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POTENTIAL ENERGY SAVINGS IN THE LIGHT-VEHICLE, LONG-HAUL-TRUCK, AND BUS MARKET SECTORS

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1.0 INTRODUCTION

The purpose of this task was to estimate the potential oil and gas savings that could be realized in the transportation sector. These savings are calculated for the years 1980, 1985, and 2000.

To date, two market sectors have been analyzed; light vehicles (automobiles, light trucks, and vans) and large vehicles (long haul trucks and buses). This paper describes these analyses. These two market sectors plus intermediate trucks (intracity freight carriers) comprise the highway component of the transportation sector. Savings have not been identified for intermediate trucks.

Potential savings are identified at the physical system and operational option level and then aggregated by generic approach. The potential generic approach savings are further aggregated by market sectors.

The physical systems and operational options investigated are shown in the transportation sector "tree" developed by the ERDA Office of Conservation Planning and Analysis. See Figure 1.1.

In calculating potential savings the physical systems level is, where appropriate, subdivided into programs. In some cases, the structure of the "tree" was altered because of the format of available data and sources used to estimate savings. Additions were made to the tree as other conservation options were revealed in the investigations.

Savings are a function of both market penetration and the technological characteristics of the old and new options. To estimate "potential" savings 100% market penetration is assumed, as a ground rule of the analysis, except where total penetration was judged highly infeasible. Such cases are noted. It should be clear to the reader that 100% penetration, or maximum feasible penetration, will rarely be realized. The estimates in this paper should thus be treated as measures of leverage rather than as expectations of actual savings.

Such "savings" at the generic approach level are aggregated from the physical systems and operational options level according to the following guidelines:

- Where technologies, or options, compete, the competitor with the largest potential is used to calculate generic savings.

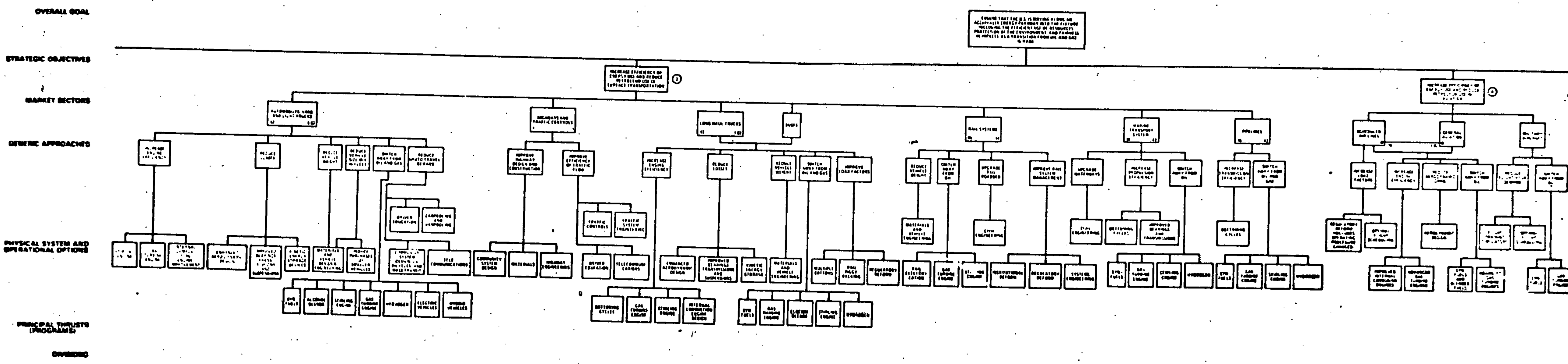


Figure 1.1 Transportation Sector "Tree"

- For the most part no attempt was made to estimate the synergistic effects of the various options. Non-competing options are simply summed to obtain generic savings. Exceptions are noted in the sector discussions below.

The baseline against which savings are computed is the "Before Conservation High Demand Scenario" generated in MOPPS, Phase I. This scenario reflects both the Energy Policy and Conservation Act (EPCA) and the Energy Conservation and Production Act (ECPA). The scenario does not reflect "The Energy Act" currently being considered in the Congress. The MOPPS, Phase I projected energy demands for highway transportation are shown in Table 1.0.

In addition to potential savings, estimates of the cost of the savings are developed for selected physical systems. These estimates are calculated as dollars per barrel of oil saved and are discussed in the market sector sections.

The remainder of this paper provides the estimated potential savings. Included with these savings is a description of the methodologies used. The potential savings are shown on charts following each generic approach discussion. References to documentation are also provided at the end of each generic approach discussion. The report is organized by market sector and generic approaches and at the end is a summary along with conclusions.

TABLE 1.0

MOPPS, PHASE I PROJECTED ENERGY DEMANDS
(Before Conservation High Demand Scenario)

	ENERGY DEMANDED (QUADS)		
	1980	1985	2000
Small Auto	1.81	1.66	1.85
Middle Auto	2.51	2.30	2.55
Large Auto and Small Truck	6.64	6.55	7.98
Intermediate Truck	.67	.73	1.21
Large Truck	1.45	1.69	2.82
Bus	.11	.13	.22

2.0 LIGHT VEHICLE MARKET SECTOR

The light vehicle market sector includes vans, small trucks, and automobiles. Light trucks are personal trucks and recreational vehicles. The potential savings are shown on the attached charts, each of which displan one or more of the generic approaches in this sector. The generic approaches treated are the following:

- Increase engine efficiency
- Reduce losses
- Reduce vehicle weight
- Reduce vehicle size mix in the fleet
- Switch away from oil and gas
- Reduce auto travel demand

2.1 INCREASE ENGINE EFFICIENCY (See Table 2.1)

1. Continuous combustion (gas turbines, stirling)

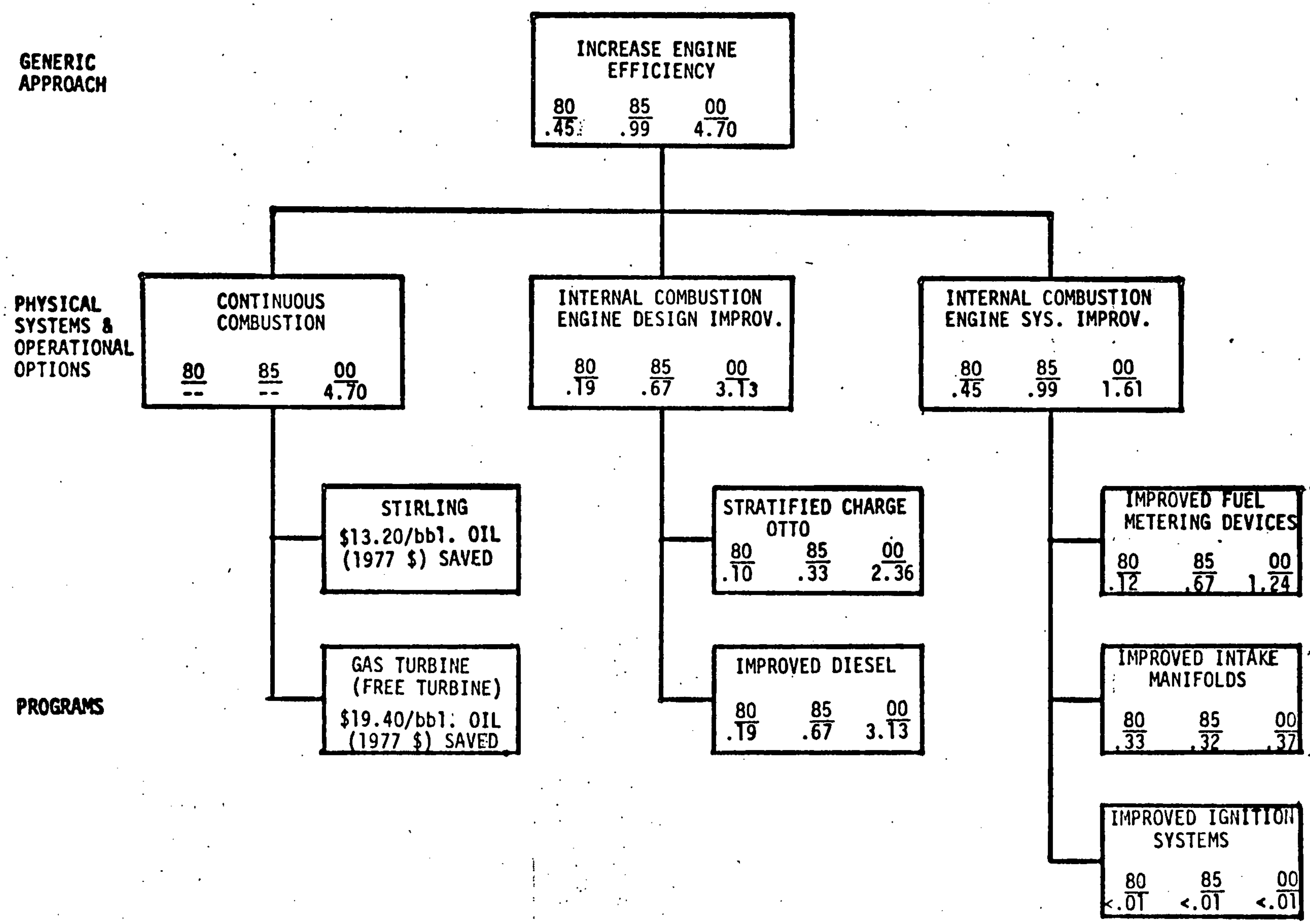
   - Fuel economy improvements from MOPPS (Ref. 2)
   - The mature configurations capture 100% of the market until the advanced is available
   - MOPPS assumes continuous combustion engines only compete in large passenger auto market. These calculations are based on the continuous combustion engine penetrating the entire light vehicle market (per APSES, Ref. 1).
   - The cost per barrel of gasoline saved is computed for the Stirling and Brayton (free turbine) compact autos. The cost estimates are from APSES and the barrels saved based on 100,000 miles of driving. For comparison purposes the June 1977 price of gasoline was \$28 - \$29.

2. Internal combustion engine design improvements

   - Fuel economy data from APSES
   - Assume mature diesel and stratified charge (SC) Otto engines available in 1980 (APSES)
   - Advanced SC Otto assumed available in 1994 when ERDA completes program on ceramics--diesel assumed available in same year for purposes of comparison

TABLE 2.1

LIGHT VEHICLES; INCREASE ENGINE EFFICIENCY



3. Internal combustion engine systems improvements

- Savings and Commercialization dates from MOPPS

REFERENCES:

(1) Jet Propulsion Laboratory, Should We Have a New Engine? An Automotive Power Systems, Evaluation (APSES), Vol. II California Institute of Technology, June 1975.

(2) Transportation Working Group "MOPPS", Review Draft, June 13, 1977.

2.2 REDUCE LOSSES (See Table 2.2)

1. All options

- Fuel economy gains and commercialization dates extracted from MOPPS and verified by other sources

- The savings computed for kinetic energy storage devices represent savings from only regenerative braking

REFERENCES:

(3) "MOPPS"

(4) APSES

(5) Colyer, CC., and Martens, S.W., and Stahman, R. C., "eds.", Automotive Fuel Economy, Progress in Technology Series, Vol. 15, Society of Automotive Engineers, Warrendale, Pa., 1976.

2.3 REDUCTIONS IN VEHICLE WEIGHT AND THE FLEET SIZE MIX (See Table 2.3)

These two generic approaches are actually the same. Both approaches seek to improve the fleet's fuel economy through decreasing the fleet's average weight. Potential savings are computed first by assuming a specific weight reduction and also by assuming a law mandating more stringent new fleet economy standards. Savings are computed only for automobiles for the year 2000. To reach the 1985 EPCA mandated standards will require extensive retooling of automobile assembly units at substantial costs. Fleet fuel economy improvements over the mandated standard are probably infeasible by 1985.

1. Reduce vehicle weight (specific weight reduction)

- According to various automobile manufacturer documents submitted to Congressional Committees, the EPA and the Department of Transportation, the average inertia weight of cars is projected to decrease from over 4,000 lbs. in 1977 to around 3,000 lbs. in 1985. (Ref. 6). This weight reduction is planned so that the auto manufacturers can comply with the 1985 new fleet economy standard of 27.5 mpg.

TABLE 2.2

LIGHT VEHICLES; REDUCE LOSSES

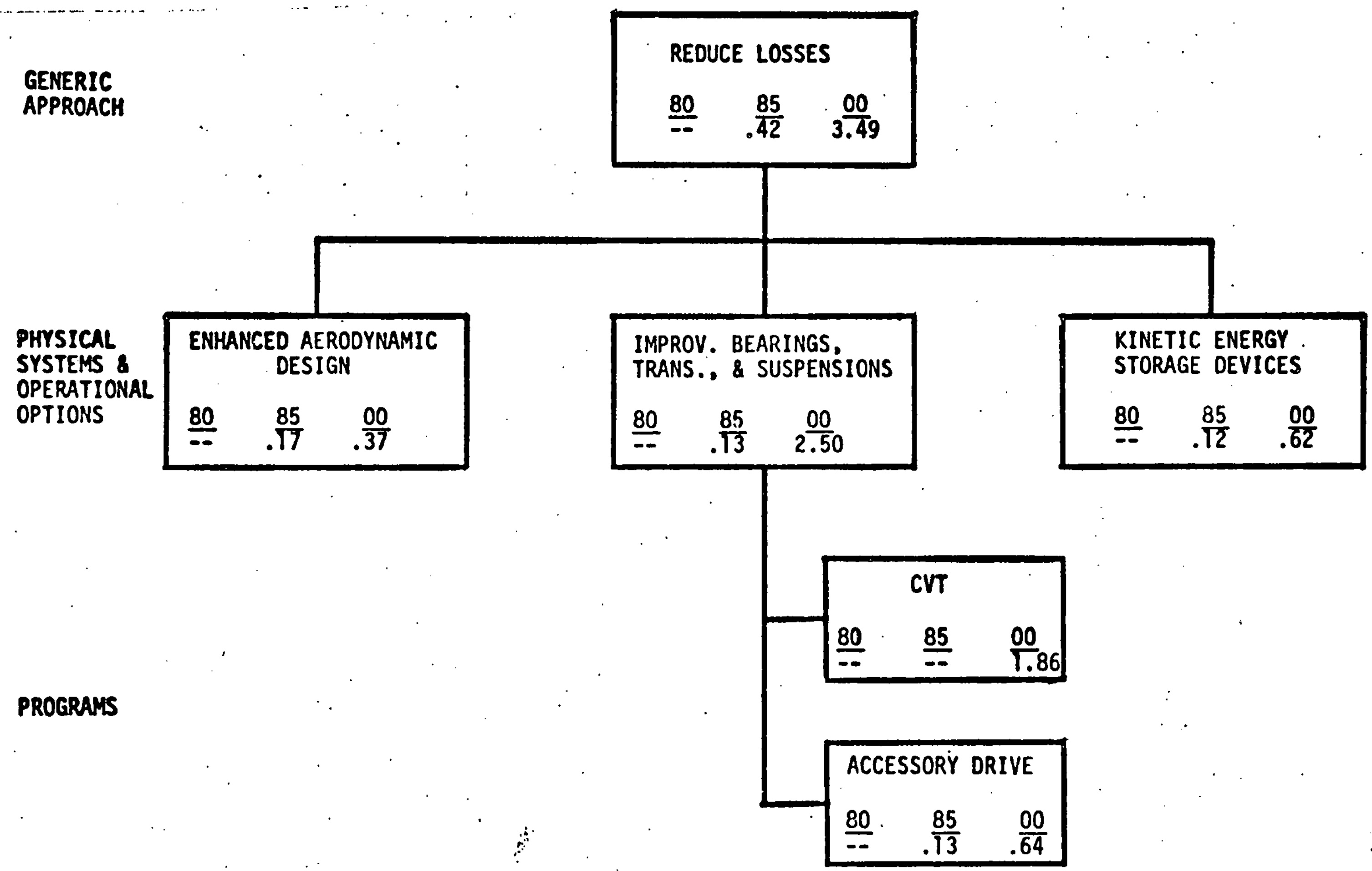


TABLE 2.3

LIGHT VEHICLES; REDUCE VEHICLE WEIGHT AND SIZE MIX IN FLEET

GENERIC APPROACH	REDUCE VEHICLE WEIGHT	80: --	85:	00: 1.12
PHYSICAL SYSTEMS & OPERATIONAL OPTIONS	MATERIALS & VEHICLE & ENGINEERING	80: --	85: --	00: 1.12
GENERIC APPROACH	REDUCE VEHICLE SIZE MIX IN FLEET	80: --	85: --	00: 1.92
PHYSICAL SYSTEMS & OPERATIONAL OPTIONS	INDUCE PURCHASES OF SMALLER VEHICLES	80: --	85: --	00: 1.92

The projected average fuel economy for autos in 2000 is 27.5 mpg. ("MOPPS") The projected potential savings in that year reflect fuel economy gains if the average inertia weight is decreased to 2,500 lbs. (Ref. 7, 8, 9, 10) New cars sold in 1976 about this size include the following: Opel 1900, Dodge Colt, Renault 12Tl, and Toyota Corolla.

2. Reduce vehicle size mix in fleet (more stringent economy regulations)

- Other than new combustion technologies the most effective options which auto manufacturers can employ to affect increased fuel economy is to decrease the weight of a car and decrease the horsepower per unit weight. Therefore more stringent new fleet economy standards would probably induce a smaller vehicle size mix in the fleet. The potential savings shown for 2000 were computed by assuming the new average fleet economy standards are increased 1 mpg/year from 1990-1999. This would result in a new fleet economy average of 37.5 mpg in 2000.

REFERENCES:

(6) "Detroit's Response to the Energy Problem," Business Week, May 23, 1977.

(7) U. S. Government, The Report by the Federal Task Force on Motor Vehicle Goals Beyond 1980, Draft, Vol. II., Washington, D. C., September 2, 1976.

(8) Hunter, D.A., and Lee, W.D., "A Study of Technological Improvements in Automobile Fuel Consumption," A. D. Little, February 1975. (This article is contained in Ref. II-3).

(9) U. S. Government, Interagency Study of Post-1980 Goals for Commercial Vehicles, Draft, Washington, D. C., June 1976.

(10) Burek, C. G., "Plastics Take the Pole in the Light-Car Race," Fortune, July 1977.

2.4 SWITCH AWAY FROM OIL AND GAS (See Table 2.4)

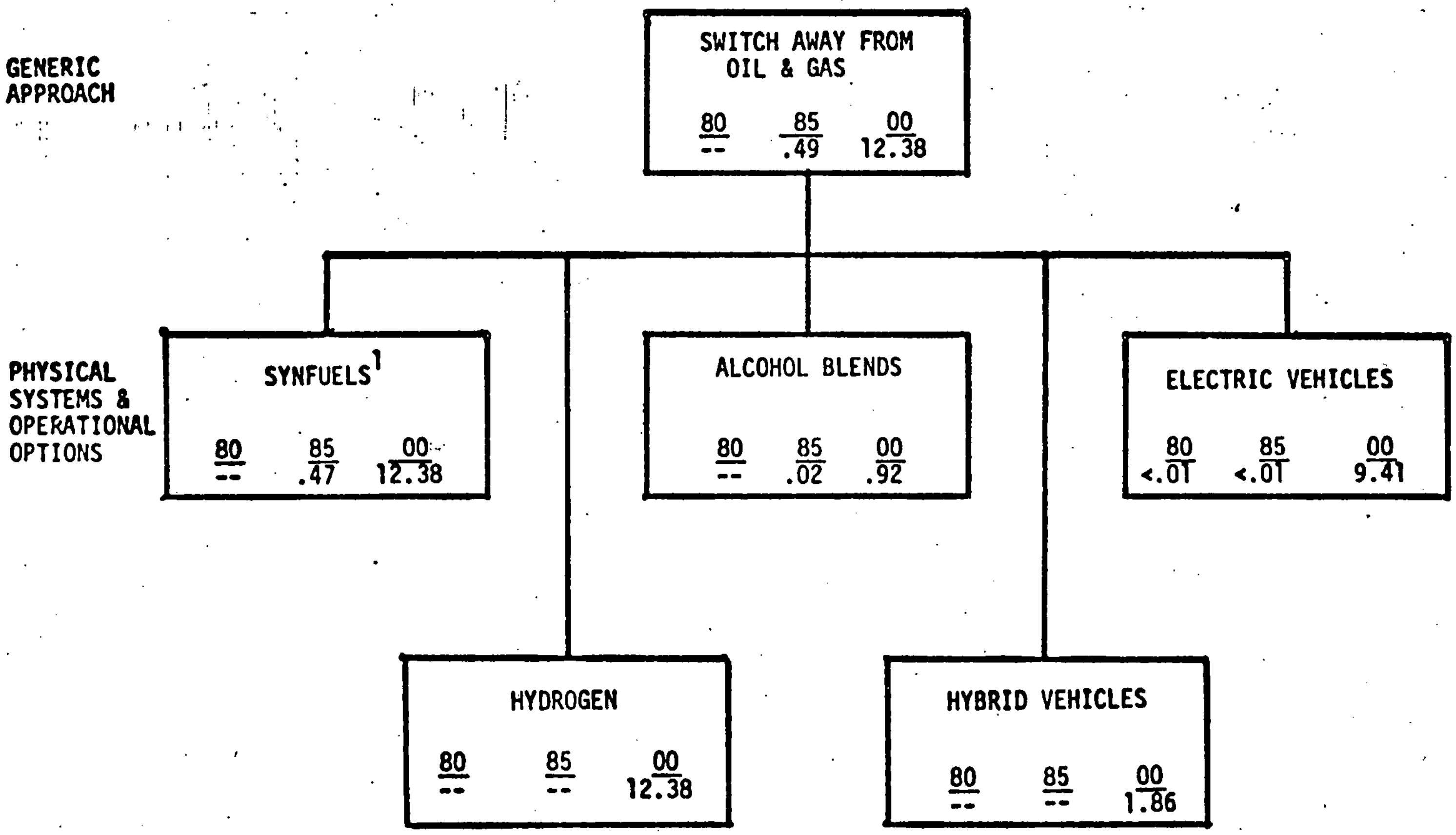
1. Synfuels

- Tar Sand, shale oil, and coal liquid projects require 8-10 years to plan and construct. Therefore, it is assumed only those plants currently planned or actually under construction have the potential for displacing petroleum products in the 1980-1985 time period. To obtain potential savings it is assumed all of these plants will in fact be constructed and at the upper output level being considered. These plants were identified in Synthetic Fuels. (Ref. 11)

- Synfuels, including methanol, have the potential of displacing 100% of the oil used in this market sector in the year 2000.

TABLE 2.4

LIGHT VEHICLES; SWITCH AWAY FROM OIL AND GAS



[1]COST PER BARREL OF OIL SAVED: (1977 $)

	$/bbl.	$/MM Btu
SHALE OIL (MODIFIED IN SITU)		
IN-SITU RETORTING.	23.65	4.95
ABOVE GROUND RETORTING	25.85	5.25
COAL OIL	35.95	6.20
METHANOL	23.20	9.65

- The total potential production of synfuels in 1985 is 1.5 quads. The number shown reflects proportional distribution of the synfuels to all oil consumers.

- The costs per barrel of crude saved are from MOPPS, Phase II, Pass III. Costs are also shown in dollars/MMBtu because the heat content of the synfuels are different from crude. The June 1977 refinery gate price of imported crude was $14.55/bbl. ($2.50/MMBtu). The price of coal feed stock is assumed to be $1.10/MMBtu.

2. Alcohol blends (Ref. 12)

   - The same methodology for computing 1985 synfuel savings is used for alcohol blends except that the savings shown is the entire potential production of methanol from coal.

   - The potential savings in 2000 reflect a 15% blend, by volume, of gasoline and methanol. This is the upper limit which would not require extensive engine modification. This amount of methanol would require the following:

     a. Blending at the pump to minimize water in the system

     b. Butane removal from the gasoline

     c. Minor fuel system modification

   - The potential savings in 2000 is not simply 15% of the projected consumption because methanol has slightly less than half the BTUs than does gasoline per unit volume.

3. Hydrogen

   - While hydrogen has the potential for displacing 100% of the oil used in this market, Exxon has determined it is not a feasible alternative candidate to petroleum. (Ref. 12)

4. Electric vehicles

   - 1980 and 1985 savings from MOPPS. (Ref. 13)

   - 2000 savings based on electric vehicles displacing conventional light vehicles for all trips less than 50 miles.

5. Hybrid vehicles

   - Savings based on potential fuel economy improvements estimated in APSES. (Ref. 14)

REFERENCES:

(11) Cameron Engineers, Inc., Synthetic Fuels, Quarterly Report, Vol. 14, Number 2, June 1977.

(12) Exxon Research and Engineering Company, Feasibility Study of Alternative Fuels for Automotive Transportation, prepared for the EPA, Ann Arbor, Michigan, June, 1974.

(13) APSES

(14) "MOPPS"

2.5 REDUCE AUTO TRAVEL DEMAND (See Table 2.5)

1. Carpooling

- Savings computed are based on an estimation of the national potential participation in carpooling. This estimation is 71% of peak period auto trips. If this potential is realized average auto occupancy would be increased from 1.2 to 1.7. (Ref. 15, 16)

2. Vanpooling

- Recent experience has shown that vanpooling works best when organized from the employer side because a great deal of logistical work is required. A general rule of thumb is that a site must have 250 employees before there is likely to be a vanpool potential. (Ref. 17)

- Vanpools are currently economical for round trips greater than 50 miles. (Ref. 18, 19, 20) As fuel prices increase this distance will decrease. Savings are estimated by assuming 100% employee participation in companies with greater than 250 people at one site.

- The savings in the parentheses indicate potential savings if all commuter traffic shifted to vanpools. Given that rising gasoline prices will decrease the distance and the required number of employees to make vanpooling economic, the two estimates shown bracket the vanpool potential.

3. Driver education

- Savings estimated from a Stanford Research Institute methodology developed for the FEA State Conservation Program. (Ref. 21)

4. Mass transit

- Savings were estimated based on a study which examined mass transit potential based on a combined strategy of auto disincentives and mass transit incentives. (Ref. 22)

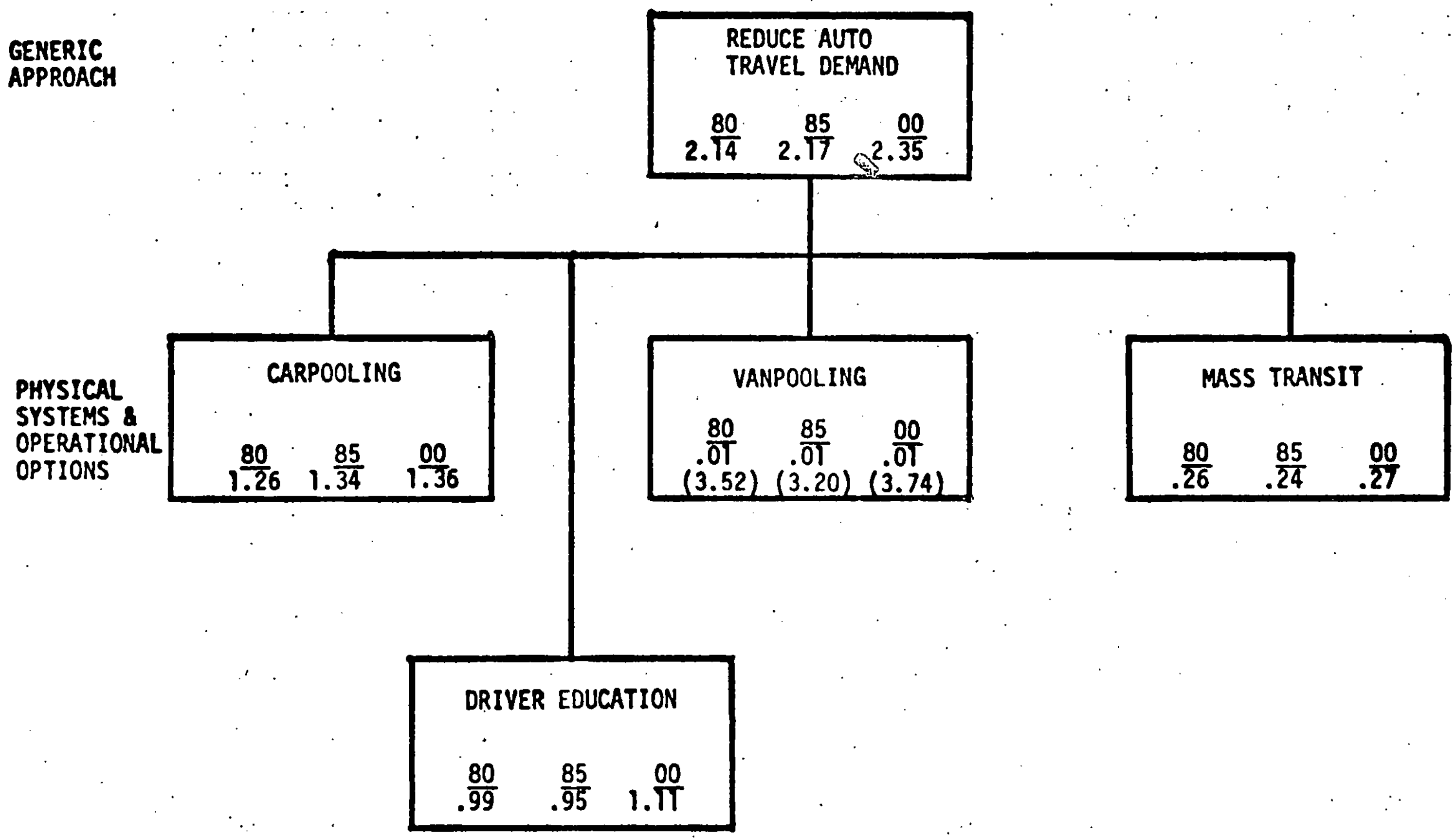
Savings at the generic approach level are computed by first calculating the vehicle miles demanded after the maximum shift to carpooling and then computing savings from driver education against this new service demand.

REFERENCES:

(15) Kendall, D.C. "Carpooling: Status and Potential," prepared for DOT (DOT-TSC-OST-75-23), June 1975.

TABLE 2.5

LIGHT VEHICLES; REDUCE AUTO TRAVEL DEMAND



(16) Peat, Marwick, Mitchell & Co., "A Marketing Approach to Carpool Demand Analysis," prepared for the FEA, Washington, D.C., April 1976.

(17) TRW, "Evaluation Manual for State Energy Conservation Plans," prepared for the FEA, Washington, D. C., February 1977.

(18) Bush, L. R., Todd, G. T., "Vanpool Implementation in Los Angeles," The Aerospace Corporation, El Segundo, California, November 1975.

(19) Owens, R. D., Sevor, H. L., "The 3M Commute-A-Van Program, Status Report," 3M Company, St. Paul, Minn., May 1974.

(20) Continental Oil Company, "Vanpooling, A Commuting Alternative That Works," Houston, Texas, July 1976.

(21) SRI, "State Energy Conservation Program," prepared for the FEA, unpublished, 1976.

(22) R. H. Pratt Associates, "The Potential for Transit As An Energy Saving Option," Kensington, Md., March 1976.

3.0 LONG HAUL TRUCKS AND BUSES MARKET SECTOR

There are three generic approaches to realizing oil savings in this market sector. They include increasing engine propulsion efficiency, reducing vehicle losses, and improving the system efficiency.

Increasing engine propulsion efficiency is defined to include any subsystem which improves the efficiency with which fuel is converted to shaft horsepower output. Reducing vehicle losses includes all subsystems which seek to prevent fuel diseconomies resulting from vehicle movement.

The generic approach, improve system efficiency, is defined to include any system or option which will save fuel by methods other than vehicle modifications. Savings for this generic approach are computed only for long haul trucks.

3.1 INCREASE ENGINE PROPULSION EFFICIENCY (See Table 3.1)

1. Waste heat utilization

   - Fuel economy improvements from MOPPS

     (i) 4% increase for regenerative braking

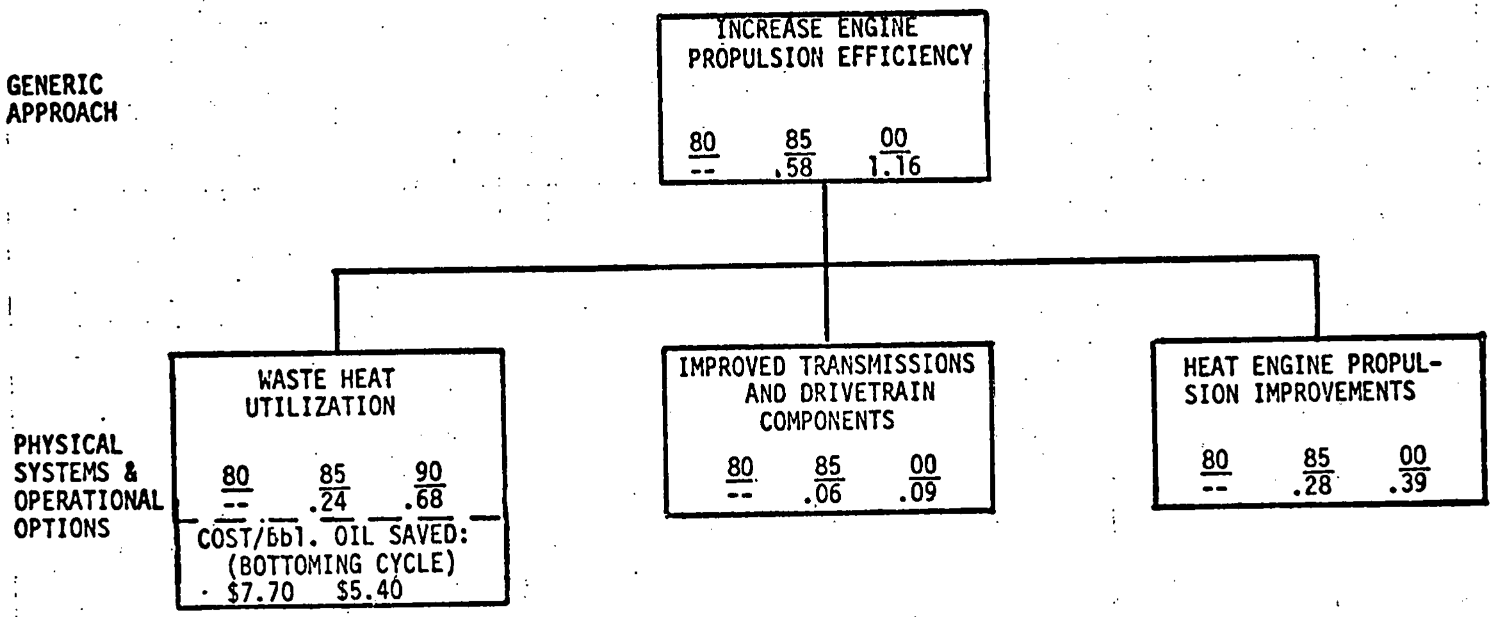
     (ii) 27% increase from bottoming cycle subsystems

   - The cost per barrel of oil saved are computed for the bottoming cycle for the years shown. Costs are in 1977 $.

2. Improved transmission and drive train components

   - Improvements in the efficiencies of transmissions and drive train components are not foreseen. However, 2-5% fuel economy improvements could be attained by the use of tag or pusher axles; rather than tandem drive axles. (Ref. 23). The 5% upper limit is used to calculate savings.

TABLE 3.1
LONG HAUL TRUCKS AND BUSES; INCREASE ENGINE PROPULSION EFFICIENCY



3. Heat engine propulsion improvements

- These improvements include the following new engine configurations: gas turbines, stirling, and adiabatic diesel.

- MOPPS projects a 15% fuel economy improvement will be realized from the "winner" of the new engine configurations.

- The "Interagency Study of Post-1980 Goals for Commercial Vehicles" projects a 10% engine efficiency improvement from "internal and cycle improvements." The 15% MOPPS projection is used to calculate savings. (Ref. 24)

REFERENCES:

(23) U. S. Dept. of Transportation, And U.S. Environmental Protection Agency," Study of Potential for Motor Vehicle Fuel-Economy Improvement," Truck and Bus Panel Report, No. 7, (Jan. 10, 1975).

(24) U. S. Government "Interagency Study of Post-1980 Goals for Commercial Motor Vehicles," Draft, June 1976.

3.2 REDUCE VEHICLE LOSSES (See Table 3.2)

1. Enhanced aerodynamic design

- Deflector/stabilizer systems are beginning to appear on tractor trailers. These can result in fuel economy savings of up to 6%.

- The next step in the bolt-on aerodynamic devices is the fairing mounted on the tractor roof and a flexible membrane sealing the gap between the tractor and the trailer. A University of Maryland team estimated that such a device will decrease fuel consumption by 12%. (Ref. 25) This figure corresponds with the 7-12% potential savings estimated in the "Interagency Study of Post-1980 Goals for Commercial Vehicles."

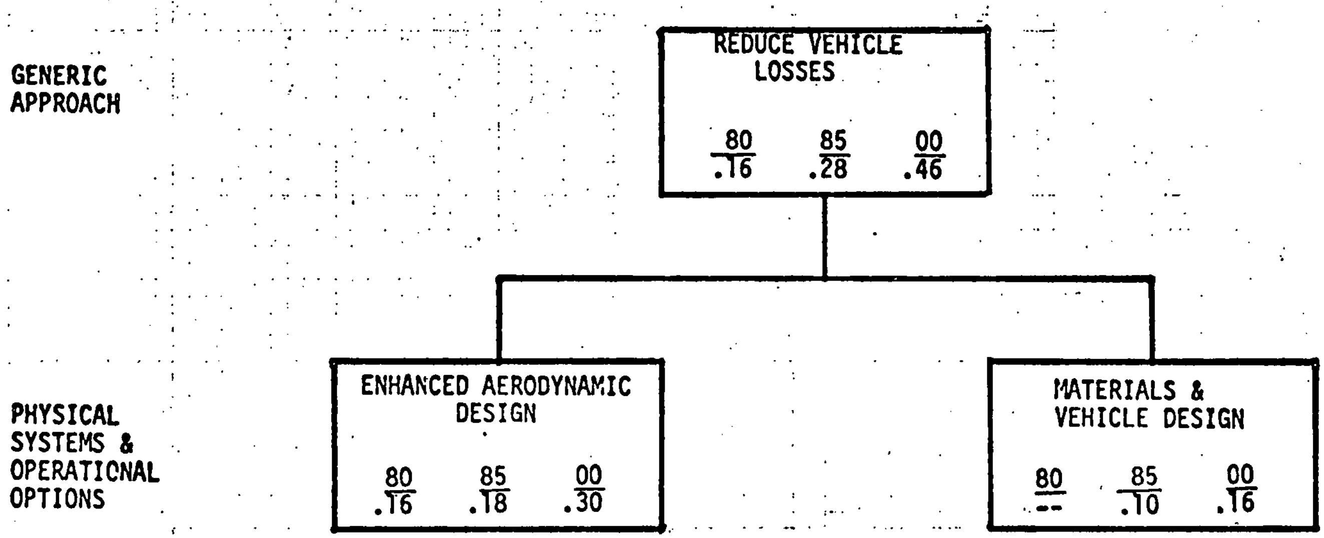
- MOPPS estimated a 10% potential savings from aerodynamic improvements. The 10% figure is used for our calculations.

2. Materials and vehicle design

- The incremental fuel economy improvements resulting from weight reductions is small for large trucks. Savings are realized because reduced tare weight allows for larger payloads. The "Interagency Task Force Study of Post-1980 Goals for Commercial Motor Vehicles" estimates a 10% weight reduction is possible. This will result in a 5.5% in fuel

TABLE 3.2

LONG HAUL TRUCKS AND BUSES; REDUCE VEHICLE LOSSES



productivity (ton-miles/gallon). (Ref. 24) MOPPS uses 10% for their calculations. We use the 5.5% figure to calculate savings.

REFERENCES:

(25) "More MPG for Tractor--Trailer Rigs," Automotive Engineering, Vol. 84, No. 6, June 1976.

3.3 IMPROVE SYSTEM EFFICIENCY (See Table 3.3)

The savings in the parentheses, below the generic approach level are computed in the following manner:

- Savings are calculated due to the shifting of freight to rail by means of piggybacking trailers on freight cars (TOFC). The savings shown reflect the increased energy use in the rail sector.
- Savings due to size and weight increases are computed for the remainder of the long haul trucks.
- The other options are computed against the new baseline consumption resulting from (1) and (2) above.

1. Driver habits

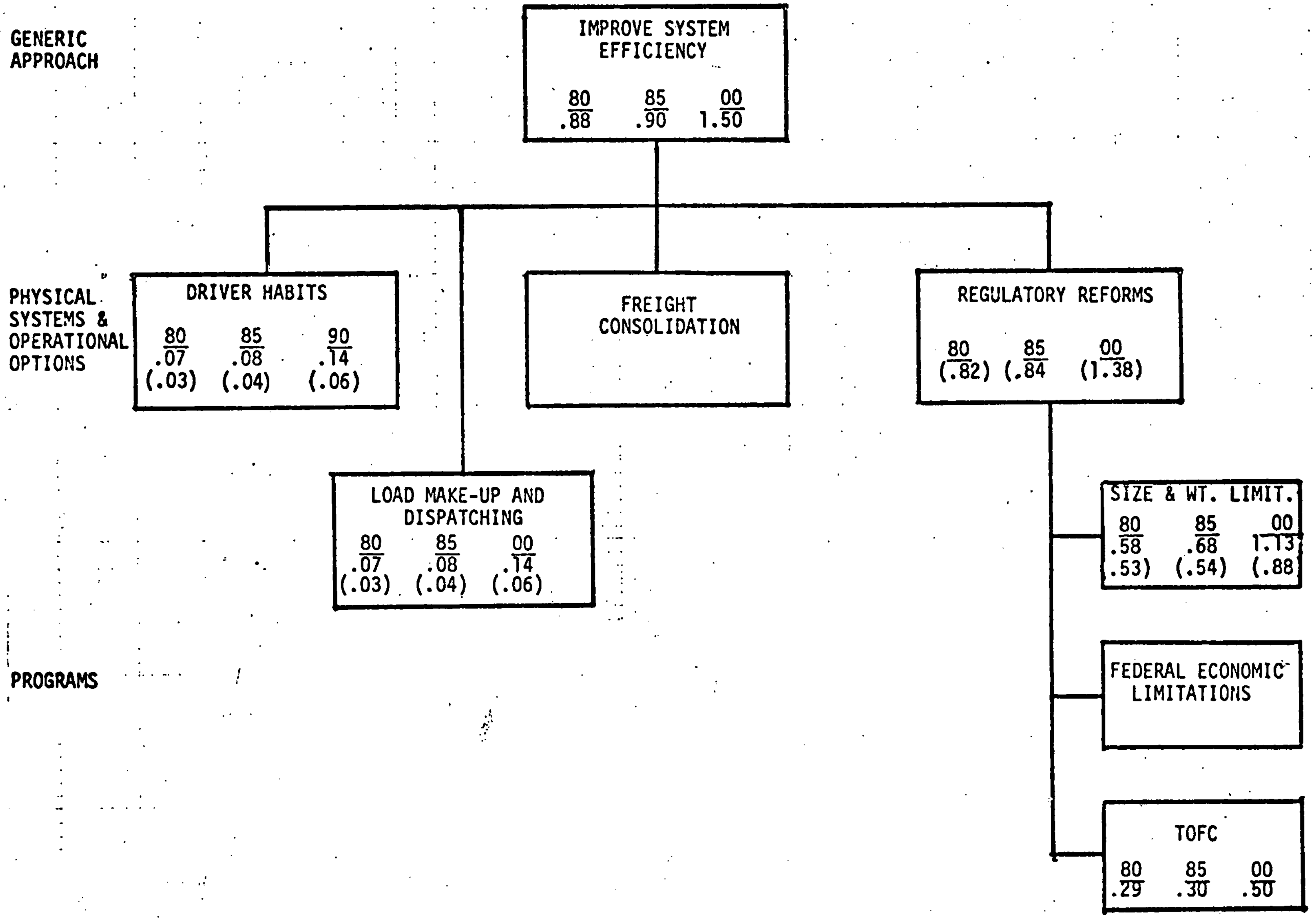
   - The Interagency Task Force on Post-1980 Goals for Commercial Motor Vehicles has estimated that from 0-10% fuel savings could be realized through improved driver habits. This estimation was based on the results of three studies. (Ref. 25, 26, 27) We arbitrarily use 5% for savings from improved driver habits.

2. Load make-up and dispatching practices

   - Some pilot projects utilizing computerized systems analysis have resulted in company truck travel reductions of 15%. (Ref. 28) The Interagency Task Force estimates that a 5% potential savings from this measure is possible. (Ref. 24) We use 5% to estimate savings.

TABLE 3.3

LONG HAUL TRUCKS; IMPROVE SYSTEM EFFICIENCY



3. Freight consolidation

- Freight consolidation could conceivably occur at all stages in freight movement by truck. Equipment pooling in over the road operations could minimize empty and low capacity mileage. Other savings could be realized through consolidation of goods movements at both ends of the inter-city route. We were not able to identify the potential savings from this option. (Ref. 24)

4. Federal economic limitations

- At any one time there are a large number of long haul truck combinations on the road carrying only partly loaded or empty loads. Estimates for empty mileage range from 7-30%. While 100% loading 100% of the time is not feasible some amount of the current inefficiency is blamed on the Interstate Commerce Commission's system of economic regulation. No estimates were obtainable as to potential savings to be realized through reform of the ICC economic regulations.

5. Size and weight limitations

- There are current federal and state regulations governing the size and weight of tractor trailers. The federal limitations specify 80,000 lbs. gross overall weight and a 96" width. An economic and technical feasibility study was done on raising the weight limitation to 120,000 lbs. and the width to 102". Such new standards were deemed feasible and the average result would be a 67% increase in ton miles per gallon. (Ref. 29)

6. TOFC (Trailers on freight cars)

- On the average, travel by truck uses 4 to 5 times as much energy per ton-mile. There are a large number of institutional and regulatory impediments to increased piggy-back track.

If all impediments were removed analyses have indicated piggy-backs and trucks would be about equal in cost for hauls between 100 and 200 miles. Over 200 miles, rails would hold the clear advantage and below 100 miles the economic choice would be trucks.

The savings shown indicate a rough approximation of energy savings attainable if all tonnage that traveled over 200 miles was by TOFC. (Ref. 30, 31, 32, 33)

REFERENCES:

(25) McDonnell Douglas Corporation, Douglas Aircraft Company, "Vehicular Energy Conservation Program, B5-529" (California: McDonnell Douglas Corporation, March 1975).

(26) E. M. Cope, The Effect of Speed on Truck Fuel Consumption Rates, a report prepared for the U. S. Dept. of Transportation, Federal Highway Administration, Office of Highway Planning, Highway Statistics Division, August 1974.

(27) Federal Highway Administration Survey of Highway Speeding (August 1975)

(28) Cargo, March 31, 1975.

(29) Winfrey et. al., Economics of the Maximum Limits of Motor Vehicle Dimensions and Weights, Federal Highway Administration, September 1968.

(30) Kneafsey, J. T., Transportation Economic Analysis, D. C. Health and Company, Lexington, Mass., 1975.

(31) Friedlander, A. F., The Dilemma of Freight Transport Regulation, Washington, D. C.: The Brookings Institution, 1969.

(32) Woods, D. W., and Domenich, T.A., "Competition Between Rail and Truck in Intercity Freight Transportation, "Proceedings of Transportation Research Forum, November 1971.

4.0 SUMMARY AND CONCLUSIONS

The two market sectors studied, the light vehicle market and the long haul truck and bus market along with intermediate trucks comprise the highway portion of the transportation sector. In 1975 the highway portion accounted for 73% of the energy consumed within the transportation sector. The two market sectors for which potential savings are computed accounted for 70% of the energy consumed in the transportation sector in 1975. Thus the two sectors analyzed are, by virture of their magnitude, the major targets for conservation in the transportation sector.

Table 4.0 shows the potential savings, by generic approach, for the two market sectors studied. The reader should keep in mind the assumptions about 100% or maximum feasible penetration assumed in these estimates. It is unlikely that such large effects can be realized in most cases.

TABLE 4.0

POTENTIAL SAVINGS BY GENERIC APPROACH FOR THE YEARS 1980, 1985, 2000 (SAVINGS IN QUADS)

MARKET SECTOR	GENERIC APPROACH	1980	1985	2000
LIGHT VEHICLES	Increase engine efficiency	.45	.99	4.70
	Reduce losses	--	.42	3.49
	Reduce vehicle wt.	--	--	1.12
	Reduce vehicle size mix in fleet	--	--	1.92
	Switch away from oil & gas	--	.49	12.38
	Reduce auto travel demand	2.14	2.17	2.35
LONG HAUL TRUCKS & BUSES	Increase engine propulsion efficiency	--	.58	1.16
	Reduce vehicle losses	.16	.28	.46
	Improve system efficiency	.88	.90	1.50

The following remarks and conclusions are derived from this table and the preceding analyses:

- In the near term, 1980, savings can be realized primarily through non-technical means. There is a potential for large savings, 2.14 quads, in the light vehicle market sector if the government can somehow stimulate increased carpooling, vanpooling, and shifts to mass transit. Additionally substantial savings can be gained by programs which improve driver habits. There is some potential for near term gains from internal combustion engine systems improvements.

- As in the light vehicle market sector, the near-term strategy that offers the largest savings in the long haul truck and bus sector is non-technical. This strategy is applicable to trucks only. The potential savings that could be realized in 1985 through such non-technical options is .62 quads. When judged by their conservation potential the two most attractive approaches that government could take would be to stimulate inter-modal shifts from truck to rail and to increase truck size and weight limitations.

- In the mid-term, 1985, non-technical options continue to offer the greatest potential for savings in the two sectors. However, by 1985, technical options could save significant quantities of energy. The technical generic approach with the largest potential, in both sectors, is to increase engine efficiency. This approach offers a cumulative potential savings of 1.52 quads in 1985.

- Of the options within the "increase engine efficiency" generic approach the one with the largest potential in the light vehicle market sector is the improvement in internal combustion engine design. This includes the SC Otto and an improved diesel engine. These two account for 68% of the 1985 potential savings for this generic approach. In the truck and bus sector waste heat utilization and improved engine design have about the same potential in this generic approach and account for 91% of the savings shown.

- In the long-term, 2000, there is the potential for eliminating all use of oil in both sectors by switching to synthetics and/or electricity. If the economics or government intervention does not prompt such a switch the largest potential savings in the light vehicle sector can be realized through new engine cycles. These cycles have the potential of saving 38% of the projected baseline energy consumption in the year 2000.

- In the bus and long haul truck sector even in the year 2000 non-technical options have the largest potential. Here also though, new engine cycles can save over one quad or 38% of the projected baseline energy consumption in 2000.