U.S. citizens overseas. A travel cost index for travel in Europe was constructed, and the index shows that the cost of traveling in Europe has virtually tripled since 1970. Conversely, travel by Europeans to the United States represents a solid bargain in terms of the air travel and total trip cost. In the future, the increasing cost of American travel to Europe will probably result in an emphasis on strategies that focus on lower cost accommodations, trips of shorter length, and fewer destinations on the same trip.

SUMMARY OF WORKSHOP SESSION 1:
Energy and Jet Fuel Implications

Roderick Heitmeyer, International Civil Aviation Organization, Moderator

I appreciate this opportunity to speak to you today about energy and fuel availability as a factor influencing the demand for air travel to and from North America. What I have to say is based upon the very useful workshop meeting we held on this subject yesterday. We also took advantage of the recent ICAO study on the future availability of aviation fuel. Energy and jet fuel availability is a complex subject with many interrelated aspects. It is a rapidly changing one and unfortunately does not lack a certain measure of uncertainty.

The obvious way in which this factor can negatively affect air travel is if there is insufficient jet fuel to operate the quantity of air services required to satisfy demand and/or if the price of jet fuel is such as to require air fares to be increased in real terms beyond "acceptable" levels.

Another consideration is the effect that future developments in the energy field -- in terms of availability and rising cost -- may be expected to have on rates of economic development and inflation, and in this way also influence the demand for air travel. For example, SRI estimates for the United States that every 10 percent increase in crude oil prices will lead to a .2 percent decline in gross national product and .4 percent increase in the consumer price index.

Demand for Energy

Oil presently provides about 50 percent of energy needs and is the most important single source of world energy. The transport sector accounts for about 40 percent of oil consumption in market economies. Aviation fuel accounts for about 4.5 percent and civil aviation alone for less than 4 percent.

The consumption of oil has tended to increase at a faster rate than the consumption of energy as a whole. However, after the escalation of oil prices in 1973 there was an interruption in this pattern in the market economies, both in the growth of energy and particularly in oil consumption.

As to the future, unconstrained projections of future oil demand anticipate lower growth rates than experienced in the past in both total energy and oil consumption. They also anticipate that oil will account for a declining share of total energy consumption. This is expected to be the result of continued high oil prices and related conservation efforts.

The substitution of other fuels for oil will also become increasingly important. Economic activities vary in their ability to use substitute fuels. The use of oil in the industrial, household and commercial sectors is expected to decline. This should relieve some of the pressure of demand on oil. However, in the transport sector, including aviation in particular, oil is expected to continue to satisfy nearly all energy needs over the next 20 years.

Supply - Oil and Alternative Energy Sources

1) Oil

Since oil based jet fuels will have to supply air transport's fuel needs for many years to come the total oil supply picture is highly relevant.

The potential availability of oil to meet future demand will be determined by the level of proven reserves, additions to reserves, consumption rates and production and distribution capacity.

However, actual availability (production rates and exports) will depend largely on the policies of the producing countries.

Estimates of ultimately recoverable world crude oil reserves range from 1600 to 3000 billion barrels (most center on 2000 b. bbls).

This compares with a total of about 640 billion barrels of recoverable proven crude oil reserves and a present (1978) world consumption rate of 22 billion barrels.

Compared with the total amount of crude oil expected to become available in terms of ultimately recoverable reserves, this corresponds to 70 to 135 years of consumption at the 1978 level, or about 35 - 55 years if consumption were to increase by 3 percent per year.

In other words we are talking about a finite resource. It must be expected that long before total depletion, limitations on the rate of output, high oil prices, and the development and use of alternative energy sources will cause crude oil consumption to level off and then decline.

The timing of this transitional process will largely depend on:

a) The policies of the oil importing countries concerning fuel conservation and the development of new energy sources;
b) The policies of the oil exporting countries concerning output and pricing.

Annual production rates in the OPEC states as a whole have tended to level off during the past few years and some of these states have recently indicated planned reductions in their levels of production. Temporary shortages of oil and aviation fuel are therefore entirely possible.

Our oil industry participant stressed that a lot will depend -- in the very short term at least -- on Saudi Arabia's level of production in particular, as to whether there can or cannot be growth in oil use by aviation this year.

Allocations of scarce supplies of aviation fuel may again be necessary in the short term.

2) Alternative Energy Resources

A great deal of attention is now being focused on the development and use of alternative energy sources. The world's resources of fossil fuels are extensive and additional reserves of other energy sources (particularly radioactive and geothermal) are available. The longer term prospects are therefore encouraging.

There are also encouraging longer term prospects for the production of significant volumes of synthetic fuels (including aviation fuels) from coal, heavy oil, shale, and tar sands. The attractiveness of such projects increases with the rising price of crude oil and much of the basic

technology already exists. However, it will take some time before synthetic fuels can make a major contribution to world energy needs. The investments involved are large; there are environmental considerations; and there are long time lags before commercial production can commence. Rapid expansion of the production of synthetic crude oil and fuels is therefore not considered likely until the 1990s. Several members of the workshop thought that the whole process might be speeded up considerably if it were given all the priority of a "Manhattan Project."

Aviation Fuel Supply

When it comes to the supply of aviation fuel there are some special additional aspects to consider.

Its availability depends not only on the availability of crude oil but also on the competition aviation faces from other petroleum fuels in the same distillation range and on the refineries' ability to produce the required amount from the crude available.

Most commercial airlines use kerosene jet fuel - which accounts for about 85 percent of the jet fuel total. The remainder consists of wide cut jet fuels (JP-4).

More kerosene could be produced from the average barrel of crude but only at the expense of gasoline and/or fuel oil. The maximum proportion of kerosene that could be produced is in the order of up to 10 percent to 14 percent or 15 percent. This compares with an average of about 6 percent at present (for aviation and other kerosene users). This technical possibility for expansion sounds encouraging, but it would mean that proportionately less of other products could be produced. A significant increase in the kerosene cut may not be commercially feasible in the short-term at least.

Two short-term measures that have been suggested to ease jet fuel supply problems are:

1) A broadening of certain kerosene jet fuel specifications.
2) Greater use of the alternative jet fuel, wide cut JP-4.
   (Kerosene jet fuel and JP-4 can be mixed in the same aircraft.)

Airline Fuel Requirements

A positive factor concerning the availability of aviation fuel for airline operation is the continuing trend toward increased efficiency in the use of fuel.

In the past, fuel efficiency has improved as the result of:

1) Increased engine efficiency
2) Increased aircraft size
3) Operational measures.

In the United States, fuel consumed per available ton kilometer (ATK) decreased by 30 percent from 1962 to 1977.

The contributions to savings in fuel consumption per ATK from a changing aircraft fleet composition and technological and operational improvements according to ICAO estimates are likely to approach 20 percent over the 1978 to 1990 period. A similar worldwide improvement in fuel efficiency appears to be possible during the 1990s. Boeing estimates 20 percent improvement in fuel efficiency in air services within North America to 1990.

Taking these assumed improvmeents in efficiency into account, if capacity operated increases between 6 percent and 10 percent per annum from 1978 to 1990, aviation fuel requirements would then increase by a factor of from 1.6 to 2.5 by 1990.

During the 1990s aviation fuel requirements will probably grow at a slower rate (assuming slower prospective traffic growth and further improvements in fuel efficiency).

Provided aviation fuel prices do not increase drastically in real terms, this means that the global demand for aviation fuel may be expected to grow considerably by the year 2000 to between 2 and 4 times the present level of consumption.

Price Trends

The historical development of crude oil prices since 1973 is quite well known including the most recent OPEC price increases. With supply and pricing expected to be decided by the oil exporting countries and with the demand for oil in the importing countries being relatively inflexible in the short-term, the price of oil may continue to vary substantially. The long-term is uncertain but may be one of slowly increasing prices in real terms. For example, SRI thought that a $42 OPEC base price per barrel by 1985 probable.

Similar trends and fluctuations may also occur in the price of jet fuel. The relative proportion of the jet fuel price accounted for by transportation, refining, and distribution might increase in the future, because:

1) Refining costs for aviation fuel might change depending on the types of crude oil available and because of possible changes in aviation fuel specifications.
2) If the transport sector accounts for an increasing share of total demand for oil products there may be changes in price relationships between aviation fuel and other products depending on developments in demand.

Fuel costs now account for a much higher percentage of airline costs than they did in the past. The figure for U.S. carriers is now 30 percent of operating costs. This means that the impact on total airline costs of any large increases in fuel prices in real terms would be greater than the impact of similar increases in the past. The consequential effects on air fares would therefore also be greater. Fare increases in the United States during the past year (generated by fuel price increases) have been around 30 percent.

The Air Transport Association (ATA) estimates the U.S. carrier fuel bill at $4 billion 1978, $6 billion 1979, and $9 billion 1980. ATA quotes a present fuel price in the United States of around 91¢ per gallon. In Europe it is around $1.08 to $1.18 and Boeing anticipates an international price of $2.00 per gallon by 1985.

Workshop Conclusions

1) World energy demand is expected to increase less rapidly than in the past, due to effects of price, conservation, greater efficiency in the use of energy, and slower rates of economic growth.
2) Within total energy demand, use of oil is expected to level off and then decline slowly from its present 50 percent share.

a) There will be an increase in the use of alternative energy sources (coal, hydroelectricity, nuclear, solar, etc.)
b) There will be an increase in the development of synthetic fuels. Dollar share may be expected to be small initially, becoming more significant after 1985 and particularly 1990.
c) It will probably be several years, however, before some of these shifts to alternative and new energy sources can be sufficiently significant to relieve the pressure of demand for oil.

3) The supply situation for aviation fuel in the short-term will most likely remain tight. It may be eased by:

a) Continued changes in the fleet mix.
b) Operational measures.
c) Possible changes in jet fuel specifications.
d) Greater use of JP-4 wide cut jet fuel where possible.
e) Further rationalization of route structures, frequencies, and charter operations.
f) Low rates of growth in market economies.

4) The possibility of a serious situation developing in the Middle East affecting oil and jet fuel supply should not be overlooked.

5) If traffic growth is not excessive (say below 10 percent) - particularly over the medium to longer term - sufficient fuel may be expected to be available under normal circumstances given the factors cited above.

6) The price of aviation fuel is high and may be expected to show a long-term upward trend in real terms. Because fuel costs now represent a much larger share of total airline costs, fare levels will be more sensitive to further increases, particularly any large increases in real terms.

7) Fuel "pass-through" arrangements may extend to the international sector in the near future. Increases in fares may, however, be less than the percent increase in fuel price due partly to improved fuel efficiency.

8) To end on a positive note, in the longer term anticipated developments in the total energy picture and in civil aviation should permit continued growth of air transport at least in the moderate 6 percent to 9 percent range.

9) Possibilities for further research were identified:

a) There is a need to develop fuel specifications for synthetic commercial aviation fuel. Some undustry groups (manufacturers, airlines, oil companies, and governments) are already examining fuel specifications for conventional (non-synthetic) aviation fuels.
b) Research is needed on what energy policies are necessary to produce synthetic fuels. A guaranteed price level would be required to make synthetic fuel facilities economically viable.

Table 1. Comparison of world energy as a whole and oil* consumption, 1965-1978. (Totals expressed in million barrels per day of oil equivalent.)

Year	Market Economies		Centrally Planned Economies		World Total	
	Energy	Oil	Energy	Oil	Energy	Oil
1965	57	27	22	4	79	31
1970	76	40	28	7	104	47
1971	78	42	30	7	108	49
1972	82	45	30	8	112	53
1973	86	48	32	9	118	57
1974	85	46	33	10	118	56
1975	83	45	35	10	118	55
1976	88	48	37	11	125	59
1977	90	49	39	12	129	61
1978	93	51	41	12	134	63

In accordance with United Nations Terminology, countries of the world are divided into these two groups: Centrally Planned Economies includes socialist States in Asia and Eastern Europe.
*Note that about 10 percent of oil consumption is for non-energy purposes.
Source: BP Statistical Review of the World Oil Industry, British Petroleum Co. Ltd., 1975 and 1978 editions.

Table 2. Trend in crude oil prices, based on a market price index* developed by the Organization for Economic Cooperation and Development (OECD), 1961-1974.

Year	Estimated Market Price	Real Estimated Market Price
1961	104	104
1962	101	102
1963	100	100
1964	95	93
1965	95	92
1966	95	90
1967	95	90
1968	93	89
1969	91	83
1970	90	78
1971	95	79
1972	125	96
1973	206	137
1974	546	325

*1963=100. Real Estimated Market Price is deflated by export prices of industrialized countries expressed in U.S. dollars.
Source: Energy Prospects to 1985, OECD, 1974.

Table 3. Average fuel expenses and total operating expenses per available tonne-kilometre for world's scheduled airlines. (Figures expressed in U.S. cents.)

Year	Fuel and Oil Expenses	Total Operating Expenses	Fuel and Oil as Percent of Total
1961	2.8	21.4	13.1
1962	2.6	20.2	12.9
1963	2.5	19.3	13.0
1964	2.28	18.3	12.5
1965	2.12	17.5	12.1
1966	2.06	17.1	12.0
1967	1.99	16.2	12.3
1968	1.88	15.6	12.1
1969	1.88	15.4	12.2
1970	1.82	16.2	11.2
1971	1.83	16.5	11.1
1972	1.94	17.6	11.0
1973	2.25	18.9	11.9
1974	4.34	22.7	19.1
1975	4.83	24.9	19.4
1976	4.85	25.2	19.2
1977	5.28	27.5	19.2

Source: Airline financial data reported to ICAO

Note: Tables selected from an ICAO publication, Aviation Fuel: Prospects to the Year 2000, cited in the ICAO Bulletin, December 1979.

SELECTED CHARTS ON ENERGY AND JET FUEL AVAILABILITY AND PRICE

John B. Brackbill, Boeing Commercial Airplane Company

Introduction

Kerosene jet fuel availability and price are two major problem areas of concern to air carriers through the 1980s. Availability and price are functions of many variables: world oil supply and consumption, conservation and efficiencies in all consuming sectors, substitution of other forms of energy for petroleum, technical efficiency of aircraft, introduction of new equipment during the 1980s, traffic trends, and utilization of equipment. (Figures 1 and 2)

These factors are integrated here to obtain estimates of kerosene jet fuel consumption and price during the 1980s for air carriers in the intra-North America and overseas-to and from-North America markets. (North America, as used here, includes Canada and the United States.) (Figure 3)

Allocation priorities were not considered as a factor in this discussion.

Aircraft Turbine Efficiency

Turbine efficiencies returned to the range of the compound piston engine and turboprop with the introduction of the turbofan engine. Potential engine efficiency gains are possible if higher pressure ratios can be attained. The major engine manufacturers are initiating programs to improve component efficiencies by 15 to 20 percent compared with current engines. (Figure 4)

Potential Technology Improvements in Air Transportation Fuel Efficiency

The U.S. commercial air transportation system is a complex blend of ground and air systems. The technology areas showing promise for improving the fuel efficiency of the system are shown in Figure 5. The airplane itself will benefit from advanced aerodynamic and structural technology; the propulsion system from new and advanced engines. Flight operations will benefit through improved air traffic control, four-dimensional navigation systems, and automatic flight management of the airplane and engines.

These technology applications will take many years to develop and to emplace in the air transportation system. These gains may not all be additive, and a realistic appraisal indicates a potential fleet fuel saving (less than a single new aircraft saving) of 15 percent due to technical advances will be incorporated in the system by 1990, as compared to a 1979 baseline. Further technical improvements are likely to be introduced around year 2000. Airline equipment currently has a useful life of about 20 years, and new technology therefore requires many years for full utilization in the system.

Airline Fleet Mix

Standard-body aircraft make up about 80 percent of the domestic trunk airline fleet today. (Since trunk airline fuel consumption is about 87 percent of total domestic airline fuel consumption, the trunk fleet conposition is representative of the domestic fleet.) The standard body share will drop to about 47 percent by 1985 and 25 percent by 1990. The new airline programs will comprise 24 percent of the fleet by 1985 and about 50 percent by 1990. (Figure 6)

The fleet mix serving the overseas-to-North America market is now heavily weighted with wide body and more fuel-efficient aircraft. Also, since the route segments are longer on overseas routes compared to domestic routes, international operators can attain greater fuel efficiencies with the existing standard body and wide body equipment. Aircraft developed in the new airplane programs will replace standard body aircraft used in shorter overseas routes.

Revenue Passenger-Mile Estimate

Revenue passenger-miles (RPMs) are projected for the domestic North American service and the overseas-to-North America market. The potential and conservative estimates on a world-wide and U.S. carriers-only basis are also shown for comparison. (Figure 7)

Load Factor Estimate

Load factors in the intra-North America area will probably rise to about .64 by 1990. Time-of-day, day-of-week, and seasonality effects will prevent attaining load factors much above this. (Figure 8)

Load factors in the overseas-to-North America market will probably rise to about .65 by 1990 as operators attempt to offset higher fuel costs.

Available Seat Miles and Type of Aircraft

As the new and larger aircraft are introduced into the fleet, and older aircraft retired, the proportion of available seat-miles provided by the more