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MASTER

**Worldwide Transportation/Energy
Demand, 1975-2000 Revised
Variflex Model Projections**

**OPERATED BY
UNION CARBIDE CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY**

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WORLDWIDE TRANSPORTATION/ENERGY
DEMAND, 1975-2000
REVISED VARIFLEX MODEL PROJECTIONS

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Abstract

This report reviews the salient features of the transportation-energy relationships that characterize the world of 1975 and projects worldwide (34 countries) long-range transportation demand by mode to the year 2000. A worldwide model is used to estimate future energy demand for transportation. Projections made by the forecasting model indicate that in the year 2000, every region will be more dependent on petroleum for the transportation sector than it was in 1975.

This report is intended to highlight certain trends and to suggest areas for further investigation. Forecast methodology and model output are described in detail in the appendices. The report is one of a series addressing transportation energy consumption; it supplants and replaces an earlier version published in October 1978 (ORNL/Sub-78/13536/1).

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PREFACE

This is one of a series of subcontract reports. Each report addresses a specific research topic related to transportation energy consumption or conservation opportunities. Worldwide Transportation/Energy Demand Forecast: 1975-2000 (Revised) is the result of work done by Variflex Corporation* under ORNL Purchase Order No. 62X-45740V under Union Carbide Corporation Contract W-7405-eng-26 with the United States Department of Energy. This report supplants and replaces an earlier version published in October 1978. While the data base and forecasting model remain substantially the same, significant modifications have been made, largely in response to comments received on the earlier version. The work was done in support of Oak Ridge National Laboratory's transportation energy program, which is an area of study for the Data Management and Analysis Group of the Energy Division and is under the direction of Dr. Andrew S. Loeb1.

This report contains a considerable amount of information, and the results are considered by the authors to be generally reasonable. However, the effort continues at a comparatively low level and there remains considerable room for future improvement both in the data base and the

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forecasting model. The results displayed hereafter highlight certain trends and suggest areas for further investigation; they are being published in this spirit. They should not, however, be regarded as definitive or final. An abridged version of this Report is being published in the Proceedings of the International Conference on Energy Use and Management (ICEUM), October 1979. The assumptions, views, and conclusions expressed in the document are those of the authors and are not to be interpreted as those of ORNL, Union Carbide Corporation, Nuclear Division, or of the Department of Energy.

1. 1975 Perspective

The subject of this report is important because transportation energy is virtually synonymous with petroleum derived fuel. Most transportation energy (except pipelines which are omitted from this analysis) comes from oil products -- about 99.9% in the U.S. -- and a fairly high percentage of petroleum products are used for transportation purposes.

For automotive vehicles and aircraft, liquid fuels obtained from petroleum are the only source of energy available today and this will continue to be true for a number of decades hence. Electricity can be used for fixed rail transport systems, though most railroads are now utilizing diesel fuel. Given the necessity and enough lead time, railroads could conceivably switch back to direct burning of coal. But this option does not yet exist for cars, trucks, or aircraft. Electric storage batteries are a potential alternative for vehicles used only for short distance commuting or deliveries. While most trips for almost all cars and trucks are fairly short, it is important for most vehicle applications not to be limited to a short distance. Thus electrification is, at best, a distant possibility for vehicles not confined to fixed guideways. The possibility of substituting alcohol derived from 'surplus' grain is marginal at best, in a world where hundreds of millions

of people are underfed. The only realistic alternative to petroleum is synthetic fuel derived from coal. Processes capable of producing synthetic gasoline were developed in Germany during World War II and are currently in use in South Africa, but have not yet been implemented commercially anywhere else.

Until a technological breakthrough that does not appear to be imminent, transportation will continue to depend on petroleum as no other category of end-use. Though not necessarily permanent, this dependence is likely to persist through the end of this century. The last row of Table 2 displays this dependency for a number of different regions of the world.* Only the Communist Bloc countries and the Less Developed region obtain as much as 10% of their transportation energy from fuels other than oil -- due primarily to policies that strongly discourage private automobiles.

Petroleum, of course, is extremely important, perhaps unique, for another reason. By virtue of its convenient form, it is uniquely easy and cheap to ship and it therefore dominates world trade in energy commodities by a wide margin. Petroleum is, in effect, the balancing commodity

*The eight regions used in this analysis comprise about 90 percent of the world population. The regions are defined in Appendix A-2. The Advanced Developing region is represented by Iran, Saudi Arabia, South Africa, Argentina, Brazil, Mexico and Venezuela. The Less Developed region is comprised of India, China, Indonesia, Phillipines, Egypt, Morocco, and Nigeria. See Appendix A-2.

Table 1 Total Energy Statistics for
Seven World Regions, 1975

	United States	Western Europe	Japan	Soviet Union	Eastern Europe	Advanced Developing	Less Developed	World
Total Energy Use								
1. Quads	70.1	47.4	13.4	40.4	15.8	15.6	30.3	24.6
2. 10^6 BTU per Capita	328	152	121	158	182	57	17	-
3. 10^3 BTU per dollar GDP	59	59	48	89	77	63	107	-
4. BTU per Capita, Relative to US	1.00	.46	.37	.48	.55	.17	.05	-
5. BTU per GDP, Relative to US	1.00	1.00	.81	1.51	1.31	1.07	1.81	-

1 Quad = 10^{15} BTU

Source: Reference 3

Table 2 Transportation Energy Statistics
for Seven World Regions, 1975

	United States	Western Europe	Japan	Soviet Union	Eastern Europe	Advanced Developing	Less Developed	World
Total Transportation Energy Use								
1. Quads	17.2	9.3	2.5	4.6	1.1	3.8	2.4	48.7
2. 10^6 BTU per Capita	80	30	23	18	13	14	1	14
3. 10^3 BTU per dollar GDP	14	10	9	10	6	16	9	12
4. BTU per Capita, Relative to US	1.00	.37	.28	.22	.16	.18	.02	.18
5. BTU per GDP, Relative to US	1.00	.72	.62	.70	.38	1.08	.60	.81
6. Transportation Energy as Percent of Total Energy	25	20	19	11	7	24	8	20
7. Transportation Energy - Percent Dependence on Petroleum	99.9	95.5	96.8	71.6	87.7	97.1	85.5	94.4

1 Quad = 10^{15} BTU

Source: Appendix C

in energy exchanges between countries. Any country that consumes more primary energy than it produces must import the difference -- mainly in the form of petroleum. For this reason countries that import most of their energy, such as West Germany and Japan, are also extremely dependent on petroleum, not only for transportation purposes but also for heating, electric power generation and other end-uses.

For the reasons sketched above, transportation assumes greater relative importance in the overall energy picture than might be assumed on the basis of its share of total energy use. As will be seen, transportation appears to offer significant opportunities for increased efficiency of energy use.

Rows 1 through 5 of Table 1 show total energy use and total energy used per capita and per thousand dollars of Gross Domestic Product (1972 \$) for the United States and other regions of the world. It is interesting to note that, while the United States consumes the most energy on a per capita basis, it (along with Western Europe) consumes less than any other region except Japan, in relation to its national income. When transportation is deducted from the total energy figure, this inverse energy-to-income relationship is even more marked. The most likely explanation, is that the United States is furthest along toward the "post-

industrial" society, (Reference 5). Evidently service sectors, except transportation, generally consume less energy per unit of revenue generated than heavy industrial activities.

Rows 1 through 5 of Table 2 display transportation energy for the regions in terms of the same measures. The contrast between transportation energy and total energy is quite striking. The United States consumes three times as much energy per capita for transportation purposes as Western Europe, four times as much as Japan, and more than five times as much as the USSR. The comparisons in terms of transportation energy consumed per unit of GDP are less dramatic, but still the United States leads by a considerable margin, except in the case of the Advanced Developing region.

Another way of looking at these comparisons is in terms of the fraction of total national energy consumption used for transportation purposes. For the United States that fraction is one fourth, whereas for the other regions it is usually much smaller (Row 6 of Table 2).

The source of the big difference between the United States patterns and that of the rest of the world can be seen more clearly from Table 3 which shows the passenger and freight components separately. In comparative terms, the high use of energy for passenger transportation (Rows 1

through 4) in the United States is quite remarkable. Per capita consumption is almost four times higher in the United States than in Western Europe, the closest rival. It is ten times higher than in Japan, sixteen times higher than Eastern Europe and the USSR and twenty times higher than in the Advanced Developing region. In relation to national income, the United States passenger energy use still outstrips Western Europe by more than two thirds, and Japan by nearly a factor of five.

On the other hand, in the case of freight transportation energy (Rows 5 through 8) the situation is different. In per capita terms the United States barely leads Japan. In relation to national income the United States is tied with Eastern Europe at the bottom of the list. We can summarize the situation by remarking that the United States is much more passenger transport oriented than any other country in the world. High income, large distances (wide open spaces) and historical accident -- notably the availability of cheap petroleum in unlimited quantities during the last eight decades -- have all contributed to this circumstance.

Rows 1 through 6 of Table 4 show that the United States uses the bulk of its transportation energy in the movement of people (69 percent), while most other regions use in excess of 70 percent of their transportation energy in moving freight. Only Western Europe has an even split between energy

Table 3 Passenger and Freight Energy Use
for World Regions, 1975

	United States	Western Europe	Japan	Soviet Union	Eastern Europe	Advanced Developing	Less Developed	World
Passenger Energy Consumed Annually								
1. 10^6 BTU per Capita	55.7	15.0	5.5	3.9	4.5	3.0	.4	7.1
2. Relative to US	1.00	.27	.10	.07	.08	.05	.01	.13
3. 10^3 BTU per dollar of GDP	10.0	5.2	2.2	2.2	1.9	3.4	2.4	5.8
4. Relative to US	1.00	.52	.22	.22	.19	.34	.24	.58
Freight Energy Consumed Annually								
5. 10^6 BTU per Capita	24.6	14.9	17.1	14.1	8.4	11.0	1.0	7.2
6. Relative to US	1.00	.60	.69	.53	.34	.45	.04	.29
7. 10^3 BTU per dollar of GDP	4.4	5.1	6.7	8.0	3.6	12.2	6.3	5.9
8. Relative to US	1.00	1.16	1.53	1.31	.81	2.77	1.43	1.33
9. Passenger Percent of Total	69	51	24	22	36	21	29	50
10. Freight Percent of Total	31	49	76	78	64	79	71	50

Source: Appendix C

Table 4 Transportation Data for World
Regions, 1975

	United States	Western Europe	Japan	Soviet Union	Eastern Europe	Advanced Developing	Less Developed	World
Passenger Kilometers Travelled Annually								
1. 10^3 per Capita	17.3	8.9	6.7	4.0	4.5	2.6	18	3.7
2. Relative to US	1.00	.52	.39	.23	.26	.15	.04	.21
3. Per dollar of GDP	3.1	3.1	2.6	2.3	1.9	2.9	4.7	3.0
4. Relative to US	1.00	1.00	.85	.73	.62	.92	1.52	.97
Domestic Ton-Kilometers Shipped								
5. Per Thousand Dollars of GDP	2.9	1.0	1.2	8.4	1.9	2.5	3.3	2.9
6. Relative to US	1.00	.33	.41	2.89	6.5	8.6	1.13	1.0

Source: Appendix C

to move people and energy to move goods.

More detailed analysis of these general relationships requires a look at some of the underlying data. It is difficult to select, from a wealth of possible measures, those which are the most significant. Nevertheless, an attempt may be worthwhile. Rows 1 through 4 of Table 4 display several key transportation measures, for the same group of regions, for the year 1975. This table reveals a fascinating fact. Although the United States is quite far ahead of most other regions in terms of Passenger-Kilometers Travelled (PKT) per capita the relationship between passenger kilometers travelled and national income is virtually the same for all countries. Indeed, the highest ratio of PKT/GDP applies to the poorest group of countries, where GDP is probably significantly undercounted by expressing them in terms of dollars at current rates of exchange. (Reference 6)

In view of the close correlation between passenger travel and national income, it is a little surprising, at first glance, to note that there is no correspondence at all between domestic freight ton-kilometers (DTK) and GDP (Rows 5 and 6). The United States is in the middle, very close to the world average. The Soviet Union is the champion in terms of this measure, which is not surprising in view of the vast distances between industrial centers. Moreover,

commodities that would be shipped by sea, for most countries, are often shipped internally by rail in the USSR. The densely populated, geographically compact countries fall at the other extreme, with only 35 to 40 percent of the DTK per dollar of GDP compared to the United States. On further consideration, it is clear that the analogy between PKT and DTK is misleading for another reason. One would tend to expect some correlation between GDP and the total mass of goods produced by an economy, allowing for differences in the "mix" of products in different countries. (Japan with its export-oriented heavy industry would be at the high end of the scale, for instance.) But if tonnage produced is the right measure, then ton-kilometers is not particularly relevant. This point is important in developing a forecast.

Several comments with possible bearing on the forecasting problem follow at this point:

(i) Two very different patterns can be discerned for the evolution of passenger transportation. One pattern applies to countries which built extensive rail networks in the 19th and early 20th centuries (North America, Europe, Japan, the USSR, India, and China). In these countries, railroads were (or are) the principal public carrier for all distances, but particularly for short trips. In countries where extensive rail nets do not exist, buses are the predominant mode of public transportation.

(ii) Public modes of passenger transport are becoming less important in most countries. This trend is pronounced everywhere, including in the centrally planned countries (Eastern Europe and the USSR) where private cars are still very scarce and expensive and public transport is heavily subsidized.

(iii) Air travel has been increasing extremely rapidly in most countries. If historical or near-historical rates continue to the year 2000, it will account for a significant fraction of all passenger-km, based on much higher totals.

(iv) It is interesting to note that trucks are already the dominant mode of short-haul freight transport in all countries, although rail still dominates for long-haul situations. No change in this qualitative situation occurs in the next few decades.

2. Summary and Projections to the Year 2000

Having briefly reviewed the salient features of the transportation-energy relationships that characterize the world of 1975, it is natural to wonder what is in store for the future. The world is certainly in a state of flux, and the patterns that will exist in the Year 2000 may be quite different from the present for a number of reasons.

In the first place, population growth rates are very different in the developed countries and in the less developed countries, especially in the Southern Hemisphere. Populations of many countries will double -- or close to it -- by 2000. To the extent population is an economic driving force, this fact may be of great significance.

Second, economic growth rates per capita are also quite variable from one country to another. Generally speaking, the developing countries are growing faster than the most advanced countries. The most rapid growth is in East Asia, where Korea, Taiwan, Hong Kong, and Singapore have already established consistent high-growth trajectories and other countries in the region may follow -- including mainland China. Some countries in Latin America are also industrializing rapidly. Brazil seems to have entered a phase analogous to the opening of the American West, which will have incalculable spinoff effects on the surrounding countries.

Of course all the OPEC countries have benefitted greatly from the flow of oil revenues, which constitute a major redistribution of international wealth.

Third, we must not forget energy prices as an economic driving force (or drag, as the case may be) which strongly interacts with economic growth. Clearly the price of energy is not determined independently of energy demand -- which is closely linked to GDP -- but neither is GDP growth independent of the price of primary inputs such as energy. The relationship is a mutual one which is much too complex for us to deal with explicitly in a Report such as this. Suffice it to say that a GDP "scenario" must also be an energy price "scenario".

The formal forecasting scheme can be summarized briefly in terms of four relationships. First, passenger transport energy is the sum over modes of passenger kilometers travelled (PKT) by mode times an energy intensity coefficient for each mode. Second, PKT by mode are projected by projecting GDP, multiplying by the ratio of PKT/GDP that was discussed above, and allocating to modes by "mode share fractions". In our model, both energy intensity coefficients and mode share fractions were projected exogenously, starting from 1975 values, based on known substitution trends and other judgmental factors. For freight transport energy the analogous procedure was used, viz. a sum over domestic cargo ton-kilometers (DTK) by mode multiplied by energy intensities for each

mode. TK by mode were projected from GDP, using a gross ratio of tons unloaded per unit of GDP, allocated to modes by fractional coefficients, and converted to TK by multiplying by ratios representing the average distance travelled (km) by each shipment of one ton, for each mode. For purposes of the two projections discussed in this paper, the latter two sets of coefficients were assumed to be stable, but mode choice fractions and energy intensities were varied moderately in line with known trends. A more detailed description of the forecasting methodology, and model, can be found in Appendix A.

Getting down to specifics, we certainly expect continued substitution of air travel for all other modes, and automobile travel for rail or bus in countries where the latter are still quantitatively important. Of course, such substitutions can be inhibited by national policy -- especially in centrally planned (i.e. communist) societies -- and it seems reasonable to assume that communist societies will continue to prefer to invest national resources in industrial growth rather than increased consumption.

On the cargo transport side, ocean freight is the fastest growing mode, reflecting the rapid growth of world trade and world economic interdependence. This trend should continue. Air freight will grow rapidly, too, but will not account for a significant fraction of energy use by the year 2000.

Among the other modes, barge ("water") transportation is usually the cheapest mode where rivers and canals exist, and this mode will hold its cost advantage. It can be assumed that this mode will not increase its existing market share except in a few countries where opportunities exist to interconnect major navigable river systems. Railroads, on the other hand, will continue to lose traffic to trucks, particularly where existing rail networks are sparse, as in Latin America and Africa. Apparently it is much easier to build passable roads than new railroads.

As regards energy efficiency ("intensity") by mode, by far the biggest opportunity for improvement is in the automobile. Substitution of smaller, front-wheel drive 'European-style' vehicles is already increasing the fuel economy of cars in the United States. We expect this trend to continue, not merely because it has been mandated by the United States Congress, but because the price of gasoline has begun to rise sharply and the United States consumer cannot expect to pay less than the world price for very much longer. The visible popularity of small, fuel efficient vehicles has already resulted in the introduction of innovations, such as the very small diesel engine recently introduced by Volkswagen, that would have seemed inconceivable in the United States a decade ago. The other big opportunity for improvement is in truck transportation, where efficiency

is held below what it could be by the anarchy of the system. The fact is that many trucks are loaded far below capacity, and the unused capacity becomes more and more of an expensive luxury as the price of fuel rises. Without specifying the details of a solution, it seems reasonable to us that progress can and will be made to increase average utilization and, thus, fuel economy.

We have made two sets of projections, a sort of "least surprise" case, or baseline, and a "conservation" case which reflects our views of the limits of what is technically and politically feasible. A number of key results are shown in Table 5.

It may be of some interest to note that in 1975 the United States accounted for about 6.4% of the world's population but produced about 29.1% of all the goods and services produced in the world (based on 1972 exchange rates). However, other nations are now growing faster, both in population and economic terms. By the year 2000, the United States is expected to decline to about 5.2% of the world's population and to produce 26-27% of the world's measurable output of goods and services. These figures are useful benchmarks for comparison of the United States with other regions in terms of energy use for transportation.

One salient observation for the year 2000 is that the

Table 5 Transportation Projections for
Seven World Regions, 2003

	United States	Western Europe	Japan	Soviet Union	Eastern Europe	Advanced Developing	Less Developed	World
Total Transportation Energy (B = Baseline Case; C = Conservation Case), Quads								
1. B	27.5	14.3	4.6	17.4	3.8	16.0	12.4	112.8
2. C	17.0	10.7	3.5	13.3	2.3	14.2	11.3	84.6
3. % saved	38	25	24	24	39	11	9	25
Percent Increase over 1975, Total								
4. B	60	54	84	278	245	321	417	135
5. C	-1	15	40	189	109	274	371	76
Percent Increase Over 1975, Transportation Energy Use per Capita								
6. B (%)	103	41	35	56	38	30	4.3	22
7. C (%)	64	31	27	42	23	26	3.9	16
Changing Passenger Energy Share (%)								
8. 1975	69	50	24	22	35	22	27	50
9. B	63	47	25	33	43	29	17	41
10. C	57	43	24	30	42	31	17	37
Changing Freight Energy in 10 ³ BTU per dollar of GDP								
11. 1975	4.4	5.1	6.7	8.0	3.6	12.2	6.3	5.9
12. B	3.6	4.9	5.1	8.5	4.2	10.2	10.6	6.2
13. C	3.0	4.4	4.6	7.0	3.4	7.6	9.5	5.4

Source: Appendix C

transportation sector in every region is even more dependent on petroleum than in 1975. For example, the Soviet Union used non-petroleum fuels for 28.6 percent of its transportation needs in 1975 but this drops to 11.6 percent by 2000 in the base case (and 13.0 percent in the conservation case).

Table 5 (Rows 4, 5) shows that the expected percentage increase in transportation energy for the base case is very large for most regions of the world. The world wide transportation energy increase of 135 percent by 2000 is equivalent to an annual growth of 3.5 percent. This is lower than the projected 153 percent increase in worldwide GDP (Comparisons with other growth projections are in Reference 7). The 60 percent increase for the United States may look large, but it is substantially smaller than the 135 percent increase that occurred from 1950 to 1975.

In the conservation case, a savings of 25 percent compared with the base case is projected worldwide (Table 5). The savings potential for the conservation case is highest in the United States and Eastern Europe (because an expected auto boom there would be aborted) with the Less Developed region achieving less than a 10 percent saving. Even with substantial conservation, most regions show a big percentage increase over 1975 in their transportation energy use (Row 5). In short, even with optimistic energy efficiency improvements,

population growth and economic development will require increases in transportation energy demands in most regions of the world, with the biggest percentage increases in the development countries. Furthermore, the form of energy demanded will be almost entirely petroleum products.

In per capita terms, the difference between the United States and the Less Developed region is expected to decline from a factor of 80 in 1975 to a factor of about 25 in the base case for the year 2000 (Row 6 in Table 5).

The percent of transportation energy used for passenger movement is shown in rows 8, 9, and 10 of Table 5. Note that in all but the last two regions, greater savings are possible on the passenger side than on the freight side. This is because it is generally easier to conserve transportation energy by making passenger travel more efficient (smaller cars, higher load factors, etc. - Reference 8). All the regions that had less than 50 percent of their transportation energy in passenger movement in 1975 increased their passenger share in both scenarios by 2000, except for the least developed countries.

The United States share of world income, population, travel demand and transportation energy are projected in both Scenarios to continue to decline as they did during the 1960-1975 period. Significantly the United States share of world transportation energy use declines most rapidly for

the three modes which account for most of the year 2000
base case transportation energy: trucks (42%), autos/
buses (29%), aircraft (11%).

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APPENDIX A

FORECAST METHODOLOGY AND MODEL

A.1 Methodological Issues

In undertaking a long-range (as opposed to a short-range) global forecast, it is important to bear in mind several important points relating to substance and method, respectively. First, a good long-range forecast is not the continuation of a good short-range forecast. The reason for this is substantive: short-range forecasts are, almost by definition, concerned with off-equilibrium cyclic fluctuations around a secular trend, whereas the long-range forecast is concerned with the secular trend itself.

Second, it is dangerously risky to project historical time series into the future as functions of time alone because this fails to allow for interdependencies.

A completely open approach is potentially inconsistent. It is useless to project a large number of economic indicators as if they were independent of each other and thus ignore their essential interconnectedness. For example, monetary and materials/energy-balance accounting relationships must hold. Outlays must equal incomes. Consumption plus investment must add up to production. Prices are functions of value-added, which depends on wage rates and labor

requirements. Materials can neither be created nor destroyed by economic activities: Outputs must account for all inputs for each sector. There are, of course, a great many other links between physical and economic variables.

Yet it is also unsatisfactory to attempt to describe the distant future deterministically by means of a finite closed system of equations (as in "systems dynamics"). Such a model would inevitably leave out of account a number of weak but pervasive influences that are important, perhaps even dominant in the long run, but which are not understood well enough to be reflected by simple mathematical relationships. Examples include changing social climate and values, changing family structure and lifestyle, growth or decline of organized religion, increasing bureaucratization of government, centralization of economic power, ease of communications, accumulation of knowledge, changes in the pattern of education, technological innovation, and cumulative exhaustion of high-quality resources. Further, deterministic models necessarily ignore the role of human choice (as expressed at the political level) as well as random or stochastic elements, such as natural disasters.

No closed dynamic model involving a small number of variables and relationships can be satisfactory for a long-time horizon because no such model can be expected to take into account correctly all the relevant "weak but pervasive"

forces that shape society. Nor can a completely closed, deterministic model adequately reflect a world where both random natural events and policy choices (made by the exercise of human free will) are constant factors. It is naive to imagine that forecasting is in any way like looking at the future through a crystal ball. The real future is still indeterminate; it is constantly being created by our present decision and actions.

The appropriate forecasting methodology, then, must incorporate some open, or exogenous, elements in a closed framework. To minimize the problem of inconsistency, the exogenous variables (i.e., those elements treated outside the model) should be as few and as highly aggregated as possible. They should, in themselves, reflect most of the variability that unpredictable events (including alternative government policies) will introduce over time. In other words, we seek a small group of macrovariables that can be forecast exogenously on the basis of qualitative socio-political scenarios and can, in turn, "drive" a group of interlinked economic models.* The basic scheme of this compromise approach is illustrated in the flow chart (Figure A-1) on the next page.

The economic models currently used in our forecasts are not particularly complex or intricate. The point is that in the future the same basic methodology should be capable of dealing with the most elaborate models.

As regards the demand projections per se, the proposed methodology involves four or five steps, depending on the amount of detailed information desired. The first step is to specify a representative group of qualitative worldwide political/economic scenarios. Next, a small group of significant "macrodrivers" is identified and exogenous forecasts are prepared corresponding to each scenario. Third, if detailed-enough international data are available, the macrodrivers would be linked to a set of final demand equations and a complete multi-sector input/output forecast for each country or region taking into account international trade relationships. (Though it is not yet functioning as a forecasting tool, the UN world input/output model recently developed by Leontief et al.¹ might eventually play such a role.)

Lacking a fully operational international input/output model, the macrodrivers can be direct inputs to a simpler form of demand model. Our current demand model forecasts aggregate total demand - rather than final demand only - for a specific type of output, namely transportation, without considering the detailed sectoral composition of that demand. The mathematical structure of the demand model is discussed in Section 4 of this Appendix.

Based on the quantitative results of the first set of model runs, a sophisticated user might revise the basic

guiding scenarios one or more times. Of course, such revisions need not be identified as an explicit step in the forecasting methodology.

It has already been argued on theoretical grounds that the demand forecasting model (or equation) should be sparing in the use of macrodrivers that are functions of time alone. Two macrovariables that are conventionally used are Gross Domestic Product (GDP) and population. For each scenario we will project these two variables as if they were exogenous. In addition, many economists would argue that one should explicitly introduce an exogenous primary energy price. Clearly, in the real world the price of primary energy is not independent of demand for energy but neither is demand independent of price. Primary energy prices are, moreover, functions of political variables (notably the cohesion of OPEC) which -- in turn -- can be traced in part to widespread perceptions of the availability of alternative energy sources at various price levels. Without forecasting price independently, we recognize that every GDP scenario is, implicitly, an energy price scenario. Transportation demand, and transportation energy requirements, are endogenous variables, derived on the basis of a number of observed historical relationships.

Fig. A.1. General Forecasting Model Scheme

A.2 Regional Aggregation

For purposes of carrying out a worldwide long-range forecast of transportation demand by mode, a set of 34 countries is considered explicitly. These countries are individually important in most cases; they jointly account for about 90% of the world's GDP, population, and energy consumption. They are also probably representative of the countries omitted, except that most of the omitted countries are individually smaller.* Also, while data are often unavailable or of poor quality for the included countries, they tend to be even less available or of worse quality for omitted countries. The individual countries have been grouped together for forecasting purposes as shown in Table A-1.

Most of the groupings are self-evidently reasonable. One exception is Australia, which originally was separated, but now has been lumped with Canada. Results for this "region" are shown in the detailed model outputs (Appendix C). One dubious case is Yugoslavia, which is very unlike the rest of COMECON in many respects, although it is not particularly similar to Western Europe either. It is lumped with the rest of Eastern Europe mainly because it is a centrally planned

*The major omissions are Hungary, Rumania, Turkey, Pakistan, Bangla Desh, Thailand, Vietnam, Malaysia, Taiwan, South Korea, Algeria, Ethiopia, Tanzania, Zambia, Colombia, and Peru.

TABLE A-1
Regional Aggregations

Country	Subregion	Region	Superregion
Belgium Denmark France West Germany (FRG) Italy Netherlands United Kingdom	EEC	Western Europe	OECD Industrialized Free-market Economies
Austria Spain Sweden Switzerland	Other West Europe		
United States			
Canada Australia	Other English- Speaking		
Japan			
Czechoslovakia East Germany (PDR) Poland Yugoslavia	East Europe		COMECON Industrialized Communist Economies
USSR			Advanced Developing Countries
Iran Saudi Arabia South Africa	Mid-East/ South Africa		
Argentina Brazil Mexico Venezuela	Latin America		Other Less-Developed Countries
India Indonesia Philippines	South Asia		
Egypt Morocco Nigeria	Other Africa		
China			

economy. "White" South Africa is highly developed and wealthy, but "Black" South Africa is not, which makes this country almost unique in many respects. It is lumped with the two wealthy oil countries of the Mid-East because the latter also exemplify the "two-society" phenomenon and incomes are comparable (or soon will be). The recent Iranian revolution obviously alters the prospects for Iran, but occurred too late to take into account in the model runs.

A.3 Projection Model and Scenarios for Exogenous Variables

As noted earlier, we cannot construct a closed set of equations that will generate a plausible long-range global "future" without some arbitrary specification of parameters. The approach we have adopted is to specify, for each scenario, population growth rates and GDP growth rates for each region for two time periods, viz

1976-1985 inclusive
1986-2000 inclusive

Two scenarios were considered. There were a "standard scenario" and a "conservation" scenario. The population growth rates for both scenarios were the same, based on the 1973 UN demographic projections.¹ These rates should probably be adjusted to reflect more recent estimates, but that will have to await a comprehensive future model update.

The assumed economic growth rates differ for the two scenarios. The "standard" scenario (labelled Case A) corresponds exactly to the "low growth" case presented in the 1978 version of this Report, while the "conservation" scenario is new. The assumed growth rates are shown in Table A-2.

The "standard" scenario is intended to reflect a situation in which the high primary energy prices of mid 1979 continue at a constant level (in real terms) to the year 2000. Since 1979 oil prices are considerably higher than

TABLE A-2 Economic and Demographic Assumptions
(annual rate of increase)

Region	Population		GDP Per Capita			
			Scenario A - "Standard"		Scenario B - "Conservation"	
			1975-1985	1985-2000	1975-1985	1985-2000
EEC	0.47	0.46	2.0	1.5	1.5	1.0
Other Western Europe	0.60	0.55	2.0	1.5	1.5	1.0
United States	1.00	0.80	2.7	2.5	2.0	2.0
Australia/Canada	1.50	1.30	2.7	2.5	2.5	2.5
Japan	0.97	0.52	3.5	2.5	2.5	2.0
Eastern Europe	0.60	0.50	3.5	3.0	2.5	2.0
USSR	1.00	0.73	4.0	3.5	3.5	3.5
Latin America	2.80	2.65	2.5	3.0	2.5	3.0
MidEast/South Africa	3.00	2.75	6.0	4.0	7.5	5.5
Other Africa	2.75	2.80	1.5	2.0	2.0	2.5
South Asia	2.50	2.00	1.5	1.5	1.5	1.5
China	1.48	1.10	4.0	4.5	4.0	4.5

1976-1978 prices, the resulting drag on the world's economy is greater and economic growth rates are generally lower than the "standard" scenario, circa 1978, would have assumed. The relative impact on Japan is likely to be greatest, due to its near total dependence on imported energy, although the United States (and Canada) have the most difficult problem of adjustment, due to a long history of exploiting cheap domestic energy. Effects on Western Europe are smaller due to the availability of North Sea oil during the next decade or so. Of course for oil exporters (e.g. OPEC) higher prices simply mean greater income transfer from the developed countries to them, resulting in greater rates of investment and consumption.

The "conservation" scenario is intended to reflect a continuing oil price escalation to the end of the century. In this case the economic drag on the industrialized world would be greater still, and the income transfer to OPEC would be correspondingly larger. Apart from the reduced amount of money available for investment in advanced economies, rising oil prices create direct inflationary pressures and an adverse balance of payments for importing countries, both of which tend to cause reserve currency (i.e. dollar) devaluation. A deteriorating currency, in turn, exacerbates the balance-of-payments problem,

raises the effective cost of imports, creating additional inflationary pressures. Under these circumstances a 'rational' short-term national economic policy for an industrial country is to restrain domestic consumption (especially of imports) while maximizing exports. Under a scenario of continuing oil price increases, most advanced industrial countries are likely to be forced to adopt deflationary 'slow-growth' policies.

The quantitative relationship between international oil prices and international GDP growth rates cannot be predicted by existing economic models. Attempts have been made to do this for the United States alone,² but only under very restrictive assumptions of doubtful relevance to the international situation.*

The situation is only slightly better as regards the reverse side of the coin, viz demand for primary energy as a function of price. Here the problem is of an empirical nature: the available data reflect recent historical occurrences and therefore tend to yield information about short-run responses (e.g. short-run price elasticity of demand, and price elasticities of interfuel substitution). But it is clear that long-run responses may be quantita-

Few of the feedback relationships between balance of payments, currency exchange rates and domestic inflation have been taken into account, for instance.

tively and, possibly, even qualitatively different, since people can make lifestyle adjustments -- such as changing jobs and residential locations -- that are not practical in the short-run. The same thing generally holds true in the industrial sphere. Nevertheless, an international model has been built to predict the impact of price changes on energy demand.³ At some future time such an approach could perhaps be applied to the transportation sector, per se, but this has not yet been done.

A.4 Projection Model for Endogenous Variables

Having prepared the framework, the way is now clear to focus on demand for transportation services and energy. As already noted, it was initially assumed that transportation demand (both passenger and freight) would be determined essentially by GDP and population plus a group of other unspecified factors, such as composition of GDP and geography, whose net effect is more or less constant over time.

The approach adopted was to project passenger-km first as a function of GDP and time. That is, for the j th country,

$$(\text{passenger-km})_j = A_j \cdot (\text{GDP})_j \cdot \exp(a_j t) \quad (1)$$

where A_j is a constant and a_j is a (recent) historical rate of change. Similarly, we assumed the relationship

$$(\text{freight-tons})_j = B_j \cdot (\text{GDP})_j \cdot \exp(b_j t) \quad (2)$$

In principle, A_j , B_j , a_j , and b_j would all be determined by a statistical best fit procedure. However, the quality of presently available data* in many cases is so poor that the statistical significance of such fits would not justify the considerable effort involved. For present purposes, the

*See PREFACE. Undoubtedly there is much room for improvement.

simpler procedure adopted was to calculate the ratios

$$\frac{\text{passenger-km}(t)}{\text{GDP/capita}(t)}_j \quad \text{and} \quad \frac{\text{freight-tons}(t)}{\text{GDP}(t)}_j$$

for as many recent years (t) as possible, estimating the constants A_j , B_j based on a standard recent year (usually 1972). The rate variables (a_j and b_j) were estimated roughly by eye. Table A-3 shows total passenger-km consumed by each group of countries per dollar of GDP for the five-year intervals 1960, 1965, 1970, and 1975. Evidently the ratios are quite stable over time and hover close to 3 passenger-km per dollar for most countries. The ratios are also surprisingly similar for different countries, subject of course to caveats as to data quality. Figures for the OECD and COMECON countries are probably quite good, at least from 1965 on. Figures for the rest of the world are much less reliable; many of the data for those countries were estimated by indirect means, as described in Appendix B.

Table A-4 shows total freight tonnage (unloaded) by country group for the same five-year intervals. In this case, the ratios are a lot less stable over time; and the differences between countries are significantly larger. The most extreme difference is between the United States, which unloads 9.5 tons per \$1000 GDP, and the USSR, which unloads 51.5 tons per \$1000 GDP. The structure of the Soviet economy, as com-

TABLE A-3 Total Passenger-Km/GDP
(Passenger-km/\$)

Region	1960	1965	1970	1975
EEC	2.21	2.33	2.67	3.13
Other Western Europe	3.24	2.84	2.78	2.88
United States	3.08	2.95	2.97	3.10
Australia/Canada	2.81	2.75	2.92	3.22
Japan	3.46	3.02	2.71	2.63
Eastern Europe	1.30	1.58	1.74	1.93
USSR	1.65	1.84	2.06	2.25
Latin America	2.25	2.45	2.63	2.85
Mideast/South Africa	3.49	3.40	3.42	2.89
South Asia	4.69	4.49	4.22	5.17
Other Africa	2.56	3.02	3.12	3.50
China	1.64	2.20	3.55	4.70

Source: Authors' calculations based on data base described in Appendix B.

TABLE A-4 Freight Shipped/GDP
(kg/\$)

Region	1960	1965	1970	1975
EEC	14.49	14.24	14.27	12.61
Other Western Europe	28.55	25.31	24.22	22.14
United States	10.86	9.85	9.42	9.53
Australia/Canada	20.27	20.65	22.16	25.24
Japan	18.72	22.43	26.10	20.52
Eastern Europe	18.97	22.84	25.27	26.20
USSR	41.24	46.57	51.43	55.01
Latin America	16.39	17.24	18.47	19.08
Mideast/South Africa	17.23	17.19	18.60	20.06
South Asia	16.68	17.86	18.64	22.68
Other Africa	11.18	10.78	10.59	17.00
China	7.33	8.31	12.44	17.00

TABLE A-5 Passenger-Km, 1975

Region	Total (10 ⁹)	Mode Fractions			
		Auto	Bus	Rail	Air
EEC	2383	0.788	0.093	0.078	0.042
Other Western Europe	412	0.733	0.113	0.095	0.059
United States	3703	0.888	0.034	0.004	0.074
Australia/Canada	525	0.856	0.021	0.024	0.099
Japan	740	0.342	0.161	0.454	0.043
Eastern Europe	394	0.413	0.335	0.236	0.015
USSR	1023	0.110	0.465	0.309	0.115
Latin America	526	0.678	0.225	0.051	0.045
Mideast/South Africa	181	0.329	0.487	0.131	0.053
South Asia	458	0.250	0.395	0.333	0.023
Other Africa	101	0.332	0.550	0.092	0.026
China	773	0.001	0.410	0.571	0.018

Source: Authors' calculations using data-base described in Appendix B.

pared to the United States economy, account for part of the difference: the United States economy is much less materials-intensive, which is tantamount to saying that it is more service-intensive. Further, there appears to be much more trans-shipment (mainly truck-to-rail) in the USSR than in the United States. The United States and the EEC are unique in possessing a network of high-performance free-ways that permit a large percentage of manufactured goods to be shipped from origin to destination exclusively by long-distance truck. In most other countries similar goods would be trans-shipped to some other mode, normally rail or barge, and then back to trucks for final delivery. Thus some goods are counted three times in the tonnage totals. It would seem, therefore, that if any other country (say Japan) undertakes a major highway construction program, its ratio of freight shipped/GDP should decline in the future. However, given the uncertainty of petroleum supplies such a program seems unlikely.

The next step is to allocate passenger-km and freight tonnage shipped by mode. Actually, the totals for 1960-1975 were built up in the first place by summing over individual modes. Thus it is simple to compute mode fractions for 1975 (Tables A-5, A-6). However, the relative importance of different modes does not remain constant over time. To project from 1975 to the year 2000, trends from 1960 to

1975 were roughly extrapolated in two stages. From 1975 to 1985 the approximate rates of change over the previous decade (1965-1975) were simply continued. From 1985 to 2000 these trends were modified based largely on case-by-case judgmental considerations.

In the case of freight transportation, one must also convert from tons shipped to ton-km, since energy consumption is obviously proportionate to the latter. The most convenient methods of doing this is to introduce the ratio ton-km/ton (Table A-7), which represents the average distance (in km) moved by each ton of freight via a given mode. These ratios are obviously dependent on the geography of the country and the transportation infrastructure that exist. Thus small, densely populated, manufacturing-intensive countries will tend to be characterized by short-distance shipments. Countries with important mining, timber, or agricultural activities will have to ship goods over longer distances.* Obviously these patterns can change significantly over time. However, it seems unlikely that there will be major changes in this regard except in the case of trucking. Because Eastern Europe and the USSR are rapidly increasing their use of motor vehicles, especially trucks, it seems probable that average distances of truck shipments will tend

*However, such countries may be characterized by short-distance trucking (from mine to river or railhead) and long-distance rail or barge shipment. This is notably true for the USSR.

TABLE A-6 Freight-tons, 1975

Region	Total (10 ⁹)	Mode Fractions			
		Truck	Rail	Water	Ship
EEC	9.61	0.723	0.089	0.068	0.120
Other Western Europe	3.17	0.808	0.066	0.081	0.045
United States	11.38	0.749	0.123	0.087	0.041
Australia/Canada	4.11	0.817	0.109	0.049	0.025
Japan	5.77	0.817	0.045	0.060	0.078
Eastern Europe	5.34	0.773	0.206	0.012	0.009
USSR	24.95	0.835	0.145	0.019	0.001
Latin America	3.52	0.858	0.073	0.042	0.027
Mideast/South Africa	1.25	0.863	0.107		0.030
South Asia	2.01	0.843	0.115	0.014	0.028
Other Africa	0.35	0.753	0.103	0.087	0.057
China	2.79	0.762	0.191	0.017	0.030

Source: Authors' calculations using data-base described in Appendix B.

TABLE A-7 Average Freight Shipment Distance,
by Mode (ton-km/ton)

Region	Truck		Rail	Water
	1975	2000	(1975-2000)	(1975-2000)
EEC	55.0	73.4	198.8	147.3
Other Western Europe	48.2	70.2	202.4	182.2
United States	84.4	84.4	1011.4	1328.2
Australia/Canada	32.3	32.3	526.6	900.4
Japan	29.4	37.7	243.2	418.9
Eastern Europe	22.4	36.7	252.3	224.1
USSR	16.2	29.3	893.8	466.3
Latin America	107.5	79.9	393.8	451.8
Mideast/South Africa	48.9	36.3	517.5	
South Asia	66.8	81.4	633.2	993.9
Other Africa	100.0	100.0	208.1	250.0
China	62.5	62.5	745.7	1250.0

Source: Authors' calculations using data-base described in Appendix B.

to increase somewhat. Our assumptions in this regard are shown in the second column of Table A-7. For years between 1975 and 2000 a linear interpretation is used. (This shift will be compensated not by decreased distance of average rail or barge shipments, but by decreases in the corresponding mode fractions.)

Tables A-8 to A-11 indicate the rates of change, by region, that have been assumed in the projections for passenger and freight modes, respectively, and for each of the two scenarios. The Tables are self explanatory.

The final step was to compute the energy requirements for each transportation mode by region, whenever actual fuel consumption by mode are not directly measured (the usual case). Based on various available data from a variety of sources, a set of approximate energy intensities expressed in Btu/passenger-km and Btu/ton-km were developed. (The details are given in Appendix B which follows.) Tables A-12 and A-13 display the estimated values of BTU/PKT and BTU/TK for 1975 and 2000, for each of the two scenarios.

The most significant improvements are projected for passenger cars, especially in North America, where the trend towards smaller, more fuel-efficient vehicles is already under way. Smaller efficiency improvements are anticipated for air travel and trucks. These changes are accelerated in the "conservation" scenario, by the higher price of energy. Values of the coefficients are assumed to change at constant annual rates during the years between 1975 and 2000.

TABLE A-8 Rates of Change, Passenger Transportation Variables,
"Standard" Scenario

Region	Passenger-km/GDP (Rate of Change)		Bus fraction $f_{bus} = \frac{PKT_{bus}}{PKT_{total}}$		Rail fraction $f_{rail} = \frac{PKT_{rail}}{PKT_{total}}$		Air fraction $f_{air} = \frac{PKT_{air}}{PKT_{total}}$	
	1975-1985	1985-2000	1975-1985	1985-2000	1975-1985	1985-2000	1975-1985	1985-2000
EEC	+ 0.54	- 0.64	- 3.00	- 1.99	- 5.00	- 5.01	+ 5.32	+ 2.41
Other West Europe	+ 0.41	0.00	- 2.00	- 3.00	- 2.01	- 5.00	+ 3.14	+ 2.15
United States	0.00	- 0.20	+ 2.00	0.00	0.00	0.00	+ 1.96	+ 2.21
Australia/Canada	+ 0.17	- 0.13	0.00	0.00	- 1.63	- 1.67	+ 1.91	+ 1.50
Japan	- 2.20	- 2.23	0.00	0.00	- 4.32	- 2.14	+ 5.65	+ 2.59
Eastern Europe	+ 2.20	+ 1.03	- 3.00	- 3.00	- 4.66	- 3.46	+ 6.97	+ 4.73
USSR	+ 2.10	+ 0.95	0.00	- 3.00	- 2.15	- 5.01	+ 1.22	+ 1.39
Latin America	+ 0.17	0.00	- 1.00	- 0.83	- 3.90	- 7.76	+ 2.87	+ 1.94
MidEast/South Africa	+ 0.04	0.00	- 1.00	- 3.00	- 3.79	- 7.82	+ 3.44	+ 1.94
Other Africa	- 0.74	- 0.89	+ 2.00	+ 1.00	- 2.90	- 3.46	+ 4.47	+ 2.41
South Asia	- 0.58	- 0.21	+ 2.00	+ 1.00	- 2.82	- 3.80	+ 3.02	+ 2.41
China	- 1.63	- 1.50	+ 2.00	+ 1.00	- 3.62	- 1.94	+ 6.94	+ 3.66

$$\text{Energy for Region (i) used for passenger transport} = GDP_i \cdot \left(\frac{PKT}{GDP} \right)_i \cdot \left(\sum_l^{\text{modes}} (f_l \cdot E_l) \right)$$

where

f_l is a fraction of all passenger-km by mode l and
 E_l is energy (Btu) per passenger-km by mode l .

Notes: Energy/P will decrease fastest in North America because cars are presently large and inefficient.

Improvement in LDCs will be slow because of use of obsolescent auto technology.

Improvement in COMECON after 1985 will be nonexistent because of "trading up" to larger cars. (Same in Spain and advanced LDC.)

Car fraction = 1 - sum over other fractions

TABLE A-9 Rates of Change, Passenger Transportation Variables,
"Conservation" Scenario

Region	Passenger-km/GDP (Rate of Change)		Bus fraction $f_{bus} = \frac{PKT_{bus}}{PKT_{total}}$		Rail fraction $f_{rail} = \frac{PKT_{rail}}{PKT_{total}}$		Air fraction $f_{air} = \frac{PKT_{air}}{PKT_{total}}$	
	1975-1985	1985-2000	1975-1985	1985-2000	1975-1985	1985-2000	1975-1985	1985-2000
EEC	- 0.09	- 0.63	- 2.03	- 1.37	- 3.90	- 4.60	+ 5.32	+ 2.41
Other West Europe	- 0.28	0.00	- 0.17	- 2.54	- 1.11	- 4.73	+ 3.14	+ 2.15
United States	- 0.67	- 0.23	+ 3.25	+ 0.69	+ 3.39	+ 0.54	+ 1.96	+ 2.21
Australia/Canada	- 0.71	- 0.23	+ 1.47	+ 0.51	+ 0.62	- 1.50	+ 1.91	+ 1.50
Japan	- 2.28	- 2.27	+ 0.98	+ 0.33	- 3.33	- 2.20	+ 5.65	+ 2.59
Eastern Europe	+ 1.31	+ 0.35	- 2.00	- 2.32	- 3.67	- 2.74	+ 6.97	+ 4.73
USSR	+ 1.04	+ 0.75	+ 0.72	- 2.43	- 1.18	- 4.60	+ 1.22	+ 1.39
Latin America	- 3.19	0.00	- 0.04	- 0.43	- 3.05	- 7.14	+ 2.87	+ 1.94
MidEast/South Africa	+ 0.04	0.00	- 1.00	- 3.00	- 3.79	- 7.84	+ 3.44	+ 1.94
Other Africa	- 1.62	- 1.35	+ 2.42	+ 1.18	- 2.50	- 2.87	+ 4.47	+ 2.41
South Asia	- 1.21	- 0.22	+ 2.45	+ 0.96	- 2.11	- 3.46	+ 3.02	+ 2.41
China	- 1.63	- 1.50	+ 2.01	+ 0.99	- 3.62	- 1.94	+ 6.94	+ 3.66

Energy for Region (i) used for passenger transport = $GDP_i \cdot \left(\frac{PK}{GDP_i} \right) \cdot \left(\sum_{l}^{modes} (f_l \cdot E_l) \right)$

where

f_l is a fraction of all passenger-km by mode l and
 E_l is energy (Btu) per passenger-km by mode l .

Notes: Energy/PKT will decrease fastest in North America because cars are presently large and inefficient.

Improvement in LDCs will be slow because of use of obsolescent auto technology.

Improvement in COMECON after 1985 will be nonexistent because of "trading up" to larger cars. (Same in Spain and advanced LDC.)

Car fraction = 1 - SUM over other fractions

TABLE A-10 Rates of Change, Freight Transportation Variables,
"Standard" Scenario

Region	Tons/GDP (rate of change)		Rail fraction g_r		Water fraction g_w		Ship fraction g_s		Truck $\frac{\text{ton-km}}{\text{ton}}$	
	1975-1985	1985-2000	1975-1985	1985-2000	1975-1985	1985-2000	1975-1985	1985-2000	1975-1985	1985-2000
EEC	- 1.00	- 1.00	- 3.50	- 2.50	- 1.00	- 1.00	+ 3.50	+ 2.00	+ 1.40	+ 1.00
Other West Europe	- 1.00	- 1.00	- 4.50	- 3.00	0.00	0.00	+ 4.00	+ 3.00	+ 2.00	+ 1.20
United States	0.00	- 1.00	- 1.00	- 1.00	- 2.00	- 2.00	+ 3.30	+ 2.00	0.00	0.00
Australia/Canada	+ 0.67	- 0.33	- 0.40	- 0.67	- 1.33	- 1.33	+ 1.10	+ 1.00	0.00	0.00
Japan	- 2.00	- 2.00	0.00	0.00	0.00	0.00	+ 3.50	+ 2.50	+ 1.00	+ 1.00
Eastern Europe	+ 1.00	- 1.00	- 3.30	- 2.50	+ 0.50	0.00	+ 0.50	+ 1.00	+ 2.00	+ 2.00
USSR	+ 1.50	- 2.00	- 2.50	- 2.00	- 1.00	- 1.00	+ 0.50	+ 1.00	+ 3.00	+ 2.00
Latin America	+ 1.00	+ 1.00	0.00	- 1.00	- 3.00	- 3.00	+ 3.00	+ 3.00	0.00	- 2.00
MidEast/South Africa	+ 1.50	+ 1.00	- 4.50	- 3.00	0.00	0.00	- 2.50	- 2.00	0.00	- 2.00
Other Africa	+ 2.00	+ 2.00	- 4.00	- 3.00	- 1.00	0.00	- 1.00	- 1.00	+ 2.00	0.00
South Asia	+ 2.00	+ 2.00	- 4.00	- 3.00	- 3.00	- 3.00	- 4.00	- 3.00	0.00	0.00
China	+ 2.00	+ 2.00	- 2.70	- 2.00	+ 3.50	0.00	- 4.00	- 3.00	0.00	0.00

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$$\text{Energy for Region (i) used for freight transport} = \text{GDP}_i \cdot \left(\frac{\text{Ton}}{\text{GDP}} \right)_i \cdot \left(\sum_l g_l \cdot \left(\frac{\text{Tk}}{\text{T}} \right)_l \cdot E_l \right)$$

where

g_l is a fraction of all domestic freight tons (excluding pipeline and shipping), carried by mode l ,

$\left(\frac{\text{Tk}}{\text{T}} \right)_l$ is the ratio of ton-km/ton for mode l , and

E_l is the energy required per ton-km by mode l .

Notes: We assume $\text{Tk}/\text{T} = \text{constant}$ for rail and water freight.

We assume $\text{Tk}/\text{T} = 1$ for shipping. Thus E_{ship} is simply energy per ton shipped. See Appendix B.

Truck Fraction = 1 - Sum over other mode fractions

TABLE A-11 Rates of Change, Freight Transportation Variables,
"Conservation" Scenario

	Tons/GDP (rate of change)		Rail fraction g_r		Water fraction g_w		Ship fraction g_s		Truck	$\frac{\text{ton-km}}{\text{ton}}$
	1975-1985	1985-2000	1975-1985	1985-2000	1975-1985	1985-2000	1975-1985	1985-2000	1975-1985	1985-2000
EEC	- 1.00	- 1.00	- 3.50	- 2.50	- 1.00	- 1.00	+ 3.50	+ 2.00	+ 1.40	+ 1.00
Other West Europe	- 1.00	- 1.00	- 4.50	- 3.00	0.00	0.00	+ 4.00	+ 3.00	+ 2.00	+ 1.20
United States	0.00	- 1.00	- 1.00	- 1.00	- 2.00	- 2.00	+ 3.30	+ 2.00	0.00	0.00
Australia/Canada	+ 0.67	- 0.33	- 0.40	- 0.67	- 1.33	- 1.33	+ 1.10	+ 1.00	0.00	0.00
Japan	- 2.00	- 2.00	0.00	0.00	0.00	0.00	+ 3.50	+ 2.50	+ 1.00	+ 1.00
Eastern Europe	+ 1.00	- 1.00	- 3.30	- 2.50	+ 0.50	0.00	+ 0.50	+ 1.00	+ 2.00	+ 2.00
USSR	+ 1.50	- 2.00	- 2.50	- 2.00	- 1.00	- 1.00	+ 0.50	+ 1.00	+ 3.00	+ 2.00
Latin America	+ 1.00	+ 1.00	0.00	- 1.00	- 3.00	- 3.00	+ 3.00	+ 3.00	0.00	- 2.00
MidEast/South Africa	+ 1.50	+ 1.00	- 4.50	- 3.00	0.00	0.00	- 2.50	- 2.00	0.00	- 2.00
Other Africa	+ 2.00	+ 2.00	- 4.00	- 3.00	- 1.00	0.00	- 1.00	- 1.00	+ 2.00	0.00
South Asia	+ 2.00	+ 2.00	- 4.00	- 3.00	- 3.00	- 3.00	- 4.00	- 3.00	0.00	0.00
China	+ 2.00	+ 2.00	- 2.70	- 2.00	+ 3.50	0.00	- 4.00	- 3.00	0.00	0.00

$$\text{Energy for Region (i) used for freight transport} = \text{GDP}_i \cdot \left(\frac{\text{Ton}}{\text{GDP}} \right)_i \cdot \left(\sum_l g_l \cdot \left(\frac{\text{Tk}}{\text{T}} \right)_l \cdot E_l \right)$$

where

g_l is a fraction of all domestic freight tons (excluding pipeline and shipping), carried by mode l ,

$\left(\frac{\text{Tk}}{\text{T}} \right)_l$ is the ratio of ton-km/ton for mode l , and

E_l is the energy required per ton-km by mode l .

Notes: We assume $\text{Tk}/\text{T} = \text{constant}$ for rail and water freight.

We assume $\text{Tk}/\text{T} = 1$ for shipping. Thus E_{ship} is simply energy per ton shipped. See Appendix B.

Truck fraction = 1 - Sum over other modes

TABLE A-12 Energy Intensity Assumptions, Base Case, 1975-2000

Mode	Year	United States	Australia/Canada	EEC	Other Western Europe	Japan	USSR	Eastern Europe	Latin America	MidEast/South Africa	South Asia
Automobile, BTU/PKT	1975	3200	2800	1600	1600	1400	1600	1600	1200	1600	1200
	2000	1800	1600	1200	1200	1200	1400	1200	1400	1400	1200
Bus, BTU/PKT	1975	1000	1000	1000	1000	650	500	500	600	600	400
	2000	1000	1000	1000	1000	650	500	500	600	600	400
Rail, BTU/PKT	1975	2000	2000	2000	2000	200	500	500	1000	1000	300
	2000	2000	2000	2000	2000	300	500	500	1000	1000	300
Air, BTU/PKT	1975	4500	4500	4000	4000	3340	3500	3500	4000	4000	3000
	2000	4000	4000	3500	3500	3000	3000	3000	3500	3500	3000
Truck, BTU/TK	1975	5000	6000	5000	5500	6000	6500	6000	7000	7000	5000
	2000	4500	5000	4000	4500	4500	5500	4500	6000	6000	5000
Water, BTU/TK	1975	340	340	1200	1200	1600	400	400	1000	1000	250
	2000	340	340	1200	1200	1600	400	400	1000	1000	250
Rail, BTU/TK	1975	450	450	1200	1200	715	400	400	800	800	350
	2000	450	450	1200	1200	715	400	400	800	800	350
Ship, BTU/TK	1975	150	150	150	150	150	150	150	150	150	150
	2000	125	125	125	125	125	125	125	125	125	125

TABLE A-13 Energy Intensity Assumptions, Conservation Case, 1975-2000

Mode	Year	United States	Australia/Canada	EEC	Other Western Europe	Japan	USSR	Eastern Europe	Latin America	MidEast/South Africa	South Asia
Automobile, BTU/PKT	1975	3200	2800	1600	1600	1400	1500	1600	1200	1600	1200
	2000	1200	1150	1000	1000	1000	1000	1000	1100	1200	1000
Bus, BTU/PKT	1975	1000	1000	1000	1000	650	500	500	600	600	400
	2000	800	800	800	800	600	500	500	600	600	400
Rail, BTU/PKT	1975	2000	2000	2000	2000	200	500	500	1000	1000	300
	2000	1500	1500	1500	1500	300	500	500	1000	1000	300
Air, BTU/PKT	1975	4500	4500	4000	4000	3340	3500	3500	4000	4000	3000
	2000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Truck, BTU/TK	1975	5000	6000	5000	5500	6000	6500	6000	7000	7000	5000
	2000	3500	3500	3500	3500	4000	4500	3500	4500	4500	4500
Water, BTU/TK	1975	340	340	1200	1200	1600	400	400	1000	1000	250
	2000	300	300	1000	1000	600	300	300	800	800	250
Rail, BTU/TK	1975	450	450	1200	1200	715	400	400	800	800	350
	2000	400	400	600	600	600	350	400	700	700	300
Ship, BTU/TK	1975	150	150	150	150	150	150	150	150	150	150
	2000	125	125	125	125	125	125	125	125	125	125

APPENDIX A REFERENCE LIST

1. United Nations World Population Prospects 1970-2000
(New York), 1973.
2. For instance, E. A. Hudson and D. W. Jorgenson,
Econometric Studies of US Policy, North Holland
Publishing Co., 1976.
3. R. Ridker and W. Watson, To Choose a Future: Resource
and Environmental Problems of the US - A Long Term
Global Outlook.

APPENDIX B
TRANSPORTATION / ENERGY DATA BASE

B.1 Data Problems

Before any forecasting is possible, it is essential to construct an internally consistent and complete data base from which recent activity levels and rates of change (trends) can be ascertained. It goes almost without saying that existing published data are both inadequate and, in many cases, unreliable. Thus two major problems need to be addressed: (1) how to make the best choice among competing sources which disagree; and (2) how to estimate or synthesize data where none exists or where available sources are evidently untrustworthy.

Regarding the first point, the following general criteria have been used more or less, although the ultimate criterion is often personal judgement by the principal author (R. U. Ayres).

1. The more internally consistent the detail available in a data source is (other factors remaining equal), the more reliable the data are likely to be. For instance, if freight carried by mode were specified by industrial commodity, by type of vehicle, or by province (or state) in one source, but only a bare total were given in another source, one would be inclined to prefer the first source.

2. Most annual compilations contain misclassifications, omissions, misprints, and/or transcription errors. (Decimal points are particularly likely to be misplaced.) Sometimes these are corrected in later editions. The latest publication in a series is likely to be more reliable than earlier ones (other factors remaining equal) because errors and discrepancies may have been noted and corrected.

3. If one must select between two sources of production or consumption data where no other internal evidence is available, the larger figures are probably the safest to use. The reason is that undercounting (omission of some vehicles, passengers, or freight) is intrinsically more likely than overcounting.

The simple criteria mentioned above are all very limited, of course, because it is rare that all other factors are actually equal. By far the most potent means of validation of questionable data is the test of internal consistency. Are accounting identities satisfied? Do the component parts add up to the published totals? A secondary test is external consistency. Do key ratios, for example, of transport demand to GDP or to DGP elements remain relatively stable over time? Are intercounty comparisons reasonable in terms of what one knows in general about geography, population density, and economic development? These tests are anything but mathematically rigorous, of course. Their use is primarily a means of assuring that magnitudes are reasonable and signs (direction of change) are correct.

B.2 Transportation Data

Table B-1 is a complete list of transportation variables that are incorporated in the data base. Tables B-2 to B-4 list the preferred sources of data for the major transportation variables that have been incorporated in the data base. Sources are listed in abbreviated form on each table. A full list of sources used is given at the end of the appendices.

Regarding the estimation of missing data, we have compiled a list of simple algorithms or rules that have been found to be useful in a variety of cases (Table B-5). For certain other cases, individual treatment has been deemed appropriate. The master list of rules follows. In addition, we provide a set of notes on each country describing which rules were applied and, where appropriate, indicating where special calculations were done. Energy data are discussed separately in later sections of this Appendix.

TABLE B-1 Transportation Variables Y_j

<u>Index</u>	<u>Variable</u>
1	cars
2	buses
3	trucks
4	tractors
5	car-km
6	bus-km
7	truck-km
8	plane-km
9	car passenger-km
10	bus passenger-km
11	rail passenger-km
12	air passenger-km
13	truck ton-km
14	domestic water ton-km
15	rail ton-km
16	pipeline ton-km ^a
17	air ton-km
18	truck-tons carried
19	domestic water-tons carried
20	rail-tons carried
21	pipeline-tons carried ^a
22	international shipping tons unloaded

^anot computerized.

TABLE B-2 Sources of Data, Motor Vehicles

		Cars	Buses, coaches	All trucks	Trucks over 10 T	Tractors nonagricultural	Truck capacity 1-5 T	Notes
		1	2	3	4	5	6	
Austria	11	IRF p74	IRF p74	IRF p74	ECE	N	ECE	Tractor data includes agriculture
Belgium	12	ΔIRF p74	ΔIRF*p74	ΔIRF p74	ECE	IRF p73	ECE	*IRF differs from ECE
Denmark	13	ΔIRF p74	IRF p74	ΔIRF p74	ECE	ECE	ECE	
France	14	IRF p74	IRF*p74	IRF *	ECE	IRF *	ECE	*IRF differs from BI, ECE
Germany (FED)	15	IRF*p74	IRF *	IRF *	ECE	IRF	ECE	*Small difference between IRF, ECE
Italy	16	ΔECE,*p74		ΔECE p74 IRF	ECE	IRF	N	*Difference between BI, ECE/IRF,ECE
Netherlands	17	ΔIRF*p74	IRF*p67	ΔIRF*p73	ECE	IRF	ECE	*Difference between IRF,ECE
Spain	18	ECE p74	ECE p74	ECE p74	ECE	IRF-ECE	N	All sources agree
Sweden	19	IRE 973	IRF*p73	IRF p73	ECE	ECE	ECE	*Small difference between IRF,ECE
Switzerland	20	IRE p74	*	IRF *	ECE	IRF	N	*Difference between BI,ECE/IRF,ECE
United Kingdom	21	IRE*p74	IRF*p74	ΔIRF*p74	ECE	IRF *	N	*Difference between IRF,ECE
Australia	22	IRE p74	IRF (75)	IRF	N	IRF incomplete	N	
Canada	23		IRF	IRF	N	N	N	
Japan	24	IRF p74	IRF p74	IRF	N	IRF	N	
South Africa	25	IRF p74	ΔIRF p74	IRF p74	N	N	N	
United States	26	DOT	DOT	DOT	census	DOT	N	75 from FHA Census of Transportation
Czechoslovakia	27	ΔIRF*p73	IRF p 73	IRF	N	N +	N	*Small difference between BI,ECE,IRF
Germany (DDR)	28	ECE p74	ECE p74	ΔECE p74	N	N	N	*Difference between BI,ECE
Poland	29	IRF	IRF	IRF p73	ECE	ECE	ECE	All agree
USSR	30				N	N	N	No data since 1974
Yugoslavia	31	ECE p73	ECE p73	ECE*p73	ECE	N +	ECE	*Difference between BI,IRF
Iran	32			IRF *	N	N	N	*Difference between BI,IRF
Nigeria	33	Firestone			N	N	N	No data since 1974
Saudi Arabia	34	IRF *	IRF *	IRF *	N	N	N	*Difference between BI,IRF
Venezuela	35	*			N	N	N	*Difference between BI,IRF
Argentina	36	ΔIRF p74	ΔIRF p74	ΔIRF*p74	N	N	N	*Difference between BI,IRF
Brazil	37	IRF p73	IRF 75	IRF p73	N	N	N	Ask 74, 75 split car/truck
Mexico	38	IRF p72	IRF p72	IRF p72	N	N	N	*Difference between BI,IRF for 73
Egypt	39				N	N	N	No data since 1973
Morocco	40		IRF *	IRF =	N	N	N	*Difference between BI,IRF
China	41		N		N	N	N	No data since 1974
India	42	*	IRF	IRF *	N	N +	N	*Difference between BI,IRF
Indonesia	43			IRF	N	N	N	No data since 1973
Philippines	44		N		N	N	N	No data since 1973

NOTE: The primary reference for columns 1-3 prior to 1974 is Business International (BI). Other references are cited insofar as they extend or replace figures in the BI data base.

IRF p74: International Road Federation (pcst 1974)
 ΔIRF p74: IRF increments (post 1974)
 ECE: ECE Transport Stats.
 DOT: Department of Transportation (US)
 Census: Census of Transportation (US)
 Firestone: Unpublished internal document

* Disagrees with other sources.
 +: Published data, rejected for reasons of
 inconsistency or improbability
 N: No reliable source (see rules)

TABLE B-3 Sources of Data, Passenger Transportation

	Loc Code	Car		Bus		Rail		Air	
		km	passenger-km	km	passenger-km	passenger-km	passenger ^a	passenger-km	passenger ^a
-----OECD plus South Africa-----	Austria	11	IRF 65 ECE 70-	ECE	ECE 70-	N +	UN	ECE	UN
	Belgium	12	IRF-ECE	IRF 68 ECE 70-	IRF 68 ECE 70-	IRF -68	UN	ECE	UN
	Denmark	13	IRF	IRF	IRF	IRF	UN	ECE	UN
	France	14	IRF	IRF	IRF	IRF	UN	ECE	UN
	Germany (FRG)	15	IRF	IRF	IRF	IRF	UN	ECE	UN
	Italy	16	IRF	IRF	IRF	IRF	UN	ECE	UN
	Netherlands	17	IRF-ECE	IRF-ECE	IRF	ECE *	UN	ECE	UN
	Spain	18	IRF	ECE 70 IRF *	IRF *	IRF-73 ECE-74 SL 70	UN	ECE	UN
	Sweden	19	IRF 65 ECE 70-	ECE 70*	IRF 65	SL 70	UN	ECE	UN
	Switzerland	20	IRF 70	N	N	ECE 70-	UN	ECE	UN
	United Kingdom	21	IRF-ECE	IRF	IRF-ECE	IRF	UN	ECE	UN
	Australia	22	IRF	IRF	N	IRF	IRF	N	UN
	Canada	23	SC *	TC 65,75	TC 74	TC 65,75	UN	ECE	UN
	Japan	24	IRF	IRF	IRF	IRF	UN	(Inc)IUR	UN
	South Africa	25	N	N	N	N	N	IUR	UN
	United States	26	IRF	IRF	IRF	IRF	UN	ECE	UN
	(Note U.S. data agree with DOT publications)								
	Czechoslovakia	27	N	N	IRF-ECE	IRF-ECE	UN	ECE	UN
	Germany (DDR)	28	N	N	N	ECE	IUR	ECE	N
	Poland	29	IRF	N	ECE *	IRF	UN	ECE	UN
	USSR	30	N	N	N	ECE	UN	ECE	UN
	Yugoslavia	31	ECE	ECE	ECE	ECE	UN	ECE	UN
-----Comecon-----	Iran	32	IRF 70,75	IRF 70,75	IRF 70,75	IRF 70,75	UN	IUR	UN
	Nigeria	33	N	N	N	N	UN	N	UN
	Saudi Arabia	34	N	N	N	N	UN	N	UN
	Venezuela	35	IRF	N	b	N	UN	N	UN
	Argentina	36	N	N	N	IRF	UN	N	UN
	Brazil	37	N	DBB	N	b	UN	(Inc)IUR	UN
	Mexico	38	N	N	N	N	UN	N	UN
	Egypt	39	N	N	N	N	UN	N	UN
	Morocco	40	IRF	N	IRF	N	UN	IUR	UN
	China	41	N	N	N	N	N	N	N
Other	India	42	IRF	IRF	IRF	IRF	UN	IUR	UN
	Indonesia	43	IRF	N +	IRF	IRF	UN	N	UN
	Philippines	44	N	N	N	N	UN	N	UN

UN: UN Statistical Yearbook
 IRF: International Road Federation
 IUR: International Union of Railways
 ECE: Economic Commission for Europe
 SL: Schipper and Lichtenberg (Sweden)
 TC: Transport Canada
 SC: Statistics Canada

DBB: Daimler-Benz, Brazil
 N: No reliable source (See Rules)
 Inc: Incomplete
^a: Not currently in computer file
^b: Included with cars
 *: Disagrees with other sources
 +: Published data, rejected for reasons of inconsistency or improbability

TABLE B-4 Sources of Data, Freight Transportation

Loc Code	Truck		Water		Rail		Air ^a	Ship ^b
	tons	ton-km	tons	ton-km	tons	ton-km	ton-km	tons
Austria	11	N +	N +	ECE	ECE	ECE	UN	
Belgium	12	IRF	N +	IRF-69*	IRF-69	ECE 70	UN	UN
				ECE 70-	ECE 70-			
Denmark	13	IRF 73	IRF	IRF 73	IRF	ECE	UN	UN
France	14	IRF	IRF	IRF-ECE	IRF-ECE	IRF-ECE	UN	UN
Germany (FRG)	15	IRF-ECE	IRF-ECE	IRF-ECE	IRF-ECE	IRF-ECE	UN	UN
Italy	16	N	IRF	N	N	IRF-ECE	UN	UN
Netherlands	17	IRF-ECE	IRF-ECE	ECE *	ECE *	IRU *	UN	UN
Spain	18	N	IRF-ECE	N	IRF	IRF-ECE	UN	UN
Sweden	19	IRF 66	ECE	IRF 66	IRF	ECE	UN	UN
		ECE 70-						
Switzerland	20	ECE	ECE	ECE *	ECE *	IRF-ECE	UN	UN
United Kingdom	21	IRF *	IRF-ECE	ECE *	ECE *	IRU	UN	UN
Australia	22	IRF *	IRF	IRF	IRF -68	IRF *	UN	UN
Canada	23	TC ^c	SC-TC ^c	ECE *	SC	ECE	UN	UN
Japan	24	IRF	IRF	IRF	IRF	IRF	UN	UN
South Africa	25	N	N	N	N	N	UN	UN
United States	26	JFA	DOT	DOT	DOT	ECE	UN	UN
Czechoslovakia	27	IRF-ECE	IRF-ECE	IRF-ECE	IRF	IRF	UN	UN
Germany (DDR)	28	ECE	ECE	ECE	ECE	ECE	UN *	UN
Poland	29	IRF-ECE	IRF-ECE	IRF-ECE	IRF-ECE	IRF-ECE	UN	UN
USSR	30	ECE	ECE	ECE	ECE	ECE	UN	UN
Yugoslavia	31	ECE *	ECE	IRF -68	IRF -68	IRF-ECE	UN	UN
				ECE 70-	ECE 70-			
Iran	32	N	IRF 70,75	N	N	IRF 70	UN	UN
Nigeria	33	N	N	N	N	N	UN	UN
Saudi Arabia	34	N	N	N	N	N	UN	UN
Venezuela	35	IRF 70,71	IRF 70,71	IRF 70	N	N	UN	UN
Argentina	36	IRF	IRF 65,66	IRF	IRF 65-67	IRF	UN	UN
Brazil	37	N	DBB	IRF 65	DBB	IRF 65	DBB *	UN
Mexico	38	N	N	N	N	N	UN	UN
Egypt	39	N	N	N	N	N	UN	UN
Morocco	40	N +	N +	N	N	IRF	UN	UN
China (PRC)	41	N	N	N	N	N	UN	UN
India	42	IRF X 10	IRF	IRF	N	IRF *	UN	UN
Indonesia	43	IRF X 10	IRF	IRF	N	IRF	UN X 10	UN
Philippines	44	N	N	N	N	N	UN	UN

UN: Un Statistical Yearbook

IRF: International Road Federation

ECE: Economic Commission for Europe

DOT: Department of Transportation

TC: Transport Canada; SC: Stats Can

DBB: Daimler-Benz, Brazil

JFA: Jack Faucett Associates

N: No reliable source (See Rules)

b: Total, including international, attributable to national airlines

c: Goods unloaded (international)

*: Adjusted to allow for private trucks

+: Disagrees with other sources

-: Published data, rejected for reasons of inconsistency or improbability

TABLE B-5
Master List of Rules for Estimation Where
Data are Missing

<u>Rule</u>	<u>Description</u>
R0	Wherever two data points are separated by one or more years, the program automatically interpolates and extrapolates back to 1954 and forward to 1975, using a best exponential fit.
R1	Estimate by the author based on similarities between countries and relationships between other factors. See note for details.
R2	Artificial zero used in some cases (e.g., truck tractors) where figures are included in another column (e.g., trucks).
R3	Forward extension of a time series (e.g., parc) from a standard source (e.g., BI) by means of adding year-to-year increments derived from a second, later source (e.g., IRF).
R4	Adjusted by subtraction of estimated or interpolated data belonging to another category (e.g., buses) from data given for a lumped category (e.g. trucks <u>and</u> buses).
R5	Adjusted by subtraction of a fixed fraction of one category (e.g., cars) and shift to another category

(e.g., trucks). May be necessary where data for different years use different methods of classification.

- R6 Calculate vehicle-km, passenger-km or ton-km Y_{k+j} for years since the last datum t_0 by computing

$$Y_{k+j}(t) = \frac{Y_k(t)}{Y_k(t_0)} Y_{k+j}(t_0) \quad .$$

This rule applies for $k = 1, 2$ or 3 (cars, buses or trucks).

- R7 Calculate vehicle-km Y_{k+4} , where no other good data exist, from the number of vehicles times the number of vehicle-km per year per vehicle, C_k

$$Y_{k+4}(t) = C_k(t) Y_k(t).$$

The parameter C_k may be estimated or derived from some independent source, depending on the country.

- R8 Calculate passenger-km Y_{k+8} (for cars $k = 1$ and for buses $k = 2$), where no other good data exist, from the number of vehicle-km times the number of passengers per vehicle based on a similar country

$$Y_{k+8}(t) = D_k(t) Y_{k+4}(t).$$

- R9 Calculate truck ton-km Y_{13} , where other data are inadequate, from the number of truck-km times the

R9 (continued)

number of ton-km per truck-km (average load), based on an earlier year or a similar country

$$Y_{13}(t) = E_7 Y_7(t) \quad .$$

R10 Calculate truck-tons carried Y_{18} from the number of trucks times the number of tons carried annually per truck, based on an earlier (later) year or a similar country

$$Y_{18}(t) = F_3 Y_3(t) \quad .$$

R11 Calculate truck, rail, or water tons from truck, rail, or water ton-km in current year and the ratio of water ton-km/water tons for another year or a similar country

$$Y_{18}(t) = G_{13}^{-1} Y_{13}(t) \quad ,$$

$$Y_{19}(t) = G_{14}^{-1} Y_{14}(t) \quad ,$$

$$Y_{20}(t) = G_{15}^{-1} Y_{15}(t) \quad .$$

Alternatively, this rule can be used to compute ton-km from tons shipped if the latter data are available and not the former.

Austria

R7 applies to Y_7 where C_3 is the same as for FRG, all years.

R9 applies to Y_{13} where E_7 is the same as for FRG, all years.

R10 applies to Y_{18} where F_3 is the same as for FRG, all years.

Belgium

R6 with $k + 3$, $t_0 = 72$ applies to $Y_7(73-75)$.

R1 applies to $Y_{13}(71-73)$. See Note (a).

R6 applies to $Y_7(73-75)$ ($C_3 = 20500$), $Y_{13}(74-75)$ ($C = 158800$),

and $Y_{18}(73-75)$ ($F_3 = 1236$).

Note: Y_7 data is taken from IRF.

Denmark

R6 applies to Y_5, Y_6, Y_7, Y_{13} for years 73-75 ($C_1 = 17200$,
 $C_2 = 55000$, $C_3 = 24900$).

R8 applies to $Y_9(74-75)$ with $D_5 = 2.2$ and to $Y_{10}(74-75)$ with
 $D_6 = 16.0$.

R10 applies to $Y_{18}(74-75)$ with $F_3 = 1285$ tons/truck.

R11 applies to $Y_{19}(74-75)$ with $G_{14} = 4667$ tons/truck.

France

R6 with $K-1,2,3$ and $t_0 = 74$ applies to $Y_5(75), Y_6(75), Y_7(75)$

$t_0 = 73$ applies to $Y_8(74-75), Y_9(74-75)$

(actual IRF avail).

Italy

R6 applies to Y_5, Y_6, Y_7 for 73-76.

R8 applies to Y_9, Y_{10} for the years 73-76 using D_1, D_2
from 72 $D_1 = 2, D_2 = 24.2$.

R9 applies to Y_{13} (75-76) using E_7 from 72.

R10 applies to Y_{18} using F_3 based on France.

Netherlands

R6 applies to $Y_5(75), Y_6(75), Y_7(75)$.

Spain

R1 applies to Y_7 , adding 10,000 to truck-km per truck data in
IRF:

R6 applies to $Y_5(75), Y_6(75), Y_7(75)$.

R11 applies to Y_{18}, Y_{19} all years using $G_{13} = \text{France } (8/5)$
and $G_{14} = 200$.

Sweden

R6 applies to Y_6 and Y_7 for years (66-75).

Switzerland

R6 applies to Y_{13} (75).

R7 applies to Y_7 all years, with $C_3(t)$ based on FRG.

R10 applies to Y_{18} (75).

United Kingdom

R1 applies to $Y_{14}(75)$.

R6 applies to $Y_7(75)$ $F = 23800$.

R8 applies to $Y_9(75)$.

R10 applies to $Y_{18}(75)$ using 1974 ratios.

Australia

R1 applies to $Y_6(65-68)$ and $Y_6(75)$. See Note (b).

R6 applies to $Y_5(75)$ and $Y_7(75)$.

R10 applies to Y_{18} for years 65-68 using F_3 for 1970.

R1 applies to Y_{14} and Y_{19} for 1970-75. See Note (c).

Canada

R7 applies to Y_5, Y_6, Y_7 with

$C_1 = 14,500$ km/year, all years

$C_2 = 13,500$ km/year (which is correct for the year 74),
all years

$C_3 = 20,000$, all years.

R8 applies to Y_9 with $D_1 = 2.2$.

R11 applies to Y_{14} , $G_{14} = 600$.

Japan

R6 applies to $Y_5(75), Y_6(75), Y_7(75)$.

South Africa

R7 applies to Y_5, Y_6, Y_7 with $C_1 =$ taken from BI, for years

South Africa (continued)

60,65,70,74; assume $C_1 = 9.6$ for 1975.

$C_2 = 15,000$, all years.

$C_3 = 20,000$ km, all years.

R8 applies to Y_9 and Y_{10} with $D_1 = 2$ passengers/car and $D_2 = 25$ passengers/bus.

R1 applies to Y_{11} . See Note (d). We assume 1 passenger-km for every 3 ton-km. We also assume there is no significant inland or coastal water transport, so Y_{14} and Y_{19} are zero.

R9 applies to Y_{13} with $E_7 = 1.5$ ton-km/truck-km based on 1974 Australian ratio.

R10 applies to Y_{18} , with $F_3 = 850$ tons/truck (based on 1974 Australian ratio).

R11 with $G_{15}^{-1} = 507$ applies to Y_{20} .

United States

R1 applies to Y_{10} . See Note (e).

R8 applies to $Y_9(65068)$ with $D_1 = 2.1$.

R11 applies to Y_{18} , using $G_{13} = 85$ ton-km/ton for years after 1970.

Czechoslovakia

R6 applies to $Y_7(70-75)$, with $t_0 = 69$, $k = 3$.

Czechoslovakia (continued)

R7 applies to Y_5 with C_5 taken from BI data, years 65,70,74.

R8 applies to Y_9 with $D_k = 2.5$.

Germany (DDR)

R7 applies to Y_5, Y_6, Y_7 , all years. C_1, C_2, C_3 are assumed to be the same as for Czechoslovakia.

R8 applies to Y_9 , all years with D_1 , same as Czechoslovakia.

R1 applies to Y_8, Y_{12} and Y_{17} . See Note (f).

R1 applies to Y_{22} . See Note (g).

Poland

R8 applies to Y_9 . Use $D_1 = 2.5$.

Soviet Union

R1 applies to Y_8 . See Note (h).

R7 applies to Y_5, Y_6, Y_7 . C_1, C_2, C_3 are assumed to be the same as for Poland.

R8 applies to Y_9 . Use $D_1 = 2.5$.

Yugoslavia

R6 applies to Y_7 .

Iran

R1 applies to Y_{14}, Y_{19} . We assume no inland water transport.

Iran (continued)

R4 applies to Y_9 . Data on private road transportation for cars and buses are lumped together. We have assumed an average bus load of 35. This yields an average car load of 2.6 in 1970 and 2.61 in 1975.

R8 applies to Y_{10} with $D_2 = 35$.

R10 applies to Y_{18} using $F_3 = 1500$ tons/truck.

R11 applies to Y_{20} with $\frac{1}{650}$ ton-km.

Nigeria

R7 applies to Y_5, Y_6, Y_7 . $C_1 = 10,000$ (all years), $C_2 = 45,000$ (all years), $C_3 = 40,000$ (all years).

R8 applies to Y_9, Y_{10} . $D_1 = 3.0$ passengers/car and $D_2 = 25$ passengers/bus.

R1 applies to Y_{14}, Y_{19} ; water transport assumed to be zero.

R9 applies to Y_{13} with $E_7 = 2.0$ ton-km/truck-km.

R10 applies to Y_{18} with $F_3 = 800$ tons/truck.

R11 applies to Y_{20} , with $G_{15} = 500$ ton-km/ton.

Saudi Arabia

R7 applies to Y_5, Y_6, Y_7 (all years). $C_1 = 10,000$, $C_2 = 40,000$, $C_3 = 50,000$.

R8 applies to Y_9, Y_{10} . $D_1 = 2.6$ (same as Iran), $D_2 = 20$.

R9 applies to Y_{13} . $E_7 = 3.0$ ton-km/km.

R1 applies to Y_{14}, Y_{19} (water transport assumed zero).

Saudi Arabia (continued)

R10 applies to Y_{18} . $F_3 = 1200$.

R11 applies to Y_{20} . $G_{15} = 250$.

Venezuela

R4 applies to Y_5 (96% of joint car and bus) and Y_6 (4%),
for years 70-72. See Note (i).

R6 applies to Y_5 and Y_6 after 1972 and to Y_{13} after 1971.

R7 applies to Y_7 , all years, with $C_3 = 40,000$.

R8 applies to Y_9 , Y_{10} , with $D_1 = 2.5$ and $D_2 = 20$.

R11 applies to Y_{14} , all years; Y_{18} after 1971; and Y_{20} , all
years $G_{13} = 310$ ton-km/ton (truck); $G_{14} = 800$ ton-km/
ton (water); $G_{15} = 300$ ton-km/ton (rail).

Argentina

R7 applies to Y_5 , Y_6 , Y_7 . $C_1 = 10,000$ km/year, $C_2 = 40,000$
km/year, $C_3 = 16,500$ km/year.

R8 applies to Y_9 , Y_{10} . $D_1 = 2.5$ passengers/car and $D_2 =$
16.3 passengers/bus (taken from 72).

R9 applies to Y_{13} after 1966. $E_7 = 1.9$ ton/km/truck-km
(taken from 66, IRF).

R11 applies to Y_{14} after 1967 through 1972, $G_{14} = 900$
ton-km/truck-km (IRF).

R10 applies to Y_{18} after 1972, with $F_3 = 300$ (taken from 72,
IRF).

Brazil

R1 applies to Y_5 . See Note (j).

R4 applies to Y_9 and Y_{10} .

R7 applies to Y_6 with $C_2 = 40,000$ and Y_7 with $C_3 = 25,000$.

R11 applies to Y_{18} , Y_{19} , Y_{20} . $G_{13} = 105$ ton-km/ton

(similar to Argentina), $G_{14} = 262$ (taken from 1965),

$G_{15} = 325$ (taken from 1965).

Mexico

R7 applies to Y_5 , Y_6 , Y_7 with $C_1 = 13,500$ (based on WAES),
 $C_2 = 40,000$, $C_3 = 40,000$.

R8 applies to Y_9 , Y_{10} . $D_1 = 3.0$ (similar to Brazil) and
 $D_2 = 25$.

R9 applies to Y_{13} . $E_7 = 2.5$ ton-km/km.

R1 applies to Y_{14} , Y_{19} (assume water transport equals zero).

R10 applies to Y_{18} . $F_3 = 1000$ tons/yr (= 100 ton-km/ton).

R11 applies to Y_{20} . $G_{15} = 500$ ton-km/ton (rail).

Egypt

R7 applies to Y_5 , Y_6 . $C_1 = 10,000$, $C_2 = 30,000$, $C_3 = 30,000$.

R8 applies to Y_9 , Y_{10} . $D_1 = 3.0$ and $D_2 = 25$.

R9 applies to Y_{13} . $E_7 = 3.0$.

R1 applies to Y_{14} . $Y_{14} = Y_{13} + Y_{15}$ for 1975. See Note (k).

R10 applies to Y_{18} with $F_3 = 900$ tons/year.

R11 applies to Y_{19} , Y_{20} with $G_{14} = G_{15} = 250$ ton-km/ton.

Morocco

R6 applies to Y_5, Y_6 for years after last data point.

R8 applies to Y_9, Y_{10} . $D_1 = 3.0, D_2 = 30$.

R1 applies to Y_{14}, Y_{19} (water transport = 0).

R7 applies to Y_7 because IRF data refer only to "public carriers" and cannot be extrapolated. We take $C_3 = 50,000$ km/truck.

R9 applies to Y_{13} with $E_7 = 3.0$ ton-km/truck-km.

R10 applies to Y_{18} with $F_3 = 1200$ tons/truck.

China

R7 applies to $Y_5, Y_6, Y_7(1970-75)$, assuming $C_1 = 10,000$, $C_2 = 50,000$ (see parc), $C_3 = 50,000$ (similar to India, Indonesia).

R8 applies to Y_9, Y_{10} . $D_1 = 2.5$ (most cars are official or taxis), $D_2 = 25$.

R1 applies to $Y_8, Y_{12}, Y_{17}, Y_{22}$, see Note (l); also R1 applies to Y_{11} , see Note (m) and Y_{14} , see Note (n).

R9 applies to Y_{13} , with $E_7 = 3.5$ (similar to India).

R11 applies to Y_{10}, Y_{19}, Y_{20} with $G_{13} = 62.5, G_{14} = 1250$ ton-km/ton, $G_{15} = 750$ ton-km/ton.

India

R11 applies to Y_{14} , using $G_{14} = 1000$ ton-km/ton.

India (continued)

Note: We multiply truck-tons (from IRF).

Indonesia

R6 applies to Y_5 , Y_7 after 1972.

R8 applies to Y_9 with $D_1 = 3.0$, all years.

R8 applies to Y_{10} after 1972 with D_2 based on 1972.

R11 applies to Y_{13} after 1972 and Y_{14} , all years; with $G_{13} = 8.15$ (calculated in 1972) and $G_{14} = 1000$.

R1 applies to 1975 values for Y_6 , Y_{10} , Y_{18} , Y_{19} , Y_{20} , Y_{22} .

Note: We multiply truck-tons and rail-tons (from IRF) times ten.

Phillipines

R1 applies to Y_2 . See Note (o).

R7 applies to Y_5 , Y_6 , Y_7 with $C_1 = 12,500$, $C_2 = 50,000$,
 $C_3 = 25,000$.

R8 applies to Y_9 , Y_{10} . $D_1 = 3$ and $D_2 = 20$.

R9 applies to Y_{13} . $E_7 = 2.0$.

R1 applies to Y_{14} . See Note (p).

R11 applies to Y_{18} , Y_{19} , Y_{20} with $G_{13} = 50$ ton-km/ton
 (2/3 X Indonesia), $G_{14} = 750$ ton-km/ton, $G_{15} = 250$
 ton-km/ton.

Note (a) Adjustment of truck-km data for Belgium

Calculate truck ton-km Y_{13} for Belgium after 1968, where existing data is untrustworthy, by adjustment of ton-km/ton ratio to match neighboring countries, especially the Netherlands, France, and FRG. We have:

<u>Year</u>	<u>Belgium</u>	<u>France</u>	<u>FRG</u>	<u>Netherlands</u>	<u>New Belgium</u>	<u>Ratio New/Old</u>
1965	37.7*	38.1	38.1	34.8		
1966	41.4*	41.6	38.9	36.1		
1967	40.9*	42.5	37.9	37.8		
1968	42.6*	40.0	38.9	40.1		
1969	38.0	40.6	39.0	42.9	44	1.16
1970	34.0	42.1	36.7	40.7	43	1.26
1971	30.5*	48.3	37.0	42.3	45	1.47
1972	31.6*	50.6	37.9	44.4	46	1.46
1973	32.0	51.8	39.4	47.2	47	1.47
1974	30.5	54.3	41.6	46.1	48	1.57
1975	33.0	64.3	44.5	47.0	49	1.48

*The "adjusted" figures reflect Belgium's physical similarity to the other countries, mainly the Netherlands. Truck ton-km are increased by the ratio new/old for years 1971-73.

Note (b)

In Australia in 1974 there were 122.7×10^3 passenger-km per bus in service. Bus passenger-km have declined slowly from 3.77×10^9 in 1965 to 3.4×10^9 in 1974. The most reasonable assumption seems to be that the number of buses and bus-km has remained constant while average occupancy has declined slowly.

Note (c)

In Australia, for years 1965-68 we estimated truck tons carried using R10 based on ton-km/ton ratios for later years. The share of total freight tonnage by water is calculated and assumed constant after 1968. This yields an estimate of water tons. To compute Y_{14} for years after 1968, we assume water ton-km/ton ratios remain constant.

$$\begin{aligned} 1968 \text{ truck tons est} &= 618.7 \times 10^6 \\ 1968 \text{ water tons} &= 27.4 \times 10^6 \\ &= 4.24\% \text{ of total tons (= 4.44\% of} \\ &\quad \text{truck tons)} \end{aligned}$$

$$\text{water ton-km/ton}_{68} = 2028$$

Note (d)

In South Africa there are no data on rail passenger-km. We assume the ratio of ton-km to passenger-km in South Africa is similar to that in Australia, the most similar country. For 1974 there were 28.3×10^9 ton-km and 9.7 passenger-km in Australia, for a ratio of close to 3:1.

Note (e)

More than half of the buses in the United States are school buses, but DOT does not provide passenger-km figures for the latter. From one independent source we obtain an estimate of 74×10^9 bus passenger-km for 1972. To adjust other years we multiply all passenger-km figures by 2.75.

Note (f)

No data are available on air transport for the DDR. Although there may in fact be no DDR airline, it would be safer to assume the DDR has, or will have, such service. The procedure adopted is to assume air-km per capita, air passenger-km per capita, and air-ton-km per capita are the same as Czechoslovakia, which is a very similar neighboring country.

Note (g)

No recent data are available on ship-tons for the DDR. Based on United Nations data from 1964 and 1965, DDR shipping activity was about 0.5 that of Poland. We continue that ratio. (Both countries have outlets on the Baltic Sea.)

Note (h)

No data are available on air-km for the USSR. Assume ratio of air-passenger-km to air-km is equal for the USSR and Poland.

$$\begin{aligned}
 1974 \text{ Poland } & 1075 \times 10^6 \text{ air passenger-km} \\
 & 21 \times 10^6 \text{ air km} \\
 & = 51 \text{ passengers per flight (1974)}.
 \end{aligned}$$

Note (i)

Car- and bus-km are lumped in Venezuela. Assuming each type of vehicle has equal annual mileage, cars account for 97% of all vehicle-miles (km). However, since buses probably run

further in a year, we set the car fraction at 95%.

Note (j)

In Brazil data for total road passenger-km are available (based on DBB). Car data are from Business International. The following scheme is used:

Year	Passengers-km (10 ⁹)	Cars (10 ⁶)	Passengers car	10 ⁴ km per car	Car passengers- km	Bus Passengers- km (10 ⁹)	Number of buses
1964	48.8	12.60 X	3.0	X 1.0	= 38.0	10.80	15,500
1965	55.9	13.03 X	3.0	X 1.0		17.5 X 40	
1966	64.1	14.83 X	3.0	X 1.1			
1967	73.1	16.45 X	2.9	X 1.1	52.5	20.05	15 X 40
1968	83.4	17.66 X	2.9	X 1.2			33,300
1969	95.2	19.46 X	2.9	X 1.3			
1970	108.6	22.54 X	2.8	X 1.3	82.0	26.6	14 X 40
1971	124.3	25.65 X	2.8	X 1.4			47,500
1972	142.1	28.65 X	2.7	X 1.4	108.2	33.9	12.5 X 40
1973	152.6	32.81 X	2.7	X 1.4	124.0	28.6	
1974	163.2						
1975	173.7					31.0	X 40
1976	184.2						74,000

*From somewhere we have a figure of 64,000 buses in 1972. Based on our passenger-km estimate this would be equivalent to 530,000 passenger-km/bus, which is realistic. If there were 700,000 passenger-km/bus in 1964, there should have been 15,500 buses. By 1975 the number of buses had probably risen to at least 72,000. The number of passengers per bus trip has accordingly dropped from around 35 in 1964 to around 22 by 1975.

Assume 10,000 km/year in 1964 rising to 15,000 km/year in 1972, 3.0 passengers/car in 1964 dropping to 2.7 in 1973.

Note (k)

No data exist on waterborne transport in Egypt. However, small boats operating along the Nile and in the Delta are, and always have been, a major mode of freight transport. (We are

only concerned with boats powered by diesel or other engines, of course.) Lacking any other data, it seems reasonable to assume that waterways account for half of all ton-km moved in Egypt as of 1975. That is, we assume water ton-km = road ton-km + rail ton-km. This assumption is very uncertain, of course.

Note (1)

No data exist on bus or aircraft use or shipping in China (PRC). Lacking other data, we assume the use of buses and aircraft in China is equal to the corresponding number in India (the most similar country) per unit of GDP. That is, we assume that for 1970-74:

$$Y_2 \text{ (China)} = \frac{\text{GDP (China)}}{\text{GDP (India)}} Y_2 \text{ (India)}$$

$$Y_8 \text{ (China)} = \text{(same)} Y_8 \text{ (India)}$$

$$Y_{12} \text{ (China)} = \text{(same)} Y_{12} \text{ (India)}$$

$$Y_{17} \text{ (China)} = \text{(same)} Y_{17} \text{ (India)}$$

Note (m)

No data exist on rail passenger transport in China. There are two possible approaches. We could assume a fixed ratio between rail/bus passenger transport (similar to India) or we could assume a fixed ratio between rail passenger-km and rail ton-km (again, based on India). Since the

rail ton-km data is more secure, we use the second approach for years 1965-71.

$$Y_{11} \text{ (China)} = \frac{Y_{11} \text{ (India)}}{Y_{15} \text{ (India)}} \cdot Y_{15} \text{ (China)}$$

Note (n)

No data exist on river and coastal waterborne transport in China, although it is obviously very important due to the major river systems of that country. Lacking other data, we assume the split between rail and waterborne transport, measured in ton-km, is the same for China and India for the years 1965-71.

$$Y_{14} \text{ (China)} = \frac{Y_{14} \text{ (India)}}{Y_{15} \text{ (India)}} \cdot Y_{15} \text{ (China)}.$$

Note (o)

There are no data on buses for the Philippines. The most similar country is Indonesia. We assume

$$Y_2 \text{ (Phillipines)} = \frac{\text{GDP (Phillipines)}}{\text{GDP (Indonesia)}} \cdot Y_2 \text{ (Indonesia)}$$

We also assume similar figures for km/year, passengers/vehicle, etc.

Note (p)

Water transport data are lacking for the Philippines. We assume the fraction of ton-km transported by water is the same for Indonesia and the Philippines, since both are archipelagos

in a similar stage of economic development.

$$Y_{14} \text{ (Phil)} = \left(\frac{Y_{14} \text{ (Indo)}}{Y_{13} + Y_{14} + Y_{15}} \right)_{\text{Indo}} \cdot \left(Y_{13} + Y_{14} + Y_{15} \right)_{\text{Phil}}$$

$$\text{or } Y_{14} \text{ (Phil)} = \left(\frac{Y_{14} \text{ (Indo)}}{Y_{13} \text{ (Indo)} + Y_{15} \text{ (Indo)}} \right) \cdot \left(Y_{13} \text{ (Phil)} + Y_{15} \text{ (Phil)} \right)$$

B.3 Energy Intensity Data

An effort was made to compile results from a number of different sources. The results are displayed in Table B-6. The numbers were, in most cases, converted from other units. For instance, United States and Canadian data are always given in ton-miles. European sources use a variety of energy units including joules, kilocalories, and kWh. A conversion table is attached (Table B- 7).

It is easily ascertained that in 1973 the average United States passenger car ran about 13.1 miles per gallon of gasoline. Even official sources vary on the correct value of average vehicle occupancy for the United States, but we assume two. This yields 26.2 passenger-miles per gallon, or 9 liters of fuel per 100 passenger-km. Since one liter of gasoline has a heat value of 32,800 BTU, it follows that in the United States, on the average, 1 passenger-km requires about 3,200 BTU. In Europe, the average fuel economy is better: about 8-9 liters of fuel per 100 car-km in 1972, or half of the United States rate. Obviously these numbers agree with our 1975 assumptions, though not with all sources shown in Table B-6. Since the computation is relatively straightforward, we are at a loss to explain most of the discrepancies. A more detailed analysis of the energy intensities of truck cargo transportation in the United States

(Section B.4) uncovered an unjustified assumption in the WAES data. Similar problems probably exist in other sources. It appears that no intercountry comparisons were undertaken by the WAES group, which is regrettable in view of the wide differences that appear between other similar countries when common units are used.

Of the other sources indicated, the SRI-FEA figures for both the United States and FRG appear to be substantially out of line in most categories. However, except for trucks, the LRL-4430 figures for the United States and Sweden appear reasonable, as are the TDA figures for Canada. We regard these sources as the most likely to be trustworthy. WAES is the only (though occasionally suspect) source for most of Europe and Japan. We have found no other published sources of energy intensity data for centrally planned or less developed countries.

Based on the above and supplemented by estimates based on (mostly qualitative) inter-country comparisons, we have prepared Tables A-12, A-13 showing the coefficients actually utilized in the model.

TABLE B-6 Energy Consumed, BTU/km by Mode

	Petroleum Press Service (US), 1973 ^a	WAES Ref. (US) 13 1972	LBL-4430 (US) 1972	Ref. 15	SRI/FEA (US) 1972	Ref. 17	TDA Canada 1973	Ref. 7	WAES Canada 1972	WAES Japan 1972	WAES (FRG) 1972	SRI/FEA (FRG) 1972	WAES (Italy) 1972	WAES (Denmark) 1972	WAES (Netherlands) 1972	WAES (Sweden) 1972	LBL-4430 (Sweden) 1970-72
PASSENGER MODES																	
Intercity auto	2650	2580 ^b	2530		7230 ^c		1930		2380 ^d								
Urban auto	3150	4130 ^b	4760				4640										
Europe, Japan																	
Intercity auto							--			1630	1745 ^e	3770 ^f	1050 ^g	1660 ^h		1590	1700 ^d
Urban auto							3350				2610		2820 ^g				1830
Electric, urban auto							2860										
Intercity bus	680	730	745				537	600		650	320 ⁱ	NA	430 ⁱ		635		1020
Urban bus	775	1075	1240				985	825			400 ^j	NA	535 ⁱ	850	955	790	
											630 ^j		820 ^j				
Rail	1060	1640	1710 (av)		4640 ^k		2810	3090	207		4150 ⁱ	5250 ^k	985 ⁱ	1505	1170	2380	1740 (av)
											622 ^j		575 ^j				
Air		5620	7450													3490	
Domestic International	6050	3000	3420		14300 ^l		4800		3340		3730	26,200 ^l	6170	2840		695	2780
FREIGHT MODES																	
Intercity Truck	1460	1625	1565				2800 pkg						1980				2130
Urban truck		4460	4840				4180 bulk					NA	5250				1440
Average truck			2180				405 pkg	3550	4830		2470						1985
Rail	413	444	470		1110 ^k		290 bulk	325	715		1350 ^d	1255 ^k	4170 ^d	2530	4250	2580	446
											(180 ^e X 3)		(335 ^e X 3)	570	740		
Waterway	337	397									1220	2130			1485		742
Coastal ship					1090		338		1600							795	
Deep sea ship											200						
Pipeline	280				1												
Air	23,000	17,600	18,600								31,000		34,700	19,300		30,600	

^aCited in ECE document.^bAssuming 1.4 passenger per urban car and 2.2 passenger per intercity car.^cPassenger cars including light trucks.^dAssuming 2 passengers/car.^eAssuming 1.4 passengers per urban car and 1.8 passengers per intercity car.^fPassenger cars include combinations.^gAssuming 1.24 passengers per urban car and 2.4 passengers per intercity car.^hAssuming 2 passengers per car; converted from k_j.ⁱNo footnote data provided (ed.).^jNo footnote data provided (ed.).^kAssuming 1 rail pk = 4.17 rail tk.^lAssuming 1 air pk = 0.2 tk.

Note: Electric energy is converted to Btu based on thermal electric power generation, efficiency 0.33.

Passengers: Btu/passenger-km

Freight: Btu/ton-km

1 kJ = 1.06 Btu

1 kWhr = 3.87 X 10³ Btu

1 kcal = 3.97 Btu

TABLE B-7

Major Conversion Factors

Energy/Energy	1 k _j	= 1.06 Btu
	1 kWhr	= 3,412 Btu (ideal)
	1 kWhr(e)	= 10,405 Btu (av)
	1 kcal	= 3.97 Btu
	1 MTCE	= 27.8 X 10 ⁶ Btu
Energy/Volume	1 liter gasoline	= 32,800 Btu
	1 liter diesel	= 36,550 Btu
	1 bbl crude oil	= 5.8 X 10 ⁶ Btu
	1 ton crude oil (WAES)	= 1.47 MTCE = 43 X 10 ⁶ Btu
	1 ton crude oil (OECD)	= 40 X 10 ⁶ Btu
	1 ton coal equiv (MTCE)	= 29.2 X 10 ⁶ Btu
	1000 cf natural gas	= 10 ⁸ Btu
Volume	1000 cm natural gas	= 3.73 X 10 ⁹ Btu
	1 m ³	= 6.29 bbl = 37.3 cf = 10 ³ liters
	1 bbl	= 42 gal = 159 liters
	1 gal (US)	= 3.78 liters
Other	10 mg	= 23.6 liters/100 km
	23.6 mpg	= 10 liters/100 km

B.4 United States Truck Energy Data

As the data presented in this section show, the "average" truck is very hard to define. Thus trucks of different sizes, used for different purposes, can and do differ enormously in terms of energy consumption per ton-km. Thus energy consumed per ton-km by the average truck in various countries depends on factors that can differ significantly; viz

- the mix of truck sizes and engine types
- the average load carried
- the average distance carried
- the average speed of the trip

For the United States it is convenient to distinguish the following five categories of non-government trucks:

(1) Small private pickups and vans, with gasoline engines (less than 6000 lb. GVW). These are used either as personal vehicles or for local cargo delivery purposes.

(2) Large (greater than 6000 lb. GVW) privately owned and operated trucks, with gasoline engines, used locally

(3) Large private diesel trucks for local use

(4) Large private trucks, with gasoline engines, used for intercity transportation

(5) Large private diesel trucks for intercity use

From DOT data (Reference 8) it appears that 4.5% of all trucks are registered to Federal, State or Local Governments.

It is reasonable to assume that they account for 4% to 5% of all truck fuel, or 1.4×10^9 gallons in 1972.

For non-government trucks, DOT has the following breakdown for 1973:

1973 Vehicle-Km X 10^9

Source	Truck Category					Total
	1	2	3	4	5	
DOT (8)	219	97.9	11.27	28.64	57.95	430

Based on published DOT fuel consumption data given separately for intercity and local trucking, and for "combinations" (tractor-trailers), we have made the following estimates by category:

1973 Truck Fuel Consumed X 10^9 gallons

Source	Truck Category					Total
	1	2	3	4	5	
DOT (8)	11.20	8.00	1.65	2.15	7.10	30.0

We have two inconsistent sources of data on cargo ton-km, viz

1973 Truck Cargo Ton-km X 10^9

Source	Truck Category					Total
	1	2	3	4	5	
JFA (18)	52.4	106.5	69.5	59.2	540.8	828.4
DOT (8)	-	NA	-	814		NA

The JFA cargo ton-km figures by truck category given above

were derived from "average load" data taken from the Annual Truck Weight Study by the Federal Highway Administration (FHA). The discrepancy between JFA totals and DOT inter-city totals is significant. The published data are taken directly from the ICC Annual Report, whereas JFA carried out a much more comprehensive and detailed analysis using ICC, Census and FHA data. Faced with a choice, we assume the JFA figures are more reliable.

Combining the JFA data on ton-km with the DOT data on truck fuel consumption yields the following:

1973 Truck BTU per ton-km

Source	Truck Category					Total
	1	2	3	4	5	
Derived from DOT and JFA	29800	10500	3310	5060	1810	50000

1973 Average Load per Truck (tons)

Source	Truck Category					Total
	1	2	3	4	5	
JFA (18)	0.24	1.09	6.18	2.12	9.45	19.2
Note that average load in each category is the ratio [ton-km/veh-km].						

There are no official United States statistics on total tons of cargo loaded or unloaded by truck. A set of approximate tonnage figures have been derived by JFA, on the basis of economic sectoral input-output data and

other information. The latest year for which JFA has directly computed a total tonnage ($\times 10^6$) figure is 1970, as follows:

1970 Cargo Tons

	Local	Intercity	Total
For-hire	0.76	0.79	1.55
Private	<u>4.93</u>	<u>1.23</u>	<u>5.16</u>
Total	5.69	2.03	7.72

Source: JFA (19)

1970 Average Truck Trip Distance (km)

	Local	Intercity
For-hire	20.45	387.0
Private	<u>24.32</u>	<u>171.5</u>
Average	23.8	256.2

Using JFA (19) truck ton-km data for 1970, we obtain

1970 Cargo ton-km

	Local	Intercity
For-hire	15.65	306.9
Private	<u>119.60</u>	<u>212.4</u>
Total	135.3	519.3

Note that average distance per truck trip must be given by the ratio [ton-km/tons].

Assuming both average loads and average trip lengths remained the same from 1970 to 1973, one can estimate the cargo tonnages for 1973, from the equation [tons = ton-km/km].

1973 (est) Truck Cargo (tons)

Category	Local			Intercity	
	1	2	3	4	5
	2.29	4.67	3.04	0.23	2.10
Total	10.0			2.33	12.33

As compared to 1970 it is obvious that there is a major discrepancy for the 'local' category whereas the 'intercity' comparisons appear reasonable. This discrepancy is evidently due to differences in the estimates of ton-km data for local trucking. The later JFA study, being specifically concerned with trucking, is presumably the more reliable in this regard.

B.5 Fuel Use Data

In principle, transport energy coefficients can be derived from fuel consumption data. However, in practice, to do this requires a detailed set of energy/fuel balances. Such balances have recently been published for OECD countries covering the years 1973-75. For prior years, data are less complete, though usable. For non-OECD countries, however, the only consistently available data are on apparent domestic consumption of various fuel products. However, except for gasoline, these do not match transportation categories. (Data on gasoline and diesel consumption are given in Table B-8.) Thus we are forced to estimate energy consumption per vehicle-km or per ton-km on the basis of engineering type considerations. A complete international set of energy/fuel balances is currently being prepared by the Department of Energy (1978).

For purposes of estimating future fuel consumption by fuel type, we have lumped gasoline and diesel fuel together as motor fuel. Similarly, we have lumped jet fuel and aviation gasoline together as aviation fuel, while some (unknown) combination of diesel and heavy fuel oil used by barges and small vessels is called water fuel for convenience. Deep water shipping utilizes heavy fuel oil exclusively. In terms of BTU, these four composite fuels are assumed as follows:

Motor fuel (gasoline)	@ $37.5-38 \times 10^6$ B /ton
Aviation fuel (kerosine)	@ 40×10^6 B /ton
Water fuel (diesel or distillates)	@ 4.4×10^6 B /ton
Ship fuel (residual oil)	@ 47×10^6 B /ton

The missing transportation category is railroads, which utilize diesel fuel, coal, or electricity, depending on country. The most recent data, from several sources, are shown in Table B- 9. Based on these data, plus guesswork, we have arrived at the assumed splits (bases on ton-km) by region (Table B-10).

TABLE B-8 Motor Fuel Use, by Fuel

		TABLE B-8 Motor Fuel Use, by Fuel					
		1973		1974		1975	
		Gasoline tons (10 ³)	Diesel tons (10 ³)	Gasoline tons (10 ³)	Diesel tons (10 ³)	Gasoline tons (10 ³)	Diesel tons (10 ³)
Austria	A 11	2,156	697	1,980	678	2,086	650
Belgium	A 12	2,569	1,251	2,508	1,024	2,765	1,141
Denmark	A 13	1,526	434	1,410	397	1,503	488
France	A 14	15,777	6,403	15,230	6,771	15,921	6,426
Germany (FRG)	A 15	18,790	7,515	18,320	6,985	20,004	7,060
Italy	A 16	11,016	4,663	10,216	4,780	11,018	4,536
Netherlands	A 17	3,515	1,254	3,162	1,350	3,433	1,454
Spain	A 18	4,046	2,896	4,130	2,357	4,284	3,127
Sweden	A 19	2,870	1,116	2,861	1,353	3,242	1,196
Switzerland	A 20	2,462	691	2,457	549	2,413	444
United Kingdom	A 21	16,926	5,658	16,483	5,519	16,125	5,414
Australia	A 22	8,894	915	9,183	1,038	9,533	1,090
Canada	A 23	23,545	1,634	24,163	1,868	25,792	2,001
Japan	A 24	19,200	7,369	19,300	7,139	20,620	4,750
South Africa	A 25	2,960		3,023			
United States	A 26	285,522	29,066	279,739	29,439	285,607	35,681
TOTAL OECD						424,346	75,458
Czechoslovakia	B 27	1,673		1,520			
Germany (DDR)	B 28	1,990		2,265			
Poland	B 29	2,977		2,849			
USSR	B 30	62,813		67,433			
Yugoslavia	B 31	1,503		1,679			
Iran	B 32	1,864		2,199			
Nigeria	B 33	762		707			
Saudi Arabia	B 34	604		626			
Venezuela	B 35	3,616		3,864			
Argentina	B 36	4,916		4,200			
Brazil	B 37	9,519		10,277			
Mexico	B 38	7,922		8,382			
Egypt	B 39	961		1,537			
Morocco	B 40	379		379			
China	B 41	4,960		6,570			
India	B 42	1,632		1,280			
Indonesia	B 43	1,900		1,888			
Philippines	B 44	1,919		1,968			

Source A - Energy Statistics 1973/75 (OECD)

B - World Energy Supplies

TABLE B-9 Railway Fuel Consumption (1973)

		Diesel		Coal		Electricity		Total MTCE
		10 ³ tons	^a	10 ³ tons	^a	10 ⁶ kWhr	Percent	
Austria	11	53	13	126	19	113	68	657
Belgium	12	148	47.5	0	0	654	52.5	510
Denmark	13	87	78	0	0	100	22	179
France	14	461	27	5	0.2	5023	73	2760
Germany (FRG)	15	517	21	699	18	5958	61	3904
Italy	16	123	12.2	163	9.8	3249	78	1660
Netherlands	17	52	21	0	0	792	79	399
Spain	18	191	47	0	0	856	53	645
Sweden	19	33	30.5	0	0	299	69.5	173
Switzerland	20	7	4	0	0	606	96	253
United Kingdom	21	862	65.6	0	0	1808	34.4	2105
Australia	22	-	-	-	-	-	-	-
Canada	23	2040	^b	0	0	12	^b	3265+
Japan	24	603	24.5	0	0	7391	75.5	3925
South Africa	25	0	0	0	0	2795	100	1120
United States	26	13,610	97.8	0	0	1247	2.2	22300
Czechoslovakia	27	397	21	1649	55	1787	24	3000
Germany (DDR)	28	496	28.5	1628	59	875	12.5	2773
Poland	29	400	12	3572	67	2803	21	5332
USSR	30	N	N	N	N	N	N	
Yugoslavia	31	159	13.5	1343	74	569	12.5	1825
Iran	32	N	N	N	N	N	N	
Nigeria	33	N	N	N	N	N	N	
Saudi Arabia	34	N	N	N	N	N	N	
Venezuela	35	N	N	N	N	N	N	
Argentina	36	N	N	N	N	N	N	
Brazil	37	^c	^c	N	N	^c	^c	
Mexico	38	N	N	N	N	N	N	
Egypt	39	N	N	N	N	N	N	
Morocco	40	11	35.2	0	0	81	64.8	50
China (PRC)	41	N	N	N	N	N	N	
India	42	557	6	13729	94	0	0	14,619
Indonesia	43	N	N	N	N	N	N	
Philippines	44	N	N	N	N	N	N	

^aPercent is based on energy content of fuel, including that consumed in energy conversion

^bData refer to nationalized railways (CNR,CPR) only. CNR consumed 1272X 10³ tons of diesel fuel and 12 X 10⁶ KWH of electricity; CPR consumed 768 X 10³ tons of diesel fuel and no electricity

^cIncomplete. Data available only for Ferrovias Paulista S.A. (FEPASA), which consumed 52 X 10³ tons of diesel fuel and 257 X 10⁶ KWH of electricity.
Note that 1 ton of diesel fuel = 1.6 tons of coal ; 1 million KWH = 400 MTCE, including thermal losses in electricity generation.

TABLE B-10 Assumed Rail Energy Sources,
1975-2000

Country	Source
EEC	60% electric
Western Europe	40% diesel
North America	2% electric
Australia	98% diesel
Japan	75% electric
	25% diesel
Eastern Europe	18% electric
	70% coal
	12% diesel
USSR	50% electric ^a
	40% coal
	10% diesel
MidEast/South Africa	60% electric ^b
	40% diesel
Latin America	20% electric
Africa	40% coal
	40% diesel
South Asia	95% coal
China	5% diesel

^aBased on extremely unofficial and unreliable information.

^bSouth Africa is 100% electric.

APPENDIX B REFERENCE LIST

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APPENDIX C

The internal table numbering follows the table numbering in the Transportation Energy Conservation Data Book (ORNL No. 5493). The Appendix consists of two identical sets of tables. C.1 is the Base Case and C.2 is the Conservation Case.

VARIFLEX World Transportation Model
7/16/79

NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

Table 8.4
Gross Domestic Product and Population for Eight World Regions, 1955 and 2000
(Money values shown in constant 1972 U.S. Dollars)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
2000 GDP billions(72\$)	2811.	401.	1555.	684.	1384.	513.	1125.	975.	9449.	10583.
2000 Population, millions	264.	48.	352.	132.	314.	100.	537.	2898.	4648.	5205.
2000 GDP/Capita (72\$)	10552.	8416.	4412.	5178.	4409.	5145.	2095.	336.	2033.	2033.
2000 GDP, % of world	27.	4.	15.	6.	13.	5.	11.	9.	89.	100.
2000 Population, % of world	5.	1.	7.	3.	6.	2.	10.	56.	89.	100.
2000 GDP/Capita ratio to world	5.2	4.1	2.2	2.5	2.2	2.5	1.0	0.2	1.0	1.0
2000 GDP, ratio to U.S.	1.00	0.14	0.55	0.24	0.49	0.18	0.40	0.35	3.36	3.77
2000 Population, ratio to U.S.	1.00	0.18	1.32	0.50	1.18	0.37	2.02	10.88	17.45	19.55
2000 GDP/Capita, ratio to U.S.	1.00	0.80	0.42	0.49	0.42	0.49	0.20	0.03	0.19	0.19
1955 GDP, billions(72\$)	584.	57.	391.	48.	168.	55.	69.	176.	1579.	1768.
1955 Population, millions	166.	26.	267.	89.	198.	74.	155.	1162.	2137.	2394.
1955 GDP/Capita (72\$)	3521.	2216.	1468.	545.	846.	1129.	446.	151.	739.	739.
1955 GDP/Capita, ratio to U.S.	1.00	0.63	0.42	0.15	0.24	0.32	0.13	0.04	0.21	0.21

VARIFLEX World Transportation Model
7/16/79

NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

Table 8.4
Gross Domestic Product and Population for Eight World Regions, 1955 and 1960
(Money values shown in constant 1972 U.S. Dollars)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
1960 GDP billions(72\$)	732.	76.	496.	78.	225.	106.	91.	187.	1990.	2229.
1960 Populations, millions	181.	28.	279.	93.	214.	79.	178.	1281.	2333.	2613.
1960 GDP/Capita (72\$)	4040.	2717.	1777.	838.	1051.	1338.	510.	146.	853.	853.
1960 GDP, % of world	33.	3.	22.	4.	10.	5.	4.	8.	89.	100.
1960 Population, % of world	7.	1.	11.	4.	8.	3.	7.	49.	89.	100.
1960 GDP/Capita, ratio to world	4.7	3.2	2.1	1.0	1.2	1.6	0.6	0.2	1.0	1.0
1960 GDP, ratio to U.S.	1.00	0.10	0.68	0.11	0.31	0.14	0.12	0.26	2.72	3.04
1960 Population, ratio to U.S.	1.00	0.16	1.54	0.51	1.18	0.43	0.98	7.07	12.87	14.41
1960 GDP/Capita, ratio to U.S.	1.00	0.67	0.44	0.21	0.26	0.33	0.13	0.04	0.21	0.21
1955 GDP, billions(72\$)	584.	57.	391.	48.	168.	85.	69.	176.	1579.	1768.
1955 Population, millions	166.	26.	267.	89.	198.	76.	155.	1162.	2137.	2394.
1955 GDP/Capita (72\$)	3521.	2216.	1468.	545.	846.	1129.	446.	151.	739.	739.
1955 GDP/Capita, ratio to U.S.	1.00	0.63	0.42	0.15	0.24	0.32	0.13	0.04	0.21	0.21

VARIFLEX World Transportation Model
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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

Table 8.4
Gross Domestic Product and Population for Eight World Regions, 1955 and 1975
(Money values shown in constant 1972 U.S. Dollars)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ABV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
1975 GDP billions(72\$)	1194.	163.	905.	281.	454.	204.	247.	282.	3730.	4177.
1975 Populations, millions	214.	37.	312.	111.	255.	87.	273.	1738.	3026.	3390.
1975 GDP/Capita (72\$)	5582.	4452.	2897.	2535.	1778.	2341.	905.	162.	1232.	1232.
1975 GDP, % of world	29.	4.	22.	7.	11.	5.	6.	7.	89.	100.
1975 Population, % of world	6.	1.	9.	3.	8.	3.	8.	51.	89.	100.
1975 GDP/Capita, ratio to world	4.5	3.6	2.4	2.1	1.4	1.9	0.7	0.1	1.0	1.0
1975 GDP, ratio to U.S.	1.00	0.14	0.76	0.24	0.38	0.17	0.21	0.24	3.12	3.50
1975 Population, ratio to U.S.	1.00	0.17	1.46	0.52	1.19	0.41	1.28	8.12	14.15	15.85
1975 GDP/Capita, ratio to U.S.	1.00	0.80	0.52	0.45	0.32	0.42	0.16	0.03	0.22	0.22
1955 GDP, billions(72\$)	584.	57.	391.	49.	168.	85.	69.	176.	1579.	1768.
1955 Population, millions	166.	26.	267.	89.	198.	76.	155.	1162.	2137.	2394.
1955 GDP/Capita (72\$)	3521.	2216.	1468.	545.	846.	1129.	446.	151.	739.	739.
1955 GDP/Capita, ratio to U.S.	1.00	0.63	0.42	0.15	0.24	0.32	0.13	0.04	0.21	0.21

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8.5
TRANSPORTATION DEMANDS FOR EIGHT WORLD REGIONS
2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Passenger Kilometers(PK),10**9	8458.	1289.	4664.	1040.	4432.	1436.	3264.	3376.	27959.	31314.
PK/capita, thousands	31.8	27.0	13.2	7.9	14.1	14.4	6.1	1.2	6.0	6.0
PK/GDP	3.0	3.2	3.0	1.5	3.2	2.8	2.9	3.5	3.0	3.0
PK/capita, Ratio to U.S.	1.00	0.85	0.42	0.25	0.44	0.45	0.19	0.04	0.19	0.19
PK/GDP, Ratio to U.S.	1.00	1.07	1.00	0.51	1.06	0.93	0.96	1.15	0.98	0.98
Truck Ton Kilometers, 10**9	1508.	279.	875.	216.	1733.	410.	1583.	1802.	8407.	9416.
Water Ton Kilometers, 10**9	1631.	325.	164.	217.	455.	37.	158.	671.	3658.	4097.
Rail Ton Kilometers, 10**9	2240.	514.	135.	79.	4949.	332.	688.	1771.	10708.	11993.
Domestic Ton Kilometers (DTK)	5379.	1117.	1174.	312.	7137.	779.	2430.	4244.	22773.	25505.
DTK/GDP	1.9	2.8	0.8	0.7	5.2	1.5	2.2	4.4	2.4	2.4
DTK/GDP, Ratio to U.S.	1.00	1.46	0.39	0.39	2.69	0.79	1.13	2.27	1.26	1.26

VARIFLEX World Transportation Model
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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8.5
TRANSPORTATION DEMANDS FOR EIGHT WORLD REGIONS
1960

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Passenger Kilometers(PK),10**9	2253.	215.	1165.	270.	371.	137.	226.	480.	5118.	5732.
PK/capita, thousands	12.4	7.6	4.2	2.9	1.7	1.7	1.3	0.4	2.2	2.2
PK/GDP	3.1	2.8	2.4	3.5	1.7	1.3	2.5	2.6	2.6	2.6
PK/capita, Ratio to U.S.	1.00	0.61	0.34	0.23	0.14	0.14	0.10	0.03	0.18	0.18
PK/GDP, Ratio to U.S.	1.00	0.91	0.74	1.12	0.54	0.42	0.81	0.83	0.84	0.84
Truck Ton Kilometers, 10**9	445.	47.	253.	17.	95.	22.	107.	72.	1056.	1185.
Water Ton Kilometers, 10**9	1004.	90.	106.	46.	107.	9.	37.	109.	1610.	1803.
Rail Ton Kilometers, 10**9	822.	117.	209.	57.	1504.	174.	75.	264.	3222.	3609.
Domestic Ton Kilometers (DTK)	2373.	254.	568.	120.	1706.	206.	219.	445.	5891.	6597.
DTK/GDP	3.2	3.3	1.1	1.5	7.6	2.0	2.4	2.4	3.0	3.0
DTK/GDP, Ratio to U.S.	1.00	1.03	0.35	0.47	2.34	0.60	0.75	0.74	0.91	0.91

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8.3
TRANSPORTATION DEMANDS FOR EIGHT WORLD REGIONS
1975

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LIC	34 COUN- TRIES	WORLD TOTAL
Passenger Kilometers(PK),10**9	3703.	525.	2795.	740.	1023.	394.	707.	1332.	11218.	12565.
PK/capita, thousands	17.3	14.3	8.9	6.7	4.0	4.5	2.6	0.8	3.7	3.7
PK/GDP	3.1	3.2	3.1	2.6	2.3	1.9	2.9	4.7	3.0	3.0
PK/capita, Ratio to U.S.	1.00	0.83	0.52	0.39	0.23	0.26	0.15	0.04	0.21	0.21
PK/GDP, Ratio to U.S.	1.00	1.04	1.00	0.85	0.73	0.62	0.92	1.52	0.97	0.97
Truck Ton Kilometers, 10**9	719.	109.	505.	134.	337.	92.	378.	273.	2547.	2852.
Water Ton Kilometers, 10**9	1320.	180.	143.	146.	222.	15.	66.	95.	2188.	2450.
Rail Ton Kilometers, 10**9	1417.	236.	213.	53.	3237.	278.	171.	553.	6158.	6897.
Domestic Ton Kilometers (DTK)	3456.	525.	861.	333.	3796.	385.	615.	921.	10892.	12199.
DTK/GDP	2.9	3.2	1.0	1.2	8.4	1.9	2.5	3.3	2.9	2.9
DTK/GDP, Ratio to U.S.	1.00	1.11	0.33	0.41	2.89	0.65	0.86	1.13	1.01	1.01

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-9
Transportation Energy (T.E.) Use for Eight World Regions
2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E. (BTU), 10**15 Relative to U.S.	27.5 1.00	4.6 0.17	14.2 0.52	4.6 0.17	17.4 0.63	3.8 0.14	16.0 0.58	12.4 0.45	100.7 3.64	112.8 4.10
T.E. (BTU) per capita, 10**6 Relative to U.S.	103.2 1.00	96.7 0.94	40.6 0.39	35.2 0.34	55.5 0.54	37.8 0.37	29.9 0.29	4.3 0.04	21.7 0.21	21.7 0.21
T.E. (BTU) per GDP, 10**3 Relative to U.S.	9.8 1.00	11.5 1.17	9.2 0.94	6.8 0.69	12.6 1.29	7.3 0.75	14.3 1.46	12.7 1.30	10.7 1.09	10.7 1.09

VARIFLEX World Transportation Model
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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-7
Transportation Energy (T.E.) Use for Eight World Regions
1960

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E. (BTU), 10**15	10.3	1.0	3.9	0.4	1.6	0.3	1.1	0.8	19.4	21.7
Relative to U.S.	1.00	0.10	0.38	0.04	0.15	0.03	0.11	0.08	1.89	2.11
T.E. (BTU) per capita, 10**6	56.6	35.2	14.0	4.1	7.4	4.0	6.2	0.6	8.3	8.3
Relative to U.S.	1.00	0.62	0.25	0.07	0.13	0.07	0.11	0.01	0.15	0.15
T.E. (BTU) per GDP, 10**3	14.0	13.0	7.9	4.9	7.0	3.0	12.2	4.5	9.7	9.7
Relative to U.S.	1.00	0.93	0.56	0.35	0.50	0.21	0.87	0.32	0.69	0.69

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-9
Transportation Energy (T.E.) Use for Eight World Regions
1975

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E. (BTU), 10**15	17.2	2.5	9.3	2.5	4.6	1.1	3.8	2.4	43.5	48.7
Relative to U.S.	1.00	0.14	0.54	0.15	0.27	0.07	0.22	0.14	2.53	2.84
T.E. (BTU) per capita, 10**36	80.3	67.6	29.9	22.5	18.0	12.9	14.1	1.4	14.4	14.4
Relative to U.S.	1.00	0.84	0.37	0.28	0.22	0.16	0.18	0.02	0.18	0.18
T.E. (BTU) per GDP, 10**3	14.4	15.2	10.3	8.9	10.1	5.5	15.6	8.7	11.7	11.7
Relative to U.S.	1.00	1.06	0.72	0.62	0.70	0.38	1.08	0.60	0.81	0.81

VARIFLEX World Transportation Model
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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

Table 8-11
Transportation Modal Energy Use (Amount and % World) in Eight Regions
2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E. (10**15)	27.3	4.6	14.3	4.6	17.4	3.8	16.0	12.4	100.7	112.8
Passenger Share Auto/Bus(10**15)	13.0	1.7	4.8	0.7	3.3	1.3	3.5	1.3	29.7	33.2
Passenger Share Air(10**15)	4.2	0.8	1.7	0.3	2.1	0.3	1.0	0.6	11.0	12.3
Passenger & Freight-Rail(10**15)	1.1	0.3	0.4	0.1	2.2	0.2	0.6	0.9	5.8	6.5
Freight Share Truck(10**15)	6.8	1.4	3.6	1.0	9.5	1.8	9.5	9.0	42.7	47.8
Freight Share Water(10**15)	0.6	0.1	0.2	0.3	0.2	0.0	0.2	0.2	1.7	1.9
Freight Share Ship(10**15)	1.9	0.4	3.6	2.1	0.1	0.1	1.3	0.5	9.9	11.1
Total T.E.(% World)	24.	4.	13.	4.	15.	3.	14.	11.	89.	100.
Passenger Share Auto/Bus(% World)	39.	5.	15.	2.	10.	4.	11.	4.	89.	100.
Passenger Share Air(% World)	34.	6.	14.	3.	17.	2.	8.	5.	89.	100.
Passenger & Freight-Rail(% World)	17.	4.	6.	2.	35.	3.	9.	13.	89.	100.
Freight Share Truck(% World)	14.	3.	8.	2.	20.	4.	20.	19.	89.	100.
Freight Share Water(% World)	29.	6.	10.	13.	9.	1.	8.	9.	89.	100.
Freight Share Ship(% World)	17.	3.	32.	19.	1.	1.	11.	5.	89.	100.

VARIFLEX World Transportation Model
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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

Table 8-11
Transportation Modal Energy Use (Amount and % World) in Eight Regions
1960

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E.(10**15)	10.3	1.0	3.9	0.4	1.6	0.3	1.1	0.8	19.4	21.7
Passenger Share-Auto/Bus(10**15)	5.4	0.5	1.4	0.1	0.1	0.0	0.2	0.2	8.9	9.9
Passenger Share-Air(10**15)	0.5	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.7	1.0
Passenger+Freight-Rail(10**15)	0.4	0.1	0.6	0.1	0.7	0.1	0.1	0.2	2.3	2.6
Freight Share-Truck(10**15)	2.2	0.3	1.3	0.1	0.6	0.1	0.8	0.4	5.8	6.4
Freight Share-Water(10**15)	0.3	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.7	0.8
Freight Share-Ship(10**15)	0.1	0.0	0.4	0.1	0.0	0.0	0.0	0.1	0.8	0.9
Total T.E.(% World)	47.	5.	18.	2.	7.	1.	5.	4.	89.	100.
Passenger Share Auto/Bus(% World)	65.	5.	14.	1.	1.	0.	2.	2.	89.	100.
Passenger Share Air(% World)	51.	3.	9.	1.	12.	0.	1.	2.	89.	100.
Passenger & Freight-Rail(% World)	17.	4.	25.	3.	26.	4.	4.	6.	89.	100.
Freight Share Truck(% World)	35.	4.	20.	2.	10.	2.	12.	6.	89.	100.
Freight Share Water(% World)	47.	4.	16.	9.	5.	0.	5.	3.	89.	100.
Freight Share ship(% World)	17.	5.	41.	7.	1.	2.	3.	13.	89.	100.

VARIFLEX World Transportation Model
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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

Table 8-11
Transportation Modal Energy Use (Amount and % World) in Eight Regions
1975

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E.(10**15)	17.2	2.5	9.3	2.5	4.6	1.1	3.8	2.4	43.5	48.7
Passenger Share-Auto/Bus(10**15)	10.6	1.3	3.8	0.4	0.4	0.3	0.6	0.4	17.9	20.0
Passenger Share-Air(10**15)	1.2	0.2	0.5	0.1	0.4	0.0	0.1	0.1	2.7	3.0
Passenger+Freight-Rail(10**15)	0.7	0.1	0.7	0.1	1.5	0.2	0.2	0.4	3.8	4.2
Freight Share-Truck(10**15)	3.6	0.7	2.6	0.8	2.2	0.6	2.6	1.4	14.4	16.1
Freight Share-Water(10**15)	0.4	0.1	0.2	0.2	0.1	0.0	0.1	0.0	1.1	1.2
Freight Share-Ship(10**15)	0.6	0.1	1.6	0.8	0.0	0.1	0.2	0.2	3.6	4.0
Total T.E.(% World)	35.	5.	19.	5.	9.	2.	8.	5.	89.	100.
Passenger Share Auto/Bus(% World)	53.	6.	19.	2.	2.	2.	3.	2.	89.	100.
Passenger Share Air(% World)	41.	8.	16.	4.	14.	1.	4.	3.	89.	100.
Passenger & Freight-Rail(% World)	16.	3.	17.	2.	34.	4.	4.	9.	89.	100.
Freight Share Truck(% World)	22.	4.	16.	5.	14.	3.	16.	8.	89.	100.
Freight Share Water(% World)	36.	5.	14.	19.	7.	0.	5.	2.	89.	100.
Freight Share ship(% World)	14.	3.	40.	20.	1.	1.	4.	5.	89.	100.

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-12
Nonpetroleum Transportation Energy Use for Eight Regions, 2000
(10**15 BTU)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E.	27.5	4.6	14.3	4.6	17.4	3.8	16.0	12.4	100.7	112.8
Electricity-Rail	0.02	0.01	0.24	0.09	1.12	0.04	0.22	0.00	1.74	1.94
Coal-Rail	0.00	0.00	0.00	0.00	0.90	0.14	0.15	0.81	1.99	2.23
Total Nonpetroleum-Rail	0.02	0.01	0.24	0.09	2.02	0.17	0.37	0.81	3.73	4.18
Nonpetroleum % Total Trans.	0.1	0.1	1.7	2.0	11.6	4.6	2.3	6.5	3.7	3.7
Rail Energy	1.08	0.27	0.40	0.12	2.25	0.20	0.61	0.86	3.78	6.48
Nonpetroleum % Rail Energy	2.	2.	60.	75.	90.	88.	60.	95.	64.	64.

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 6-12
Nonpetroleum Transportation Energy Use for Eight Regions: 1960
(10**15 BTU)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E.	10.3	1.0	3.9	0.4	1.6	0.3	1.1	0.8	19.4	21.7
Electricity-Rail	0.01	0.00	0.39	0.06	0.34	0.02	0.04	0.00	0.86	0.96
Coal-Rail	0.00	0.00	0.00	0.00	0.27	0.08	0.03	0.14	0.52	0.58
Total Nonpetroleum-Rail	0.01	0.00	0.39	0.06	0.61	0.09	0.07	0.14	1.38	1.55
Nonpetroleum % Total Trans.	0.1	0.2	10.0	15.7	38.9	30.1	6.0	17.3	7.1	7.1
Rail Energy	0.44	0.10	0.65	0.08	0.68	0.11	0.11	0.15	2.32	2.60
Nonpetroleum % Rail Energy	2.	2.	60.	75.	90.	38.	60.	94.	59.	59.

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-12
Nonpetroleum Transportation Energy Use for Eight Regions, 1975
(10**15 BTU)

	UNITED STATES	AUSTRAL- +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E.	17.2	2.5	9.3	2.5	4.6	1.1	3.8	2.4	43.5	48.7
Electricity-Rail	0.01	0.00	0.42	0.08	0.73	0.03	0.07	0.00	1.34	1.50
Coal-Rail	0.00	0.00	0.00	0.00	0.58	0.11	0.04	0.35	1.09	1.22
Total Nonpetroleum-Rail	0.01	0.00	0.42	0.08	1.31	0.14	0.11	0.35	2.43	2.72
Nonpetroleum % Total Trans.	0.1	0.1	4.5	3.2	28.4	12.3	2.9	14.5	5.6	5.6
Rail Energy	0.57	0.13	0.70	0.11	1.45	0.16	0.19	0.37	3.78	4.24
Nonpetroleum % Rail Energy	2.	2.	60.	75.	90.	88.	60.	94.	64.	64.

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-13
Passenger & Freight Energy Use Per Capita and Per GDP
For Eight Regions, 2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
Passenger Energy/cap. 10**6	64.9	52.3	19.1	8.8	18.0	16.3	8.5	0.7	9.0
Relative to U.S.	1.00	0.81	0.29	0.14	0.28	0.25	0.13	0.01	0.14
Passenger Energy/GDP 10**3	6.1	6.3	4.3	1.7	4.1	3.2	4.1	2.1	4.4
Relative to U.S.	1.00	1.02	0.70	0.28	0.67	0.52	0.66	0.35	0.72
Freight Energy/cap. 10**6	38.3	43.9	21.5	26.4	37.5	21.5	21.3	3.6	12.7
Relative to U.S.	1.00	1.14	0.56	0.69	0.98	0.56	0.56	0.09	0.33
Freight Energy/GDP 10**3	3.6	5.2	4.9	5.1	8.5	4.2	10.2	10.6	6.2
Relative to U.S.	1.00	1.44	1.34	1.40	2.34	1.15	2.81	2.91	1.72

JARIFLEX World Transportation Model
7/16/79

NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-13
Passenger & Freight Energy Use Per Capita and Per GDP
For Eight Regions, 1960

	UNITED STATES	AUSTRA.. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
Passenger Energy/cap. 10**3 Relative to U.S.	19.4 1.00	20.7 0.13	6.7 0.17	1.1 0.03	1.5 0.04	1.1 0.03	1.3 0.03	0.2 0.00	4.5 0.12
Passenger Energy/GDP 10**3 Relative to U.S.	9.7 1.00	7.6 0.78	3.8 0.39	1.3 0.14	1.4 0.14	0.8 0.09	2.6 0.27	1.3 0.13	5.3 0.54
Freight Energy/cap. 10**6 Relative to U.S.	17.2 1.00	14.6 0.85	7.3 0.42	3.0 0.17	5.9 0.34	2.9 0.17	4.9 0.29	0.5 0.03	3.8 0.22
Freight Energy/GDP 10**3 Relative to U.S.	4.3 1.00	5.4 1.26	4.1 0.96	3.5 0.83	5.6 1.32	2.2 0.51	9.6 2.26	3.2 0.75	4.4 1.04

VARIFLEX World Transportation Model
7/16/79

NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-13
Passenger & Freight Energy Use Per Capita and Per GDP
For Eight Regions, 1975

	UNITEI STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
Passenger Energy/cap. 10**6 Relative to U.S.	55.7 1.00	41.7 0.75	15.0 0.27	5.5 0.10	3.9 0.07	4.5 0.08	3.0 0.05	0.4 0.01	7.1 0.13
Passenger Energy/GDP 10**3 Relative to U.S.	10.0 1.00	9.4 0.94	5.2 0.52	2.2 0.22	2.2 0.22	1.9 0.19	3.4 0.34	2.3 0.24	5.8 0.58
Freight Energy/cap. 10**6 Relative to U.S.	24.6 1.00	25.9 1.05	14.9 0.60	17.1 0.69	14.1 0.58	8.4 0.34	11.0 0.45	1.0 0.04	7.2 0.29
Freight Energy/GDP 10**3 Relative to U.S.	4.4 1.00	5.8 1.32	5.1 1.16	6.7 1.53	8.0 1.81	3.6 0.81	12.2 2.77	6.3 1.43	5.9 1.33

VARIFLEX World Transportation Model
7/16/79

NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

Table 3-14
Energy Intensity Assumptions for Eight Regions
2000

		UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
BTU/PK	Automobile	1800.	1600.	1200.	1200.	1400.	1200.	1400.	1200.	1504.
BTU/PK	Bus	1000.	1000.	1000.	450.	500.	500.	600.	400.	541.
BTU/PK	Rail	2000.	2000.	2000.	300.	500.	500.	1000.	300.	546.
BTU/PK	Air	4300.	4000.	3500.	3000.	3000.	3000.	3500.	3000.	3524.
BTU/TK	Truck	4200.	5000.	4137.	4500.	5500.	4500.	6000.	5000.	5075.
BTU/TK	Water	140.	340.	1200.	1600.	400.	400.	1000.	250.	473.
BTU/TK	Rail	450.	450.	1200.	715.	400.	400.	800.	350.	443.
BTU/TK	Ship	125.	125.	125.	125.	125.	125.	125.	125.	125.

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

Table 3-14
Energy Intensity Assumptions for Eight Regions
1960

		UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
BTU/PK	Automobile	3200.	2800.	1600.	1400.	1600.	1600.	1312.	1200.	2678.
BTU/PK	Bus	1000.	1000.	1000.	650.	500.	500.	600.	400.	681.
BTU/PK	Rail	2000.	2000.	2000.	200.	500.	500.	1000.	300.	831.
BTU/PK	Air	4500.	4500.	4000.	3340.	3500.	3839.	4000.	3000.	4215.
BTU/TK	Truck	5000.	6000.	5077.	6000.	6500.	6000.	7000.	5000.	5437.
BTU/TK	Water	340.	340.	1200.	1600.	400.	400.	1000.	250.	446.
BTU/TK	Rail	450.	450.	1200.	715.	400.	400.	800.	350.	477.
BTU/TK	Ship	150.	150.	150.	150.	150.	150.	150.	150.	150.

VARIFLEX World Transportation Model
7/16/79

NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

Table E-14
Energy Intensity Assumptions for Eight Regions
1975

		UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
BTU/PK	Automobile	3200.	2800.	1600.	1400.	1600.	1600.	1257.	1200.	2391.
BTU/PK	Bus	1000.	1000.	1000.	650.	500.	500.	600.	400.	598.
BTU/PK	Rail	2000.	2000.	2000.	200.	500.	500.	1000.	300.	611.
BTU/PK	Air	4500.	4500.	4000.	3340.	3500.	3500.	4000.	3000.	4080.
BTU/TK	Truck	5000.	6000.	5122.	6000.	6500.	6000.	7000.	5000.	5651.
BTU/TK	Water	340.	340.	1200.	1600.	400.	400.	1000.	250.	503.
BTU/TK	Rail	450.	450.	1200.	715.	400.	400.	800.	350.	450.
BTU/TK	Ship	150.	150.	150.	150.	150.	150.	150.	150.	150.

VARIFLEX World Transportation Model

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New Base, May 79 (78 Data Base) New Passenger Fractions, New Energy Intensities, New Ship Calculations (72 \$)

Table 8-14A
Energy Intensity Assumptions for Seven Developed Areas
1975-2000

		UNITED STATES	AUSTRAL. +CANADA	E.E.C.	OTHER W.EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE
		-----	-----	-----	-----	-----	-----	-----
1975 BTU/PK	Automobile	3200.	2800.	1600.	1600.	1400.	1600.	1600.
2000 - Same		1800.	1600.	1200.	1200.	1200.	1400.	1200.
1975 BTU/PK	Bus	1000.	1000.	1000.	1000.	650.	500.	500.
2000 - Same		1000.	1000.	1000.	1000.	650.	500.	500.
1975 BTU/PK	Rail	2000.	2000.	2000.	2000.	200.	500.	500.
2000 - Same		2000.	2000.	2000.	2000.	300.	500.	500.
1975 BTU/PK	Air	4500.	4500.	4000.	4000.	3340.	3500.	3500.
2000 - Same		4000.	4000.	3500.	3500.	3000.	3000.	3000.
1975 BTU/TK	Truck	5000.	6000.	5000.	5300.	6000.	6500.	6000.
2000 - Same		4500.	5000.	4000.	4500.	4500.	5500.	4500.
1975 BTU/TK	Water	340.	340.	1200.	1200.	1600.	400.	400.
2000 - Same		340.	340.	1200.	1200.	1600.	400.	400.
1975 BTU/TK	Rail	450.	450.	1200.	1200.	715.	400.	400.
2000 - Same		450.	450.	1200.	1200.	715.	400.	400.
1975 BTU/TK	Ship	150.	150.	150.	150.	150.	150.	150.
2000 Same		125.	125.	125.	125.	125.	125.	125.

VARIFLEX World Transportation Model
5/22/79

New Base, May 79 (78 Data Base) New Passenger Fractions, New Energy Intensities, New Ship Calculations (72 \$)

Table B-14B
Energy Intensity Assumptions for Five Less Developed Areas
1975-2000

		LATIN AMERICA	MIDEAST S.AFRICA	SOUTH ASIA	OTHER AFRICA	P. REP. OF CHINA
1975 BTU/PK	Automobile	1200.	1600.	1200.	1200.	1200.
2000 - Same		1400.	1400.	1200.	1200.	1200.
1975 BTU/PK	Bus	600.	600.	400.	400.	400.
2000 - Same		600.	600.	400.	400.	400.
1975 BTU/PK	Rail	1000.	1000.	300.	300.	300.
2000 - Same		1000.	1000.	300.	300.	300.
1975 BTU/PK	Air	4000.	4000.	3000.	3000.	3000.
2000 - Same		3500.	3500.	3000.	3000.	3000.
1975 BTU/TK	Truck	7000.	7000.	5000.	5000.	5000.
2000 - Same		6000.	6000.	5000.	5000.	5000.
1975 BTU/TK	Water	1000.	1000.	250.	250.	250.
2000 - Same		1000.	1000.	250.	250.	250.
1975 BTU/TK	Rail	600.	600.	350.	350.	350.
2000 - Same		600.	600.	350.	350.	350.
1975 BTU/TK	Ship	150.	150.	150.	150.	150.
2000 - Same		125.	125.	125.	125.	125.

VARIFLEX World Transportation Model
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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

Table 8-14B
Energy Intensity Assumptions for Ten Basic Areas
1975-2000

		UNITED STATES	AUSTRAL. +CANADA	E.E.C.	OTHER W.EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	LATIN AMERICA	MIDEAST S.AFRICA	SOUTH ASIA
1975 BTU/PK	Automobile	3200.	2800.	1600.	1600.	1400.	1600.	1600.	1200.	1600.	1200.
2000 - Same		1800.	1600.	1200.	1200.	1200.	1400.	1200.	1400.	1400.	1200.
1975 BTU/PK	Bus	1000.	1000.	1000.	1000.	650.	500.	500.	600.	600.	400.
2000 - Same		1000.	1000.	1000.	1000.	650.	500.	500.	600.	600.	400.
1975 BTU/PK	Rail	2000.	2000.	2000.	2000.	200.	500.	500.	1000.	1000.	300.
2000 - Same		2000.	2000.	2000.	2000.	300.	500.	500.	1000.	1000.	300.
1975 BTU/PK	Air	4500.	4500.	4000.	4000.	3340.	3500.	3500.	4000.	4000.	3000.
2000 - Same		4000.	4000.	3500.	3500.	3000.	3000.	3000.	3500.	3500.	3000.
1975 BTU/TK	Truck	5000.	6000.	5000.	5500.	6000.	6500.	6000.	7000.	7000.	5000.
2000 - Same		4500.	5000.	4000.	4500.	4500.	5500.	4500.	6000.	6000.	5000.
1975 BTU/TK	Water	340.	340.	1200.	1200.	1600.	400.	400.	1000.	1000.	250.
2000 - Same		340.	340.	1200.	1200.	1600.	400.	400.	1000.	1000.	250.
1975 BTU/TK	Rail	450.	450.	1200.	1200.	715.	400.	400.	800.	800.	350.
2000 - Same		450.	450.	1200.	1200.	715.	400.	400.	800.	800.	350.
1975 BTU/TK	Ship	150.	150.	150.	150.	150.	150.	150.	150.	150.	150.
2000 Same		125.	125.	125.	125.	125.	125.	125.	125.	125.	125.

VARIFLEX World Transportation Model
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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-15
Projected GDP and Population for Eight World Regions
Ayres' Low Estimate for the Year 2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
2000 GDP (10**9 1972 Dollars)	2310.	401.	1555.	684.	1386.	513.	1125.	975.	9449.	10583.
2000 Population, 10**6	266.	48.	352.	132.	314.	100.	537.	2898.	4648.	5205.
2000 GDP/capita, (1972 Dollars)	10552.	8416.	4412.	5178.	4409.	5145.	2095.	336.	2033.	2033.
2000 Population, % of world	5.	1.	7.	3.	6.	2.	10.	56.	89.	100.
2000 GDP/capita, ratio to world	5.2	4.1	2.2	2.5	2.2	2.5	1.0	0.2	1.0	1.0
2000 GDP/capita, ratio to U.S.	1.00	0.80	0.42	0.49	0.42	0.49	0.20	0.03	0.19	0.19
1975 Population, % of world	5.	1.	9.	3.	8.	3.	8.	51.	89.	100.
1975 GDP/capita, ratio to world	4.5	3.6	2.4	2.1	1.4	1.9	0.7	0.1	1.0	1.0
1975 GDP/capita, ratio to U.S.	1.00	0.80	0.52	0.45	0.32	0.42	0.16	0.03	0.22	0.22

VARIFLEX World Transportation Model
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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-16
Transportation Energy for Eight World Regions, 1975, 1985 and 2000
(10**15 BTU)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total Transportation - 1975	17.2	2.5	9.3	2.5	4.6	1.1	3.8	2.4	43.5	48.7
1985	21.6	3.3	12.1	3.6	9.7	2.1	7.4	4.8	64.6	72.3
2000	27.5	4.6	14.3	4.6	17.4	3.8	16.0	12.4	100.7	112.8
% change, 1975-2000	60.	86.	53.	86.	280.	235.	317.	408.	131.	131.
Passenger - 1975	11.9	1.5	4.7	0.6	1.0	0.4	0.8	0.7	21.6	24.2
1985	14.1	1.9	6.0	1.0	2.1	0.8	1.7	1.1	28.6	32.1
2000	17.3	2.5	6.7	1.2	5.7	1.6	4.6	2.1	41.7	46.7
% change, 1975-2000	45.	65.	43.	91.	473.	313.	450.	217.	93.	93.
Freight - 1975	5.3	0.9	4.6	1.9	3.6	0.7	3.0	1.8	21.9	24.5
1985	7.5	1.4	6.1	2.7	7.6	1.3	5.7	3.7	35.9	40.3
2000	10.2	2.1	7.6	3.5	11.8	2.1	11.5	10.3	59.0	66.1
% change, 1975-2000	94.	120.	63.	84.	226.	193.	280.	479.	170.	170.

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-17
Share of Passenger & Freight Transportation Energy Use
For Eight World Regions, 1975 and 2000 (Percent)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
1975 Passenger/Total	69.4	61.7	50.3	24.2	21.5	35.0	21.6	27.1	49.7
2000 Passenger/Total	62.9	54.6	47.1	25.0	32.5	43.2	28.5	16.9	41.4
1975 Freight/Total	30.6	38.3	49.7	75.8	78.5	65.0	78.4	72.9	50.3
2000 Freight/Total	37.1	45.4	52.9	75.0	67.5	56.8	71.5	83.1	58.6

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-19
Transportation Energy (T.E.) Use Relative to Population and GDP for Eight Regions
Ayres' Low Estimate for the Year 2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LIC	34 COUN- TRIES	WORLD TOTAL
Total T.E. (10**15 BTU)	27.5	4.6	14.3	4.6	17.4	3.8	16.0	12.4	100.7	112.8
BTU/capita, 10**6	103.	97.	41.	35.	56.	38.	30.	4.	22.	22.
BTU/GDP, 10**3	9.8	11.5	9.2	6.8	12.6	7.3	14.3	12.7	10.7	10.7
Passenger T.E. (10**15 BTU)	17.3	2.5	6.7	1.2	5.7	1.6	4.6	2.1	41.7	46.7
BTU/capita, 10**6	65.	53.	19.	9.	18.	14.	9.	1.	9.	9.
BTU/GDP, 10**3	6.1	6.3	4.3	1.7	4.1	3.2	4.1	2.1	4.4	4.4
Freight T.E. (10**15 BTU)	10.2	2.1	7.6	3.5	11.8	2.1	11.5	10.3	59.0	66.1
BTU/capita, 10**6	38.	44.	21.	26.	37.	21.	21.	4.	13.	13.
BTU/GDP, 10**3	3.6	5.2	4.9	5.1	8.5	4.2	10.2	10.6	6.2	6.2

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NEW BASE, MAY 79 (78 DATA BASE) NEW PASSENGER FRACTIONS, NEW ENERGY INTENSITIES, NEW SHIP CALC. MONEY IN 72 US \$

TABLE 8-20
Energy Intensity Measures for Eight Regions
1975 and 2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
BTU/PK Auto - 1975	3200.	2800.	1600.	1400.	1600.	1600.	1257.	1200.	2391.
- 2000	1800.	1600.	1200.	1200.	1400.	1200.	1400.	1200.	1504.
% Increase	-44.	-43.	-25.	-14.	-13.	-25.	11.	0.	-37.
BTU/PK Air - 1975	4500.	4500.	4000.	3340.	3500.	3500.	4000.	3000.	4080.
- 2000	4000.	4000.	3500.	3000.	3000.	3000.	3500.	3000.	3524.
% Increase	-11.	-11.	-12.	-10.	-14.	-14.	-12.	-0.	-14.
BTU/ton-km Truck - 1975	5000.	6000.	5122.	6000.	6500.	6000.	7000.	5000.	5651.
- 2000	4100.	5000.	4127.	4500.	5500.	4500.	6000.	5000.	5075.
% Increase	-10.	-17.	-19.	-25.	-15.	-25.	-14.	0.	-10.
BTU/ton-km Ship - 1975	150.	150.	150.	150.	150.	150.	150.	150.	150.
- 2000	125.	125.	125.	125.	125.	125.	125.	125.	125.
% Increase	-17.	-17.	-17.	-17.	-17.	-17.	-17.	-17.	-17.

VARIFLEX World Transportation Model
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Aures' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

Table 3.4
Gross Domestic Product and Population for Eight World Regions, 1955 and 2000
(Money values shown in constant 1972 U.S. Dollars)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
2000 GDP billions(72\$)	2439.	393.	1374.	577.	1320.	402.	1299.	985.	8790.	9845.
2000 Population, millions	263.	48.	352.	132.	214.	100.	537.	2898.	4646.	5205.
2000 GDP/Capita (72\$)	9158.	8254.	3901.	4367.	4202.	4033.	2419.	340.	1891.	1891.
2000 GDP, % of world	25.	4.	14.	6.	13.	4.	13.	10.	89.	100.
2000 Population, % of world	5.	1.	7.	3.	6.	2.	10.	56.	89.	100.
2000 GDP/Capita, ratio to world	4.8	4.4	2.1	2.3	2.2	2.1	1.3	0.2	1.0	1.0
2000 GDP, ratio to U.S.	1.00	0.16	0.56	0.24	0.54	0.16	0.53	0.40	3.60	4.04
2000 Population, ratio to U.S.	1.00	0.18	1.32	0.50	1.18	0.37	2.02	10.88	17.45	19.55
2000 GDP/Capita, ratio to U.S.	1.00	0.90	0.43	0.48	0.46	0.44	0.23	0.04	0.21	0.21
1955 GDP, billions(72\$)	584.	57.	391.	48.	168.	85.	59.	176.	1579.	1768.
1955 Population, millions	166.	26.	267.	69.	198.	76.	155.	1162.	2137.	2394.
1955 GDP/Capita (72\$)	3521.	2216.	1468.	545.	846.	1129.	446.	151.	739.	739.
1955 GDP/Capita, ratio to U.S.	1.00	0.63	0.42	0.15	0.24	0.32	0.13	0.04	0.21	0.21

JARIFLEX World Transportation Model
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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

Table 8.4
Gross Domestic Product and Population for Eight World Regions, 1955 and 1960
(Money values shown in constant 1972 U.S. Dollars)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	DEV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
1960 GDP billions(72\$)	732.	76.	496.	78.	225.	106.	91.	187.	1990.	2229.
1960 Populations, millions	181.	28.	279.	93.	214.	79.	178.	1281.	2333.	2613.
1960 GDP/Capita (72\$)	4040.	2717.	1777.	838.	1051.	1338.	510.	146.	853.	853.
1960 GDP, % of world	33.	3.	22.	4.	10.	5.	4.	3.	89.	100.
1960 Population, % of world	7.	1.	11.	4.	8.	3.	7.	49.	89.	100.
1960 GDP/Capita, ratio to world	4.7	3.2	2.1	1.0	1.2	1.6	0.6	0.2	1.0	1.0
1960 GDP, ratio to U.S.	1.00	0.10	0.68	0.11	0.31	0.14	0.12	0.26	2.72	3.04
1960 Population, ratio to U.S.	1.00	0.16	1.54	0.51	1.16	0.43	0.98	7.07	12.87	14.41
1960 GDP/Capita, ratio to U.S.	1.00	0.67	0.44	0.21	0.26	0.33	0.13	0.04	0.21	0.21
1955 GDP, billions(72\$)	534.	57.	391.	48.	168.	85.	69.	176.	1579.	1768.
1955 Population, millions	166.	26.	267.	89.	198.	76.	155.	1162.	2137.	2394.
1955 GDP/Capita (72\$)	3521.	2216.	1468.	545.	846.	1129.	446.	151.	739.	739.
1955 GDP/Capita, ratio to U.S.	1.00	0.63	0.42	0.15	0.24	0.32	0.13	0.04	0.21	0.21

VARIFLEX World Transportation Model
7/15/77

Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

Table 3.4
Gross Domestic Product and Population for Eight World Regions, 1955 and 1975
(Money values shown in constant 1972 U.S. Dollars)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	DEV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
1975 GDP billions(72\$)	1194.	163.	905.	281.	454.	204.	247.	282.	3730.	4177.
1975 Population, millions	214.	37.	312.	111.	235.	87.	273.	1738.	3026.	3390.
1975 GDP/Capita (72\$)	5562.	4452.	2897.	2535.	1778.	2341.	905.	162.	1232.	1232.
1975 GDP, % of world	29.	4.	22.	7.	11.	5.	6.	7.	89.	100.
1975 Population, % of world	5.	1.	9.	3.	8.	3.	8.	51.	89.	100.
1975 GDP/Capita, ratio to world	4.5	3.6	2.4	2.1	1.4	1.9	0.7	0.1	1.0	1.0
1975 GDP, ratio to U.S.	1.00	0.14	0.76	0.24	0.38	0.17	0.21	0.24	3.12	3.50
1975 Population, ratio to U.S.	1.00	0.17	1.46	0.52	1.19	0.41	1.28	8.12	14.15	15.85
1975 GDP/Capita, ratio to U.S.	1.00	0.80	0.52	0.45	0.32	0.42	0.16	0.03	0.22	0.22
1955 GDP, billions(72\$)	384.	57.	391.	48.	168.	85.	69.	176.	1579.	1768.
1955 Population, millions	166.	26.	267.	89.	198.	76.	155.	1162.	2137.	2394.
1955 GDP/Capita (72\$)	3521.	2216.	1468.	545.	846.	1129.	446.	151.	739.	739.
1955 GDP/Capita, ratio to U.S.	1.00	0.63	0.42	0.15	0.24	0.32	0.13	0.04	0.21	0.21

VAFIFLEX World Transportation Model
7/15/79

Agres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8.5
TRANSPORTATION DEMANDS FOR EIGHT WORLD REGIONS
2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Passenger Kilometers(PK),10**9	6835.	1140.	3849.	865.	3699.	1006.	3694.	3237.	24325.	27244.
PK/capita, thousands	25.7	23.9	10.9	6.5	11.8	10.1	6.9	1.1	5.2	5.2
PK/GDP	2.8	2.9	2.8	1.5	2.8	2.5	2.8	3.3	2.8	2.8
PK/capita, Ratio to U.S.	1.00	0.93	0.43	0.26	0.46	0.39	0.27	0.04	0.20	0.20
PK/GDP, Ratio to U.S.	1.00	1.03	1.00	0.53	1.00	0.89	1.01	1.17	0.99	0.99
Truck Ton Kilometers, 10**9	1309.	274.	774.	182.	1651.	322.	1743.	1820.	8075.	9043.
Water Ton Kilometers, 10**9	1416.	318.	145.	183.	434.	29.	158.	673.	3356.	3758.
Rail Ton Kilometers, 10**9	1944.	504.	120.	67.	4716.	260.	796.	1773.	10179.	11400.
Domestic Ton Kilometers (DTK)	4668.	1096.	1038.	432.	6801.	611.	2698.	4265.	21609.	24202.
DTK/GDP	1.9	2.8	0.8	0.7	5.2	1.5	2.1	4.3	2.5	2.5
DTK/GDP, Ratio to U.S.	1.00	1.46	0.39	0.39	2.69	0.79	1.09	2.26	1.28	1.26

VARIFLEX World Transportation Model

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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8.5
TRANSPORTATION DEMANDS FOR EIGHT WORLD REGIONS
1960

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Passenger Kilometers(PK),10**9	2253.	215.	1165.	270.	371.	137.	226.	480.	5118.	5732.
PK/capita, thousands	12.4	7.6	4.2	2.9	1.7	1.7	1.3	0.4	2.2	2.2
PK/GDP	3.1	2.8	2.4	3.5	1.7	1.3	2.5	2.6	2.6	2.6
PK/capita, Ratio to U.S.	1.00	0.61	0.34	0.23	0.14	0.14	0.10	0.03	0.18	0.18
PK/GDP, Ratio to U.S.	1.00	0.91	0.76	1.12	0.54	0.42	0.81	0.83	0.84	0.84
Truck Ton Kilometers, 10**9	445.	47.	253.	17.	95.	22.	107.	72.	1058.	1185.
Water Ton Kilometers, 10**9	1106.	90.	106.	46.	107.	9.	37.	109.	1610.	1903.
Rail Ton Kilometers, 10**9	822.	117.	209.	57.	1504.	174.	75.	264.	3222.	3609.
Domestic Ton Kilometers (DTK)	2373.	254.	568.	120.	1706.	206.	219.	445.	5891.	6597.
DTK/GDP	3.2	3.3	1.1	1.5	7.6	2.0	2.4	2.4	3.0	3.0
DTK/GDP, Ratio to U.S.	1.00	1.03	0.35	0.47	2.34	0.60	0.75	0.74	0.91	0.91

VARIFLEX World Transportation Model
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Agres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8.5
TRANSPORTATION DEMANDS FOR EIGHT WORLD REGIONS
1975

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Passenger Kilometers(PK),10**9	3703.	525.	2795.	740.	1023.	394.	707.	1332.	11219.	12565.
PK/capita, thousands	17.3	14.2	8.9	6.7	4.0	4.5	2.6	0.8	3.7	3.7
PK/GDP	3.1	3.2	3.1	2.6	2.3	1.9	2.9	4.7	3.0	3.0
PK/capita, Ratio to U.S.	1.00	0.83	0.52	0.39	0.23	0.26	0.15	0.04	0.21	0.21
PK/GDP, Ratio to U.S.	1.00	1.04	1.00	0.85	0.73	0.62	0.92	1.52	0.97	0.97
Truck Ton Kilometers, 10**9	719.	109.	505.	134.	337.	92.	378.	273.	2547.	2852.
Water Ton Kilometers, 10**9	1320.	180.	143.	146.	222.	15.	66.	95.	2188.	2450.
Rail Ton Kilometers, 10**9	1417.	236.	213.	53.	3237.	278.	171.	553.	6158.	6897.
Domestic Ton Kilometers (DTK)	3456.	525.	861.	333.	3796.	385.	615.	921.	10892.	12199.
DTK/GDP	2.9	3.2	1.0	1.2	8.4	1.7	2.5	3.3	2.9	2.9
DTK/GDP, Ratio to U.S.	1.00	1.11	0.33	0.41	2.89	0.65	0.86	1.13	1.01	1.01

VARIFLEX World Transportation Model
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Ayres' Conservation Estimates - May 79. Note GDF, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72-US \$)

TABLE B-9
Transportation Energy (T.E.) Use for Eight World Regions
2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E. (BTU), 10**15	17.0	3.2	10.7	3.5	13.3	2.3	14.2	11.3	75.5	84.6
Relative to U.S.	1.00	0.19	0.63	0.21	0.78	0.14	0.84	0.66	4.44	4.98
T.E. (BTU) Per capita, 10**6	63.8	67.7	30.5	26.5	42.2	23.3	26.4	3.9	16.3	16.3
Relative to U.S.	1.00	1.06	0.48	0.42	0.66	0.37	0.41	0.06	0.25	0.25
T.E. (BTU) Per GDF, 10**3	7.0	8.2	7.8	6.1	10.1	5.8	10.9	11.4	8.6	8.6
Relative to U.S.	1.00	1.18	1.12	0.87	1.44	0.83	1.57	1.64	1.23	1.23

VARIFLEX World Transportation Model
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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-9
Transportation Energy (T.E.) Use for Eight World Regions
1960

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E. (BTU), 10**15 Relative to U.S.	10.3 1.00	1.0 0.10	3.9 0.38	0.4 0.04	1.7 0.17	0.3 0.03	1.1 0.11	0.8 0.08	19.5 1.90	21.9 2.13
T.E. (BTU) per capita, 10**6 Relative to U.S.	56.6 1.00	35.2 0.62	14.0 0.25	4.1 0.07	8.1 0.14	4.0 0.07	6.2 0.11	0.6 0.01	8.4 0.15	8.4 0.15
T.E. (BTU) per GDP, 10**3 Relative to U.S.	14.0 1.00	13.0 0.93	7.9 0.56	4.9 0.35	7.7 0.55	3.0 0.21	12.2 0.87	4.5 0.32	9.8 0.70	9.8 0.70

VARIFLEX World Transportation Model
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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-9
Transportation Energy (T.E.) Use for Eight World Regions
1975

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E. (BTU), 10**15 Relative to U.S.	17.2 1.00	2.5 0.14	9.3 0.54	2.5 0.15	4.6 0.27	1.1 0.07	3.8 0.22	2.4 0.14	43.5 2.53	48.7 2.84
T.E. (BTU) per capita, 10**6 Relative to U.S.	80.3 1.00	67.6 0.84	29.9 0.37	22.5 0.28	18.0 0.22	12.9 0.16	14.1 0.18	1.4 0.02	14.4 0.18	14.4 0.18
T.E. (BTU) per GDP, 10**3 Relative to U.S.	14.4 1.00	15.2 1.06	10.3 0.72	8.9 0.62	10.1 0.70	5.5 0.38	15.6 1.08	8.7 0.60	11.7 0.81	11.7 0.81

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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

Table 8-11
Transportation Modal Energy Use (Amount and % World) in Eight Regions
2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LIC	34 COUN- TRIES	WORLD TOTAL
Total T.E. (10**15)	17.00	3.23	10.74	3.51	13.27	2.33	14.20	11.28	75.55	84.61
Passenger Share Auto/Bus(10**15)	6.98	1.08	3.30	0.50	1.94	0.74	3.27	1.10	18.90	21.17
Passenger Share Air(10**15)	2.56	0.51	1.17	0.29	1.78	0.18	0.99	0.55	8.03	8.99
Passenger & Freight-Rail(10**15)	0.84	0.24	0.24	0.10	1.91	0.16	0.63	0.77	4.89	5.48
Freight Share Truck(10**15)	4.58	0.96	2.71	0.73	7.43	1.13	7.84	8.19	33.57	37.59
Freight Share Water(10**15)	0.42	0.10	0.14	0.11	0.13	0.01	0.13	0.17	1.21	1.35
Freight Share Ship(10**15)	1.61	0.35	3.17	1.78	0.08	0.11	1.34	0.51	8.95	10.02
Total T.E. (% World)	20.	4.	13.	4.	16.	3.	17.	13.	89.	100.
Passenger Share Auto/Bus(% World)	33.	5.	16.	2.	9.	3.	15.	5.	89.	100.
Passenger Share Air(% World)	28.	6.	13.	3.	20.	2.	11.	6.	89.	100.
Passenger & Freight-Rail(% World)	15.	4.	4.	2.	35.	3.	12.	14.	89.	100.
Freight Share Truck(% World)	12.	3.	7.	2.	20.	3.	21.	22.	89.	100.
Freight Share Water(% World)	31.	7.	11.	8.	10.	1.	9.	12.	89.	100.
Freight Share Ship(% World)	16.	3.	32.	18.	1.	1.	13.	5.	89.	100.

VARIFLEX World Transportation Model
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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

Table 8-11
Transportation Modal Energy Use (Amount and % World) in Eight Regions
1960

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E.(10**15)	10.26	0.99	3.89	0.38	1.73	0.32	1.11	0.83	19.51	21.85
Passenger Share-Auto/Bus(10**15)	6.44	0.51	1.38	0.05	0.11	0.05	0.17	0.16	8.86	9.92
Passenger Share-Air(10**15)	0.62	0.03	0.09	0.01	0.12	0.00	0.01	0.02	0.92	1.03
Passenger+Freight-Rail(10**15)	0.44	0.10	0.65	0.08	0.68	0.11	0.11	0.15	2.32	2.60
Freight Share-Truck(10**15)	2.23	0.28	1.29	0.10	0.77	0.13	0.75	0.36	5.91	6.61
Freight Share-Water(10**15)	0.38	0.03	0.13	0.07	0.04	0.00	0.04	0.03	0.72	0.80
Freight Share-Ship(10**15)	0.15	0.04	0.36	0.06	0.01	0.02	0.03	0.12	0.79	0.88
Total T.E.(% World)	47.	5.	18.	2.	8.	1.	5.	4.	89.	100.
Passenger Share Auto/Bus(% World)	65.	5.	14.	1.	1.	3.	2.	2.	89.	100.
Passenger Share Air(% World)	61.	3.	9.	1.	12.	3.	1.	2.	89.	100.
Passenger & Freight-Rail(% World)	17.	4.	25.	3.	26.	4.	4.	6.	89.	100.
Freight Share Truck(% World)	34.	4.	19.	2.	12.	2.	11.	5.	89.	100.
Freight Share Water(% World)	47.	4.	16.	9.	5.	0.	5.	3.	89.	100.
Freight Share ship(% World)	17.	5.	41.	7.	1.	2.	3.	13.	89.	100.

VAREFLEX World Transportation Model
7/15/79

Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

Table 8-11
Transportation Modal Energy Use (Amount and % World) in Eight Regions
1975

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E.(10**15)	17.18	2.48	9.34	2.50	4.60	1.12	3.84	2.44	43.50	48.72
Passenger Share-Auto/Bus(10**15)	10.65	1.27	3.75	0.43	0.42	0.33	0.65	0.40	17.90	20.04
Passenger Share-Air(10**15)	1.23	0.23	0.49	0.11	0.41	0.02	0.13	0.08	2.72	3.04
Passenger+Freight-Rail(10**15)	0.67	0.13	0.70	0.11	1.45	0.16	0.19	0.37	3.78	4.24
Freight Share-Truck(10**15)	3.59	0.65	2.59	0.80	2.19	0.55	2.64	1.36	14.39	16.12
Freight Share-Water(10**15)	0.45	0.06	0.17	0.23	0.09	0.01	0.07	0.02	1.10	1.23
Freight Share-Ship(10**15)	0.58	0.13	1.63	0.82	0.03	0.06	0.17	0.20	3.61	4.04
Total T.E.(% World)	35.	5.	19.	5.	9.	2.	8.	5.	89.	100.
Passenger Share Auto/Bus(% World)	53.	6.	19.	2.	2.	2.	3.	2.	89.	100.
Passenger Share Air(% World)	41.	8.	16.	4.	14.	1.	4.	3.	89.	100.
Passenger & Freight-Rail(% World)	16.	3.	17.	2.	34.	4.	4.	9.	89.	100.
Freight Share Truck(% World)	22.	4.	16.	5.	14.	3.	16.	8.	89.	100.
Freight Share Water(% World)	36.	5.	14.	19.	7.	0.	5.	2.	89.	100.
Freight Share ship(% World)	14.	3.	40.	20.	1.	1.	4.	5.	89.	100.

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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-12
Nonpetroleum Transportation Energy Use for Eight Regions, 2000
(10**15 BTU)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E.	17.0	3.2	10.7	3.5	13.3	2.3	14.2	11.3	75.5	84.6
Electricity-Rail	0.02	0.00	0.15	0.08	0.95	0.03	0.25	0.00	1.48	1.65
Coal-Rail	0.00	0.00	0.00	0.00	0.76	0.11	0.13	0.72	1.73	1.94
Total Nonpetroleum-Rail	0.02	0.00	0.15	0.08	1.72	0.14	0.38	0.73	3.21	3.59
Nonpetroleum % Total Trans.	0.1	0.1	1.4	2.2	13.0	6.0	2.7	6.4	4.2	4.2
Rail Energy	0.34	0.24	0.24	0.10	1.91	0.16	0.63	0.77	4.89	5.43
Nonpetroleum % Rail Energy	2.	2.	60.	75.	90.	88.	60.	95.	66.	66.

VARIFLEX World Transportation Model
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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-12
Nonpetroleum Transportation Energy Use for Eight Regions, 1960
(10**15 BTU)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LOC	34 COUN- TRIES	WORLD TOTAL
Total T.E.	10.3	1.0	3.9	0.4	1.7	0.3	1.1	0.8	19.5	21.9
Electricity-Rail	0.01	0.00	0.39	0.06	0.34	0.02	0.04	0.00	0.86	0.96
Coal-Rail	0.00	0.00	0.00	0.00	0.27	0.08	0.03	0.14	0.52	0.58
Total NonPetroleum-Rail	0.01	0.00	0.39	0.06	0.61	0.09	0.07	0.14	1.38	1.55
NonPetroleum % Total Trans.	0.1	0.2	10.0	15.7	35.5	30.1	6.0	17.3	7.1	7.1
Rail Energy	0.44	0.10	0.65	0.08	0.68	0.11	0.11	0.15	2.32	2.60
NonPetroleum % Rail Energy	2.	2.	60.	75.	90.	88.	60.	94.	59.	59.

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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE B-12
Nonpetroleum Transportation Energy Use for Eight Regions, 1975
(10**15 BTU)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E.	17.2	2.5	9.3	2.5	4.6	1.1	3.8	2.4	43.5	48.7
Electricity-Rail	0.01	0.00	0.42	0.08	0.73	0.03	0.07	0.00	1.34	1.50
Coal-Rail	0.00	0.00	0.00	0.00	0.58	0.11	0.04	0.35	1.09	1.22
Total Nonpetroleum-Rail	0.01	0.00	0.42	0.08	1.31	0.14	0.11	0.35	2.43	2.72
Nonpetroleum % Total Trans.	0.1	0.1	4.5	3.2	28.4	12.3	2.9	14.5	5.6	5.6
Rail Energy	0.67	0.13	0.70	0.11	1.45	0.16	0.19	0.37	3.78	4.24
Nonpetroleum % Rail Energy	2.	2.	60.	75.	90.	88.	60.	94.	64.	64.

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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-13
Passenger & Freight Energy Use Per Capita and Per GDP
For Eight Regions, 2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
Passenger Energy/cap. 10**6 Relative to U.S.	34.1 1.00	34.1 0.94	13.2 0.36	6.4 0.18	12.7 0.35	5.8 0.27	8.1 0.22	0.6 0.02	6.0 0.17
Passenger Energy/GDP 10**3 Relative to U.S.	3.9 1.00	4.1 1.05	3.4 0.86	1.5 0.37	3.0 0.76	2.4 0.61	3.3 0.85	1.9 0.48	3.2 0.80
Freight Energy/cap. 10**6 Relative to U.S.	27.7 1.00	33.6 1.21	17.3 0.62	20.1 0.72	29.6 1.07	13.6 0.49	18.4 0.66	3.2 0.12	10.3 0.37
Freight Energy/GDP 10**3 Relative to U.S.	3.0 1.00	4.1 1.34	4.4 1.46	4.6 1.52	7.0 2.32	2.4 1.11	7.6 2.51	9.5 3.15	5.4 1.79

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Agres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-13
Passenger & Freight Energy Use Per Capita and Per GDP
For Eight Regions, 1960

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
Passenger Energy/cap. 10**6 Relative to U.S.	39.4 1.00	20.7 0.53	6.7 0.17	1.1 0.03	1.5 0.04	1.1 0.03	1.3 0.03	0.2 0.00	4.5 0.12
Passenger Energy/GDP 10**3 Relative to U.S.	5.7 1.00	7.6 0.78	3.8 0.39	1.3 0.14	1.4 0.14	0.8 0.09	2.6 0.27	1.3 0.13	5.3 0.54
Freight Energy/cap. 10**6 Relative to U.S.	17.2 1.00	14.6 0.85	7.3 0.42	3.0 0.17	6.6 0.39	2.9 0.17	4.9 0.29	0.5 0.03	3.8 0.22
Freight Energy/GDP 10**3 Relative to U.S.	4.3 1.00	5.4 1.26	4.1 0.96	3.5 0.83	6.3 1.48	2.2 0.51	9.6 2.26	3.2 0.75	4.5 1.05

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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-13
Passenger & Freight Energy Use Per Capita and Per GDP
For Eight Regions, 1975

UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LIC	WORLD TOTAL
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Agres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

Table 8-14
Energy Intensity Assumptions for Eight Regions
2000

		UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
BTU/PK	Automobile	1200.	1150.	1000.	1000.	1000.	1000.	1141.	1000.	1109.
BTU/PK	Bus	800.	800.	800.	600.	500.	500.	600.	400.	519.
BTU/PK	Rail	1500.	1500.	1500.	300.	500.	500.	1000.	300.	512.
BTU/PK	Air	3000.	3000.	3000.	3000.	3000.	3000.	3000.	3000.	3000.
BTU/TK	Truck	3500.	3500.	3500.	4000.	4500.	3500.	4500.	4500.	4157.
BTU/TK	Water	300.	300.	1000.	600.	300.	300.	800.	250.	360.
BTU/TK	Rail	400.	400.	600.	600.	350.	400.	700.	300.	397.
BTU/TK	Ship	125.	125.	125.	125.	125.	125.	125.	125.	125.

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Ages' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

Table B-14
Energy Intensity Assumptions for Eight Regions
1960

		UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
BTU/PK	Automobile	3200.	2800.	1600.	1400.	1600.	1400.	1312.	1200.	2678.
BTU/PK	Bus	1000.	1000.	1000.	650.	500.	500.	600.	400.	681.
BTU/PK	Rail	2000.	2000.	2000.	200.	500.	500.	1000.	300.	831.
BTU/PK	Air	4500.	4500.	4000.	3340.	3500.	3839.	4000.	3000.	4215.
BTU/TK	Truck	5000.	6000.	5077.	6000.	8105.	6000.	7000.	5000.	5580.
BTU/TK	Water	340.	340.	1200.	1600.	400.	400.	1000.	250.	446.
BTU/TK	Rail	450.	450.	1200.	715.	400.	400.	300.	350.	477.
BTU/TK	Ship	150.	150.	150.	150.	150.	150.	150.	150.	150.

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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-13
Passenger & Freight Energy Use Per Capita and Per GDP
For Eight Regions, 1975

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
Passenger Energy/cap. 10**6 Relative to U.S.	55.7 1.00	41.7 0.75	15.0 0.27	5.5 0.10	3.9 0.07	4.5 0.08	3.0 0.05	0.4 0.01	7.1 0.13
Passenger Energy/GDP 10**3 Relative to U.S.	10.0 1.00	9.4 0.94	5.2 0.52	2.2 0.22	2.2 0.22	1.9 0.19	3.4 0.34	2.3 0.24	5.8 0.58
Freight Energy/cap. 10**6 Relative to U.S.	24.6 1.00	25.9 1.05	14.9 0.60	17.1 0.69	14.1 0.58	8.4 0.34	11.0 0.45	1.0 0.04	7.2 0.29
Freight Energy/GDP 10**3 Relative to U.S.	4.4 1.00	5.8 1.32	5.1 1.16	6.7 1.53	8.0 1.81	3.6 0.81	12.2 2.77	6.3 1.43	5.9 1.33

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Ayres' Conservation Estimates - May 79. Note GDF, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

Table 8-14A
Energy Intensity Assumptions for Seven Developed Areas
1975-2000

		UNITED STATES	AUSTRAL. +CANADA	E.E.C.	OTHER W. EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE
1975 BTU/FK	Automobile	3200.	2800.	1600.	1600.	1400.	1600.	1600.
2000 - Same		1200.	1150.	1000.	1000.	1000.	1000.	1000.
1975 BTU/FK	Bus	1000.	1000.	1000.	1000.	650.	500.	500.
2000 - Same		800.	800.	800.	800.	600.	500.	500.
1975 BTU/FK	Rail	2000.	2000.	2000.	2000.	200.	500.	500.
2000 - Same		1500.	1500.	1500.	1500.	300.	500.	500.
1975 BTU/FK	Air	4500.	4500.	4000.	4000.	3340.	3500.	3500.
2000 - Same		3000.	3000.	3000.	3000.	3000.	3000.	3000.
1975 BTU/TK	Truck	5000.	6000.	5000.	5500.	6000.	6500.	6000.
2000 - Same		3500.	3500.	3500.	3500.	4000.	4500.	3500.
1975 BTU/TK	Water	340.	340.	1200.	1200.	1600.	400.	400.
2000 - Same		300.	300.	1000.	1000.	600.	300.	300.
1975 BTU/TK	Rail	450.	450.	1200.	1200.	715.	400.	400.
2000 - Same		400.	400.	600.	600.	600.	350.	400.
1975 BTU/TK	Ship	150.	150.	150.	150.	150.	150.	150.
2000 Same		125.	125.	125.	125.	125.	125.	125.

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Agres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

Table 8-14B
Energy Intensity Assumptions for Five Less Developed Areas
1975-2000

		LATIN AMERICA	MIDEAST S.AFRICA	SOUTH ASIA	OTHER AFRICA	P. REP. OF CHINA
		-----	-----	-----	-----	-----
1975 BTU/PK	Automobile	1200.	1600.	1200.	1200.	1200.
2000 - Same		1100.	1200.	1000.	1000.	1000.
1975 BTU/PK	Bus	600.	600.	400.	400.	400.
2000 - Same		600.	600.	400.	400.	400.
1975 BTU/PK	Rail	1000.	1000.	300.	300.	300.
2000 - Same		1000.	1000.	300.	300.	300.
1975 BTU/PK	Air	4000.	4000.	3000.	3000.	3000.
2000 - Same		3000.	3000.	3000.	3000.	3000.
1975 BTU/TK	Truck	7000.	7000.	5000.	5000.	5000.
2000 - Same		4500.	4500.	4500.	4500.	4500.
1975 BTU/TK	Water	1000.	1000.	250.	250.	250.
2000 - Same		800.	800.	250.	250.	250.
1975 BTU/TK	Rail	800.	800.	350.	350.	350.
2000 - Same		700.	700.	300.	300.	300.
1975 BTU/TK	Ship	150.	150.	150.	150.	150.
2000 Same		125.	125.	125.	125.	125.

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Agres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

Table 8-14C
Energy Intensity Assumptions for Nine Basic Areas, One Group
1975-2000

		UNITED STATES	AUSTRAL. +CANADA	E.E.C.	OTHER W.EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	LATIN AMERICA	MIDEAST S.AFRICA	P. REP. OF CHINA
1975 BTU/PK	Automobile	3200.	2800.	1600.	1600.	1400.	1600.	1600.	1200.	1600.	1200.
2000 - Same		1200.	1150.	1000.	1000.	1000.	1000.	1000.	1100.	1200.	1000.
1975 BTU/PK	Bus	1000.	1000.	1000.	1000.	650.	500.	500.	600.	600.	400.
2000 - Same		800.	800.	800.	800.	600.	500.	500.	600.	600.	400.
1975 BTU/PK	Rail	2000.	2000.	2000.	2000.	200.	500.	500.	1000.	1000.	300.
2000 - Same		1500.	1500.	1500.	1500.	300.	500.	500.	1000.	1000.	300.
1975 BTU/PK	Air	4500.	4500.	4000.	4000.	3340.	3500.	3500.	4000.	4000.	3000.
2000 - Same		3000.	3000.	3000.	3000.	3000.	3000.	3000.	3000.	3000.	3000.
1975 BTU/TK	Truck	5000.	6000.	5000.	5500.	6000.	4500.	6000.	7000.	7000.	5000.
2000 - Same		3500.	3500.	3500.	3500.	4000.	4500.	3500.	4500.	4500.	4500.
1975 BTU/TK	Water	340.	340.	1200.	1200.	1600.	400.	400.	1000.	1000.	250.
2000 - Same		300.	300.	1000.	1000.	600.	300.	300.	800.	800.	250.
1975 BTU/TK	Rail	450.	450.	1200.	1200.	715.	400.	400.	800.	800.	350.
2000 - Same		400.	400.	600.	600.	600.	350.	400.	700.	700.	300.
1975 BTU/TK	Ship	150.	150.	150.	150.	150.	150.	150.	150.	150.	150.
2000 Same		125.	125.	125.	125.	125.	125.	125.	125.	125.	125.

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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-15
Projected GDP and Population for Eight World Regions
Ayres' Conservation Case Estimate for the Year 2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
2000 GDP (10**9 1972 Dollars)	2439.	393.	1374.	577.	1320.	402.	1299.	985.	8790.	9845.
2000 Population, 10**6	266.	48.	352.	132.	314.	100.	537.	2898.	4648.	5205.
2000 GDP/capita, (1972 Dollars)	9158.	8254.	3901.	4367.	4202.	4033.	2419.	340.	1891.	1891.
2000 Population, % of world	5.	1.	7.	3.	6.	2.	10.	56.	89.	100.
2000 GDP/capita, ratio to world	4.8	4.4	2.1	2.3	2.2	2.1	1.3	0.2	1.0	1.0
2000 GDP/capita, ratio to U.S.	1.00	0.90	0.43	0.48	0.46	0.44	0.26	0.04	0.21	0.21
1975 Population, % of world	6.	1.	9.	3.	8.	3.	8.	51.	89.	100.
1975 GDP/capita, ratio to world	4.5	3.6	2.4	2.1	1.4	1.9	0.7	0.1	1.0	1.0
1975 GDP/capita, ratio to U.S.	1.00	0.80	0.52	0.45	0.32	0.42	0.16	0.03	0.22	0.22

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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE E-16
Transportation Energy for Eight World Regions: 1975, 1985 and 2000
(10**15 BTU)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total Transportation - 1975	17.2	2.5	9.3	2.5	4.6	1.1	3.8	2.4	43.5	48.7
1985	17.0	2.3	10.5	3.1	8.4	1.7	6.9	4.6	54.9	61.5
2000	17.0	3.2	10.7	3.5	13.3	2.3	14.2	11.3	75.5	84.6
% change, 1975-2000	-1.	30.	15.	40.	189.	107.	269.	362.	74.	74.
Passenger - 1975	11.9	1.5	4.7	0.6	1.0	0.4	0.8	0.7	21.6	24.2
1985	10.5	1.5	5.0	0.6	1.7	0.6	1.6	1.0	22.7	25.4
2000	9.6	1.6	4.6	0.8	4.0	1.0	4.3	1.9	27.9	31.2
% change, 1975-2000	-19.	6.	-1.	40.	302.	147.	421.	184.	29.	29.
Freight - 1975	5.3	0.9	4.6	1.9	3.6	0.7	3.0	1.8	21.9	24.5
1985	6.5	1.2	5.5	2.3	6.7	1.1	5.3	3.6	32.2	36.1
2000	7.4	1.6	6.1	2.7	9.3	1.4	9.9	9.4	47.7	53.4
% change, 1975-2000	41.	69.	31.	40.	158.	85.	227.	428.	118.	118.

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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-17
Share of Passenger & Freight Transportation Energy Use
For Eight World Regions, 1975 and 2000 (Percent)

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
1975 Passenger/Total	69.4	61.7	50.3	24.2	21.5	35.0	21.4	27.1	49.7
2000 Passenger/Total	56.5	50.4	43.2	24.2	30.0	41.8	30.5	16.7	36.9
1975 Freight/Total	30.6	38.3	49.7	75.8	78.5	65.0	78.4	72.9	50.3
2000 Freight/Total	43.5	49.6	56.8	75.8	70.0	58.2	69.5	83.3	63.1

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Ayres' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-19
Transportation Energy (T.E.) Use Relative to Population and GDP for Eight Regions
Ayres' Conservation Case Estimate for the Year 2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	34 COUN- TRIES	WORLD TOTAL
Total T.E. (10**15 BTU)	17.0	3.2	10.7	3.5	13.3	2.3	14.2	11.3	75.5	84.6
BTU/capita, 10**6	64.	68.	30.	27.	42.	23.	26.	4.	16.	16.
BTU/GDP, 10**3	7.0	8.2	7.8	6.1	10.1	5.8	10.9	11.4	8.6	8.6
Passenger T.E. (10**15 BTU)	9.6	1.6	4.6	0.8	4.0	1.0	4.3	1.9	27.9	31.2
BTU/capita, 10**6	36.	34.	13.	6.	13.	10.	8.	1.	6.	6.
BTU/GDP, 10**3	3.9	4.1	3.4	1.5	3.0	2.4	3.3	1.9	3.2	3.2
Freight T.E. (10**15 BTU)	7.4	1.6	6.1	2.7	9.3	1.4	9.9	9.4	47.7	53.4
BTU/capita, 10**6	28.	34.	17.	20.	30.	14.	18.	3.	10.	10.
BTU/GDP, 10**3	3.0	4.1	4.4	4.6	7.0	3.4	7.6	9.5	5.4	5.4

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Ages' Conservation Estimates - May 79. Note GDP, PK/Capita, Passenger Mode Fractions & Energy Intensities. (72 US \$)

TABLE 8-20
Energy Intensity Measures for Eight Regions
1975 and 2000

	UNITED STATES	AUSTRAL. +CANADA	WESTERN EUROPE	JAPAN	SOVIET UNION	EASTERN EUROPE	ADV. DE- VELOPING	OTHER LDC	WORLD TOTAL
BTU/PK Auto - 1975	3200.	2800.	1600.	1400.	1600.	1600.	1257.	1200.	2391.
- 2000	1200.	1150.	1000.	1000.	1000.	1000.	1141.	1000.	1109.
% Increase	-62.	-59.	-38.	-29.	-38.	-38.	-9.	-17.	-54.
BTU/PK Bus - 1975	1000.	1000.	1000.	650.	500.	500.	600.	400.	598.
- 2000	300.	800.	800.	600.	500.	500.	600.	400.	519.
% Increase	-20.	-20.	-20.	-8.	00.	00.	00.	-0.	-13.
BTU/PK Rail - 1975	2000.	2000.	2000.	200.	500.	500.	1000.	300.	611.
- 2000	1500.	1500.	1500.	300.	500.	500.	1000.	300.	512.
% Increase	-25.	-25.	-25.	50.	00.	00.	00.	00.	-16.
BTU/PK Air - 1975	4500.	4500.	4000.	3340.	3500.	3500.	4000.	3000.	4080.
- 2000	3000.	3090.	3000.	3000.	3000.	3000.	3000.	3000.	3000.
% Increase	-33.	-33.	-25.	-10.	-14.	-14.	-25.	-0.	-26.
BTU/ton-km Truck - 1975	5000.	6000.	5122.	6000.	6500.	6000.	7000.	5000.	5651.
- 2000	3500.	3500.	3500.	4000.	4500.	3500.	4500.	4500.	4157.
% Increase	-30.	-42.	-32.	-33.	-31.	-42.	-36.	-10.	-26.
BTU/ton-km Water - 1975	340.	340.	1200.	1600.	400.	400.	1000.	250.	503.
- 2000	300.	300.	1000.	600.	300.	300.	800.	250.	360.
% Increase	-12.	-12.	-17.	-62.	-25.	-25.	-20.	00.	-28.
BTU/ton-km Rail - 1975	450.	450.	1200.	715.	400.	400.	800.	350.	450.
- 2000	400.	400.	600.	600.	350.	400.	700.	300.	387.
% Increase	-11.	-11.	-50.	-16.	-13.	00.	-13.	-14.	-14.
BTU/ton-km Ship - 1975	150.	150.	150.	150.	150.	150.	150.	150.	150.
- 2000	125.	125.	125.	125.	125.	125.	125.	125.	125.
% Increase	-17.	-17.	-17.	-17.	-17.	-17.	-17.	-17.	-17.

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- 493. Fred Westbrook, TERA, Suite 888, 1901 N. Ft. Myer Drive, Arlington, Va. 22209.