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National Defense Aspects of Energy Imports

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ABSTRACT

The United States is now importing 46.6 percent of its petroleum. This 46.6 percent amounts to over 7,000,000 barrels per day. This paper discusses the adverse effects of these oil imports primarily from an Antisubmarine Warfare (ASW) point of view. In the event of an oil embargo and/or an attack by enemy submarines, there are serious questions as to the U.S. ability to support NATO, or even to sustain an efficient economy.

1. INTRODUCTION

Figure 1 illustrates the approximate current energy usage in the U.S. It is based on References 1, 2 and 3. The U.S. is now importing 46.6 percent of its oil. This corresponds to over seven (7) million barrels per day. Petroleum supplies about 46 percent of the total energy consumed in the U.S. and essentially all of the energy consumed in the transportation sector.

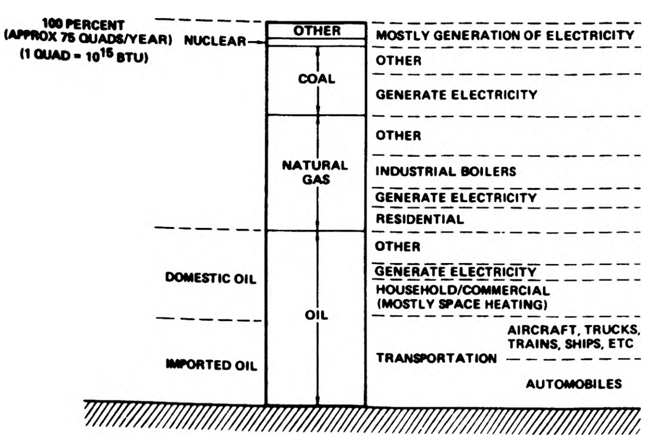


FIGURE 1
ENERGY USAGE IN THE U.S.

If all other uses of petroleum were held constant and if the U.S. could eliminate all use of petroleum in automobiles, it would still be necessary to import petroleum in order to keep our economy functioning. This is a far different situation than existed in World War II when the U.S. was able to permit all essential uses of petroleum, including a degree of automobile usage, fuel the war machine and still export petroleum to its allies.

The primary purpose of this paper is to call attention to the adverse aspects of being dependent on importing roughly 7 million barrels of petroleum per day. In particular, a major oil tanker fleet is required to maintain this flow of oil and the oil tanker fleet could be vulnerable to the Soviet submarine force.

2. ENERGY USAGE IN THE U.S.

There is some variation between references, but the energy requirements of the United States are being met approximately as follows based on Reference 1:

Source	Percent
Coal	18
Crude Oil	46
Natural Gas	30
Nuclear	2
Other (Hydroelectric, etc.)	4
	100

Our supplies of coal are adequate for at least a hundred years, but we are already importing 46.6 percent of the petroleum. Natural gas is in short supply in many areas. Clearly, the law of supply and demand will soon operate to force changes in the uses of energy. In the meantime, the United States is becoming increasingly vulnerable to a possible oil embargo and/or to submarine warfare. The political question is "Do we Americans really want to do something about our energy problems?" We must approach this question with full realization that there are no easy solutions. In particular, we must be prepared to support political figures who will take significant (and probably unpopular) actions to conserve petroleum and natural gas.

In part, Figure 1 shows that about 46.6 percent of our petroleum is being imported and that roughly half of the petroleum is being burned in transportation related areas. If we set the transportation sector aside as a special requirement, natural gas then becomes the largest single source of energy. However, the primary point to be noted in Figure 1 is that only 18 percent of our energy is being produced from coal--the most available U.S. source. The scarce fuels, crude oil and natural gas, accounted for 76 percent. Thus, it is clear that our National policy should call for the use of coal to a much greater extent than has been true in the recent past.

The transportation sector deserves special attention. This is a big country. It needs transportation because various essential functions are specialized in different parts of the country. For example, wheat is grown largely in the Midwest, but it is consumed over the whole country. Specialization requires transportation and transportation requires petroleum products. At the present time, petroleum supplies essentially all of the energy used in transportation.

3. ENERGY RESOURCES OF THE UNITED STATES

The literature now contains many estimates of energy reserves, years of supply at projected usage rates, projections of gains in petroleum recovery technology, etc. Naturally there are significant differences in these estimates, but that is to be expected in analyses in which human judgement and assumptions must be employed. Figure 2 is taken from Reference 3 and it provides a good perspective as to the available energy from recoverable domestic energy resources. Note that the amount of energy is denoted by area. If we think in terms of planning for this country's energy supplies over the next hundred years, our attention is naturally turned to the "breeder" reactor, coal and possibly to oil shale. Oil shale is of special interest for the transportation sector since it yields a product similar to petroleum.

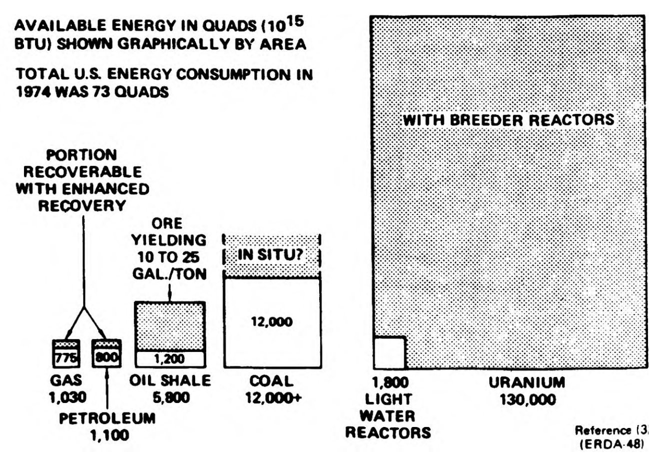


FIGURE 2
AVAILABLE ENERGY FROM RECOVERABLE DOMESTIC ENERGY RESOURCES

Figure 3 is an attempt to put the "inexhaustible" energy sources in perspective. In this context, solar energy stands out from all the others. However, in order to keep solar energy in perspective, it is instructive to calculate the surface area required to support a 1,000 megawatt electric plant which would meet the electrical energy requirements of about 1,000,000 people. Over a 24 hour day, 1,000 megawatts correspond to 24,000 megawatt-hours which further corresponds to 81.9×10^9 British Thermal Units (BTU):

$$(24{,}000)(10^6) \text{ watt-hours} = (24.0 \times 10^9 \text{ watt-hours})\ (3.413\ \frac{\text{BTU}}{\text{watt-hour}}) = 81.9 \times 10^9 \text{ BTU}$$

ETERNAL POWER SOURCE	APPROXIMATE POWER POTENTIAL [FRACTION (OR MULTIPLE) OF WORLD REQUIREMENTS]
HYDROELECTRIC	1/20
TIDAL	1/100
WIND	100
SOLAR	30,000
GEOTHERMAL	
• TAPPABLE HEAT FLOW	1/100
• TOTAL ENERGY BANK	100,000

FIGURE 3
ALTERNATE ENERGY SOURCES

St. Louis receives about 1,000 BTU/FT^2 of solar energy on a horizontal surface on an average day in March. If one assumes a highly optimistic overall conversion efficiency of 10 percent from the solar energy received to the electrical output of the plant, there is a surface area requirement of about 29.4 sq. miles:

$$\frac{81.9 \times 10^9 \text{ BTU}}{(0.10)(1{,}000)} = 81.9 \times 10^7 \text{ SQ. FT.}$$

$$= (81.9 \times 10^7)\ (2.296 \times 10^{-5}) = 18{,}804 \text{ ACRES}$$

$$= (18.804 \times 10^3)\ (1.562 \times 10^{-3}) = 29.4 \text{ SQ. MILES}$$

If all of this energy were collected and focused by mirrors 10 feet by 10 feet, there would be over 8,000,000 mirrors!

When it is appreciated that electricity represents only about 26 percent of our present energy consumption, it becomes apparent that very large areas would be required to collect enough solar energy to meet our total energy requirements. This remark is not intended to detract from the potential applications of solar energy, but it helps to put our total energy requirements in perspective. It is believed that solar energy will find its initial commercial applications in space heating and in domestic water heating.

When solar energy is considered for space heating and domestic water heating applications, it is possible to think of efficiencies as high as 50 percent. In round numbers, the St. Louis area receives about 500 BTU per square foot on an average day in December and January. In October and March, the average is about 1,000 BTU per square foot. While average values must be used with caution, it is interesting to estimate the monetary value of the energy collected during a heating season of six months at an average value of 750 BTU per day per square foot.

At an efficiency of 50 percent, each square foot of horizontal collector area will have contributed about 67,500 BTU during a heating season:

$$(750\ \frac{\text{BTU}}{\text{DAY}}) \cdot (180 \text{ DAYS}) \cdot (0.50) = 67{,}500 \text{ BTU}$$

This 67,500 BTU is equivalent to 19.78 Kilowatt-Hours (KWH):

$$(67{,}500 \text{ BTU}) \cdot (2.930 \times 10^{-4}\ \frac{\text{KWH}}{\text{BTU}}) = 19.78 \text{ KWH}$$

At 5 cents per KWH, the 19.78 KWH would be worth $0.99:

$$(19.78 \text{ KWH}) \cdot (0.05\ \frac{\text{DOLLARS}}{\text{KWH}}) = \$0.99$$

In passing, it is noted that most utilities now supply electrical energy for less than 5 cents per KWH from both coal fired and nuclear power plans. Since the U.S. has adequate coal to operate coal fired electric plants for many years, it is reasonable to consider electric space heating - either directly through resistance elements or indirectly through heat pumps. In this context, the cost of electrical energy can be used as a standard of reference for the evaluation of competitive space heating systems such as solar collectors.

If the installed solar collector system involved a total investment of $10.00 per square foot, the interest at seven percent would be $0.70 per year per square foot. Based on the above estimates and after meeting the interest payment, there is only $0.99 - 0.70 = $0.29 left (per year per sq. ft.) to amortize the investment and maintain the solar space heating system. The essential aspects of the above estimates are summarized in Figure 4.

- **SIX MONTHS AT AN AVERAGE OF 750 Btu PER DAY:**

  $$(180 \text{ DAYS}) \cdot (750 \frac{\text{Btu}}{\text{DAY}}) = 135{,}000 \text{ Btu}$$

- **EFFICIENCY = 50 PERCENT FOR SPACE HEATING:**

  $$(135{,}000)\,(0.50) = 67{,}500 \text{ Btu}$$

- **CONVERT TO KILOWATT-HOURS (KWH):**

  $$(67{,}400 \text{ Btu}) \cdot (2{,}930 \times 10^{-4} \frac{\text{KWH}}{\text{Btu}}) = 19.78 \text{ KWH}$$

- **VALUE AT 5 CENTS PER KWH:**

  $$(19.78 \text{ KWH}) \cdot (0.05 \frac{\text{DOLLARS}}{\text{KWH}}) = \$0.99$$

SAY THAT INSTALLED COST IS $10.00 PER SQ FT

- **INTEREST ON TEN DOLLARS AT 7 PERCENT:**

  $$(10.00 \text{ DOLLARS}) \cdot (0.07) = \$0.70$$

FIGURE 4
APPROXIMATE VALUE OF SOLAR ENERGY PER SQUARE FOOT OF COLLECTOR AREA

Of course, the above estimates constitute a rather superficial analysis of the fundamental aspects of solar energy systems. However, for the purpose of this paper, it is apparent that solar energy is not a panacea for the present need to import over 7,000,000 barrels of petroleum per day. In the first place, very large areas are required to collect the amount of solar energy needed for many industrial applications. In the second place, solar energy is not easily converted for use in the transportation sector.

4. PROJECTED VOLUME OF OIL IMPORTS

The National Energy Plan (NEP), Reference 4, envisions that oil imports in 1985 can be reduced from a potential level of 16 million barrels per day to 6 million if the entire NEP is implemented. However, several studies have indicated that there is little chance that the NEP would limit oil imports to 6 million barrels per day. For example, Roger F. Naill and George A. Backus of Dartmouth College recently reported on the results obtained from a comprehensive energy model developed for the Energy Research and Development Administration (ERDA). See Reference (5). In part, Naill and Backus predict that the NEP will fall short of attaining its most important goal of restricting oil imports. That is, their model predicts that oil imports will rise to 13 million barrels per day by 1985 with the NEP instead of dropping to 6 million barrels per day.

Based on the above, it seems almost certain that the level of oil imports will remain at least as high as 7 million barrels per day for the immediate future. In any event, the following discussion of oil tanker requirements is based on an import level of 7 million barrels per day. It will be shown that this level of imports results in an undesirable exposure to Antisubmarine Warfare (ASW).

5. ANTISUBMARINE WARFARE (ASW)

The current import rate of 7 million barrels per day corresponds to roughly

1,100,000 long tons per day. If we assume that an average oil tanker brings in 50,000 tons, there is a requirement for 21 such tankers to make port each day. (In this connection, there are only a few of the super tankers hauling oil to the U.S.) If the "average" tankers were sailed in 42 ship convoys, there would be a convoy arrival every other day. Those familiar with ASW will appreciate the magnitude of the ASW resources required to protect the U.S. petroleum imports. At the present time, something over 25 percent of our oil imports come from the Middle East and the percentage is increasing. Other major suppliers are Venezuela, Nigeria and Algeria. All of these imports require an ocean passage. The route from the Middle East involves a very long voyage around the Cape of Good Hope and would require many escort ships, convoys at sea, etc.

As a related subject, the Alaskan pipeline will supply a maximum of 2,000,000 barrels per day when the pipeline is fully operational in 1980. The Alaskan crude oil must then be moved by tanker from the port of Valdez. Thus, the Alaskan pipeline will not alleviate the necessity for importing oil from foreign sources and the threat of submarine warfare will remain.

The oil supply for the NATO countries involves still other factors which would increase the ASW burden. Western Europe now imports over 13 million barrels per day - much of it from the Middle East via the Cape of Good Hope.

Even if we, in the U.S., do not consider the wartime aspects of being dependent on oil from overseas, we must pay for imported petroleum. In 1976, the U.S. imported approximately 34 billion dollars worth of foreign petroleum. As a standard of reference, this is equivalent to 3,400,000 jobs at $10,000 per year. It is also larger than the U.S. earnings from the sale of farm products.

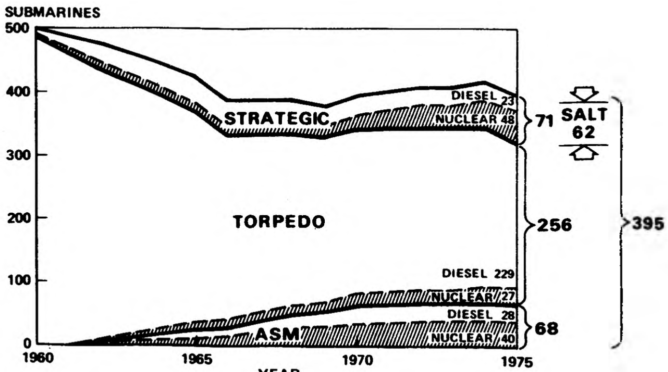
There is no simple way to illustrate the potential threat posed by the Soviet submarine force. However, a degree of perspective can be gained from a study of Figures 5, 6 and 7. The necessity for handling an inbound 42 ship convoy every other day approaches the level of shipping handled in World War II.

- CURRENT IMPORTS .... 7,000,000 BARRELS/DAY
1,100,000 L. TONS/DAY
- AVERAGE TANKER .... 50,000 TONS (CARGO)
21 TANKERS/DAY
- 42 SHIP CONVOY EVERY OTHER DAY
- GERMANY STARTED WW II WITH 55 SUBMARINES
- SOVIET UNION HAS 330 ATTACK SUBMARINES
- OIL IMPORT ROUTES NOW MUCH LONGER THAN THAN WW II CONVOY ROUTES TO EUROPE

FIGURE 5
VULNERABILITY OF OIL IMPORTS

	WORLD WAR II	PRESENT TIME
PROPULSION	DIESEL-ELECTRIC	MANY NUCLEAR
WEAPONS	TORPEDOES	TORPEDOES PLUS MISSILES
SUBMERGED ENDURANCE	50 HOURS	NUCLEAR ALMOST UNLIMITED
WEAPON RANGE	THOUSANDS OF YARDS	MISSILES HUNDREDS OF MILES
TARGET DETECTION	FEW MILES	HUNDREDS OF MILES
SUBMERGED SPEEDS	10 KTS FOR FEW HOURS	20 - 30+ KTS FOR NUCLEAR
SUBMARINE DETECTION STILL BASED ON UNDERWATER SOUND		

FIGURE 6
SUBMARINE CHANGES



Source: Janes Fighting Ships 1974/75

Note: Janes Does not Explain Their Difference Between 71 Strategic and Salt Limit of 62

FIGURE 7
SUBMARINES OF THE USSR
1974/75 TOTAL

The changes in submarine technology since World War II are summarized in Figure 6. While progress has been made in Antisubmarine Warfare (ASW), it is probable that changing technology has tended to favor the submarine. Figure 7 shows the evolution of the submarine force of the USSR. It is many times larger than the submarine force with which Germany started World War II.

Submarines are not the only threat to the shipping of the non-communist countries. Figure 8 is an unclassified representation of the threat to ships at sea. It should be noted that the relatively new Anti-Shipping Missiles (ASM) have provided submarines, surface ships, and aircraft with a long range stand-off capability which did not exist in World War II.

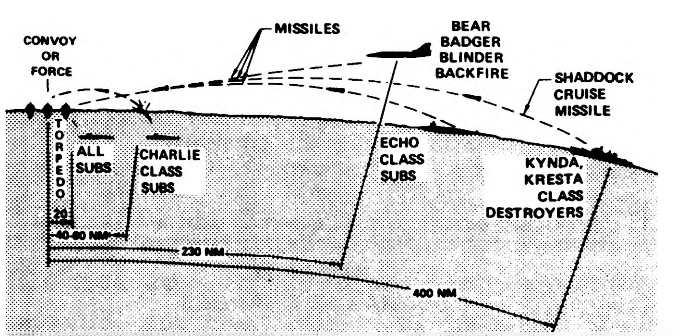


FIGURE 8
THE THREAT

Figure 9 presents the same type of data as Figure 8, but also emphasizes that the world is round. It should be noted that Airborne Early Warning (AEW) services are now an essential part of ASW and general defense of shipping. If AEW services are not provided, surface vessels (including oil tankers) will have no warning of inbound ASMs until the missiles come over the surface vessel's radar horizon at a nominal 12 n. miles. Even a subsonic missile (10 nm/min at sea level) would impact 1.2 minutes after it came over the radar horizon. In part, the ASM threat is responsible for the current Navy interest in an AEW version of a Vertical and Short Takeoff and Landing (V/STOL) aircraft which could provide AEW services from ships other than aircraft carriers. Such an AEW version of a V/STOL aircraft would provide more adequate warning and defense against enemy ASMs. Unfortunately, such a V/STOL aircraft will not reach operational status until the 1990's.

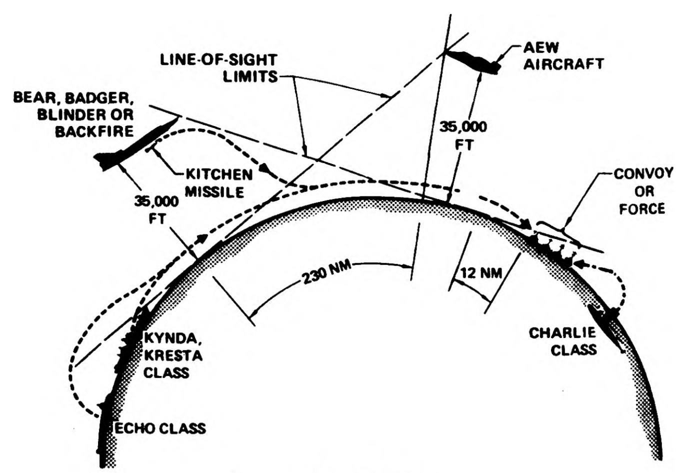


FIGURE 9
THE WORLD IS ROUND

In summary, the continuing need to import 7,000,000 barrels of petroleum per day raises serious doubts as to our ability to support our NATO allies. There is also serious doubt as to whether our economy would function efficiently if the imported oil were cut off by either embargo or submarine warfare.

6. CONCLUSIONS

1. The U.S. is faced with the necessity to import at least 7,000,000 barrels of petroleum per day for the immediate future.
2. The current Soviet submarine force could pose a severe threat to both the U.S. and NATO.
3. Drastic actions beyond those contemplated in the current National Energy Plan (NEP) will be needed to reduce the U.S. dependence on imported oil.

7. REFERENCES

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8. BIOGRAPHY

Mr. Weatherup is a graduate of the U.S. Naval Academy (B.S.), the U.S. Naval Postgraduate School (BSAE) and the California Institute of Technology (MSAE). His operational career included both ship and squadron command. Decorations included two Distinguished Flying Crosses, four Air Medals and a Purple Heart. Duty ashore included the Office of Naval Research and the Naval Air Systems Command. Since retirement from the Navy, Mr. Weatherup has been employed by the McDonnell Douglas Corp. in the area of Operations Analysis. His work in energy related areas has been an avocation.