to the whole syste and a cost/benefit analysis which expresses the whole energetic, economic and socic-environnental 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 baseline:

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I, Transportation energy consumption is usually expressed only? in terns of direct consumption, thats gasoline and oil. Even thie account represents upward of 30% of the total energy budget in Puerto Rico in a given year. Great deal of energy is, however, consumed indirectly for transportation purposes: losses in gasoline refinenent, distribution, evaporation; manufacture, transport, sale, maintenance, repairs, parking, garaging, adninistrative and enforcenent 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 estinated and totalled, Puerto Rico consumes some additional 20% of indirect transportation energy. As a result, transpor-?tation consumes directly or indirectly about one-half of the total yearly energy, that is as mich as all the other sectors together: residential and municipal, Light end heavy industry, commerce, communications and services. Upward of 80% of the transportation energy is coneuned by private autonoviles (Figure 3).

With adequate maintenance of engines, vehicles and roads, with

and acquisition of convenience power equipment, with reduction of driver demand (short trips, low occupancy, nonessential driving) and with the upgrading of overall driver behavior to the standards of the ?traffic code and of common sense, all the safe essential mobility of per- Sons in Puerto Rico could be satisfied with as little as 50% of the present ?total direct transportation energy (Table 1).

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

IV, Transportation energy ?conservation cannot be effectively impl mented outside an adequate transportation system managenent, that 1s the integration of transportation planning and management with the whole social and resource system, The present lack of such a system management creates adverse impacts on public and environmental health, land use and esthetics ?that must be assumed to be equal in magnitude to the energy and economic cost of automobile-vased transportation.

It ie expected that detailed quantification and fine tuning of the underlying model,which this snalysis attempts to stimulate and facilitate, will results in sone adjustments, but that it will not affect the involved

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orders of magnitude which determine the longer-term policy options and decisions.

?The need for fairly rapid changes in the whole transportation system As imperative, No effective transportation energy conservation is considered possible without them. ?Technical fixes are not sufficient be~ ?cause the problem of energy conservation is a problem of decisions about energy use. Thus it is primarily a human, social and therefore political probler

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 pre-

snt status and plans for transportation systom management in the light of energy, enforcenent and future transit requirements. Occasional spe- cific reference ie included also in this section to indicate the wealth of information and imowhow available to the decision makers through further policy research and development.

Sone defects of the present implementation system are also illustra- ted (sect. 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 implenentation system.

Education is aloo mentioned with regard to the study topic, as well fas the widespread experience that driver education is ineffective where At is not reinforced by economic end enforcement factors.

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ABBREVIATIONS. ACRONYMS. TEAMS 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 DOB)

Federal Highway Administration (part of Dot)

Motor vehicle population; total of vehicles which serve

@ specific purpose

Heavy vail [transit], also referred to as

Inspection/Maintenance

Input/output [analysis]

Thousand

Kilometer (.62 mile)

Light rail transit

Maluion [mil2ion gation]

Mile (1.6 km)

per gallon

per hour

No date

U.S. National Highway fraffic Safety Administration

(part of Dor)

Operation/naintenance [cost]

Property-danage-only [accident]

Group 2f vehicles travelling together, such as from

one traffic light to tho next

Passenger miles travelled

Private-vehicle transportation aysten

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?Traffic checkpoint within an area

San Juan Metropolitan Area

?Total direct transportation energy

?rangportation energy conservation

Getteosive tranoportation of passengers on esparste

idewaye wien increase speod, capacity and. safety.

fEeldetlnedyGeannit dove nov nwod any wath ateranites tease" and "rapid")-

Traneportation eysten management

U.S. Urban Mass Transit Administration (part of DoT)

Vehicle miles [travelled]

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1. INERODUCTTON

Lil Bregas

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

@ particularly complex and intensive mix of technical, human and environnental factors and mutual impacts. Tt is suited asa tople for a policy study on both substantive and methodological grounds. In terme

of substance, there is a great need and opportunity to reduce the exist-

Ang waste of energy in transportation in Puerto Rico. In terms of metho-d:logy, any contemporary social policy analysis mist ultinately address itself to the presently weakest link in public decision making: the te-?uous, 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 eocial systen analysis, as a state of mind, as an analytical-technical instrument, and as an operational frane of reference. The topical and highly visible nature of energy

ses and abuses in transporation in Puerto Rico provides therefore a concrete and particularly relevant setting for a policy exercise which ?ins not only at a set of specific recommendations, but also at a contri-bution to the improvenent of policy development and decision making, with reference to priorities and tine horizons that correspond to the nature and magnitude of the problems rather than to other, shorter-term consi-derations.

The working thesis of this study is stated in greater detail in sec.

1.21 the foous and methodology are elaborated in sec. 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 denand of the present transportation system. The analysis of the aggregate and the disaggregated energy demand is expressed in the firet two policy baselines.

Chapter 3 analyzes the system with regard to cost and benefit-- the

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car owner's, tne full economic cost and the full social cost. This C/B analysis yields two additional policy baselines.

Chapte: 4 synthesizes and interprets these bases as a starting point for the developsent of a comprehensive and refined model of transportation energy conservation (TEC) and transportation ayatem management (TSM) and lists some directions, assumptions and recommendations for this task.

The task of gathering and organizing a sufficient empirical data base for policy development was inhibited by the well-known deficiencies in Puerto Rican statistics. Instead of finding all or most of the ne: sary information in a form suitable for policy analysis, considerable search, comparisons and pocket calculator operations were necessary to develop the data and reconcile them. The genoral problem was described in @ recent report, also in the field of traneportation, as follows: "The analytic effort was unnecessarily complicated by the dispersion of the basic data and the incompatibility of the statistical series....conside-rable but recessary tine was spent on the structuring of the problem and ?the determination of how the compiled data should be [utilized]..." (12, ch.II, IV). But why should the transportation eector have foolproof data on, for example, the number of motor vehicles actually in use, when the health department (with a much longer statictical tradition and experien-ce) 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 which sounded dubious, was checked out with a local radio-television station, and turned out to be completely incorrect?

Gm the other hand , and as distinguished from technical-engineering studies, the importance of data in relation to a social policy study lies Jess in their serial completeness and decinal-point precision that in providing @ sufficient basis for order-of-nagnitude estimates and for the detection vf trends through longitudinal comparigons. Moreover, sone characteristics of the private-vehicle-transportation system in Puerto Rico appears co einilar to the PVTS ssctor in the mailand United States that critical interpolations from there are possible and legitimate. It should not be overlockedeither, that statisticians anywhere will collect and organize information in their way if the users--planners, policy analysts, Political and operational decision nakers--do not provide then with sone

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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 @ few references that could be incorporated into the typesoript 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 menorandum 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 becone a major factor in transportation decision-making" (U.S. Secretary of Transportation, 17 September 1975), the need and the potential for conservation fare 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, ae meaeured 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 19508 wae a partial explanation. But @ great deal of energy was wasted due to construction practices, unsuitable designs and standards requiring intensive airconditioning and ?space lighting, as well ae simply wasteful habite of consumer, favored until recently by low basic costanda regressive rate structure.

Puerto Rico depends on petroleum for over 99% of its energy n Internal transportation in Puerto Rico depends almost entirely on gas Line-powered vehicles. ?They consune directly some 30 per cent of the ?total energy budget. By contrast, United Statesrelied on petroleum for one-half or less of its energy needs (46 per cent in 1972, the remainder coming from natural gas, coal, hydro- and nuclear power: 13, 9). Transportation used about 25 per cent of the petroleum this represented in terms of the 1972 data only 11.5% of the total energy, as compared with the

308 direct consumption in Puerto Rico, entirely petroleun-tased. According ?to another calculation (55), the approximately $00 million gallons (Me) of gasoline used in Puerto Rico in 1972 represented five tines the United

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States consumption per square nile in the same year. This was approximately the double of the ratio between the Puerto Rican and the United Sta- ?tes overall energy consumptions per square mile, In other words, the ?wansportation sector in Puerto Rico used twice ae much energy as compared with the overall energy budget than the transportation sector in the Uni~ ted States. ?This estimate is of the sane order of magnitude as that oited above, arrived at from different data and through a different caleu- dation.

?hus there is an ample margin for transportation energy conservation (TRC) in Puerto Rico. In fact, this study ceneludes that as mich as 50 per cent of gasoline can be conserved in transportation in Puerto Rico without any reduction of necessary driving. Apart from the coneiderable additional benefits this would bring to environmental resources and the human ecosyeten as a whole (these are elaborated below, especially in sec. 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 Sti tes--a glut of gasoline at @ price which is about one-third of ?the average in other major Western countries--is partly an acci-

dental aberration (the overproduction in 1977 of hone-heating
oll, gasoline being in fact a byproduct), and certainly a ten-
porary one. It is also being heavily paid for: the relative
deciine in the United States economic power and the value of the
dollar is ascribed principally to the huge trade deficits which
are the result of the imports of OPEC crude--$42 billion (B) in
1977, as compared with $48 in general trade surplus, for a trade
deficit of $38,

* Puerto Rico has no general surplus in its socioeconomic accounts
to start with. Yet the 105 million barrels (MBBL) of crude and
naphta imported in 1976 cost more than the total amount of the
governnent budget for that year.

* Tt ds generally expected that by the mid-1980s at the latest, the
Western world wi face again a critical situation in ters of
petroleun-derived energy. A less sanguine estimate ie that the
?oil crunch" is coming "perhaps in 2-3 yeare" (bk, 28 November

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1976 and 16 April 1978). A laconic summary of more distant future projections, released in September 1977 ty the World Energy Con~ ference, was that "oil supplied will fall short of our needs in 15 to 30 years...if tremendous fields are discovered and unex- pectedly double our reeerves...that would delay the peak for only perhaps 15 years" (142. [October 1977], 246-50).

Under these circumstances, the find of petroleum reserves off the north coast of Puerto Rico (the exploration is to start in 1979) would merely postpone difficult fundamental decisions. For a comparison, the Prudhoe Bay field in Alaska, the largest ever @iscovered in North Anerica, anounts to a 2b-year supply at the present rate of consumption. Evon if the drilling in the Atlantic Ocean off the New Jersey coast meets the most optimistic estina- tes, it will £111 total U, S. ofl needs for some three months and natural gas demand for five monthe (JMB, 1 May 1978).

Lead times involved in the development and implenentation of policies--technical and, especially, secial--in a field as com plex ae transportation energy, are very long. For instance, to make operational a major light rail transit and the supporting transportation nanagenent eysten for metropolitan San Juan would ?take at least ten years. Of course, another oil embargo, gascli-ne rationing or rise of the pump price to the real cost level, would do conservation wonders. But it would not by itself produce a substitute energy-efficient transportation system,

?The substantial margin for TEC in Puerto Rico is accompanied by a wide margin for changes and improverents in political decision making related to tranepertation. The present transportation sys-?tem ig in part the result of cheap energy--gasoline. The range of 70-764/gal. in mid-1978 may represent as Little asthirtyfive per cont of the real cost. The low price results from the inclu-sion of Puerto Rico in the United States system of averaging ?the price of domestic and imported crude. But the transportation systen prinarily reflects a sequence of governnent policies and non-policies--politically motivated choices, yielding to special interests, eternal studying of alternative transportation node: without taking any effective action, overdependence of local Planning on the availability of federal funds, and other factors.

Above all, however, past policies in transportation in Puerto

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Rico were characterized by the failure to perceive and plan a coherent syston a a function of the whole society, economy and environment. It is 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 increa: Anfluence public decision making. Even such well-known unfavorable impacts of this kind of traneportation as exorbitant fatality risk (using fixed rail as a base = 1, the fatality wisk factor for commercial airliners is about 1.5, for private automobiles about 50and urban air pollution (up to 80 per cent of CO is generated by motor vehicles) were largely ignored as decisional factors.

© Tt is ascuned that strategic decisions with regard to TEC, as well as their concrete inplenentation,will be facilitated if the analysis and the resulting reconnendations are eet in a comprehensive franework of all relevant energy, technological, social, economic, administrative, regulatory and political/decisional data.

© Anmajor obstacle to effective TEC is also the widespread public Agnorance about the nature and scope of the energy problem, comined with a consumption-oriented value aystem. In the United States, the first factor was confirmed by a poll taken one year after President Carter's nationally televised energy message (april 197)1 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 progran which does not rely entirely on rationing and taxing. The conception and inplenentation of such public education can be only enhanced by perceiving the problem in the broad frame of reference outlined above.

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1,3 Eocus and method

The nature, method and sone limitations of a policy study of TEC in Puerto Rico need to be briefly discussed.

First, and by definition, only factorsthat can influence TEC policy development and decision making in Puerto Rico are analyzed here. Since no autonotive research and development, nor production, take place in Puerto Rico, data on the improvement of fuel efficiency through better engine design or the developnent of alternative power plants (13, 56, etc.), or other technical information of this kind, is of course int resting, but is secondary to other TEC elenents and consideration, aleo in view of the present and the prospective age compositions of the motor vehicle fleet on the island.

Second, . 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 a widely officially used terminology--"science and technology policy"--ie at dest ambiguous: policy for the enhacement of science and technology? Policy, in the development of which science and technology data repre-sented 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 a recent vintage. With specific reference to environnent and resources, it served as a focus for the econanagenent conception (52 [1967], 110-M), the principal nethodolo-gical characteristics of policy research and development in this context were confirmed in the comparative evaluation of 18 regional environsental system nanagenent projects sponsored by the U.S. National Science Foun-dation (137 [1977], i-iv)--nost of then originally designed along eco-nonetric Lines, that is as quantification and computer processing exer-

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Policy research and development require both more and less. On the one hand, decision making can not wait for mathematical models. Tt must take place with the data availabler numerical data as far as possibl ?but also incomplete, uncertain, fuzzy data, interpdlatad and projected as well As the numbers permit; concepts; values; intuition. In the present state

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of the art, policy development in any real social situation must pro~ ceed predominantly on basis of qualitative rather than quantified infor- mation. On the other hand, the essence of policy research and develop- ment which is the transformation of all the relevant data into reasoned policy options ("decisional vectors") does not require the precision of electronically processed mathematical models. Social decision making, including the most serious and complex problems on the interface man/ Fesources, will always be intuitive--short of a community of completely progranned robots. The point is to replace raw political intuition by educated intuitive decision making. Therefore, the need is to put to- gether al) essential information on the level of order-of-nagnitude data oF educated estimates, rather than only some information with a decimal- Point precision. The practical goal is to approximate without distorting,

Where enpirical data are missing, ?sound technical judgment? helps to complement them (122).

Third, this kind of policy development differs at first sight from the conventional ?policy making." Every decieion, public or private, executive, legislative or judicial, implements a policy in the sense that At has sone purpose in mind. But this policy making or application do not usually follow the organic path fron the facts, through their analy- ?sis/eynthesis, to the acceptance of the most favorable or justified option. "Policy making" has been often an ex post rationalization of a prior decision arrived at ona lece complete and rational basis. At other ?times, such as in the case of many environmental impact statements, the data were amassed, but not adequately analyzed and transformed into alternative options which would merit the technical designation of policies.

Fourth, proper policy research and development is, at least at thi stage, more likely to raise questions than to give answers. Gaps in the data may be pointed out to the information generators. Competent policy analysts are likely to be generalists, synthesizers, or at least look across disciplinary lines fron the vantage point of their own different background. ?They may question the way in which information wae put together--or even stacked up--by the technical planners. They may suggest other ways of looking toward a solution. They are likely to become ?spoilers,? especially when planning has gone forward on less than all ?the important considerations-- particularly social and environmental

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Denefits and costs--long enough to have created its own monentum,? ?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 thoy can be evaluated in a comprehensive policy perspective, with a possibility that better technoeconomic concepts may be developed. (For the 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 re- sources can not be repaired.

Firth, extensive search in materials produced in North America, in ?Burope and by international organizations, indicates that the kind of po- Licy 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 be therefore judged as a tontative 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 deci~ sion makers in the fields of energy and transportation in Puerto Rico to mutually relate their data and perspectives and to integrate then into a progressively complete and sophisticated operational and predictive model. With such @ model available, no separate policy studies will be necessary. ?The systen will function in an environment of direct input from, and communication to and anong all the participante--data producers, project designers and planners, policy analysts, decision makers, citizens and usere, resource managers, monitoring/teedback systens--facilitated by a common conceptual language and policy principles. Systen analysis applied to social resource management becomes a state of mind.

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2. DATA BASE

2.1 Present traneportati 12 and operat:

2.21 Vehicle population.

In mid-1977, there were 630,373 active motor vehicles of all clas: in Puerto Rico. This figure is based on registration licences renewed by 31 June 197 and on the number of vehicles registered for the first time during #11977 (fiscal yoar 1976-77). The Notor Vehicles Bureau Bakes also other estimates. For instance, vehicle Licences which were not renewed are still counted for another PY 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 wore ow: 1 M (million) vehicles in Puerto Rico in 1977, of which ver 290 K (thousand) were ?not renewed." However, this calculation, with the addition uf new registrations does not add up to 830,373.

Nor does th: registerediactive vehicle ratio .778, based on a 1971 stu- ay (cited 41. 12, 48) appear correct in 197. Accepting the figure of

1M "registered" vehicles, the real ratio would be closer to .825. Sinilar estimates of vehicle population in the United States appear equally un- Feliable as compared with a count a of @ certain date (132, supp.83-12), ?the difference being as much as -12,88 in 1975.

The point is not to dwell on statistical vagaries, but to draw the attention to uncertainty about the rate of scrappage and other factors that are essential if one ains at projections with a tolerable margin of error, In fact, past projections concerning motor vehicle transportation in Puerto Rico :ave generally not been within this margin--whether they erred on the side of over-or underestimation. Tt is, however, not impossible te reconcile the figures and methodologies in short term projections. Thus, taking the 1977 figure of 830K, adding the new registratiors for the firet eight monthy of FY 1978 and projecting then for the whole year,

and utilizing tne accepted 8% scrappage rate based on United States data, we arrive at an estimate of 870K active motor vehicles as of 31 June 1978. This is within less than 1% margin of the gross estinate of the Motor Vehicle Bureau that 875K or more registrations will be ?renewedy If thie is understood--as it must de--as the total number of active ve~ hicles. But if this eatinate is based on the total of 950K renewal notic sent out (1M, 7 May 1978) and the reasonably probable projection of

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sone 110K new registrations in FY 1977, the cumulative total of all registered cars (as explained above) would anount to 1,060K, not the bur figure of 1,005K.

The total motor vehicle population increased from 248K in 1965 to ?774K in 1975, that is more than three times. The yearly growth was as much as 70K vehicles (15.28), in FY 1971. By PY 1976 it was down to 50K Vehicles (7.1% increase over previous year). The 1977 figure is less than 2%, but the 1978 estimate above is over 5f, Even considering the uncertainty implicit in this variable (in the San Juan Metropolitan Area, the increase in motor vehicles has varied by as mich ag a factor of 10 over a five year period 1968-69 to 1972-73, and as much as a factor of 7 from one year to another), it appears unlikely that the projection of the Planning Board and the Department of Transportation and Public Works for @ mean vehicle population of 1.1M in 1980 (eited in 12, 48, based on 1970-75 data and U.S. national transportation studies) is correct.See(22,35)-
The person-vehicle rate in Puerto Rico increased from 10 in 1965, ?to in 1975 and 3.7 in 1977. Thiswas below the U.S, figure of 2. However,

?the vehicle density in Puerto Rico is much higher. In San Juan, with 40x of households not owning a car, the density was in 1974 about 2335 vehicles/ wn? (6050 veh./sq.mile), 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. (30, 103). These figures have increased since then. ?The absolute figure for San Juan was 401K vehicles in 1977, that is slightly under one-half of all vehicles in Puerto Rico,

Of the 830K motor vehicles, 660K are classified as private cars. But Af one adds the other sedans and minibuses (taxis, ?pfblicos," governnent vehicles) and most of the 92K so-called pick-ups (classified as ?camionetas privadas," private minitrucks popular because of the reduced 10% import ?tax but mostly used for personal transporation), the total of motor vehicles other than comercial trucks, trailers and motoreyples (less than 7%) Se between 750 and 75K. This would amount to 92-96 of venicl used for personal transportation (the number of buses in Puerto Rico is statistically insignificant) and correlate with earlier data based on a different classification, which indicated that the growth of private automobile in Puerto Rico was much faster than that of commercial vehicles (6%). In contrast, in the mainland United States personal vehicles represented only about Gof of the total (116, 9).

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2.12 Structure and state of the fleet

In addition to absolute numbers, of particular interest to trans portation energy conservation (TEC) is the composition of the personal Yonicle fleet by weight and horse-power (KP), and the ratio of imported lused care. These figures are, in fact, interrelated in the senso that ost used care inported in Puerto Rico are heavy.
in 1977, about 55% of personal vehicles were in the ?standard?

category (3000-000 Ibs); YK were Light (2000-2500 Ibe), and 10,58 wore heavy. If, however, the heavy category ie defined as vehicles 4000 1be or more, there wore more than 225K of auch vehicles (314). The "medium heavy" category (3500 and 4000 lbs vehicles) comprised over 45% of the total.

About 22.56 of the cars imported in 1977 were used, The great ma- jority were 3500 lbs or more and had engines of 130HP or more. In the LplMP-or-nore bracket, 8 new and 182 used cars were imported in

the last quarter of 1977. In the 110HP/<23001be bracket, 8525 new cars were imported, against only 387 used ones. These new, fuel-efficient cars

?represented about 10% of the whole fleet at that time,

Another measure of the state of the fleet from the standpoint of TEC are vehicle inspection statistics. The state-level inspection pro- gran which consists of an apparently superficial check on mechanical~ sazety equipment, resulted in 1976 in a reject rate of 30%, A nigh per- centage of vehicles, 138, were not inspected. It is impossible to esti- mate how many of these vehicles were in fact active at the time of the Angpection which ie spread over the twelve months of each year; but it Ae Likely that many of the non-inspected active vehicles would have been rejected. A federally funded 1/M (inspection-maintenance) project in Puerto Rico, which also checked enissions--an important indicator of the fuel efficiency of the vehicle--had a roject rate of 90%. And at that rate the project was criticized as using too lax criteria (30, 56).

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a

2.13 Transportation network

Internal transportation in Puerto Rico depends entirely on roads. Railroads were eliminated in the mid-1950s. Transportation on water is de minimis--a conmuter-ferry line in-San Juan harbor. The developnent of the road infrastructure responded to numerical growth of vehicles, but also to such factors as the Fonento policy of decentralized industrial

@evelopnent and the advent of containerized cargo shipping, most of which enters Puerte Fico through San Juan. ?he highway network grew by about 20% fron 1965 to 1975, to a total of almost 9,000 km; the surfacing impro- Yed fron 79% paved in 1965 to 85% in 1975. New construction in 1969-73 cost Almost $550M (almost $1,000K in 1978 dollars). Most of those funds were Provided by the federal governsent. Tho Expresso Las Antricas (P.R. 52), paid for largely by bond issues, cost $291M to construct. With financing costs of $396M uver thirty years, and 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 sone 91kn/60mi long.

?The expected net revenue in PY 1976 was on the order of $¥M. The effects of the structure and state of the highway system on TEC, and the plan- ning perspective will be discussed below.

2. uattic intensity ang vehicles.

From the standpoint of policy analysis, absolute numerical data about traffic intensity are of interest only in terns of possible controls on further growth and of measures to enhance the individual and aggrega- ted fuel efficiency. The feasible controls and measures are discussed below. So interconnected are the components of the transportation/enerey

syeten that measures which foment fuel-efficient cars also tend to redu-
ce traffic congestion, that is. too high traffic intensity. This is so
Decause fuel-efficient cars are generally smaller. Thus they take less
Aighway paces this tends to reduce the severity of congeation--not to

speak of the fuel wastage and impact on air quality which traffic jano
cause.

?The capacity of the highway system in and arowid metropolitan areas
in Puerto Rico to handle the traffic requirenents is fair to poor not only
in the experience of individual motorists, but also in the judgment of
transportation adninistrators and experte. A scale developed by the
Mighway Research Board (U.S. National Academy of Science, 1965) rate:
service on five levels, fron A (1ight, sporadic traffic) to P (bumper-

---Page Break---

to-bumper traffic with intermittent stoppages). Level C is ?normal?
traffic, that is the planned flow in terms of numbers and specd. On this
scale, ?las Anfricas" was expected tohave in 1977 still only 8/C service
devel in its 8-lane metropolitan segment; instead, it operated generally
etween C and D and, at sone tines, even between D and P. Barbosa Avenue,
fa 6-lane access corridor to the Hato Rey central district, operated du-
ring 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 carc/day in 1970, was janned ty 140,000 cars/day in 1966, Similarly in Burope, for example a major exit corridor from Paric, the l'Autoroute de 1"Quest, was so saturated in 1968 ?that a routine accident on the outskirts of the city could cause a traffic jam extending 10 kn into the center. The Firet Law of Motodynamics--"If Left alone, autonodiles always multiply faster than highways [and parking Lots] ean be built"--operated everywhere, including Puerto Rico where it was originally proposed ($2, 66, 199, 209).

?he rush hour intensity in metropolitan San Juan could be also iulustrated by soreen-Line measuronents in the four major boroughs. Of

the 2k-hour total, 8-9 of traffic moved between 0700 and 0800 he: 7-88 between 1600 and 1700, the following hour being only sLightly lower. Thus almost one-quarter of the 24-hour volune moved in fact in three hours,

?The came 1976 cordon-Line (at the Limite of the metropolitan area) and screen-Line (at selected points within the city) figures indicated re~

atively low occupancy rates. In Rfo Pledrac, ona total of 415K vehicles/ week, the private vehicles occupancy was 1.57) all vehicles (including plblicos and buses) had occupancy rate of 1.78. For Santurce, the figure were) 400K vehicles, occupancy 1.54/1..56; Bayanfni 164K vehicles, 1.63/ 1,8; Cla San Juan: 85K vehicles, 1.62/2.15. The average was 1.63 for all vehicles at all gereen-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 reflected probably largely the ?plonico? traffic with often 5-6
hours.

ssengere per car during the 12 day-

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 1.2 in Nasoau County, Long Toland (5§) and in California (13, 80). By

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1978, the Nassau County rate roi

tioning during the

to 1.4) @ crisis such as gasoline ra

cond world war raised the California rate only to 1.7.

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 three person:

Empirical observation of the 0800 traffic on Barbosa Avenue indicates an

even higher proportion of passengerless cars, despite the higher screen-

Line average for Rfo Piedraz, Such a level of use of cars and highways

As not only exorbitant energywise (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 the two examples above, 17% of land in Nassau County is occupied by highways and parking lots; the figure for Los Angeles is close

to 4Of. The figure for San Juan is not available but is probably comparable. *

?This impact of the present transportation system will be further developed, together with other itens, in the section on secondary, indirect transportation energy demand.

2.15 Beip purpose

The cordon- and séres

-Line figures cited above indicate also that

?the great majority of private vehicle trips take place in the San Juan Metropolitan Area (SJMA). This share, and the corresponding travel intensity in the SIMA, 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 6¥f 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 traneportation and relatively cheap

(in fact, subsidized; see sec. 2.6) private vehicle transportation

systen (PVIS). To make a geographically distant and culturally different

comparison, 87% of all urban trips in Australia were by private vehicle

in the early 19708 (93, 261).

The 1970 figure for strect gurface in the SIMA, about 8.5% (71, 25)

?gt provide a base for a reliable estinate. flot only is if-aut ef

?but? i dove not inciade parkingy sereover,, the cordon Line enoor-

Fastée,nor_culy Sold, oie a stn Junr sbregion,* with 308 undevelopea

Langs govinates of street ourface in urbanieatiine within the S98 bance

from 258 to 40%. A "guostimase" based_on guon factoroaa. the 70K growth

in street surface between 196h and 1970, the undeveloped Land anf the

Tate of development (almost 208 fron {96h to 1970), the construction or

Eerzanaclon' of govaral urfan expteaowayn (entinetadiand use fe gore? than

?acres of land per 1 km) ana 1x for offetreet parking upace.(inclu=

?ing? the big new shopping centera), sums up to almost 25%.

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?An urban PVIS has two characteristics that are important from the standpoint of energy conservation:

a) Urban trips are relatively short. Tt was estinated that in 1965 auto trips 4 kn/2.5mi or shorter represented 60f of all urban trips in terms of fuel consumption. Sone ten years later, trips shorter than 8 kn /sni. 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 508 more fuel than that consumed by all auto tripe 60kn/lOmi or longer. Precise data are again lacking, but empirical observation indicates that ?the situation in urban areas in Puerto Rico is eimilar. A particularly @ranatic, but apparently not untypical, example is provided by the traffic

Detween the faculty residences and the principal canpue of the Universi-

ty of Puerto Ricor nany S-shaped trips of more than 1 km are made daily

to the overtaxed parking lots inside the campus; direct walking dis-

tance, with no parking problens, is one-half as long. This example also

illustrates the second characterietic of urban PTS:

jonzessential, Transportation

studies typically classify trips in the following categories:

(4). Home to work (444) Home to shop/pereonal business

(44) Home £0 Sehoot (y)" Wome to social/recreation

(¥) Wonhone based trips

The division between essential and nonessential trips is not uni-

form, It 1s probably fairly close to reality to draw the line as follows:

Essential are groups (i), (ii), 50% of (414) and 508 of (v).

Nonessential are group (iv) and 50% of (414) and (v). The 50% guess

for groups (iii) and (v)--nothing better is available in the literature??

ean be justified, anong other, by such data as thest

* Car ownership tends to generate trips and not to consolidate two

oF more purposes or destinations into one trip. For example, before traffic restraints were instituted in the Singapore CED in 1975, vehicle owning households generated 40f more tripg/day than households which had to use other mode than private ear (60, 179).

*¢ The Los Angeles Regional Transportation Study (1967) identified 228 of trips as other than home-to-work/achool/shop (11, 87), with the implication that these were non-essential shopping and driving-around trips

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

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* Although the non-hone-based group tends to be a catchall, ?it obviously includes a substantial portion of soctal/recreational trips.

If the formila for the calculation of nonessential trips, as suggest ed above, is applied to SIMA data, 35.5% of the 1.9M daily person trips (1970 estimate; Z1, 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 te 1972 federal study cited above (63, citing 102) which arrived at the figure of 36.7% nonessential person trips using a sonewhat different method and inputs. (Incidentally, the state of the art can be Allustrated by the fact that only & 1970 estimate was available for an update studymade in 1975; the second study made in 1976, corrected ?the trip total from the estimated 1.9 to a "real" 1.53M, but then went on to make probably another exaggerated projection for 1990, In this projection the nunber of "other", mostly nonessential trips, is increased ?vy a factor of alnost 3.1 between 1964 and 1990. These uncertainties about the absolute nunbers of trips do not affect the estimated percentages of nonessential trips.)

2.16 Collective transportation, As used here, the term collective transportation means transportation of passengers who pay for their seat (ouses,"ptiblicos") rather than for the vehicle and the driver (taxi), and who are not moved on a separate guideway which increases speed, capacity and safety. The latter type of collective transportation is

currently referred to as trangit--and if eo defined, does not need any attributes such as "mass" or ?rapid.

Under these terns, a system such as the AMA (San Juan metropolitan bus authority) does not qualify as transit. Even where these buses move in separate counterlanes, their average speed is 7mph (1977). According toRIA's om figures (1U6, 16 Feb. 1978), the mileage/year has remained unchanged since 1973, at 13,5M mi/ 21,7itkm; thé number of passengers decreased from 45% to 3i.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 airconditioned buses--on the ground that some 95% of bus users had incomes below $8,000/year/family); consequently, AIA had a de-fleit of $9.5Min 1973, which grew to $1l.2Hin 1977. Additional data Found out the description of the SJMA bus system

© The system consisted of $2 routes approximately 850mi/1360km long (975).

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© Tt had in the came year 390 buses, of which ony 290 were in vice on a typical day. The rest wae immobilized by mechanical defects or absenteeism of personnel.

© The ratio of passenger trips per bus mile, eteadily decreasing since 1960, was 3.3 in 1973, and 2.6 in 1977. That means that buses for? 50 seated passengers carried on the average only 2.6 persons. (the data for the total mileage/year, 13.50 mi, differ fron data provided by the

AMA's accounting office to the Office of Bnergy--11.7H mi for 1977, a steady decrease fron the maximum mileage of 13.9M mi in 1974. The Lower dus-mile figure still yields aratio 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 persona/bus in 1972. This figure is 3.5 times higher than the actual ratio for that year (3.l5) 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 estinated 2,792 BIU based on the 12 pascenger/impg base (78a, 3). *

* The energy efficiency of the buses, which averaged 5.Impg from 1970 to 1974, suddenly dropped to 3.95mpg in 1975 and averaged 3.98mpe between 1975 and 1977, @ 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 airconditioned buses. However, the Sudden jump of average cost per passenger from 49¢ in 1976 to 63¢ in 1977 can not be explained in terms of wages or fuel cost. These new buses still operated on the 25¢ fare basic. The loss was 38 per passanger trip.

© Tho velocity of express buses in the ?exclusive? counterlane sone Agmi/2iim long was 12mph in 197%; it dropped to below 1Omph in 1977 and, Af 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 ?.2mph. This was, according to AMA technicians, not too different from

?the average speed in congested U.S. cities; in low-density-traffic citi:

?the average bus speed was 12-1bmph,

* The service did not operate on any reliable schedule. The headway

detween buses (that is the time elapsed between the departure of one bus

and the arrival of another on the sane route) was aS much as 23 minutes

* The Toad factor of 12, used by the Planning Board in the 1974 National

?Transportation Study, ig a9 far oft probably pecauge it 4s based on avera

ge weekday occupancy? (19753, ?Wiehoae?aletiad ten oF the Lneten Sethe eet.

For comparison, U;S; data(i970) were: 10 gase./veh.for urban buses; 2940 BTU

per passenger at daiimpe (120, 5 [Praize et al.,197#1).

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Ed

uring working day hours.

Private buges served SIMA principally between Bayamfn and Rfo Picd-
ras, providing the only bus connection between these two major boroughs
and the Medical Centers and between Bayamfn and Santurce. The ridership,
estimated in 1964 at 45K/passongers/year, dropped to some 10K by mid-
19708. 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-Maysgiez
?trip--5 hours, compared with 3 hours for a "ptblico? and under 2 hours
for private car.

?The decrease in bus ridership (omitting the small fractions for
private buses) from the 66 peak in 1966 to the 35M in 1977 was 47#--
rather comparable t0 the estimated overall drop in riderehip in the U.S.
1955-71, which was 52.5% (123, 125). But {f such an obvious variable
?as the population increase in the SJMA is taken into account--it went
?from 542K in 1960 to 820K in 1970 (51.58) and the growth rate in the
19708 was projected at some 20% (72, Tables II-3, II-H)-~the real 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-econonically, the trend was reversal in the early 19708 and the bus ridership grew by 278 (from 55 to 70K/day, for a total of more than 20i/year; 50% revenue: cane from passenger fare; the 1977 operating deficit was etill $9.6M; 55, 17).

?Piblicos? represented the relatively most efficient component of ?the collective transportation in Puerto Rico, in fact, 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 licence). The rest was owned argely by cooperatives. About 2,000 pfiblicos operated in the SJMA and sone 800 operated on routes in and eut of the SMA. Pfblicos totaled over 150K person trips on an average weekday. Outside of the 0600 to 1800 period, there was little if any service. Despite law and regulation, the system operated on the base of geni-fixed routes, without fixed echedule {except on sone lag interurban routes by reservation), and on the principle ?that the vehicle departs only when it is full. However, during the 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 wit that of the airconditioned AMA buses in the SJMA. The constant ?problens" with the so-called "phantoms" --unlicensed pfiblicos competing with

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?the busee--indicate that at that rate the pfblicos made a reasonable pro-

fit. They also rendered important public services during strikes at the

Labor-problens-plagued AKA. Contrary to the decrease of AMA ridership,

?the pfiblico ridership increased between 1964 and 1976 by 29% in SIMA,

and by 19% on the island as a whole. fhe net ridership on the island

decreased slightly during this pericd, from 40K to 38K passengers/day.)

Tt would not be correct to say that the pfiblico system was unique

to Puerto Rico. For example

Caracas had a very efficiont system of ?por puesto" (paying for the seat) taxis already inthe 1950s. But as a flexible systen of regulated private enterprise--with substantial margins for Amprovenent to make it even more attractive and useful--it wae one of the cornerstonesof 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 connent about public collective transportation was made in connection with the tiniest compo- nent, the San Juan-Catafio ferry. Operated by the Ports Authority, it epent $1 to transport one passenger paying 10¢ for the crossing. The daily total was come 6,200 passengers, practically unchanged fron 196i ?to 1975. Although the U.S. UNTA made a grant to the government of Puerto Rico to upgrade the ferry system, ?expectations are that service will continue at about the sane level " (72, 57,83). The rate structure of ?the ferry system, which required an untolerably high subeldy of some 90%, was possibly based on a wrong reading of the AMA statistics. It is true ?that the drastic reduction in AMA ridership occured since 1969 (64x passengers to 47K in 1972); but during these years, private car owner- ship rose from 260K vehicles to 340K in the SJMA, without doubt more in response to deliberate government policies than to the fare raise. For the fare rose only to a double (if inflation is taken into account); uses with the original 10 fare remained in service; and the increas in vehicle ridership still left some 43 families in the SJMA without car, that is dependent on the public transportation. At 1.5 occupancy Fate, the 60K additional private vehicles accounted for 22. 5K passenger ?trips/year, counting working days only, Crash highway building program and reduction in vehicle import and registration fees facilitated this ?ewitch from public to private transportation.

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To round out the account of collective transportation, mention: must de made of the fact that undetermined but substantial number of hone to school trips in the SJWA is made by school buses. On the island, estina-?ted 156,000 students were going to be transported every day in 35 mnicl-palities in the school year 1977-78, at a cost of over $9. No data on ?total mileage or fuel consumption were available.

2.27 Traneportation of fretent.

A controlling survey of cargo transportation in Puerto Rico was made An 1976 (12). Although the perspective of thie study is regulatory (and An thie 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, with apparent effects also on fuel economy.

rey

Fron the standpoint of TEC policy analysis, these were the main sa-Jient 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 renaining .Wf 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 about OK? dry cargo, more than 90% entered and left through San Juan, ess than 5% through Ponce and about 2.5% through Nayagilex. ?The San Juan maritine traffic consisted of 439K 1ift- or roll on/off vans in 19751

the majority were delivered in the SJWA, but a eubstantial minority went

to various points on the whole island.

* If cargo vehicles wore classified ae 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./K 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 estinate of

20.4K active truck out of 22.9K registered would indicate 11 scrappage

rate, a compared with the 8% generally assuned for the fleet as a whole.)

© Of the estimated 1975 total of 7.44BVM (vehicle miles), 820Nvit

(Q1#) were assigned to freight. No estinate 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

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ofthe SJWA relative to that-of the island, a major portion of the Vit must have been driven outeide the SIMA.

'® 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 1bs) and dump-trucke (15-16,000 Ibs) indicate that fuel consumption is comparable at constant speedsof 10mph and 50mph (15, 17, Fig. 1). Data for policy development would have to analyze the impact of urban congestion, ?caused by passenger cars, on truck movenent and fuel consumption; and ?the impact of trucksnégotiating gradients at 15-25aph on SOmph-Limit. ?two-lane highways, holding up a platoon of pacsenger vehicles behind then.

* The maximum intensity of truck entry into the SJMA was measured Detween 0900 and 1000 hy in Ponce between 0800 and 0900. Of a maximum out-of-city traffic on a four-lane highway between San Juan and Cagué (4238 vehicles in both direction, between 1600 and 1700), 8.1% were heavy ?trucks.

* Of probable relevance to TEC analysis is the general conclusion of a 1974 study by the regulatory agency, the P.R. Public Service Commi: sion (6) on the low efficiency of terrestrial freight transportation in Puerto Rico, The focus of the study was the rate structure. But conclusions

on relative efficiency of light v. heavy trucks and on the high proportion of IML (Less-than-truckload) traffic must be taken into account in ary fuel consumption analysis.

2.18 The human elenent.

Tt does not need to be particularly stressed that people are an in-Portant element of any transportation system. With respect to TEC, the human element looks ike the key. The reference is not so much to technological development, but to the assumption that on any level of transpor-?tation technology the relative energy account is ultinately determined by ?the denand for private vehicle transportation as against other practical nodes, from walking to transit; by the use of cars (intensity of driving, ariver behavior, education and discipline, and diligence/nogligence in vehicle maintenance); and by social controls (policy and planning based on the real systemic nature of the transportation/energy complex: poli-?tical intelligence and will; rules and enforconent).

The human element is here listed only for the sake of conpletencs: More detailed analysis and recommendations are developed farther in the stuay.

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2.2 1 aor: is

The following Figure 1 shows the disaggregation of total demand

and transportation consumption in the United States (105, ly 12):

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19.6f- 100% 80.4%

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Another caloulation of the TUTE for the United States is 25.9% (63). this estinate is possibly nore realistic, especially because of the steady Growth in private auto consumption since 1974. Both numbers represent, hoever, only the direct portion of: the total transportation energy, thet As fuel, oi1 and electricity used for propulsion and lubrication. Trane Portation requires also a substantial indirect energy input (see 2.22 below). he estinates vary from about 50% to 66.58 (63, 5-6). Again, the {etter calculation is considered closer to reality. ?The total grangporta- Hon energy use Le thens ROME 19.6/25.38 x 1.5/1.66 = approx. 0/u2. 98 of

"Total Girect transportation energy

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total energy consumed. Sweden, which is considered an energy-efficient country, reported TDIE at 17%, indirect transportation energy at 2f--but that includes apparently only wanufacture(?Jhoth Sweden and a substantial part of the mainland United States have cold weather during 5-7 monthe: ?cold? starts of motor vehicles are known to consune outproportionate anounte of fuel.

Figure 2 shows comparable data for Puerto Rico (29s ?8jupdated).

Trucks are classified as heavy (see 2.17 above); arbitrary energy consumptions factors are assigned to then as follows: direct consumption equals 2.5 x passenger vehicle: indirect consumption is calculated using fa factor of 3.0, largely on account of poor controls on load and the re~ sulting excessive highway wear. Bus TOTS is considered insignificant, tor ine emray eparate listing.

?TOTAL ENERGY

(62m bbt_petroleun J

o0rE ?BEL OTHER

soto"

30% = 100%

70%

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axlox 25/82. 54

(78 total feet) ee

5/17. PRIVATE CAR COLLECTIVE

(92% total fleet) ?TRANSPORT

24/808 2.56 Ynorrect

RANGFOREARION

Iheser

TOTAL 15/208

(= 50/66. 5% TOTE)

?aaa

6-40R

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?All the energy accounts are significantly higher in Puerto Rico than in the United States as a whole

IDME is 20/346 higher, depending on which base figure is used (see Figure 1 and comnent).

?Total transportation energy, compared on the sane basis, is 15/50% higher in Puerto Rico.

Private car consumption (using the 63180 ratio for the relative pro- Portions 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 eignificant margins of apparent energy waste. They need to be disaggregated and reassenbled 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 unde

state the energy account of the transportation sector. And the higher

?the ratio of private vehicles in the eysten, as it ie 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 cum

?total. What needs to be added is a factor which represents the relative

wastefulness of the internal combustion engine. Thie consideration

especially relevant when one considers not only the TEC potential in a

system based overwhelmingly on PVP, but considers the medium- and long-

range alternatives of other modes and transportation eystem mixe

Energy loss in processing and use ie 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 (29, 48). The effective

fend use of energy in transportation is 25%, for a loss of 75%. Electrical

energy is 35% effective. Although the 658 loss is identified in (79) as

?loss in the generation process", the total figure compares with other

eetimates which calculate loss in generation and distribution of electri

city (for example, U.S. UTA, information sheet on "Energy efficiency of

@itferent urban [transportation] modes,"1976, uses the figure of 59%

for generation losses and 8% for distribution losses, a total of 678).

?The 75% loss of energy in the transportation sector partly duplicates

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oh

items included in the figures for indirect energy consumption (gasoline refining, evaporation in fuel transportation and sale, etc.). There is apparently no basis for useful estimatos here, except for the well-known energy efficiency data of internal combustion engines--generally in

?the 258 range. (Only the 1976 U.S. models were considered ?clearly better?

?that their predecessors, in terms of energy efficiency.)* Although substantial improvements in the energy efficiency of motor vehicles can be expected with the development of new engines , fuels, switch to diesel engines, etc. (representative of the vast literature are 561 the SAE Publications in the series exemplified by 47 to 49s 118: 90), electricity-powered transit has already an energy edge now (not to mention other advantages discussed below) and the generation efficiency ie also expected to be sensibly improved. Beyond electricity derived from fossil fuel, there is wind and ocean thermal energy. The link-up of these sources with an urban and island-wide rapid rail system muet be kept in mind in any future technical and policy analysis.

2.21 Direct energy.

Gasoline consumption. The consumption of diesel oil in transporta-?tion in Pur te Rico is insignisicant (industrial consumption was at the rate of 7-86 of the gasoline total in 1976; 82). The total gasoline consumed ir FY 197 was 646Wg in transportation (the grand total, inclu-ing nontranspor tation consumption, wa 66Uilg.) This represented more than & double of the 1967 consumption of 316g; the number of motor vehicles grew in the same period 2.64 tines. 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 the light trucks are lumped together. with passenger vehicles--see the rationale in 2.11 above; and also 22). The latter percentage, probably more realistic, means that gasoline consumption grew faster in recent years than the category of vehicles comprizing 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, TA Hine must be dram between engine efficiency and fuel economy, as

expressed in mpg, Engine efficiency ig a measure of how well the. eng

SOmNBEES Ge, aneEEy, $0, the, fuel, to Uoeful, work: "me fuel, Soneumots

goonony depends also on other variables such aa the chatacteriaies of

She vehicle, the style of driving,the traffic conditions, etc. (See 126,5)

ane

---Page Break---

While the indicator of galons-per-vehicle ie about ae refined as the per capita incone, it affords some comparisons. The 1975 average for the U.S. was 816 @/vehicle. The consumption ranged from Wyoning,996 e/vehicl ?to Hawaii, 516 g/vehicie. Puerto Rico's 772 @/veh. thus put St below the national average, but above California, 765 g/veh. and Florida 720 @/veh. Considering these figures and the relative size of Puerto Rico (48th in ?terms of area), which means shorter distances, these figures also illustre-

?te 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 oxample,Western Germany, the exorbitant con sumption is even more dramatic. For a comparable economic and living stand- ard, United States consunes four times more transportation energy per capita (46, s-IV): since Puerto Rico consumed 25% or more of "DIE tian U.S. as a whole, ite energy intensity per capita is at least five tines ?that of Western Germany, while its eccnomy and standard of Life are consi- dorably lower. (Comparisons are difficult because of inflation and chang- ing dollar value, if not also the different components of a good living standard; if, however, the West German per capita income is very con- rvatively estimated at three times the value/level of Puerto Rico, the factor of transportation energy intensityrises to an incredible1sMl this is not out of line with the general energy inefficiency in Puerto Rico in relation to GNP. See, 136, 189-90; 66.)

In addition to the vehicle's weight and power plant, summarily referred to in 2.12 above, there are other factors related to optional equipment, operations and maintenance, that increase energy consunption far beyond the reasonable minimum needed for safe mobility. Because of their nature, these factors are much more amenable to reduction or elimi. nation through various measures. Thus they constitute the primary target for TEC. ?They are discussed, with the indicated TEC estimates, below in 2.3.

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2.22 Indirect energy. There are four principal groups of trant portation-related activities which consume great quantities of energy in addition to TORE:

a) Refining and distribution of gasoline. In one calculation, multiplier of 1.26 was arrived at (27, 675, based on E. Hirst; see also

105, 22, Table 6); in other words, refining and distribution of gasoline added 26% to TDTE. Another calculation arrived at 9.5% of the total U.S. energy budget, or 37.5% of TDTE. (63, 5-4). The problem of losses through evaporation in the distribution of gasoline was pointed out already in ?the mid-1960s as a problem of environmental pollution (52, 41). More re= contly it was publicized specifically with respect to the high anbient content of benzene--a gasoline additive and a suspect carcinogen-~in ga- soline pump areas. Since (63) is an input-output analysis, this fuel oss through evaporation is most 1ikely included.

>) Manufacture to services. Tais group includes particularly:

Manufacture, transportation and sale of notor vehicles

Maintenance, repair, parte, tires

Parking, garaging, toll collection, insurance (enerey expendi- tures only, not costs). This group should algo include the energy cost of traffic and parking enforcement--an ites that is not expressly mentioned in the various calculations.

?The total estinate for group 8) is on the order of 4 of the total energy (equal to 17% TDTE); another estimate is of additional 3400 BTU/VM (22, 673). At 136,000 BTU/gallon and the national average of 1smpq at that time, this would add sone 37.5 of indirect energy. While these eotinates soem 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). Ie auto manufacturing figures for 1968 are interpolated into the 1970 series on which the calculation is based (1970 shows a 25% de ereage in auto manufacturing energy consumption, probably because of industry recession), the indirect energy sums to 55.6% of TDTE.

c) Highway construction and maintenance, ?This group should include also the construction and maintenance of rail traneit eystens, especially the energy-intensive heavy rail. Sone ectinates address themselves to ?this account. ?the parameters of group c) can be inferred from these data:

* Avasic estinate for ?highway construction? is 1.7% of total

energy, or 7% TDTE. This based on 1967 data and 1/0 analysis.

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?

© With reference to the controversial planned West Side Highway in

New York City, the construction: energy for the system (road and transitvay, both partly tunelled) was estimated at 74 x 1012 Bru 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 systemowr 50 years of operation, construct-ion was estinated at Mi, propulsion at 4of, station operation and systom maintenance at 16% (105, 22, Table 5).

© Still another energy cost estimate could be derived from the @ollar cost of the upkeep and renovation of the U.S. interstate highway system, put at $329Bfor the 1978-1990 period (IMB, 24 duly 1978).

The relevance of these figures for transportation policy analysis in Puerto Rico is obvicus especially with regard to, on the one hand, ?the deterioration of the existing system and, on the other hand, the construction and maintenance of toll roads, complex tunelled urban Anterchanges (for example, the planned connection of the las Anfricas 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 sibly more favorable alternative (see 3.12 below).

4) Rnerey cost of accidents. This category of indirect energy re. quirements does not appear to be included in the controlling estinates cited above. It is only marginally mentioned in one source (22) with @ nontechnical 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 véhicles 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:

© Bnergy costs of fmerais, 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 pre-

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cise enumeration. (The energy used by ambulances, tow trucks and other energency vehicles is direct energy and thus part of TDTE.)

?The accident statistice show cone discrepancies as between such agencies as Department of Transportation's Bureau of Traffic Safety, ?the Police and the state Commission for Traffic Safety. The difference is ap 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 there was in fact an increase of alnost 6%. Next year (1976), accidents grew another

?natural? 6.58. According to the apparently most reliable count by the Department of Transportation and Public Works, there were some 360,000 accidents in Puerto Rico from 1973 to 1977, for a yearly average of 96000.

?Tis total shows the following cumulative ratios: ?(of accia.)

traffic deaths (including pedestrians) 75

Heavy injuries (standard category A, roquiris

?trlnspartation of the victis, fon? the sce 13.0

Total injuries 45.0

D0 (property damage only) 68.0

Important for the energy interpretation of these figures would be at least the following considerations:

One of 9 cars will have a recorded aceident in an average year.

?The energy cost (or even dollar cost) of PDO accidents is virtually impossible to calculate at the present. Only accidents worth more than $200 need to be reported to police under the law. Not all are. Nor are ll ouch omall damages repaired, as the state of many cars in the active fleet shows. Only a fraction of private vehicles--in fact even pfiblicos, Licensed public carriers--have individual private insurance. The obliga~

?tory state insurance (ACCA) does not cover property damage. Even if the net cost of repairs could te learned, it would not be disaggregated in categories appropriate for this analysis. 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 payments, on the enerey budgets of such major emergency facilities as the Centro WBdico, and on longer-term hospitalization and followup therapy could yield reasonable input in the overall energy estimate. On the other hand, monetary esti- nates of the cost of traffic accidents in Puerto Rico--$239M in PY 1976. fare dased on U.S. mainland values and costs, mechanically transferred and, ?therefore, having more a shock value than analytical value. For instance,

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?the $100,000 assigned by the U.S, National Safety Council av a loss ?caused dy 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 eurvivors cost about $250M; the indirect economic cost (including sone enerey expense) was estinated at $580, for a total of $830M in 1974 (143, 28 February 197; 28, YL). ?The first figure, directly relevant to indirect energy estimates, comes to over $85,000 per ca:

Data are algo lacking for an estimate of the energy budget with ri gard to repair of damage to public property caused by traffic accidents. Where the driver can be identified, the police notifies the regional ai- rector of Transportation and Public Works. The cost le assessed and the ariver is made to pay it, in instalments corresponding to his economic situation. According to the finance division of the department, the bill is often in the $1500-2000 range. But the divieion keeps no statistics on ?the total of the damage caused and recovered.

2.23 Qverviow. 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 impo-je9 @ conclusion: The present statistics, limited to TDTE, grossly under-state the real energy cost of transportation in Puerto Rico. Thus they do not represent a base for realistic energy and gocial policy. Figure 3 Graphically represents the elenents of a comprehensive model of trans-portation energy budget in Puerto Rico. It does not attempt to show how intervowen the system is--a reality which makes the present IDI data

look even more reductionist. For example, tires inflated to only 16 ibs. ae against the optimun 24 lbs.--a hardly visible difference--increase aixect fuel consumption by reducing mpg (see 2.33 below). The undorinfla-tion can also deteriorate the tires at a 50% higher rate. This requires an earlier replacement; if not replaced, defective tires are contributing to more than 10% of all accidents in the U.S. (1.2 - 1.5¥/year; 143,31 January 1977). Either alternative caused additional indirect energy con-?sumption, (To complete the system on the preventive side, one mist con-sider also the social management factors of surveillance to reduce vanda-

isn of the air pumps and regulation to force gasoline retailers to keep ?then in working order.) °S? &

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Eigure 2 of total energy co! sot

if 1 so

TOTAL TRANSPORTATION ENERGY *

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RULES Z

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* The broken lines suggest some obvious TDTE resulting from transportation

Felated activities/events, and the multiple intraeysten effects of a minor

factor--the example of underinflated tires in the preceding text.

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a

Tho stark conclusion to be drawn from the inventory and the known or

interpolated nunbers in Figure 3 and expressed in the "bottom line?. is that

Buerto Rico uses about one-half of it total annual energy budget in al-

Foot or indireot transportation accounts. At least 80% of this oneray

(that 46,408 or more of the total energy) are consumed by private vehi-

Figure 2); these are gstinated to make over one-third of nen-

(see 2.15 above).

The Uyper range of the U.S. coefficient, interpolated in the Puerto

Rican model as 208 of TDTE, is considered more realistic on several

grounder

a) ?he study from which it is taken (62) is the nost comprehensive

and recent in the literature. The interpolation is on the conservative

sider the order-of-nagnitude value used here ("two-thirds") corresponds

toa coetficiont of .666: in (63) it 1s closer to .69, Another estinate

of comparable competence (105, 19, based on E, Hirst) ie much higher--

approxinately 100% TDTE or an increase coefficient of 1.0--expressed by

saying that indirect energy reduces the mpg of the motor vehicle fle to one-half, from the then national average of mpg to mpg. In other words and applied to Puerto Rican figures, the total transportation enerey used in FY 1977 would represent the equivalent of gone 1.3 Bg--rather ?than the ?official? rigure of 646 Ne (of gasoline).

») The U.S. figures apparently do not include the not negligible indirect energy consumption in colum (4) of Pigure 3 ~ Accidente.

©) he only items anong the standard components of the indirect transportation energy account, which do not apply to Puerto Rico, are in colum (b)s manufacture of vehicles, tires and most parts. A more refined quantification would therefore require that the mergy estimates corre-sponding to the new and used vehicles introduced in Puerto Rico in the given year (the recent average has been >100K), and the imported tines and parts. On the other hand, some parte are produced in Puerto Rice for U.S,-made moter vehicles.

on these considerations {t appears unlikely that the fine tuning of the ?tentative heuristic nodel in Pigure 3 will eubstantially change she

Pisst taseline for policy development and decision saking in Puerto Rico.

in Se aren of this study: Gransportation consumes about ag mich enerpy

sii the other sectors put together: households and goverment, Tight

and heavy industries, commerce, communications and services. Compared

ef transportation energy in the total energy budget may te ae ace ee

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2

2.9 Buerey demand 111 Microanalyeis.

?As overwhelming as the preceding conclusion on the total direct and indirect transportation energy demand in Puerto Rico may be, its trans- ation into concrete TEC policies and recommendations requires a more specific determination of the energy minina necessary for safe essential mobility, given the ineufficient collective transportation and the ab- sence 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 cumlative impact on TEC is the purpose of the following nicroanalysis? of transportation onergy demand in Puerto Rico.

2.31 Age and maintenance of the fleet.

The age structure of the Puerto Rican fleet, especially the over 908 of private vehicles, apparently does not fit the standard of useful Life of vehicle used by the U.S. EPA--9 years/100,000 mi [160,000 kn] Qu1, 8[1977]29). Neither does, for example, California where the "volu-metric decay rate for autonobiles? shows that it takes between 11 and 12 years before one-half of any year's vehicles are retired (11, n.p.[63]s there is, however, a sharp increase in retirenent fron 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 on

shows in the following figures: the 1977 U.S. model cars tested at an average of 18.7 mpg and effectively operated at f 17 mpg; but the whole fleet had an average f.e. of only 13.7 mpg (132, S3-29; 148, 11 april 1977).

While the size/weight paraneter can be optimized only slowly, as auto-
nobiles are replaced by smaller and lighter models over a period of 10 or more years, maintenance can be improved relatively quickly and with 4 great impact on f.c, tne particularly important and telling yardstick of vehicle performance and f.e. is the rate of polluting emissions. Much of the data on f.e. nave been collected with prinary interest in the control and reduction of emissions. But a car which exceeds pollution standards is a car which bums gasoline inefficiently and therefore ust nore fuel than it should with relation to its performance.

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The margins for improvenent in maintenance can be gleaned frém such

?theses

* na sample of 5600 cars tested in 27 different eites in the U.S.

4 out of five had sone maintenance deficiency which had an adverse effect

on f.e., exhaust emissions or performance. The U.S. DO? estinated that

cars needing @ tune-up wasted 375 Ko/petroleum/day (__, 18 July 1977).

© An EPA study, related to a pilot I/M (inspection-maintenance)

Program in New Jersey, concluded that ?improper adjustments and lack of

Proper maintenance? were the major reasons for the perceived ?shortfal)

in the Federal motor vehicle control progran? and that "the latest. techno-

2ogy.+.8eens as sensitive as older care to proper maintenance and adjust~

nent? (22, 24).

Visible exhaust is one indlestor of a badly out-of-tune vehiole,

withan fe, penalty of 258. This was asguned to be in 1974 one out of

every ten vehicles (220, 7). Empirical observation indicates a much

higher proportion of euch vehicles in the Puerto Rican fleet, Thia state

of engine maintenance was also confirmed by the high reject rate (90%)

of a tenporary 1/M progran which tested also emissions, as compared with the standard inspection progran in Puerto Rico (eince 1969) which records only 308 of rejects (see 2.12 above). For a comparieon, a rejection rate of elightly under 20% in Ohio (including emission testing) was considered too high and the EPA went to court against the state of Ohio, although ?the police issued almost 79,000 citations in the preceding year 1976 (QU, 30 January 197, supplemented by EPA, Region V).

These data indicate the magnitude of the problem and the margin of opportunity for better maintenance and enforcenent 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 notoriste wore 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 Cincinatti, Ohio test, Te Riverside test tock place two years before the Ohio test (1975-1977) which cortainly affected the age-efficiency factors it 1s also ascuned that the Cincinatti fleet ie relatively younger.

data

The major elements of maintenance with regard to f.

Tune-up. OF the wealth of data--and also s:

stinate:

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a

© Following manufacturer's specifications (e.g., with regard to correct ignition setting, not »5 degrees off) makes 3-9% difference in the car's f.e. (220, 7).

© Simple exchange of spark plugs improves f.0. by 3.5% (1K, 18 July 1977). Que non-functioning spark plug substantially reduces f.e.

* Proper tune-up of the nation's fleet would improve the overall f.e. by some 11.5%, but some automobiles could improve their f.e. by as much as 50%. (Id.) Tuning vehicles every 6K mi, instead of the present average of 12K mi) would represent a saving of 1.58 of the TDTE (62, 2-16).

dling. A particular aspect of tuning ie the proper setting of

?the idling speed of the engine. In urban stop-and-go or janned 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 f.e, can occur also in exurban traffic. On an April 1978 weekend, traffic between the edge of the SJMA and Iuquillo (beach) and Fajardo (boat show) was reported averaging 12 mph for a strech of some 20 miles

Inbrication, te use of a 10W-K0 of1, instead of 30W of1, is rePorted to have sensible effect on f.0.Umne applicability to of this datum to the relatively uniform temperature in Puerto Rico ought to be established. A recently developed ?uniflow? of2 claine an mpg improvenent ranging from 9.8 to 22.7 per tankful; this would mean an average "PE improvenent of sone 48.

A symthesis of various estimates for £.e. improvenents 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 trattic management.

Extensive tests in Pennsylvania showed that it cost an average 41% more ?to drive on deteriorated [fair to very poor] pavenent because of Aigher fuel consumption, accelerated tire wear and danage, and greater Vehicle wear and damage. The impact on f.e, can be inferred fron the fact that fuel accounted for 75% of the total running costs of the test Nenicles (101, 7). The state and progressive deterioration of roads in Puerto Rico in the last several years probably increases the f.0. penelty

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above the Pennsylvania figure, which translates into 5 mpg loss for an average vehicle (1977 = 17 mpg). Even at an average figure of 20% lose of f.e. on account of less than excellent road gurface--L.e+, 3.5 mPE

for the average vohicle--this factor amounts to an astronomic figure.*

Traffic management consists of engineering, laws and regulations, and enforcement. The low state of the art in all these departments in Puerto Rico 1s 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 TEC is illustrated by the following sample of data:

?* ?The reduction of stops--nostly on account of faulty timing of traffic lightsor oversaturated traffic--by 15% during a typical urban ?wip results in a 36 improvenent in f.e. (62, 2-21).

© At an average traffic flow of 25 mph, the fuel saving is 40f as compared with a ?normal? stop-and-go city traffic (Id., 2-20)

?* In exurban driving, combination of highway design and poor enforcenent that results in steady speeds of 70 mph--such ac on the Las Ané-

ricas toll road--represent a fuel loss of sone 24% when compared with a

steady speed of SOmph, and some 30% in conparigon with the most economic

steady speed of approximately 4omph (24).

2.39 Zines and proper alimment of wheels.

The relative drag of tires has considerable impact on f.e. The coas

ing distance trom 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 maximum recommended by the manufacturer, improve f.¢.

by sone 7% over bias-ply tires: the ?oval? model is said to represent

additional 3-8% (U8, 10 October 1977) or 7-108 (163, Nov. 1977) inprov

nent over radials--approxinately .3 mpg on the average car. Using the

Wr data for Puerto Rico, this seemingly minute f.e. Improvenent amounts

to sone 240 miles more traveled by the average car annually, using the

ne amount of gasoling

Proper alignment of wheelsis also listed as a perceptible factor in

(2). As many of the other factors, itom also influence indirect

energy consumption?pyan accelerated wear of tires and contribution to

accidents if tires are not replaced in tine.

fe

?Another supportive estinate is 15% fuel pe:

speed over ?badly broken and patched asphalt

?ity at omph cruising

(268,11).

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2.94 Convenience power equipment.

?This category includes four principal types of optional equipment that carry fuel penalty, on account of added weight and operation.

a) Automatic transmission. As compared with manual gear shifting, autonatic transmission reduces f.e. by about 1 on account of the added weight, and by 10-15% on account of operation consumption, with urban driving the less economic. ?The fuel efficiency of both the manual and the automatic systems are being improved: manual by going from 3 speeds to 4 or 5; automatic by a similar increase in speeds, by a switch to infinitely (constantly) variable transmission, and by adding locking torque devices to prevent slippage (56, 294; 4B, 13; 31, 140: Technol. Rov. III-1V/1977). Among the top 31 care in the 1977 EPA mpg tests, 30 had manual transmission, one (number 17) automatic (148, 3 October 1977).* Manual transmission appears to havean f.e. edge which even the best im Provenents in automatic transmissions--80-100% in performance or 15-20%

in f.e,--will have @ difficulty to erase, because of other diseconomies of the automatic mode when operated by an average driver. Indeed, the engineering efforts probably respond to the fact that the automatic trans Mission is more energy efficient than the average-to-poor driver, that ?the bottom two-thirds of the driving population. With manual tranmission, ?these drivers tend to shift too slowly into higher gears, thereby revving ?up the engine more than corresponds to the actual speed. However, the sane drivers are often equally clunsy with autonatic equipment: by not Jetting off the accelerator, they delay the gear shifting (2). At the sane ?time, they feed the engine more fuel than it can burn. The only way out for the unburned energy is through the tailpipe--an f.e. lose as well as @ source of air pollution. The greatest disservice of automatic trans. mission is probably the fact that many of these energy-wasting drivers would Likely not drive at all, or would drive mich less, if they had to shift gears manually.

Fite the 1978 teats (1979 models), ali the top 10 cars Listed in the first

press report (UPI, 15 September 1578) had manual transmissions; elgnt had

?the standara"Buropear' speed gear shift, two had an improved S-speed shift.

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4

>) Airconditioning. ?his option is generally considered the most

energy-draining. It increases consumption 1-2% on account of weight, and

9-20K when operating. The high figure corresponds to urban stop-and-go

?traffic on a not dajt2tnis would seem to be the condition which prevails

whon automobile airconditioning is used in Puerto Rico.* It was aggrava-

?ted in the last decade ty the systenatic desertification of urban areas

and highway fringes, depriving then of trees and bushes--the natural air

conditioners and purifiers. However, as is explained in the nxt para-

graph, airconditioning is a dubious protection against air pollution in

heavily travelled corridore--no doubt the apparent justification in the

mind of many drivers, in addition to the safety factor of keeping the

car windows closed at all tines.

Ho data are available at this time on how many cars in Puerto Rico have airconditioning. Local industry data indicate that airconditicners are being installed into small new and many used cars at the rate of sone 6000 unitafear. Paradoxically, these units are of the so-called vacuum ?type which ig much cheaper (f $365), but more useful as a protection against foul air since they circulate only the air inelde the vehicle. The factory-installed aircanditioersare of the ventilation type: for an average cost of $900 they not only aircondition, but also force inside ?the car traffic fumes--unless the vent is opened and shut according to ?the outside ambiental conditions, which is probably beyond the attention capacity of the average user. Very sensitive measurenents of traffic CO were made inside a car with only this ventilation open (Lit).

A srall-scale study of bicycling and air pollution by UsS. DOT (reported in Science 199, 1187 [1978]) also showed that the control group riding in airconditioned cars showed more CO absorbed than the cyclists in hot, polluted Washington air, probably because the latter moved faster through jams. This example takes us back to the f.e. as related to idling and is just one of many illustrations of the systemic interlocking of many of these factors, separated hore for the purpose of analysis.

F Simiated tost with a 1972 standard automobile in Puerto Rico arrived

at the figure of 176 (20, 72). It is probably low as compared with

Feal operational conditions as summarized in the text above.

---Page Break---

°) Be s sakes, seats, window ?oof.

This equipment adds up to 2% in weight; the anunt of energy varies

with the frequency of use (steering, brakes, as compared with the occa

sional use of the other options).

4) ¥8 engine instead of V-6 enging

The average performance of standard cars without these power opt. -¢

(and high fe.) was 23 mpg: with the power equipment of all four catep

ries it wae 16.3 mpg, for a total fuel penalty of 41 (2, 5).

2.35 Nonessential driving.

Nonessential trips were already defined and estinated at 35-40% v1

the total trips in Puerto Rico (sec. 2.15 above). If the conclusion tat

?the VIET per household per year vary more with annual ine me that with o-y other factor, this would mean that higher-income drivers who own on the average bigger, less enorgy-efficient cars, do more driving in general and therefore also more nonessential driving. This wovld tend to increase ?the energy consumption above the overall estimate based on nonessential ?Wa, putting it somewhere between 40 and 50f of TDTE. Some doubt may have been cast on the correlation income/WMT cited at.ve (132, 3-10) by a mid-1978 survey related to the cost-of-life index in Puerto Rico. It

was reported (146, 3 Septembor 1978) that both » typleal family close t2 ?the poverty Line (income of $6000/year) and one at the middle-class level (826,000/year) spent about $40 a month for gasoline that is over 55 gal. at the prevailing average price of $ .725/g. But the higher-income family did at least 450 miles/nonth of nonessential driving (daily roundtrip hone for lunch, 10 mi each time; and a 60 mi. roundtrip out of town on ?the weekends), that is over 56% of the total 600 miles (55 ¢@ 14.5 mpg). Yo data were available to calculate the nonessential driving, if any, of ?the poor family.

Another kind of energy-expensive driving--and often nonessential, too--are short trips. Here the U.S. data probably cannot be applied without taking into account the climatic conditions. Trips under 5 miles

0 not normally allow the engine to reach its best operating condition;

on the other hand, warm-weather driving tends to improve f.e. by ae much

a9 8% (130, 6-7). With specific Puerto Rican data interpalated, the ba: 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 mi each, using 25g of gasoline with an f, of 16 mpg, the same

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amount of fuel will be spent on 60 4-nile tripe, 90 2-mile trips or 100 1-nile trips. The respective total distances driven are 400, 20, 180 and 100 miles; the shortest trip is four times ae energy expensive

?as the longest.

A special category of nonessential consumption are recreational Powerboats. Boat engines and motors are notoriously energy-inefficient. ?At 6,200 BTU/PA for a recreation boat carrying 4 persons, the enerey 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). Powerboate are frequently excessive ly overpowered. ?The 15-foot-Light-weight-flat-bottom ?cruiser?, equip- Ped with two outboard motors totalling 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 powor and thus to consume even more energy is greater on water than on highways, though the eense of safety decause 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 motore of more than 75 HP (144, 22 May 197). The boating Cadillacs have conmonly engines of 300 KP or more. Although ?those 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.

Driving style which results in substantial f.e. (not to speak of fety and lower polluting emissions) requires nothing more than to observe the rules of the road, to use common sense and to act with a modicum of courtesy and disciplin. ?this kind of driving is almost becoming an exception. All the transportation and f.e. specialists, since at east the late 19508 (15, 42), agree on these simple rules:

* Be gentle on the accelerator. Do not practice "rabbit" starts. Once the car moves, it takes only 10 HP to keep it moving. By not pressing hard on the accelerator, you allow the engine to use effectively every drop of fuel.

* Maintain ao steady speed as poseible. Adjust your speed to the density of the traffic.

* Leave some space ahead of you. Anticipate stops, In tight urban

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traffic, look two Lights ahead. Coast to a red Light as soon as you see it. Do not keep on running at the same speed and then break 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.

Difference of 20% in fuel consumption due to differences in driving style was denonstrated (63, 2-19). basis of a pilot program of the U.S. DOE, carried out in Nevada, it was concluded that the f.e. of any ariver can be improved "up to 15%" by instructing him on the simple rules of acceleration, stopping and steady driving speed (16,6 December 1977). In view of the ?up to 158" for the average driver, the 208 figure elted above may be @ conservative optimum. Inetant fuel concuption meter be necessary as a standard equipment, *

To suggest just one more example of the? interrelated 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 an-other is (i) a major source of fuel diseconomy, (14) leads to longer idling tines at the stop lights where (iii) the fuel consumption ie a fuction 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:

may

© Design speed of roads. While, for example, the Las Anfricas toll road has the federal speed limit of 55 mph, ite design speed is 7Omph in ?the northern segment, 60 mph in the central segment (Caguas-Salinas) and 80 mph in the southern segment (Salinas-Ponee). During the National Speed Monitoring Program in 1977 it was found that over 50% of drivers An Puerto Rico exceeded the 55 mph Limit; 17.6% exceeded 65 mphy the overall average was 52 mph (the speed linit on most highways in Puerto Rico is 50 mphi some 60mph signs "nay have been left by oversight").

* ERDA began testing similar meters of electricity consumption in house~ holds in Washington in 1977 (lid, ? October 1977)

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a

The invitation to speeding and its acceptance was such that a respected columnist could write after the inauguration of the final segment of

Tas Anfricas (1M6, 7 Oct. 1977) that "as almost everybody else? he was not observing the speed limit; and to predict that the short travel timo from Ponce to San Juan would bring many people ?to get in line? on @ new Popular movie, Calculating this combination of speeding (4 65 ni,plus city driving) and nonessential driving induced by the expressway (130 mi round trip) cones out to some 11 gallone (at 14 mpg, with a 208 fuel pe- nalty for the 65 mph average as compared with a 50 mph average).per car --8 considerable energy price to see the ?Star Ware" perhaps two weeks earlier.

* Publicised industry acceleration standards. These are usually expressed by the time needed to accelerate from 0 to 60 mph. The ?nacho? appeal is measured in tenths of second . The planned new Delorean DMC-12 car has @ "0 to 60 performance of about seven and one-half seconds, clo ?to the Porsche 912? (uit, 18 September 1977). The acceleration capacity gees hand-in-hand with speed performance; go the DMC-12 is also ?designed for...survivability at an 80-nile-per-hour-plus head-on collision.? ?The more sedate standards of the big auto makers are in the 11-14 seconds range for the acceleration. Now the industry seems to fear that this Propaganda may backfire and make the new GM diesel passenger cars ?un- acceptable? to the consumer, as they take 15 secs 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 secs, 2.% mpg would be added; a

car with @ 20 secs acceleration tine would gain 5 mpg (22, 28).

* Driver attitude. This 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 docunented (e.g-, 19,

20, 126a,b). A table in the latter source shows the following "cruising"

Performance for a "typical domestic autonobilé

ge gat ay ge

oo? 22.5 " 70" 123"

According to these figures, the f.0. penalty at # 70 mph 4s -236 as con-
Pared with 6 40 mph; -19.5% as compared with f 50 mph. Other data indi-
cate stiffer fe. penalties. EPA's own penalty figures derived fron the

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52

?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 mphy calculation confirmed in (Zit).

The table also offers an argunent in favor of a minimum speed Limit
of 30-35 mph on exurban primary highways; and it allows another calcula
?tion of f.e. penalty of urban stop-and-go driving. At 6 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 -40f, The average speed in
congested urban areas, such as SJMA, is eatinated at only 10 mph or less.
?These figures are in the same range as (63, 2-20), cited in 2.32 above.

A combination of speeding, abuse of the acceleration capacity and erratic driver behavior--such as passing at speeds above the raximun Limit--aleo results in heavy fuel penalty. At 50 mph (the maximum speed on most primary roads in Puerto Rico), one speed change (acceleration) per mile can result ina penalty of -25% (126a, 11).

2.38 Baxnfree gasoline, Analysis of consumption of tax-free gasoline (24), used mostly if not exclusively by governnent vehicles, shows surprising increase. In FY 1975, the 11 Mg of this gasoline represented 2% of the total transportation gascline consumption. In FY 1976, it was 3.98 of the total, and in FY 1977, 29 Mg or 4.5K, It is conceivable that ?the Lower cost (the tax ie 16¢ per gallon) nakes the governnent users ess conscious of the consumption. In addition, governnent cars have

to bun more fuel to travel to separate central pumping stations to fi12 w.

2.99 Sumary. 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 denand beyond the minimun necessary for gafe essential mobility; and the table presents the Sorresponding fuel penalty estimates. These are weighted approxinate median values derived from the indicated sources, taking into account some special circunstances in Puerto Rico.

?Thus the table indicates how much transportation energy could be conjerved in Puerto Rico without affecting the basic social and economic Reed for mobility. The sun of the TEC potential represents a second Roldcy baseline: The essential functions of the present (private) trans-

Roxtation system in Puerto Rico could be satisfied with as little as ?S08 of the current TDTE,

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table 4 the categors:

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CAUSE OF ADDITIONAL) Rove tn [punaziy® | commas? POTENTIAL,

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22. Speeding 2.37

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?Table 1 - Continued &

SUBDOTALS! Its wes

#

3 36:0

Baer

"ul

GRAND TOTAL (rounded) 10.0

?EXPERIMENTAL FORMULA FOR THE CALCULATION OP TEC POTENTIAL!

?Essential? fuel consumption .... + 100

?Real" aggregate fuel penalty:

(2) 50% of the grand total? = + 70

(Gi) 756 of non-essential trips = + 30

Tos

TIE es eeeees wees + 200

TEC POTENTIAL EQUALS THE AGGREGATE FUEL PENALTY,

?THAT IS 100 = 50% OF TDTE.'

Notes

EOS PE Ime wht dom, woo fn the pamaer described at. be

inning of this section 2.99, are ys Gs FE dee 8. 220 23 ake aoe fel $5. 26, ?tai shia: $i8" Dhae" i "eonsadesn the axpati ce

with EPA's city/country (55/45) driving formula, abandonned in 1978 as

realistic, ihe median estimates are weighted toward: the urban driving

», .

'o means country (driving): 0 means operating (consumption); U means

urban;'W means Weight.

ome fuel penalty incurred by one 1972 test car, in an out-of-

eine Songttton, was 424 Clo, Sa). ine vette of ehis eiente Rottney ie

Fepresents @ real measurement in? Puerto Rico. It does not, however, re-

present a statistical sanple+

@Not a11 cars incur all fuel penalties, nor will all of these be eliminated. The 50% figure is, however, considered realistic especially if it 1a noted that the estimates in Table 1 refer only to direct energy, and not Also to indirect consumption on account of acoidente, where there is a wide margin for improvenent in Puerto Rico, desirable. also for other than energy conservation reasons.

?due to absence of data on fuel consumption of heavy trucks (see 2.11 and 2.2, Fig. 2, above) and on their equipment, no effort is made here to disaggregate TDTE in the private-passenger and the freight sectors. As in Figure 2 above, bus TDTE is incignificant at the level of analysis at-?tempted here.

mis reference is not to the weight of the vehicle, but to objectssto-red and "permanently" carried in it.

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3. COST/SENEFIT ANALYSIS

3.1 The auto omer'a cost.

?The preceding data and analysis show that a) over 90f of transportation in Puorto Rico is by passenger vehicles or their equivalents; ») over 99.5% of these vehicles are privately owned; c) this private vehicle transportation system (PVPS) consunes over 80% of the total di-Fect and indirect transportation energy budget. It is therếfore the pri-nary target for TEC. Unless otherwise indicated, the renainder of this study addresses itself to PTS.

?The principal benefits of the omer of an automobile ares

The satisfaction of the need for essential mobility, in the absence of an alternative (collective) transportation mode.

?© Freedom of nonessential mobility.

* Status symbol; opportunity for conspicuous consumption.

* According to studies in such long-distance commuting areas as, for example, Los Angeles, the vatisfaction of a psychological need for privacy snd own space in an increasingly crowded and noisy environment.

?The cost of owning and operating in 1977 in Puerto? Rico an automobil acquired in 1973 for $5,000, with an estimated 1ifetine of 10 years and 100K mi, was calculated at $ .3218 per mile (including the usual finan- cing 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, $ .2363 per mile (U4, 18 September 1977)-- ?the figure for Puerto Rico is + 36, The Boston figure is so high on account of insurance; the Puerto Rico figure is distorted for the sane Feason . It includes $l,830 insurance cost over 10 years, whereas the goat majority of auto owners in Puerto Rico have only the obligatory third party Lisbility insurance which would cost them only $350 over the sane period of time. On this base, 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 coot of car omerstiip is estimated at more than 20% of personal/ family incone, ae much as 278 in the latest statistic for the U.S. (142, 2 July 1978), These data need to be interpreted for the purpose of TEC

snalysis. In this perspective, three conclusions are particularly Levant.

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First. Despite the cost increase, the ownership and operation of an automobile has becone progressively cheaper. Although the 1977 figure of 27% represented an increase of 7% over 1976, the share of personal Ancone dedicated to automobile in 1976 was higher (28.7). Income has grown much faster than prices (147, 31 October 1977). Especially the principal energy parazeter, gasoline, has been getting progressively less expensive. The CPI figures show that between 1940 and 1970, all ite inereased by a factor of 2.8; gasoline only 2.5 (Ui, 1 May 1977). In

1975 dollars, gasoline cost in 1960 $ .576/gallon, in 1976 (that is after the post-1973 increase) only $ .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 the 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 had protably an inverse effect on f.e.1 engine maintenance cost were cut, consumption of fuel as the economically cheaper factor was increased.

Third. The operating cost represent neither the full economic cost (3.2 delow), and even less the full social cost (3.3 below). The PVIS is highly publicly subsidized.

3.2 The ful) 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 capabilities to acquire then. Personal/family budgets have shown our-prising elasticity in this regard. The facilities for financing, the cost of which are "hidden" or at least co distributed that they can be met, are probably most responsible. This factor wae apparently not sufficient-Ly considered ty decision makers. During the 1969-1972 period, when e rything possible was done in highway development and reduction of auto taxes to facilitate acquisition of automobiles, the widely reported tacit Premise was that the private economic capacity will limit the vehicle po-Pulation to a maximum of 600K. The error in judgment was 240% (1969 = 4ABK registered vehicles, 1978 = 874K). There are algo social implications which will not be further discussed in sec. 3.3. Money spent for an auto, not matter how "inconspicuous," is not available for other family needs. Puerto Rico's rate of private indebtness ie substantially higher than that of the world's foremost credit economy, the United States as a whole.

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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 itens of operating an

automobile, with connents on the real economic cost.

Gasoline: vage price. The price of crude imported in Puerto Rico

rose by a factor of alnost 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 is .#5 more than in Puerto Rico, While the absolute prices of ga~

soline are higher in Puerto Rico, they rose about 31f less than in the

U.S. during the last five years.

Gasoline tax. No federal gasoline tax (4 a gallon at this tine)

is collected in Puerto Rico. The local state tax remained unchanged at

$ .11/eal. from 1966 to 1974, despite highway investment which amounted

?to $520K between 1969 and 1972. A tax increase was then contenpla-

ted but not enacted. The tax is at $ .16 since 1974 the CPI has risen

over 40 points since then. Just to reflect inflation and the correspond~

ing increases in average income, the gasoline tax would have to be now in

1978 at $ .23/gal. Even at 16 cents it was in 1977 the highest state tax in the U.S.

The U.S. gasoline price and tax policy, which Puerto Rico follows, As very low by world standards (105, 13). Prices in a representative sample of foreign countries, in Europe and the Americas, ranged in April 1977 fron $2.13/gal. in Italy to $1.04 in Chile, for an average of $1.38 (242, April 1977). In several countries, they have risen since then. The difference is even more striking when the cost of gasoline is conpa~ red with GNP as an approxinate indicator of the ability to pay. If the U.S. cost (per litre) is 1.0, Sweden is 2.41, West Germany is 3.0, Italy 7.06 and India 115.3 (12, 29). Bven these absolute/relative prices were considered as not expressing the real cost (Zib, 41).

The fact that the U.S. (and Puerto Rican) gasoline prices are de- Pressed by government control was emphasized in an official report to the Congress on ?automotive fuel economy? (117, 33 (Jan. 197]).

Highway uge. A heuristic calculation based on U.S. (lik) and Puerto Rican data indicated that highway users pay in Puerto Rico as mich a

258 less than the 8.7% assigned to the average mainland noteriet on

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account of highway use and maintenance (§2b, n79). In fact, highway users in Puerto Rico pay nothing directly for road maintenance. All the gasoline tax goes for construction and financing of new highways. Main-?tenance and repaire depend on general budgetary assignations. These have decreased from $15.8M in PY 1972, assigned for the maintenance of 6530 km, ?to $13.7H in 1977, for a network of over 7000 km. The maintenance assig-nation isslated toreturn to the 1972 level only in 1980, in current, not constant dollars. The accelerated deterioration of the highways and the effects on f.e. were already discussed above in 2.32. By not being assessed an adequate tax for road maintenance, drivers in fact spend more on fuel and vehicle; since maintenance cost come from the general budget, nondrivers or occasional highway users pay along with regular users.

Transportation costs ap a function of the consumer price index (CPE

Between 1974 and 1977, the consumer cost of private transportation rose

by 30-68, of public transportation by 41.3% (82, 31 March 1977). When the price of gasoline rose in 1974-75 by 47%, the PYTS/CPI rose only by 20%, ?the public by 278. These comparisons are rough because public transportation includes wages and other costs which do not enter the PVPS account, but in absolute terme vublic transportation became almost one-third more ?expensive--an incentive/subsidy in favor of the PVIS. The growing deficit of the ANA wae, however, covered also from the general budget, that ie paid for by the residents of the whole island, not by San Juan residents whose preference for PIM contributed to AMA's deficits. (29).

Parking subsidies.

a) No-fee parking on governnent-owned lots.

) Specific parking space requirements in commercial buildings as precondition for construction permit.

4) Control of parking prices in privately omed commercial lots, by ?the DACO (department of consuner affairs). This may seem to be a laudable policy of consumer protection, butitis totally wrong in transportation energy perspective. Urban parking space is a very costly land, the use

of which ought to be costed at its real value. The differential between ?the presently allowed rates and the real cost represents a margin for some price increases for the operators, as well as a parking tax. More Amportant, the tax would be an instrunent of traffic management: it would reduce nonessential trips to expensive parking areas and would allow

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distinctions between commuters and shoppers by making all day perkins substantially more expensive per hour than short parking. Similarly, parking during working hours could be easily distinguished from evening OF weekend parking which serves noncongested traffic.

Parking violations. The fine of $7 for on-street or sidenalk park-Ang, 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) invite the motorist to take a chance. ?There is no increase of the fine Zor repeaters. Autonodiles cause damage to the sidewalk pavenent, according to the director of Bublic works for SJMA (146, 24 Varch 1977). Even the fact that i is Possible to pay the fine with a delay of ae much as 12 months without any interest or surcharge is a form of subsidy.

Miscellaneous, The foliowing--and perhaps still other. sent an undetermined economic subsidy for the PVIS:

© The yearly cost of licence plates is deductible from income tax.

© The Highway Authority bonds are tax exempt.

* Transportation adninistration and enforcement cost cone from the General budget.

* Cost of repairing danage to public property caused by accidents 4s only partially recovered.

* The low I/M standards represent an indirect subsidy at the cost of air quality, accidents and other social costs,

~itene repre-

In sun, automobile users do not pay the whole economic cost of their ?transportation. (Nor do, for that matter, the users of collective trans. Portation, since the bus rates are underpriced and the pfiblicos are sub- Sidized on many of the listed accounts along with private vehicles.) As @ Fesult, those who drive sparsely, pay also a share of the economic cost for those who drive intensively; those who do not own an automobile ?upward of 40% families in SMA--pay in two ways: first, because gent Fal public funds mist be used to subsidize the PV?S, instead for services and facilities; second, because PYTS not supplenented by adequate collec ?tive 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 conclu- Ged that ?American highway investment in urban areas results in social Costs that far exceed the present taxoe and charges and taxes on American Griving? The real cost, expressed in terme of a ?toll per unit of driving,?

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to be added a tax to the cost of gasoline, was calculated at $ .50/gal,

?Tho rewulting third policy bageline ic thict PVRS, the almost ex-

rangportation mode in Puerto Rico, ie not_only an, exevsaive

nergy consumer, but ig aleo highly publicly cubsidized, partly at the

cost of those whose mobility depends on public transportation.

3.3 The ful) gocia cost,

The total veonomle cout of motor-vehicle transportation ie not

the total cout. Althowh tho focus and interest of thie study Le policy

for TEC, it will be arguabolow that a more energy-effective eystem, with

?a planning horizon of several decades, must be an integral part of a com

prehensive vision of the whole socicty. and its energetic and environnental resources and proupects--in other words, Puerto Rico viewed ae a human ecosysten (52: S20, 21f.).

It is therefore convenient at least to list the major interactions between the present transportation system and the human systen it serves. Im addition to the factors of mobility and energy consumption, the ¢/2 analysis of which has been outlined above, the precent PYIS involves a nunber of other factors and impacts that are not perceived as cost either by thom who drive or by the society at large.

© Air uality. Tis is generally considered to be the most serious problen (e.g., 12, 149; 60, 54 128, lll; 134, 42). The contaminante are principally CO, NOx, airborne lead, HC. Direct correlations between the: 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 re- eidents near a local highway, as compared with those living 500 m or farther calculation vere applied, to the tells charged at the Jas Anfri-

expressway, the cost for the whole ould be a

S*feane no" ea ?penalty for apsedings bevtaveraging the: Fleet} equals

ions @ $ .50/gal. surcharge). it is only $1.95. Recent figures:

id by, the iiighway stoma (iu6, 10 Septender i978) iilusteates the

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tion) shorter travel time; decr

fort-totalied almost $80K in FY

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tor that year--wnich is, in prineiple,

financed fron the gasoline figures wore possibly Teleased to

assuage, the ?exprosevay usere who prot Sted. in 197? against the raise. of

O40 $1.35." But te poling te that tne S60H worth of public benefit.

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6

away. Aromatic HC, measured in tailpipes of passing cars, and in coil ?and ooot around the homes, was identified ac the probable cause. The traffic dencity was neasured 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 expreseway in San Juan. The concentra~ tions 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 mo- ?torists, 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 nonent only a mathenatical simulation model of air contamin tion fron mobile sources (1971). The Highway Authbrity's office of en- vironmental studies does not include air pollution in impact analyses, relying on dispersion. ?The Environmental Quality Board has prepared only in 1978 a request for federal funding to establish a monitoring network which would collect real data. ?The Netstal story was published also in ?the local press (146, 2 November 1977). The solution of the impact of automobiles on air quality through emission control devices is far away and problematic. Only 16% cars of a fleet of about 107M had enission controls installed in the United Stated in 1977. The effectiveness of ?the present catalytic converter after $0,000 miles is subject to doubt. ?The proportion of enigsion-device-equipped cars in Puerto Rico is smaller. The device ca be, in the absence of regular and stiff controls, dis. connected or made inoperational by the use of leaded gasoline or of some substitute additives to boost the octane rating--that is the capacity to accelerate and speed.

© Other sources of environmental pollution. One instance of seve- ral is the problem of disposal of used lubricating oll. In 1976, there were about 10Mg of it in Puerto Rico, representing a problem of disposal. for sone 100 gasoline stations. The seven oil companies which operate gasoline stations were ordered to instal disposal tanks. Five complied completely, one partially, one not at all. Thie mean that a considerable number of gasoline stations in Puerto Rico does not have this means of disposal. Nor is it clear what happens with the used oil when the dispo- sal tank is full.

© Congeation,

+ Tine spent in travel. In Caracas, which hac a traffic a ty

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somewhat comparable with San Juan, it was estinated that up to one hour may be lost by travellers every day because of traffic Jame. The total was (in 1975) some 1.5M 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 for the same reason extra US$200,000 worth of gasoline monthly, that is 1 Mg at the prevailing price of US$ .20 or less per gallon (26, 120). Th impact on air quality does not have to be belabored.

Pedestrian delay.

Noise and vitration, both directiy correlated with pubiie and

mental health paraneters.

Accidents. This factor was already discussed in 2.22 d) above.

In the hunan 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

sive noice they make.

Tand_use.

+ Direct use for highways, streets and parking (see also 2.14

above).

+ Disruption of r

construction.

Impact of and 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 flood ing, run-off, underground water replenishnent, miniclinat:

+ Decline of public transportation, Interference with enerey-effective modes indicated for short trips, such as walking and byeicling.

+ lack of mobility of nondrivers.

Environmental esthetics. The question is not only one of unfa-

Jidental and busine

districts by highway

---Page Break---

vorable impact ("visual instrusion") but of esthetic opportu-
nities and their relation to broader aspects of environmental
managenent. An example is landscaping, including the maximum
of tree planting, on the right-of-ways of new expressways,

especially their urban segments. This was specifically proposed for the Mutloz Rivera Expressway, but renains on paper several years later. The relation between euch ?esthetics? and

. air quality and conditioning wae already referred to (2.34 b/ above).

?The preceding is only an illustrative inventory. ALL the categories could and should be developed into sutmodelefor further policy analysis and synthesis which is outside the scope of this study. Much data is ayailable or can be developed when the conceptual model is constructed. Sone 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-doller? cost to soctety...the aofal cost of urban transportation modes? (J, 42-3). The ?transportation system in Puerto Rico is in this sense an urban system.

3-4 Summary.

In oun, PVIS in Puerto Rico is not only an excessive energy consuser which does not pay for itself in economic teras, but it generates social land environmental costs not enumerated in the preceding discussion but extensively generally docusented. Until they are sufficiently quantified for Puerto Rico, these externalities must be assuned to equal in magni= tude the energy and econonic costs. The first of several causes of the excessive extemal conte has been the separation of transportation planrning and development from the whole social and resource eysten.

The consequent olicy baseline ig twofo:

2) _ransportation energy conservation can not be effectively impl.
mented outside an adequate transportation system management (TSM),

the development of such a TSM is not possible unless -tr =
tion is perceived and planned as part of the whole human ecosystem, and
itored with reference to an equally whole cos! it calculus,

---Page Break---

4, POLICY DEVELOPMENT! BASES AND SOME RECOMMENDATIONS

4.1 The policy bagelines

Te discussion of transportation energy demand and the cost/benefit
analysis of the full economic and social cost of the present transporta-

tion 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 consumes directly and indirectly about as much

energy as all the other sectors put together. This share of

?transportation energy in the total energy budget may be as much

6 10% higher than in the United States as a whole.

II, All the cafe essential mobility of persons in Puerto Rico could

be satisfied with as little as 50% of the current TDTE, with

Adequate maintenance of engines, vehicles and roads, with redu-

ced use and acquisition of convenience power equipment, with re-

duction of driver demand (short trips, low occupancy, non-

essential driving) and upgrading of overall driver behavior to

?the standards of the traffic code and of connon sense.

XIL, The PVIS is highly publicly subsidized. That means that the

users of autonobiles do not pay the full econonic cost of gaso-

Lime, highway use, parking, and that they are also subsidized

on @ number of other accounts.

IV. Transportation energy conservation can not be effectively imple

mented outside an adequate transportation eysten management,

?that is the integration of transportation planning and manage-

jent with the whole social and resource system, This will also

reduce the social and environmental cost (that is, adverse in.

Pacts on public and environmental health, lahd use and esthetics)

which must be assumed to equal in magnitude the energy and eco-

nomic cost of automobile-based transportation.

Tt Se concluded that a detailed quantification and fine-tuning of the

conceptual and methodological model that underlies these policy baselines

Ray adjust the implied relations and vectors for the purpose of interim or

?tactical measures, but that it will not affect the orders of magnitude

which are the proper base for longer-term policy options and decisions.

---Page Break---

4.2 Collective development of a policy model.

The need for a fairly rapid change in the whole transportation sys.

?tom that the numerical and policy data indicate is staggering. No effecti-

ve TEC is considered possible without such change:

?The lead tines necescary to achieve anything but bandaid treatment

fare 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 systen of technical data and elements, of

?their interrelations and tradeoffs; of government processes and financing;

of social and economic expectations and vested interests, is mindboggling.

The power of the ?auto-transportation-industry complex to resist even re-

medial 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. compa~

nies; 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 na-

nufacturers and distributors, 2) financing companies, 3) gasoline dis-

?twibutors (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 ori- sis. Small, incremental changes such as right-turn-on-red, increased excise tax on the heaviest automobiles, small park-and-ride programs, Amprovenent of traffic light timing at a few intersections--create a feel- Ang that something is being done, while in fact they amount to a no-action, when the systen 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.

Tt is evident that the useful function of a single policy analyst ends when he has inventoried the principal factors and inputs, estinated ?their magnitudes and relations, and arranged then ina tentative but Teasoned pattern--where there were before only so many scattered data, ?technical studies with a limited technoecononic focus, sectoral prograns

---Page Break---

66

and decisions, and vague impressions about the serviceability, the impacts and the social value of the product.

Fron this point on, the developsent of a policy model based on all the available empirical and decisional data and-indicating pragmatic decisional options, pricrities and tradeoffs, becones the task of a tean of transportation and energy specialists, regional planners, policy analysts and synthesizers, and government administrators--seoking and applying industry, commerce and community input where indicated.

It would be presumptuous, if not impossible, to try to anticipate the specific reasults of such a collective exereice--even though @ 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, sone directions for further policy research and development for the purpose of decision making follow so clearly fron the policy baselines that they are at least briefly outlined below.

4.3 Sone directions and recommendations.

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

FIRST RECOIMENDATION: THE CONSIDERATION AND IMPLEMENTATION OF TEC MEASURES OUGHT 0 BE INTEGRATED WITH THE OVERALL TRANSPORTATION PLANNING ?AND SYSTEN 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.

© Speeding and erratic driving is a great fuel waster.

© Enforcement of the highest speed linit (55 mph) cannot be sopara-

Be Hen general entofconsn! of 1opai?apeea Disa oer' ese

driver, (voth of them TSH measures), because it ie a
matter of xsd wior in general. Over 50 of
arivers were shown exceeding the maximum sOmph speed on prima-

ry roads? in Puerto Rico.

* 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,

Qhe source of TEC is the gradual replacenent of heavy autonobiles by compact and snail Rodel. ?the proportion is sxpected to be about 50150-In 1960. But there ig a tradeoff: in a collision with a heavier automobile or truck, the Fisk of death increases by 758 for the small car passengers, the Fisk of permanent inju-

---Page Break---

bs (Anistate Insurance Go., Automobile rating progran,

Rovomber 19761 00 algo Sey aise ime nemenaty aE EET ae

creases proportionstely with gpoed? (ul)

») Transit and fuel econony.

There is a but relatively minor f.e, in having an oper

?tional transit in addition to other transportation medes.

* The nore important fe, is indirect. It comes from the constraints

on PVTS which can be inpiemented when satisfactory transis is in

place.

. (xt)--apart from being less energy-intensive

in ?the construction phase and cheaper--is more favoratie with

Tegard to restraints on PYTS. ?Since it runs in principle enti-

rely at it forces TSM'to implement reetraints on PYTS in

ora

the IRT Gorridors. Hi iy is constructed around the existing

DVIS and has nv measereve TH walucs

* A fayorable concept of transit algo enhances two other concerns

urban human envi

of TSM aie ty and the renabilitation of urt

ronment. (Appendix Ar i, 9) 10)

?The second oF

© for the reconmedation discussed in this section is

+f & decisiona! nature, Even minor, short-term TEC measures need to be

presented to political decision makers ina policy context that makes then

appear 1s orderly and necessary stops in the right direction, rather than

vnly either-or s gestions, the acceptarliity of which may be determined

by considerations extraneous to the real problem.

432 tof int criteria and

SECOND RECOMMENDATTON: SIMPLE BASIC GUIDELINES FOR FUTURE TRANS-PORTATTON ENEHGY AND DEVELOPMENT POLICTES OUGHT TO BE AGREED UPON AND PROMULGATED.

Even a tentative list for further consideration and elaboration is likely to contain the following criteria and indicators:

* Transpo: tation energy prospects and constraints, Convergence of the ?principal long-term trends: energy, populations tere ee sources and the Telated economics--advocutes coneetveeine Policy thinking based? on the assumption that severe constewinty what preva, in the future over the ?Lint tless® epperniniries Maton shaped the decisions in the last 25 years in Puerte Rice meat tn much o: the world Gaza 2°)"

* The need for, and content of, long-term policy decisions rather @ series of crisis responses and makeshift "solutiona.*

* Social criteria for transportation system development, rather

?then merely engineering parameters and economic cost.

* Pulley concer about essential mobility with reasonable margins

---Page Break---

for personal freedon of choice at real economic cost.

?© ?The close relation TEC and the turn to an ecosystenic ci-
villzation which conserves not only transportation energy, but
also conserves, reuses and recycles other forma of energy, water,
materials and other resources.

© Transportation as a function of the urban habitat: physical en-
hancenent, environmental quality, human and esthetic improvenent,
reversal of urban nenplanning and of land wastage.

'* Te economics and institutional aepects of TEC (to be specifically mentioned below).

Already the first San Juan ?netro? study (1964-67), focused on techni-
cal planning, urban land use paraneters and financing, concluded that the transportation plan "will require pooling of resources and foresightedness to bring about the greatest concerted effért ever undertaken in Puerto Rico by both private and public sectors and the eitizens in general.? The so-
cial dimension of this planning appeared thon to be too narrow (52) but was more than the decision naking process could handle. The present cap ?to be spanned can be inferred from two recent policy documents: the latest Governor's message to the Legislature (February 1978), makes only an inci-
dental reference to transportation with regard to the economics and re-
gulation of the "pfblico" sector; the "energy problen? is dealth with with a similar lack of prominence * and narrow economic focus. The draft ?Plan of integral development," prepared by the Planning Board (Narch 1978) devotes four out of a total of 210 pages to generalities about transporta-
?tion and energy; the first of six specific transportation objectives is "to develop a vast progran of highway construction" to supplement the existing network. Transportation energy conservation ie not mentioned or implied.

4.93 Near-torm TEC policies and measures.

THIRD RECOIDENDATION: THE SCOPE OF PRESENT AND PROPOSED TEC ACTIVI~

TIES SHOULD BE ENLARGED 0 RESPOND TO THE FIRST, SECOND AND THIRD POLICY BASELINES.

?The supportive data andanalysis are in sec. 2.2, 2.3 and 3.2. Th invite further development and refinement. The policies and measures could be conveniently grouped in the following categories:

420 of & total of 1026 colum/centineters, i.e, some 2.4 of the total

---Page Break---

© Piscal/economie

© Technical/mechanical (including vehicle and road maintenance and Amprovenent)

Flanning/nanagenont (the bulk of TSH)

Legal/regulatory

Enforcenent/surveiliance

Driver infornation/edueation

Inprovenent in data generation/processing

4.3% Setting a limit on enersy consumption in transportation.

FOURTH RECOMMENDATION: TEC POLICY OUGHT TO FOCUS AS SOON AS POSSIBLE ON MEASURES THAT WILL DIRECTLY LIT? ENERGY AVAILABLE 70 PYTS.

?There are at least four possible approaches!

* Ceiling on petroleun imports, This has been implemented in such counties" ae: France and Brasi2, tt ip implica teeene tes, ones Plan. The consideration of this altemative would obviously ree quire a review of the outstanding petroleun import? and gasoline export commitments of the Puerto Rican refineries.

* Gelling on gasoline avaiiable on Puerto Rican domestic market,

Eiutpmeatigt, 2 contingent the longer tere const tnente ana/or

1° possi of exporting greater quantities of gasoline ree

fined in Puerto Ricos? ® ° ?

* Raising the consuner price of gasoline progressively to its real

economic value,

Eotablishing @ 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 which ean

importantly affect gasoline consumption. The elasticity of desand te seen

that the cost Decones effective only when it Peaches the range of 1,50

to $2/gal.

>) Altowing the gasoline price to raise to thie love! would caus

substantial hardship, not justified in view of the fact that tt sae wast

covernsent ?planning? that created the dagree of dependence en vet een

eesential mobitity,

©) The government has no duty to provide unlimited supply of gaso-

tine.

4) A surtax would in fact created a double price level:

(4) A ressonabie allotment of gascline for essential econonte

crivings

(14) free pitenave of additional gasoline at current price plus

Tod Er ELS SR324 "700004208 e200

8 share of transportation energy estina-

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curtax, If the gurtax amounted to 100% of the current pri-

ce in mid-1978, the total price per gallon of the free gaso-

Line would merely equal the contemporary average price ina

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 subsidi-

zed (as gasoline is subsidized now); coneumption above the reasonable ni-

nimun 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 ac the U.S. standby rutioning plan. Rationing absolutely limits the anount of gagoline available. But 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 higher price to others. However, the surtax proposal for Puerto Rico was notivated also by the necd to generate funds for transits the Schle-Singer "white market" concept turns nunconsunption into private profit enterprii

4.95 Positive restraints on Pins.

FLFR RECOMMENDATION: ENERGY PRICE AS THE KEY 70 TEC MUST BE ACCOMPANIED BY OTHER NEASURES SUCH AS WITHDRAWAL OF "HIDDEN" SUBSIDIES OF PV"S.

Price is the key, but not the only key. Observation of the Tokyo ?transportation system, suksequent to the preparation of the report on San ?Juan Transit, established a surprising, tenacity of PVTS in the face of:

* the of the nost extensive, efficient and reasonably attractive combined urtan/exurban rapid Fail systems in the world

© Prige of gasoline of $1.68/gal. in 1977 dollars, $2.28 in mide 1978 doluars. . ? .

* Uncomfortable traffic density and congestion, despite an elabora~ ternetwork of urban toll exivesomayer °

?The conclusion must be that in addition to gasoline price and the

availability of transit, positive cteps to restrain PTS must be under

taken. In Puerto Rico, a substantial restraint would probably result from

withdrawing the various subsidies enjoyed by PYIS and putting it pro-

Gressively on equal footing with other transportation modes. That presuppo-

06 the next policy direction. Before going to the next point it should be

---Page Break---

a

noted that the preceding concentration on PVIS corresponds to the ?nuneri-

eal preponderance and dominance of thie sector and to the resulting TEC

potential. It does not imply that the collective ang freight transporta-

?tion sectors operate economically and should not be monitored and analyzed

for possible TEC gains,

4.36 Shift to rail as the dominant node 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 ISEANDWIDE OUGHT TO BE ANALYZED SO AS TO FACILITATE FUTURE DECT-

STON MAKING.

Reference is made to the relation between rail transit and TEO, touched upon in 4,31 b) above. The concept is to substitute eventually rail transit for PVES as the dominant mode for essential travel.

?The following premises ought to be verified:

© The past "Metro" planning was conventional, misled and requiry dramatic conceptual innovations,

* Tt was not prageatic enough in terms of cost, equipment, simple Adequate technology needed to serve transit heeds in the avacla~ bieTecononie and scctal framework:

It was therefore too expensive. ?Metro? (heavy rail) is cogtl; economically (ine new eysten for Carseas is budgeted at US¢l0 per nile; the care proposed for the San Juan "Seto" were the Rost expensive Boeing model, costing $560k each in 1975). "Metro ype transit is also costly? in eonesruetion enerey and nenviron-

Rental impacts during the construction phase:

© ERE is the mode indicated for San Juan as well as islandwise.

he prageding points wore e1avoraved sore tn (saby eee Appendix

ane

© Although econonic cost was always cited as the principal ob-

Stacle, 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

St operates on separate guidewaye (Appendix A: l.2).

Rail transit as a cubstitute 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 Ar 6.).

4.37 Adequate 15x

SEVENTH RECOMMENDATION: THE EXISTING TSM PLANS OUGHT TO EE THO-

ROUGHLY REVISED IN THE LIGHT OF BNERGY, ENFORCEMENT AND FUTURE TRANSIT

REQUIREMENTS, AND IMPLEMENTED AS SOON AS POSSIBLE.

---Page Break---

2

The existing TSM plan for SJMA (75) needs to be reviseLand broadenedi

© TSM is an essential factor in the effort to conserve transports

tion enerey.

© TSM is not only an engineering enterprii

enforcement. Traffic lights are meaningless if they are ignored. i

SERfic Jané are caused or aepravaved by intersootions boeked by

arivers who entered the areawithout having a clear exit in their

direction. Most often these drivers enter after green had switched '

to amber.? Traffic engineering would be to cleariy advise the dri- '

ver that unless he has crossed a (yellow?) line before the amber

signal came on, he must stop. But this would be a waste of paint without enforcement and sufficient fine for violation.

© Finally, Psi in the sense of the best use of what ie avallable and of graduate improvement, is an absolute precondition for satistactory functioning of the feeder system of buses, vans, pblicos, park-and-ride lots, otc. on which rail transit depends.

© Ag transit planning, traffic engineering in Puerto Rico has been plagued by tendency? to rely on too complicated and costly techno~ Jogies (e.g., underground gencore to activate traffic lights, which tend to break down after a while), Instead of such simple techniques as to advise the driver by neane of a snall eign at what steady speed he ought to trawl to make the next Lignt. This ?to be cheaper and more adequate than six different ed prograngfor various traffie densities--which are out of order most of the tine,

© TSK ought to be also coordinated with all the other planning, Baintensnce, enforcement and public safety factorsneeded to foster low-energy mobility such ag walking and byeieling.

4.38 laws institutions, information, education.

The best policies for TEC and transportation in general are useless unless reflected in law, institutional implementation and enforcenent, information access and utilisation, and continuous education of all the actors. This implenentation system is a subject fer a whole separate stuay and analysis.

Only sone current reference is made here:

* The Traffic Code (Ley de Vohfoulos y Prfinsito), now being revised, does not reflect TEC concerns and hie not analequate philosophy of penalties. It ought to rewritten in this respect,

* Me statue and personnel of the traffic police (November 19761 5.26 of ali policenen, 7.28 of ail police employees, no separate giganization?l status, as it had in the past) ie severely cut of Une with the sige and needs of the transportation systen. The philosophy of enforcenent is selective se that the police consand~ ers determine in fact which law or laws (also noise, littering:

©.)will be enforced at what tine,

* The recent internal reorganization of the DIOP is a step in the Fight direction, But this is only one agency involved. TEC and 75M

but depends heavily on

---Page Break---

require close integration of policies and prograns between DPCP, Office of Energy, Environmental Quality Board, Planning Board, Police Department, Public Service Commission, Department of Con-Suner Affairs, Public Instruction and perhaps still other agen-cies. If the ?forthcoming reorganization of the executive branch is intended to be nore than a mere nominal simplification of the Sgrermnent?s oreanogram, it should cxarine the? "deep structures of major social problems and issues, and shape the institution: accordingly. The transportation energy and management field ie & strong candidate for this kind of analyeis/aynthesis.

?The inadequacy of the information system for policy analysis was mentioned at the outset of this study. There is much more in=formation and know-how in Puerto Rico than has been effectively used in past decision making,

When education is mentioned in conection with transportation, the meaning is usually limited to the basic imowledge of driving and of the rules of the read. Even in this narrow sense, a grest Gear renaing 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 (August 1977) was Inplenented at 80% of intersections @ year later; but a substantial portion of drivers either did not know about it, or abused it to turn to eft. A ?campaign? was planned only in mid-i976,

* Information about TEC should be included in drivers test; driVers should be periodically retested when their licence expies. Public gervice tine on radio and television stations

(sone 12% of total broadcasting time) should be effectively used to enhance TEC.

© Contrary to the belief in the effectiveness of driver education, it has deen shown time after time that educational effort which is not reinforced by economic incentives and by Police enforcenent, is wasted. In a recent California expee

00 drivers were saturated with leaflets, tips and jow=to-do information. "Six monthe later, ?the rate of traffic yoolations and accidents in this groupe was the same ae in an

(uneducated control group (1u6, 2 April 1978). Ina federally

sponsored study (132; 83-34), ?Information on energy conserva:

Hon was found to be'the least offective of four apyroaches,

[Exnortation/pronpting" was the last-but-one in effectiveness.

Eoononic motivation was the most effective approach.

© Apart trom its continuity, education in the field of transportation in genoral and TEC in particular is probably most useful when it is not considered as a sector or element, bitas a diension and & tranenigeion belt of applied knowloage, from thi lecision nakers, thraugh the administrators and technicians

to the individual motor vehicle operators,

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APPENDIX. A.

SAN JUAN PRANSIT

QUTLINE OF A POLICY ANALYSIS FOR DECISTON MAKING

By Jaro MAYDA

The author is Professor of Law and Public Policy in the University of Pierto Rico, Rfo Piedras Campus 00931; and Pringipal Investigator intls current study of Energy Conservation in Transportation in Puerto Rico (Center for Bnergy & Environment Research/U.P.R.

This menorandun, derived from the broader study, ie made available ina preliminary and separate form to provide a specific policy focus on the San Juan Transit plang, in view 2f decisions on the concept which need to be made in the near

The analysis and conclusions reflect the best present judg- ment of the author on basis of data available to him. They do not express any position of the CER.

october 1977,

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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 fom it is a rush job with only rudimentary randon 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 problen is conceived in this analysis as

a particular problem of allocation and management of the total

Fesources~-hunan, energy, environmental, econonic--in other

words, an econanagenent problem ousceptible of being attacked

by the particular kind of systen analysis/synthesis which is

?the methodology of econanagenont.

In this framework, the scattered pieces soon to fal) in place

ghough to wake possible the threshold decision. The ball te

?then back in the technical planners? court.

While the typescript was being readied, the Anerican Public

Transit Association met in Atianta. Statements made there by

federai and state officials confirmed the policy premis

summarized in Section 2.2 below.

eM.

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Appendix A-3

suIOARY

?This meaorandum draws attention to the policy defests of past planning and cost-benefit analysis related to the San Juan Transit (832).

Tt assumes that the next round of competition for federal funds will take place at the beginning of FY 1979.? Very early deck~ sion in principle is necessary to meet this deadline with a competitive revised proposal. The state funding conmitnent must be accompanied by other advance steps related to Trane: portation Syetem Managenent.

There appears to be a substantial convergence between the most Pragmatic concept of the SJT and the present federal funding pricritice,

The "Metro" alternatives of 1976 are analyzed under the assunp- tion that the more simple, innovative and dollar-effective the SUP will be, aid the more'positive social cost-benefit ratio it witt achieve, the higher the probability of 4 funding. The? social accounting includes not and technical-oporational factors such as speed and capacity, but also considerations of energy efficiency, lend use economy, air quality, safety and long-range flexibility.

To enhance both the economic feasibility and the social balance of the $JZ, an innovative approach to the dominant mode and to its interface with the private vehicle transportation sector, 19 unavoidable.

?The concept which appears best justified in terme of a synthesis of the various policy consideration is proposed for technical and econonic reevaluation. Tt ig a modified Poly-Modal Alterna?tive, organized around Light Kail Transit, with predominant at-grade guideway, no subway section(s), and operating in. a Pedestrian environment along the "Spine" --the Old San Juan to Rfo Piedras corridor.

Supportive concepts, incentives and disincentives are exemplified.

The available data are considered sufficient to justify an intul-

tive strategie decision with a time horizon well into the 2ist

century.

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rity

Appendix A-4

REPEATEDLY USED ABBREVIATIONS

Advanced Bus alternative

[san Juan] Metropoliten Bus Authority

Billion,

Bayanon Crescent alternative alignnent

British Thermal Unit

Heavy Rail

Improved Bus alternative

Light Raia

IR Transit

IR Vehicle

Milo,

Miles per gallon

North-South alternative alignnent

Poly-Modal Altemative

Poly-Nodal Systen

Passenger miles travelled

Private vehicle transportation system (on

Right-of-way

?SOMA San Juan Metropolitan Area

S22 Sen Juan Trensit

ISM Transportation System Management

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?The ?Spine? ie the Old San Juan - Santurce - Rfo Pledras

?segnent of the BC or the MMA alignnente.

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Appendix AS,

TABLE OF CONTENTS,

WITH SECTION SUMMARIES

Planning any transportation system is not pri-
warily a techno-economic problem, but a com

interrelated process of decigion making
about, and management of, human, social and
envirennental resources.? The policy analysis
in this memorandum aims at supplementing "the
technical submodel of the 37 with considera-
?tions derived from a broader social model. The
limited function of such an exercise ia to
raise questions at the technical end, and to
stimlate the process toward a timely and jus
Gifiable go-shoad decision.

1.1 Basie propositions concerni: =

geiented transportation plaming in Puerto
?Rico are Listed

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A threshold policy question ag to whether ex-
elusive 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 sectory and on the
Possibility of constrainte which federal fund=
ing might impose cn the most cost-effective
procurenent of equipment for the SJ7. ?The me-
torandun is, however, based on the general
asoumption that federal funding will and
should be sought.

2.1 Posgit e usive state

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Appendix A-6

plan for S37 ready at the beginning of

federal FY1979 see ee se tet ts

2.22 ?The federal "new look" for transit is in

accord with the real needs and means of

Puerto Rico sere ct rset ees 5

2.23 The better the SJT plane reflects real-

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

Bel

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33

?The pragnatic posture of the present adnini~ stration and the technical groundwork are fa~ vorable, ?The state nats

raised through a partial diversion of auto- related revenues (which ancunted to a total of $8690 in the last five years), combined with @ surtax on excess gasoline? consumption, modeled on the two-tier rate etructure for residential electricity consumption. The sur- tax is judged to be a priority mechanign be- gause of its multiple beneficlal impacts on ?the whole transportation system, beyond the initial financing of the SJ%. To enhance th probability of federal funding, ce steps toward TSI/TIP are a9

Assignnent to the 83? of @ portion of the to-
?tal state revenues from autonotiles. Rovi~
sion of the auto excise tax. Shift of the
corresponding portion of the gasoline tax re-
venues from highways to transit. Surtax on
excessive gasoline use, to be earmarked for
SUZ directly or through the general fund,

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3.6 Ingtitutional changes neod to accompany on

ational planning

& UME eee te ee

37 yum of this actions will ini-

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Puerto Rico, with the SJ

3.8 ation of policy recommendati:

soncerning the concept and finding sss ss «13,

3.81 Operative 15H Ss a precondition of SJR,

ERED greatly necaed irvespective sitit

3.82 Gasoline ourtax will be a substantial

initial source of revenue for the SUT

funding, but will decrease in proportion

to its full beneficial impact.

3.83 Gasoline surtax will not affect the essen-

?tial functioning of the present PYIS. It

should therefore not be mistaken for'a

@isincentive directed at the PVIS.

3.84 An SUT concept which is simple, efficient,

economic snd: therefore competitive in the

quest for federal funding, requires a

fresh, innovative approach.

4. SAN JUAN TRANSIT: INNOVATION AS THE PATH TO

Qf the options evaluated in the latest consult-
ing study, the dus alternatives I8/AB are not

gapable of solving tho transit problems beyond
1990) the total cost of AP ie higher than that
of URail; and bus transit can not have the ne-
eescary beneficial impact on the urban environ
ment. ?The rail and mixed options appear to be

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operating almost entirely at grade

pedestrian nail environment through-

out te tenger of Ponce do Lan Avanos

Gig San Juan to'Rfo Fiearas--is propo

Soncopt which is feasible economical iy. and

ctfere conaidersbie opportunities for pimilta-

Roots urban snd sossal enhancement, Other

Opportunities which such total ?raicst pian~

ning affords--ouoh ae the tranaformation of

Gid'san Juan ins pedestrian city, and @ water:

way fron Old San? Joan to. Catol ina Nerth--are

Geeeosted, Aspects of a decieion in favor of

?hernew Sir concept are discussed.

me t "Metro" study ouggest: =

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Accom: n-ctreut feeder svstem » . 2b

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Bosentially an AMA ?inprovement. Unrealistic

capital cost estimates. quick aaturation.

Later conversion to Li pos:

able. ?AB option more costly to opera:

IR. "Bus maintenance estinated costlier. Even

4B service deemed inadequato to permit effecti-

ve disicentives directed at PVTS. Bus unfevo-

rable on additional accounts: Snergy. Air pol-

lution. Ambiental noise. Accidents

18

cost ?Technical data bast

criteria for cost-benefit analys:

cal PTS projections. Technic

engineering.

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Gonventional design and assumptions. Construct

ion time and disruption. Balanced and open=

ended recommendations,

Reasons why "Metro '76" as presently conceived

ignot feasible Ste eet ee es 20

ochnological design unnecessary and too cost-

ly, for Puerto Rico and to win federal cupport.

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Appendix A-9

Insufficient calculated impact on urban and

human environment, and on energy efficiency»

46 which corresponds to transporta-

ee ee fovationg s+ s+ +20

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Right-of-way. Construction costs. Visual

controls. Cost of cars. lo need for climate

control. Frills vs. no-frills. UTA concludans.

4.8 Light rati su7 ae instrument onenviron=

mental reconstruction and erfiandenent + ss 2k

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9 A heroic" gecision to ban auto tre

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?Supported by OverwhoTming agunente ss... | 28

Transit economics. Routine engineering so-

lutions, Enhancement of retail business. Easy

pedestrian mobility. Possibility to supple~

Rent access and mobility by Dikeways.

Several prejudices need to be faced: The transference to the LRT of the "poor-man? of trolleys through unwarranted historical/economic linkage with the old San Juan to Rfo Pled=ras tramway. Erroneous impressions of deci-on makers thet any luunan operated aysten must

be inferior and that only an automated subway

ean function well. ?A planning complex about

obligatory operations deficit of any new tran-

sits The Sut"e intorfuce with the PYIS has

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Appendix A-10

patiefactorily addressed. Although no inmediate

Gecisions are called for, the following hypothe

sis should be analyzed: that the PYIS ts @ highly

Publicly subsidized systen; and that, if allow

a to compete on economically equal terms, the

SUP might require only minor disincentives ?di-

Fected at the private automobile

5-1 Welding? the WP see 58

Groative retrenchment. Feasibility of human

efficiency, The operations deficit complex.

5.2 The interface SNPS... 1... Ok

5.3 BOS in Puerto Rico ie a highly subsial,

Sransportation syston--which 1s also dicriai-

ory agains! oor, the aT =

8 ?oEhGr nOnoWers oi onobile. 35,

54 Some examples of subsidies are listed 2... 36

Gasoline base price. Gasoline tax. Transpor-

HEE, oO8E_ Be, 8 uhenion ofthe! GPr. Mawar

way user charges than in the mainland U.S.

Parking subsidies. Nonenforcement of park=

ing violations.

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6. CONCLUSION

The decision about San Juan Transit can not be based on ering and economic data alone, When the whole transportation and social model is considered within ?the indicated tine frane of several decades,

?the data base and the policy vectors become so com?

lex, that the decision on the principle must be in-

?tive. The empirical and analytical data avail~

gble are considered sufficient +0 make an informed Antuitive decision now vee ee ea teen 39

---Page Break---

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APPENDIX 8.

LIST OP SOURCES CITED AND CONSULTED

American Automobile Association. Your driving cost. (Ed. 1977)

Almod6var, I, Puerto Rico's renewable energy resources. CEER/
UPR. May 1977.

Altschuler, A. "The politics of urban transportation innovation."
?Technology Review 79(May 1977)51-8-

Anonymous. | "Agonda for the survival of the automobié

* techno

?logy Review 79(March-April 1977)65-6.

Bay Area Rapid Transit District [BART]. Document file, March-July

i977.

Bellone, S. et al. "Guidelines to reduce energy consumption

?thrown transportation actions.? Planning Environnent Briefs

1/3 (an. 1976).

Berry, D. The gasoline mileage book. She1i[011 Co.] Answer Book

#3. Houston TX, 1977.

Bonnafous A, & 3. Gerardin. Passenger transport demand in urban

?areas: Wethodology for analysic and forecasting. European. Con-

ference of Ministers of Transport. Roud Table 32. Paris 1976.

Ganbridge Systematics, Inc. Guidelines for travel denand analyses

of program measures? to promote carpools, vanpoole and public

?traneportation. FEA, Nov. 1976.

Carlo, E.P, Studies on the use of safety belts in Puerto Rico.

P.R: Traffic Safety Commission 1976.

Gans sommia; Departnent of Trancportation, rangpertation energy

conservation (Draft; by D.H. Benjamin & S.J, Balog). Jan. 1976.

California, transportation Plan Task Force. Energy and Transpor-

?tation. paper 12 (by W.J. Hoffman), June 1976.

Iden. Technology assessment. Tesue Paper 14 (by M. M. Morehed).

June 1976. pe wy >

One Be "Son nenortde autoneh te, eplenione, peared fron

ior of a traveling automobile,? Science 19911205. (2

March 1978). ne 2G?

Chaffey, PJ, "Time and fuel consumption for highway-user- benefit studies." Public Roads 31 (April 1960)16-21.

---Page Break---

BOB OB

E

a

a

Bie

26.

me

2B.

2.

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a

da

Appendix B= 2

Claffey, PJ. Running costs of notor vehicles as affected by road

design and? traffic. Highway Rosearch Board/NAS-NAE. Washington ign.

Consuttores Tonicos Asociados. Estudio de transportacifn de carga

len Puerto Rico}. San Juan, Decenber 1976,

Gooner, J.C. ?Solving the energy dilemma." The Futurist X1(1977)

228.

Cope, E-Hl. The effect of speed on autonobile consumption rates.

iti, October 1975+

Iden. the effect of 51

?August 1974.

fed on truck fuel consumption rates. PWIA,

European Co: ference of Ministers of Transport.

?Twenty-second Annual Report and Resolutions. Copenhagen-Paris

1975.

Impact of the structure and extent of urban development on the

Choice of modes of transportation: The case of Inrge conuhe-

tions. Round Table 33 (by P. Merlin). Paris 1976,

Energy Research Council. The report oy the Federal Task Force on

?motor vehicle goals beyond 1980. Vol. I: Executive summary:

wast ington, September 1976,

Evgis, i et al. Gasoline consumption in urtan traffic. Autonotive

Engineering Congress/Society of Automotive Engineers. Detroie 1976.

French A: 4.1. Bishop. Analysis of fuel savings through reduced

speed Limit: ?FHWA, December 1973 (rev. April i97h),

French. A. "ransportation energy considerations.? ?ranep. Engin.

Journal 102(Feb. 1976)27. os °

Geige! wope-Bello, N. EL ambiente de Caraca:

ecologia urbana. ?Caracas 1976-

Una introduccifn a la

Gerrard, M., ?Disolosure of hidden energy denandsi A new challenge

for NEPA.* Environmental Affaire "VOgfsheee: ne

Obtbert G; &J.8. Dajant. ?Energy, urban form and transportation

Dolicy.* ?nrangp. ?Research VIET (gTeIEGe? *

GonaBlez-Tejera, E. Transportation in Puerto Rico: A search for

& new regulatory philosophy. Rfo Pledras, PR. 1974

Gorgiti--Calvelo, E. Contaninantes ataos!

afviles. Thesis, 0. of Puerto Rico, 1976,

fricos producidos por auto-

Grey, J: 0 al. "Fuel conservation and applied research,? ?Science

200 (iu apr. "1978) 135.

Hagnond, AL. "Alcohol: A Brazilian answer to the energy oriei:

Science "135 (11 Feb.'1977) $68~

---Page Break---

Appendix B= 3

Hanson, ME. & J.W. Witchell. A model of transportation enerey ise in Wisconsin Denorraphic considerations and uitersative seevarios. Eneruy Systeme and Policy Recearch Group/Ingtitute for Environ mental Studies, U. of Wisenngin. Madison Wi, December 1975,

F

yoo, De Energy: The cage for conservation. Washington (Worlawatch Institute), January 1976.

Raye of hopes The transition to a post-petreleum world. New

iF.

Mealy, R.G. & HR. Herzfeld. Bnercy conservation utrategies. Wash

ington? (Gonservation Foundation) neds [1973].

er C. et al. ?The distrust of nuclear pow

+ 1997)25.

Science 196

Ingurance Institute for Highway Safety: Profile. Washington 1975.

BEE RE F

Towa Department of Transportation. Energy and transportation for

?the future. May 1977.

Inwin, WA; ct al. A model used of recyeling act. Washington (En-
vironmental Law Inctituto for ERDA) Autust 1976.

Kelley; B. Speed and car crashworthiness: Unfixing a great gulf.
Washington (IIHS, see Lton 33) 1973.

Kent M-P., ?Fuel. and tine consumption rates for truck in freight
Service." Public Roade KXX1 (April 1960)22.

targe, D:B. the hidden waste. Washington (Conservation Foundation)
mea: Li995)

Ligton: U1, & C-A. Aiken. Cost of owning and operating an autono-
biler 1976. Washington? (FIWA) 1976"

Uimnroth, M. gt al. Energy in transition. Stockholm (Secretariat
for Future Studies), March 19?7-

loving, A.B. Bhergy strategy: the road not taken. or 2,

October 1976. ey reign Affair:

we

wee

wa

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ee

a2

weer fetes in tetig CONCH description of auto fuel economy and

Beeler ne Aieogeent Rodel care. Automotive Mgineering Goretocn?

Society of Automotive Engineers, Detroit, Februsey toice

AB. Iden ot al. Simulated sensitivities of auto fuel econony, perform.

ance and emissions. Idem, Bye Benforn,

42. Mupreld, J-D. et at. Light duty autonotive fue

through ipp7e* Saz?, Meh? duty automotive fuel economy - trends

40, Mark, RAK. & DE, Stuart-Alexander. ?Disaster

of benefit-cost analysis." Science 197(16

---Page Break---

Appendix B.- 4

4 Waugh, 1.8. 11. "Rorefined of1+ An option that saves oi2, minini-

he Mansy? polation.? ?Selence 19937 Sopee 1976)1100~

2a Mayda, J.

.. EnvSronpent & Bron conservation to econanagenent.

= ?Rfo Piedras PR 1967, 1968.

San Juan Transit: Outline of a policy analysis for decision ma-

& king. October 1977 (see Appendix A.)

22 "he legal-ingti tutional framework for environmental, resources

&: UNanagenon®. (ecominagenens).? Legal provection of the environ

(cotfoqultim 197k) ubiiestion

ont? in developing eounar

Tat, heioo 19779 Linas.

1 "Eeology of changes Toward planetary eccpanagenent? (Keynote

& address, International Symposium III, EXPO'74, Spokane WA). In

Gike Dalen" CoR-aipton (ede), Creating the futures? Aventas

for" tomorrow. "Columbus Of (Batelle Instivate) L975.

Mela, D.F. ?How cafe can we be in snail cars?" Proceedings, IIT.

International Congress on Autonotive Safety. Washington (GPO) 1974,

Morales-Cardona, T. & V. Sfinches-Noralé

"Realidades y perspecti-

vas en el ugo?de energfa en Pierto Rico." Rev. CIAA de P.Re

XXIV/2(1973)46.

Nagsau, County of [L.I., NY]. Office of Public Transportation. Nassau County public mobility plan. Mineola NY, June 197? (rev. July 1978).

Nago/Committee on the Challenges of Modern Society. ?Symposium on low pollution power systems development (Conference, Ann Arbor MI, October 1973). NATO Doe. 32, n.de L197H].

BR FP

Bg

National Research Counci1/NAS. Committee on Nuclear and Alternative ?Energy §; ?Unite Statos energy? demands Sone low energy futures.? yee 200(14 Apr.i978)1e2.

National Safety Council. Accident Facts - 1976. Chicago 1976.

EDC. Environment Directorate. Environmental implications of options An?urban nobility. Paris, September 1973.

PBB

Idem, Evaluation of traffic policies for the improvement of the

?urban environment. Paris 1996.

"Mme potential for fuel conservation: The case of the

"'Pransp. Research VIII(197#)247.

2

Betimated highway fuel cavings. FHWA, November

ce

p

Pollard, J. ot al. A sumary of opportunities to conserve trans-

Portation energy. Washington (DOH/Oftiee of Mransportation Bnerey

Policy) August 1975.

---Page Break---

Appendix 3-5

Puerto Rico. Conisién de Servicio Pfiblico, Estudio de transporta~
eign torrestre de carga en Puerto Rico.? San Juan, Janvary? ioe,

Iden. Documentation file.

Puerto Rico, Department of Consumer Affairs. The energy conserva-
?ton plan of [for] Puerto Rico. Technical Report Nov2, waren i977,

Puerto Rico. DrOP/isghway Authority. Tol system ooonomic feasibi-
Ui studs PR ?58 [Eno intricas Bepresenay}e oy Wr Saleh hese
siates. "Novenber i966.

BE BP P

Iden. abt Coste de poseer y operar un automBvil en Puerto Rico. 1979
(upaatea 1977).

Taga, The recommended plan and growth analysis Mayagtex. Tranopor-

?tation study: Summary. nds [9707

Iden. Idem: Ponce.

Top, San, Juan Metropolitan Area Transportation Study. By $.¥

ailla y Asociados and A.W. Voorhees & Associates. ?Sine 197m,

PF PEP B

fdgm. Metro for San Juan: A study of transit alternatives for the

Metropolitan Area of San Juan. Drafts by Gonsultsres Teenivon

Asociados and A.M. Voorhees # Assoc.) Ostober 4e6°

Idem. | Status del proyecto de transportacitn colectiva répida (Netro)

para el Area Metropolitana de San Juan. Revised Septenbes 1s¢e°

Idem. Puerto Rico Highway Statistics 1974-75 (updated tc 1977).

Iden. | Transportation system management for the SJMA 1976-80,

ALLL 1976:

De

The

2,

Pegrte Rico The Governor's Advisory Council for the Development of

Government Prograna. People and their envirennenss NCGLepeeMt 22

ZL. Fugyto Rico. Office of Economie Opportunity. Mw impact of the ener.

2, {nhsacon, the" tow Income people in Aisrto Ricsr ef ney ener

Setions?Sepeenter 1975.

28. Purte Rico. Office of nergy.

&: F- Castellfn, Ponencia ante 1a Cons

P, del S. 462. aren 1978.

Ja Ayase MONEY, efficiency in the mass transit aysten of the

Fogsunah Me®ropolitan Area. Rogearch Report No. 2° Presto Ries

Fegsonal Energy Wodel/Transportation Submodel.? Seprany Weis"

2a. Pwrte Riv. Office of Petroleum Fuel Affaire,

Hpeanientos para 1a forgulacisn de wa polfticn energttica para

Puerts Rico. December 1976. * pas

4+ Smopsis of the energy situation of Puerto Rico, 1976. Apri 1977.

?sign del Senado sobre el

---Page Break---

:

85.

86.

82.

88.

82.

20.

ae

Be

De

De

25n

6

22 Statement of the development of thePuerto Rico Energy Model.

April 1977.

Puerto Rico. Jynta de Planificacifn. Plan de uso de los terrenos y

?transportaciént Area Metropolitana de San Juan, 1985. August 1970.

Iden. Statistics on petroleum products and motor vehicles. August

1976.

Iden. Monthly economic indicators of Puerto Rico (1977).

Iden.

Informe econfmico al Gobernador, 1975-76. May 1977.

Idem, Socioeconomic otatistics of Puerto Ricor Fiscal years 1940,

3950, 1960, 1965-76. neds [1977 }-

Puerto Rico. University of see University of P.R,

Rechel, B, Transportation policies and energy conservation. Wash-

{ngtin (conservation Founeation) neds (19/54.

Rice, R.A. System energy as a factor in considering future trans-

Portation. New York (ASME) "1970.

Ross, Mi. & RH, Williams, "The potential for fuel conservation.?

Technology Review IXXIX(Feb.1977 349.

Santiago VAzquez, A. & Assoc. ?Transportacién 2000, [Part oft Pro-

yecto San Juan 2000]. March 1976.

Schipper. L. & AJ, Lichtenberg. "Efficient enerey use and well-

being: The Swedish exanple.® Science 194) Dee. 1976}1001~

Stanford Research Institute. Long term energy alternatives for

?automotive propulsion: Synthetic fuel versus batvery/electric

Syston. (EcE, Hughes et al: for NSP). Auguet 1976°

Iden, A nethodol genent of passenger

?transportation Re ah. tor UssNavy

and BROA). April 1977

Systen Design Concopts (N. Petersilia & A. Reno). Operating multi-

?Roda urban transportation systens. DON, Decenber 1977 =

Taplin, J-H.E. "Energy and transportation in an island continent.?

ransp Research VIII (1974)259.

Taylor, J.T, et al. Major interchange design, operation and traffic

control. Vols I-III. ?FHWA, July 1973. ?

?Transportation Research Board/NRC/NAS. Light Rail Transit. Special

report 161 (National Conference, Philadelphia, June 1975). Wash-

ington 1975.

Idem. Advisory Committee on Light Rail Traneit. thie is light rail

---Page Break---

PER ER

BF

BE E

BEE

a

B.

ud

E

Appendix B- 7

transit. Washington, June 1975.

Iden. Transportation programming, economic analysis and evaluation

?Of enerey constraints, Boo. TRA 599. washington 1976.

Iden. Urban transportation alternatives: Evolution of federal poli-

cy. Special report. Washington 197.

?Trangportation Regearch Institute [Carnegie-Wellon U.] Urban rapid

Gransits Concepts and evaluations ?Pittsburgh 1968.

Idem, latent demand for urban transportation (by L.A. Hoel et al.)

Pitteburgt, ned. [1969].

?The Road Information Program [TRIP]. The effect of eubstandard

roads on Vehicle operating Sosts in Pennsylvania. Washington.

Nay 1977.

?TUS (transportation and Urban Settlements] Planning. San Juan

bigyele transportation study. San Juan (DPOP) July 1975.

University of Puerto Rico, Office of the Prosident (for P.R. Envi

ronmental Quality Board). Energfa: su uso e implicaciones en

Puerto Rico (by &. Gonzfiex). May 197%.

0-5, Congress. House Suboomnt ttee on Energy and Power. Middle= and

long-range, energy policies and alternatives. Hearings 25-26 Narch

1976.?Washington, 1976.

Iden. Office of Technology Aa

?transit. December 1975.

sement. Energy, the economy and mass

Iden. Senate Committee on Internal and Inaular Affairs, Political
?and economic factors governing access to energy in the decade
ahead. Hearings, 1 Poberuary 1977. Washington 1977.

U.S. Council on Environmental Quality. The growth shay
Systems and Engineering). Washington, Way 1976

8 (by Urban

Idem. Environmental Quality ~ 8th annual report, Washington 1977.

U.§; DOU/EINA. Nationwide? personal transportation study. Nos 1-11,
Wastington, April 1972 - December 1974. a

Torr, Federal-aid highway program manual. Updated. 15 April 1976.

Idem. Right-turn-on-red °AT0R], Vol. + Final technical report
UY wie ates ef aly oP Arti vourhoes & hoase So nas doe

don. Energy, conservation in ground transportations A comparison
f alternative strategies. August ir me

U.S. DOI/MHSTA. Another look at car eize and safety. October 1973.

on, A statigtical relation between oar wolght and Anjur

Sebruary 1975. te

---Page Break---

BF BREE

BE EI

F BEBE BBR E

Idom. ?Traffic safety - 1975. Washington, n.d.

Idem. 55 MPH Fact Book. Washington, December 1976.

Idom. Automotive fue) economy program. iret Annual Report to the

Congress. Washington, January 197.

Idem, Data and analysis for 1981-1984 passenger autonoblle fuel

?economy standards.? Summary report and Documents 1-s, February 1977.

Idem. Passonger automobile average fuel economy standards. 41 Fed. Register 10311. 22 February 1977.

U8, pot/transportation Systens Center. Energy primer. Washington 1976.

Ug, DOT/WITA. CuldeLines to reduce energy consuaption thro Brangporttion actions toy? Aili Voorhees @ hesoe,)e kay aE

Idem, Energy efficiency of differont urban modes (extract). n.d.

Idem. Light rail transits A state of the art review. Executive ?summary. (By De Louw, Cather).[Spring]1976

Tdgn, (together with the Niagara Frontier Transportation Authority). Bufsalo Light Rall Rapid Transit Project. Snvironaental Impact, Statenont (draft, June 1977; final, December 1977).

Iden. Transportation system management: The record and the look ahead. January 1978.

U.S. BPA. Factors affecting fuel economy. Publication PM-215. Washington 1977.

Idem. The need for and benefit of inepection and maintenance of intuge motor vehicles (M.P. Waleh, ed.). November 1976.

Iden. Transportation controls to reduce automobile use and improve air quality in cities: ?the need, the options and effects on urban activity. November 197i,

Iden. ?Trends in the quality of the nation's air. march 1977.

Iden (with DOE). 1978 Gas mileage guide. Second edition. Febr.1978.

Ug, EROA. A national plan for enerey

jenonstration. June 1975. Update 4976.

Iden. Transportation Energy Conservation Data Book. Ed. 1 (by D.B. Shonka et al.) October 1976. Supplement III (by A:S. LoebL) Hay

arch, development and

Idem. Introduction to the ERDA Electric & Hybrid Vehicles Denonstra-?tion Project. March 1977,

---Page Break---

gk, Idem, transportation energy conservation: A program plan of policy-oriented research (by MITRE Corp.), Washington, nd~ [1975]

35. U.S. FEA. Energy reporter (file).

126. Ward, D.E. & D.C. Kendall. Providing increased transit capacity during peak period: Examination of two techniques. Technical report. Washington (DO?) February 1975.

32. Washington. University of. Department of Civi1 Engineering. Regional txvfronsonyay syotens, [Assessment of NSE/HAMMeATo}eGRE] Beene ear Near [19774

138, Wheaton, W.c. Price induced distortions in American highway investment. Draft paper. Cambridge MA (NIT, Department of Eeononics and Urban Planning), February 1977.

39. Wendell, A. "Conserving transportation energy." Oregon L. R. LIV

(2975)503.

Wohl, M. "Increasing the tax:

Rev. (July-August. 1976)i5.

E

8 role in urban Anerica." Technology

Buggy of National. Aftairs (BNA). Environment Reporter. Current

developments (file). Waching?

Fortune. Chicago IL. (file).

Moneysworth. New York NY (fi2e!

Now York Times (file).

Time. New York NY (file).

San Juan STAR (file).

United Press International [UPI] (file).

FEREREE EF

U.S. News & World Report. Washington (file).

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