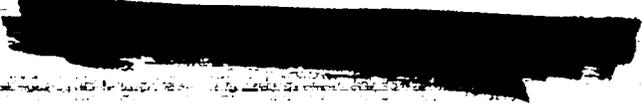


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Strategic Trends and Critical Choices



Los Alamos Los Alamos National Laboratory
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Strategic Trends and Critical Choices

Donald M. Kerr
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LOS ALAMOS NATIONAL LABORATORY



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CONTENTS

STRATEGIC TRENDS AND CRITICAL CHOICES

	<u>Page</u>
INTRODUCTION	1
DEFENSE TRENDS AND TECHNOLOGY	10
INTERNATIONAL STRATEGIC TRENDS AND PROJECTIONS	10
Geopolitics	10
Military Trends	27
Ideology and Religions	54
UNITED STATES STRATEGIC POLICY	58
Evolution of United States Strategy	59
The Current Situation	60
New Directions	66
DEFENSE TECHNOLOGY REQUIREMENTS	69
Strategic Nuclear Forces	69
Theater Warfare	72
ENERGY TRENDS AND TECHNOLOGY	74
INTERNATIONAL ENERGY TRENDS AND PROJECTIONS	74
Past Trends	74
International Projections	88
United States Projections	102
International Energy Agency Policy Response	113

UNITED STATES ENERGY POLICY ISSUES	116
Domestic Oil Supply and Conservation	116
Energy Technology Research, Development, and Demonstration Priorities	119
Economic and Regulatory Policies	119
Environmental Constraints on Energy Development	120
Strategic Materials	120
International Strategies	120
ENERGY RESEARCH REQUIREMENTS	122
Domestic Research and Development	122
CONCLUSION	127

INTRODUCTION: OUR BIPOLAR OR MULTIPOLAR FUTURE

The role of technology in creating conditions for change in the international system and for developing means to cope with changing military, political, and resource conditions is the special concern of the Los Alamos National Laboratory. The discovery and development of nuclear weapons technology by two nations with very large resource and economic bases contributed to the formation of the bipolar world that emerged after World War II. Development of new types of weapons could lead to qualitative military superiority for one side and so make possible a world imperium. Conversely, the proliferation of nuclear weapons, the diffusion of world power, or the manipulation of vital industrial resources by resource-rich developing countries could contribute to a more decentralized world order. In those circumstances the United States would require new energy and materials technologies very soon, and new means for projecting American power into areas important to the national interest.

These examples are indicative of the kinds of strategic defense and energy security issues facing the United States in the 1980s. Before we go into an analysis of trends and projections that affect American security capabilities and requirements, we will take a few moments to examine the kind of world we are entering.

The world, as viewed from the United States, is in a period of rapid and fundamental change. This perception of change, prevalent in American writings about foreign policy since at least the early 1970s, was expressed concisely by former Defense and Energy Secretary James Schlesinger in September 1980. He said, "Though the outlines for the future remain dim, we are in a period of international transition. The old order changeth, yielding place to the new."* The features of the old order (i.e. the post-World-War-II world) are thought to be well known, but opinions differ significantly about what sort of "new order" will or should take its place.

Under the old order the world was dominated by the two post-World-War-II superpowers, the United States and the Soviet Union. Of these two powers, only the United States was a truly global force, able if often unwilling to assert its will anywhere in the world except on the immediate periphery of the Soviet Union. United States post war policy aimed explicitly at the containment of the Soviet Union, leaving the rest of the world to live more or less contentedly behind the American shield. In the early 1960s, influenced by a number of changes not the least of which was the growing prospect of a mutually devastating nuclear war with the Soviet Union, the United States endorsed the Soviet call for "peaceful coexistence" (although perhaps not

*James R. Schlesinger, "Third World Conflict and International Security in the 1980s," Survival, November/December 1980, p. 274.

understanding it precisely as its originators meant it). Further, the United States decided to allow the Soviet Union to achieve strategic military parity. Because of the equal dangers that would prevail under parity, it was hoped that the two superpowers would find ways to settle their differences peacefully, curtail their building of nuclear weapons, and moderate the competition where their interests conflicted.

By the early 1970s, as Soviet strategic military power approached that of the United States and America's disenchantment with its world-wide role increased, the United States strove even harder to end the head-to-head competition with the Soviet Union. Detente and arms control were designed to regulate and eventually reduce East-West tension, so that American policy could address problems associated with the new international order that was thought to be replacing the old "bipolar" world. As Secretary of State Kissinger said in September 1974, "A new international system was emerging. America's historic opportunity was to help shape a new set of international relationships--more pluralistic, less dominated by military power, less susceptible to confrontation, more open to genuine cooperation among the free and diverse elements of the globe."* The relaxation of tensions between the United States and the Soviet Union was for Kissinger the prerequisite to America's dealing with the problems of the new order.

Other American foreign policy thinkers, however, believed that the "balance of power approach to world affairs" which they believed was still at the root of the Nixon-Kissinger foreign policy was irrelevant to the world of the 1970s. For them, grappling with the new order was the most pressing requirement, while the East-West problem was already fading. As the future national security adviser, Zbigniew Brzezinski, wrote in 1973, "How to deal with the Communist world remains a key problem for US foreign policy, but it may no longer represent the central problem." Probably more important, he thought, was

the problem of the less-developed countries [which] is the moral problem of our time Access to literacy, circulation of newspapers, the impact of mass communications, increased political participation are more rapidly transforming the way people think than economic growth is transforming the way people live. The consequence is a heightened awareness of global inequality and an increased determination to erase it. Intensified social strife and global animosity are bound to be the consequence of mankind's failure to tackle the problem of global inequality.

*Henry Kissinger, "Detente with the Soviet Union: The Reality of Competition and the Imperative of Cooperation, "U.S. Department of State Bulletin, October 14, 1974, p. 508.

As a result, "the next two or three decades . . . will witness an intensified crisis in the Third World." To deal with the new international order Brzezinski suggested that the United States should seek "reconciliation with the Communist elites," and "active promotion of trilateral [i.e. American, Western European, and Japanese] cooperation," in order to address "the backwardness and poverty in the Third World."*

The line of thought represented by Brzezinski's article and pursued as policy by President Carter** in the first years of his administration received several shocks from world events during the 1970s. The first was the oil embargo of 1973 and the manipulations thereafter of the world oil supply for political purposes by the OPEC cartel. This demonstrated a significant vulnerability in the economies of the industrialized democracies, and created tension and distrust between them and this increasingly militant portion of the Third World. The North-South relationship seemed headed for competition rather than cooperation. A second shock was administered by the deployment of Soviet "proxy" forces (mostly Cubans) in Africa, both in Angola's revolution, and in the Somali-Ethiopian border war.

Then, the decade of the 1980s began with several acts of violence that intimately affect the traditional pattern of relationships among the nations: the Soviet Union's invasion of Afghanistan, the border war between Iran and Iraq threatening critical oil supplies, and the Iranian militants' capture of the American Embassy hostages. The Iran-Iraq war brought substance to fears that the vital interests of industrialized nations could be endangered by the national affairs of emerging, resource-rich states over which the traditional world powers have little influence. The terrorist action in Iran can be viewed as a precursor of the new kind of turbulent world we may face, as developing nations have to cope with the problems of modernization. The Soviet invasion of Afghanistan and President Carter's warning that the United States would use military force, if necessary, to protect its vital interests in the Middle East focused attention on the East-West superpower confrontation that has long dominated the world's attention.†

The actions by the Soviets, and the vehement American response, have dealt a serious blow to the detente process. The freezing if not the destruction of detente is signified by the delay in submitting the second arms control agreement to the United States Senate for ratification, and the commitment of both major parties in the 1980 United States Presidential campaign to increased defense spending.

*Zbigniew Brzezinski, "U.S. Foreign Policy: The Search for Focus," Foreign Affairs, July 1973, pp. 717, 721, 723, Emphasis added.

**See Jimmy Carter, "A Foreign Policy Based on America's Essential Character," an address at Notre Dame University May 22, 1977, in U.S. Department of State Bulletin, June 13, 1977, pp. 621-624.

†"Afghan Action Accompanied by Extension of Soviet Intervention Doctrine," Soviet World Outlook, Vol. 5, No. 1, January 15, 1980.

These events have shaken American analysts of foreign and defense policy, but they have not yet generated a consensus about the new international order that is emerging or the proper American policies for the coming decades. Several recent analyses have described the major alternative American views on the world's future, and appropriate United States foreign policies. One such effort identified six fairly distinct perspectives that presently exist in the United States.* Of these six the two central views--essentially representing the positions of Kissinger and Brzezinski--were said to be the most pervasive and influential. Another analysis identified just two prominent views, while recognizing that more radical ones exist on the fringes of the left and right.** In this second analysis, written in the wake of the Soviet invasion of Afghanistan, the views are shifted somewhat to the right, but are still essentially the same two central positions.

In any case, we can now identify two fundamentally contrasting views about the new order and the appropriate United States response to it. They differ on two questions important to our task. The first is the future of the United States-Soviet contest. The second is the importance of the Third World in future international relations.

The first view follows from the Carter-Brzezinski foreign policy in that it still sees the Third World's problems as the most important focus for United States foreign and defense policy and holds that the United States-Soviet conflict will become progressively less important. This view recognizes that the United States has declined in world influence, but argues that this is not necessarily bad, since the Soviet Union is now or soon will be declining also. In a recent article, Senator Gary Hart elaborated this view. While taking notice of Soviet military expansion in the 1970s, he still strongly evokes Brzezinski's 1973 world view.

The Soviet Union has virtually nothing to offer except military strength. Other than arms, few of her exports are attractive. While varieties of socialism and even communism are of interest to some developing states, Soviet-model state socialism is increasingly recognized for what it is: a new tsarism [As a result] the nations of the Third World increasingly recognize Soviet policy for what it is: neo-colonialism of the worst sort.

*Robert J. Pranger, "Six Perspectives on Soviet Foreign Policy," Foreign Policy and Defense Review, Vol. One, No. 5, 1979.

**Robert E. Osgood, "Containment, Soviet Behavior, and Grand Strategy," a paper presented at the Los Alamos National Laboratory conference, Western Strategy for the Eighties, 16 September 1980.

At the same time, according to Hart, "the capabilities of other nations have risen relative to the two superpowers." This is a development the United States should recognize and take advantage of by supporting emerging nationalisms where they appear, not by responding spasmodically to every revolutionary movement as though it were an instance of Soviet expansionism. To carry out this policy Hart calls for a new emphasis on a "maritime strategy" and on forces able to project American power into the Third World. Inevitably this implies de-emphasis of central strategic forces.*

The second view was expressed by James Schlesinger in his September 1980 speech. He believes growing world instability is a consequence of declining United States power.

The basic reason for increased turbulence is . . . simple: the relative decline of American power and associated with it, the reduced will of the American people to play a combined role of international guardian and self-appointed moral preceptor--in short, the end of Pax Americana.

This school of thought generally regards this decline as regrettable. It is the more so because it has coincided with an increase in Soviet military power and world-wide influence, that is, with the Soviet Union's emergence as a global superpower. Recent Soviet aggressiveness is variously interpreted as reflecting a Soviet grand design for world domination or a policy geared to exploit targets of opportunity wherever they appear. In either case, the prime requisite for American policy in this view is to prevent further Soviet expansion. Much of the danger arising from turbulence in the Third World, in this view, is that it represents exploitable opportunities to the Soviets which, when capitalized upon, expand Soviet power while reducing the security of the United States and the West.

While these two views differ in ways that may appear merely academic, they have profoundly different implications for United States defense and foreign policy. The first counsels de-emphasizing the US-USSR equation (both diplomatically and militarily), placing primary emphasis on improving United States policy coordination with its industrialized allies, and supporting the independent development of the Third World. The second school favors continuing America's primary emphasis on the United States-Soviet confrontation--perhaps by a return to "containment" as the aim of United States policy, but certainly by placing the highest defense priority on strategic weapons and doctrine.

*Gary Hart, "Toward a New Consensus on Defense," Strategic Review, Fall 1980, pp. 9-14.

While the character of the world that will replace the Pax Americana is still largely unknown to us, speculating about alternative world conditions can help point out problems we may have to face in the future. We examine next four such sets of conditions. While not intended as projections or forecasts, these four "worlds" indicate important contingencies that must be considered in national security planning.

Three possible worlds are determined by the character and importance of the continuing struggle between the United States and the Soviet Union. If the ideological, political, and economic conflicts between these superpowers dominate the world strategic environment, three fundamentally different worlds may be hypothesized. We call these "competition," "cold war," and "cooperation," respectively, depending upon whether the current intensity of competition between them remains about the same, is significantly increased, or is substantially reduced.

A fourth possible world future can be postulated if we focus on recent developments in Central America, Southeast Asia, and the Persian Gulf. The destabilizing political and economic trends in these economically less-developed areas may be unrelated to the US-USSR struggle, and they may come to rival or overshadow in importance the US-USSR competition over the next 20 years. The domination of the future world by these trends, which might be accompanied by the development of a multi-polar world, we characterize as "turbulence."

1. Competition - Continuation of the Present World. Although violence in Iran, Afghanistan, and elsewhere has stimulated debate about the adequacy of American military strength to protect American interests, many observers believe these events have not shifted the world into a radically different trend from that existing in the past two decades. In this view, the United States and the Soviet Union will continue to be the world's leading powers for the next two decades, coexisting but competing across a wide spectrum of geography and interests. Japan and members of the Western and Eastern European communities will become increasingly important economic world powers (with Japanese GNP second only to that of the United States) and perhaps mitigating US-USSR conflicts in the developed European heartland. But the two superpowers would remain the dominant strategic and conventional military powers.

2. Cold War--Intensive Superpower Struggle. In this scenario, the recent assertiveness of the Soviet Union based on what that nation views as a major shift in the "correlation of world forces" will continue and even intensify as that correlation shifts further during the 1980s. In response the United States would continue to strengthen its resolve in accordance with the public support shown for defense preparedness in the late 1970s. Both superpowers would seek to shore up their current alliances, cultivate new allies, and engage in forceful maneuvers to extend their own spheres of interest or resist such an extension by their counterparts.

This intensification of superpower competition would involve a much more significant economic dimension than in the original cold war period. The free world, and especially the United States, has not been able to maintain high levels of economic growth in recent years; the rate of gross national product growth in the United States fell from 4.1% in the 1960s to 2.8% in the 1970s. The rate of Soviet GNP growth has also declined from 5% in the 1960s, to 3.5% by 1975, and is expected to fall to 2.5% in the 1980s. However, the Soviet Union has continued to invest much more heavily in its industrial base than the United States has in recent years. If this results in increased industrial productivity in the Soviet Union, the Soviets could improve their global economic position in relation to the free world. Further, if the performance of the American economy continues to degrade and the value of the dollar is not stabilized or increased, continuing economic tension may result within our Organization for Economic Cooperation and Development and NATO alliances. This tension could be exploited by the Soviets to degrade our military agreements, such as funding arrangements for NATO forces, and the terms on which both troops and missile facilities are located on allied soil.

Oil and other energy supplies play a special role in any world view. Many of the economic growth problems experienced in the United States (and elsewhere in the West) in the 1970s were due to sudden price jumps for imported oil. While the Soviets have not had to place reliance on oil imports, they and their principal client states may begin to compete for world oil supplies as Soviet crude oil production peaks. Increased Soviet efforts to secure political influence and even military control over significant oil production in the Middle East would be feasible. The United States might seek to project its interests by becoming more closely aligned with some Mid-Eastern governments, causing strains both within OPEC and within NATO. Strenuous United States efforts to rejuvenate the NATO alliance and to lead Western efforts to manage critical oil supplies would be required.

In this scenario a period of maximum danger could be reached in the second half of the 1980s, as the Soviet Union tries for maximum military advantage and free world energy and economic difficulties intensify, but the Soviet advantages face the imminent prospect of withering away as American defense programs begin to come on line and allied energy and economic policies become effective. The possibility that the United States would become involved in serious warfighting in this world is significant.

3. Cooperation--Superpowers Solve World Problems Together. The United States and the Soviet Union would, in this view, remain the dominant world powers. For reasons of enlightened self-interest, humanitarianism, or economic advantage, they would cooperate to resolve a set of mutual problems. These problems could include the emergence of significant conflict between the industrialized North and the underdeveloped, but resource- and market-rich, Southern Hemisphere -- a contest of the economic haves versus the have-nots.

Most projections agree that the economic gap between the rich and the poor nations will grow larger. Internal friction caused by an inability to solve population, economic development, and international trade problems has led numerous less developed countries to call for a "New International Economic Order." This new order would redistribute control of global resources and alter the terms of international trade to their advantage. Emerging claims from the less developed countries include easy access to new technologies, increased financial transfers to help pay for energy imports, and even attempts to control the world press reporting of Third World news through a UNESCO-sponsored review mechanism.

Emergence of a North-South conflict could bring the United States and the Soviet Union into closer harmony to address the new situation by one of a number of strategies. These range from one extreme, the joint domination and exploitation of the South by the industrialized North, to the other, the engaging by the North in the economic and technological development of the underdeveloped South. Any important degree of Northern cooperation would imply a major reduction of US-USSR competition, probably on the ideological and military as well as political levels.

In this scenario, the management of East-West relations in Europe and relations between the industrialized world and the OPEC cartel are critical. During the 1970s, governments of OPEC replaced oil companies as the primary sellers of crude oil and governments became the primary buyers in several European countries. This scenario could involve counter-cartel activities by oil consumers to bargain with OPEC about the terms of oil trade; or even more extreme measures could be taken such as the imposition of an entirely different international oil ownership and allocation system. A further consequence of this world view would be an increase in trade between East and West and an eventual merging of Western and Eastern European economies.

4. Turbulence--Regional Powers Rival Superpower Influence. In such a world, the dominating role and influence of the superpowers would decrease and be replaced by a major disaggregation of world power. Regional hegemonies and coalitions would develop throughout the world. Economic, religious, and ideological issues would gain in importance as sources of alliances and enmities, but the ability of any nation to impose order upon more than a relatively small region would gradually decline. The world would be characterized by uncertainty and turbulence and widespread but lower-level threats to national interests.

Several major economic and demographic trends lend credence to this analysis. World population will increase significantly in the next two decades; 90% of this increase will occur in the Third World. In many Third World countries, rising population will continue to be associated with declining living standards, lowered nutritional levels and life expectancy, lower income and housing quality, and higher morbidity and mortality rates. Further, much of the population in the developing world

is moving into urban areas and creating teeming shantytowns of the poor and disenchanted. The World Bank estimates that cities in developing countries will more than double their populations before the end of this century, gaining close to a billion people. This poses an increasing threat of urban violence and political instability in these countries.

Long-term ethnic and religious differences within many developing countries add to the above problems the possibility of communal warfare between various ethnic and religious groups. Also, large-scale migration of populations from Third World countries to seek jobs in the industrialized world has established large, unassimilated immigrant populations. Frequently these populations are discriminated against economically and socially. In some cases such populations may be amenable to calls for revolutionary change; in others they can give foreign states a strong interest in their expatriate nationals abroad, and how they are treated.

In this world, both the United States and the Soviet Union would remain relatively ineffectual in influencing conflicts in the most destabilized region, the Middle East. Continued warfighting and terrorism could continue to characterize the region, with heightened possibilities for severe oil shortages in the West. The OPEC cartel would potentially become much more powerful in this world view, as both Western and Eastern alliances fail to adopt policies for counteracting cartel oil price and supply policies, and as the world becomes steadily more dependent on OPEC governments for oil imports. The potential for world-wide economic damage in such a scenario is very great.

DEFENSE TRENDS AND TECHNOLOGY

This section begins with an analysis of world defense trends and projections that may provide some insight into the emerging international order and indicate whether the bipolar or multipolar world view more closely represents that order. We then review previous adaptations of United States defense policy to the changing international situation and look at the major alternatives for American defense doctrine in the 1980s and beyond. Finally, we briefly consider new defense technology requirements that may be generated by future United States strategic policies.

INTERNATIONAL STRATEGIC TRENDS AND PROJECTIONS

Geopolitics

Geopolitics is the study of the relationship of geographic setting and national power to international politics. This section reviews a few of the salient features of the world's leading nation-states and examines some of the manifestations of their external policies in relation to other states and the world geographical setting.

Strategic Geography. The ability to control strategic pieces of geography -- high places and access points on the ground, ports and shipping choke-points at sea -- has traditionally been a decisive factor in the clash of national interests. The importance of such considerations to international security in the nuclear age is disputed. But those who argue that the development of nuclear weaponry has outmoded all considerations of geopolitics have been refuted in the late 1970s by the Middle East problem. The requirement to keep open the Persian Gulf and the sea lanes which connect it to the free world nations (a traditional geopolitical concern) has emerged as a high priority for defense and foreign policy planners. But it is a task which cannot be accomplished by strategic nuclear weaponry. At the level of the superpowers, armed with large nuclear arsenals, it still is arguable whether traditional geopolitical factors retain their old importance. It is possible that the evolution of opposing strategic nuclear forces has done no more than make the world "safe" for conventional and perhaps theater nuclear war, restoring geopolitical concerns to their former prominence.

Since the end of the Second World War the Soviet Union has subjugated a number of satellite states and extended its interest into a number of others. These include, fairly recently, several states in the Third World. The United States, pursuing a policy of attempting to contain Soviet expansion, established a series of treaties soon after the War that were designed to hem in the Soviet Union. Except in Europe, the American treaty system has weakened over time.

In the years since the War, China and Japan have emerged as major powers in the Far East. In the Third World, the primary development since the War has been the elimination of colonial or dependent status and the establishment

of many new, independent, weak nations, often mutually hostile. The late 1960s and the 1970s witnessed the gradual withdrawal of United States forces and bases from many of their advanced positions overseas. Figures 1a-1d show patterns of Western and Soviet world influence since the Second World War.

The two schools of American foreign policy analysis interpret these post-war geopolitical trends differently. The first school argues that Soviet geopolitical advances have generally been offset by reverses -- for example the Soviet expulsion from Egypt -- and that whatever Soviet intentions may be, the Soviets have developed no real momentum and now pose no greater threat to the security of the free world than they did in former years. In fact, because of internal problems, the Soviet Union is thought by some members of this group to pose a diminishing threat.*

The second school of American analysts argues that Soviet geopolitical advances since World War II imply a Soviet design to obtain strategic command of Western Europe by surrounding the northern and southern flanks of NATO and intimidating or defeating the nations of NATO's center. That policy, they argue, is allied with an observable, tenacious Soviet effort to gain control of the maritime lifelines of the major Western allies and Japan.**

Comparative National Power. National power is used to support a nation's interests, insure its security, and effect its designs outside its borders. But national power is difficult to quantify, and shifts in relative power are hard to perceive when they occur gradually.

The Soviets take calculations of national power seriously and judge their ability to achieve their national objectives by the current state and likely trends in the "world correlation of forces." Any attempt to estimate relative national power must take into account a number of ingredients that contribute to it. One such estimate includes assessments of population and territory, economic capability, military capability, national strategy, and national will.+

It is important to note that in most analyses the Soviet Union maintains its status as a world power primarily because of its military capabilities, including its national will and national strategy. In terms of economic power and inherent geopolitical weight, the United States and its allies are vastly superior to the Soviet Union and its allies.

Since the late 1960s the power of the Third World nations has probably grown moderately in relation to the developed nations. From 1968 to 1978 the developing nations' percentage of the world gross national product grew by 4%. One third of that growth was among the oil exporting nations.++

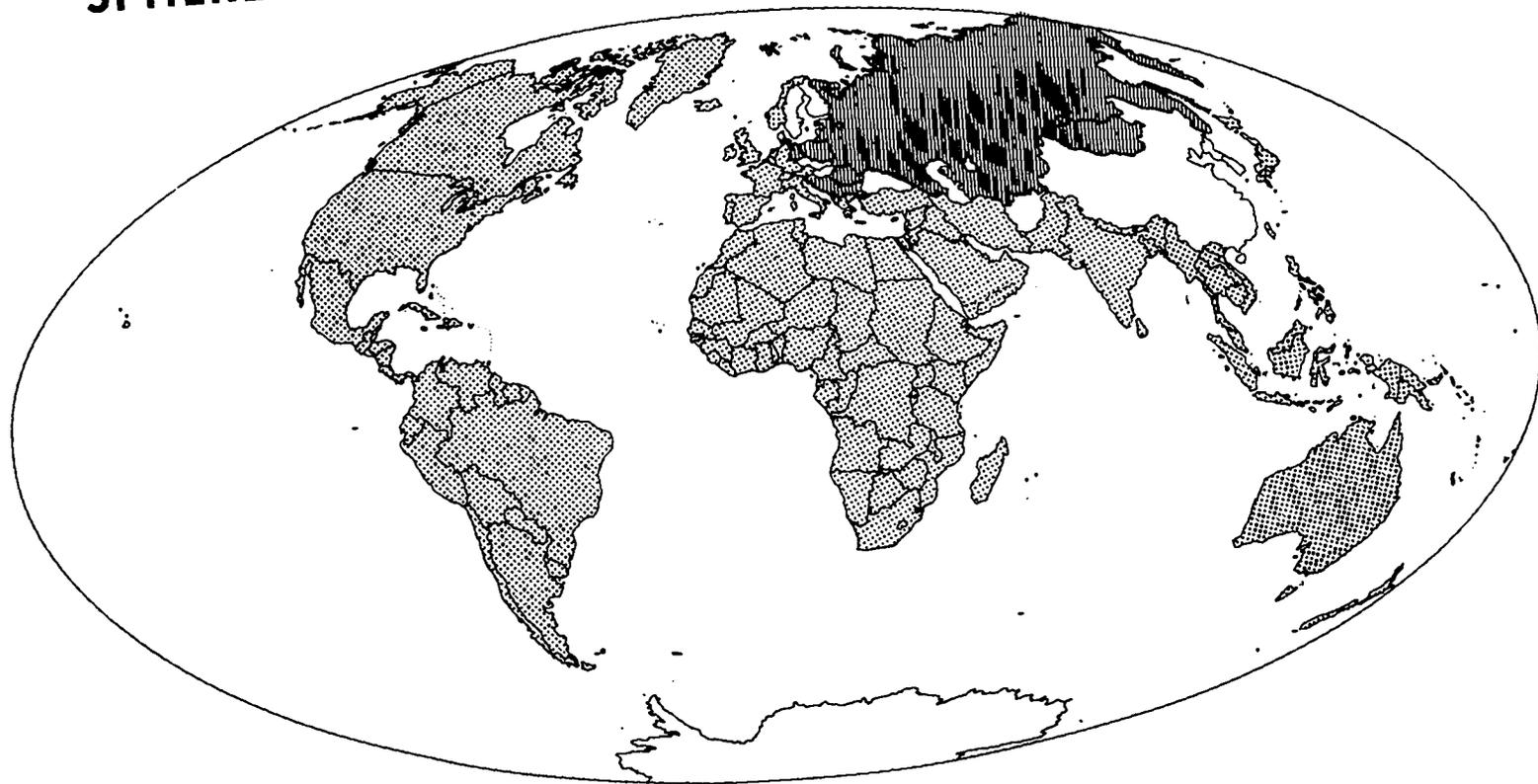
*See, Center for Defense Information, The Defense Monitor, January 1980; and Carl Gershman, "The Rise and Fall of the New Foreign Policy Establishment," Commentary, July 1980.

**See, for example, Colin S. Gray, The Geopolitics of the Nuclear Era.

+Ray S. Cline, World Power Trends.

++U.S. Arms Control and Disarmament Agency, World Military Expenditures and Arms Transfers, 1968-1977, pp. 27-31.

SPHERES OF WESTERN AND SOVIET INFLUENCE, 1945



12

Figure 1a

SPHERES OF WESTERN AND SOVIET INFLUENCE, 1960

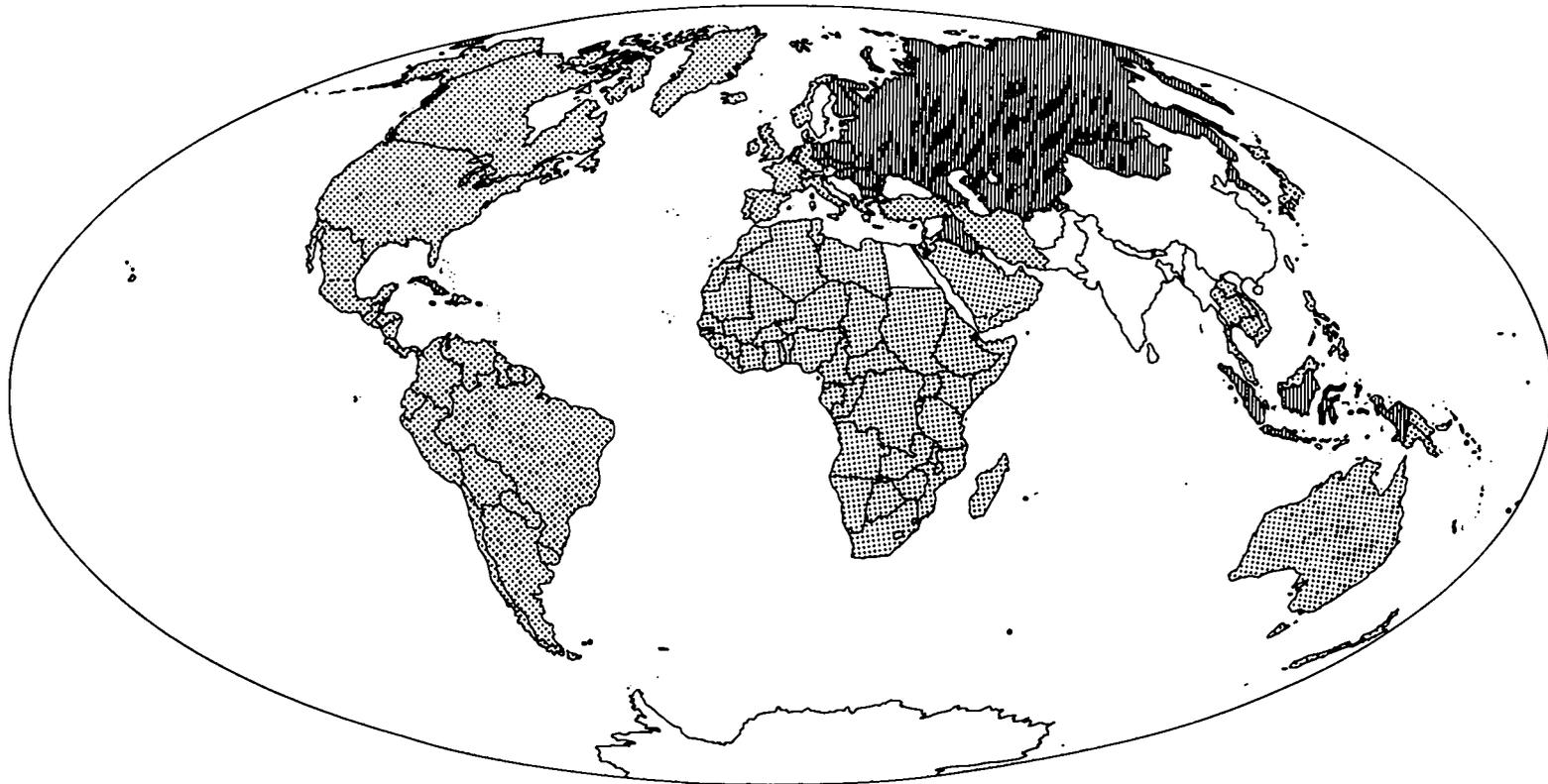


Figure 1b

SPHERES OF WESTERN AND SOVIET INFLUENCE, 1975

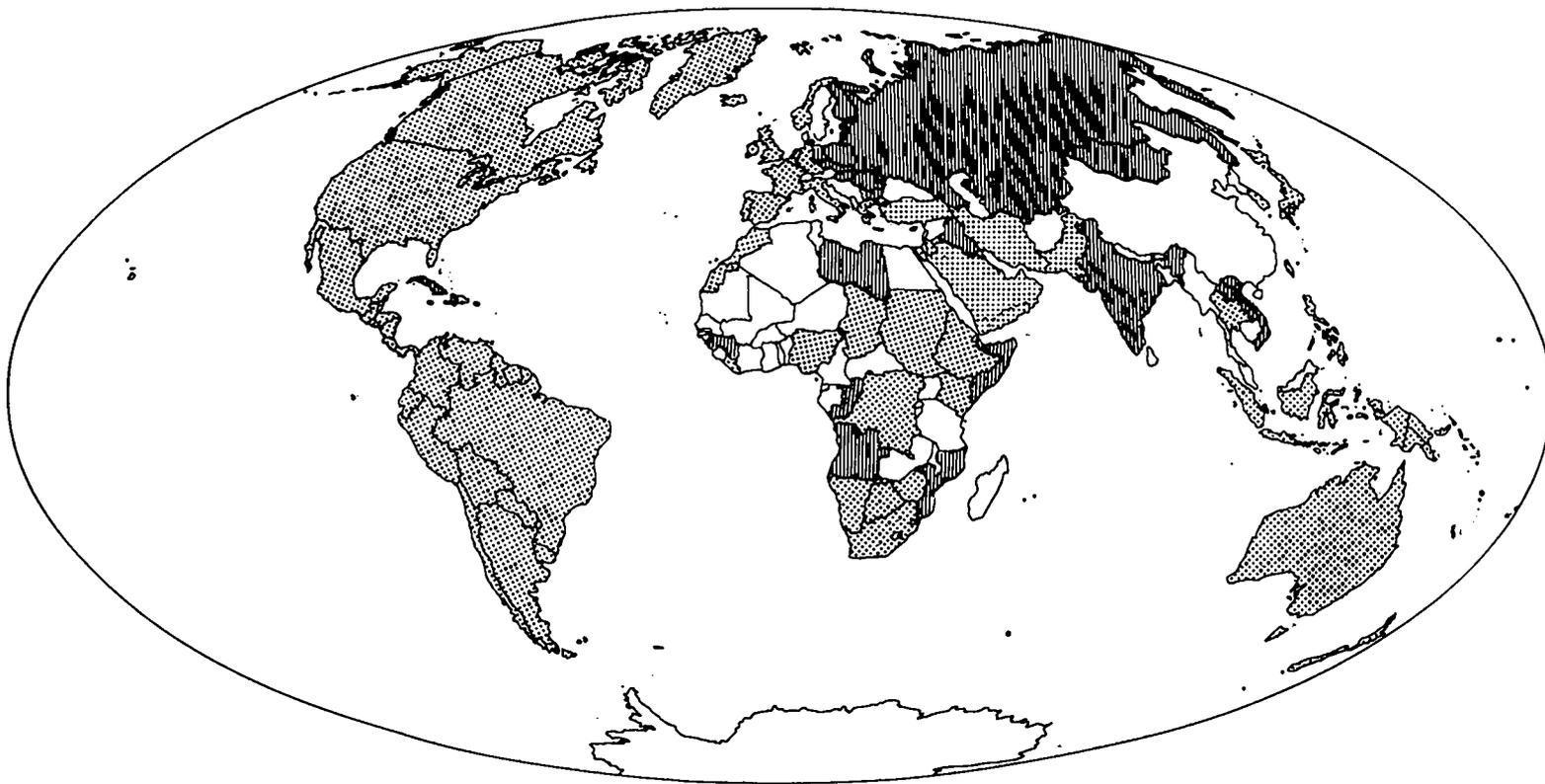
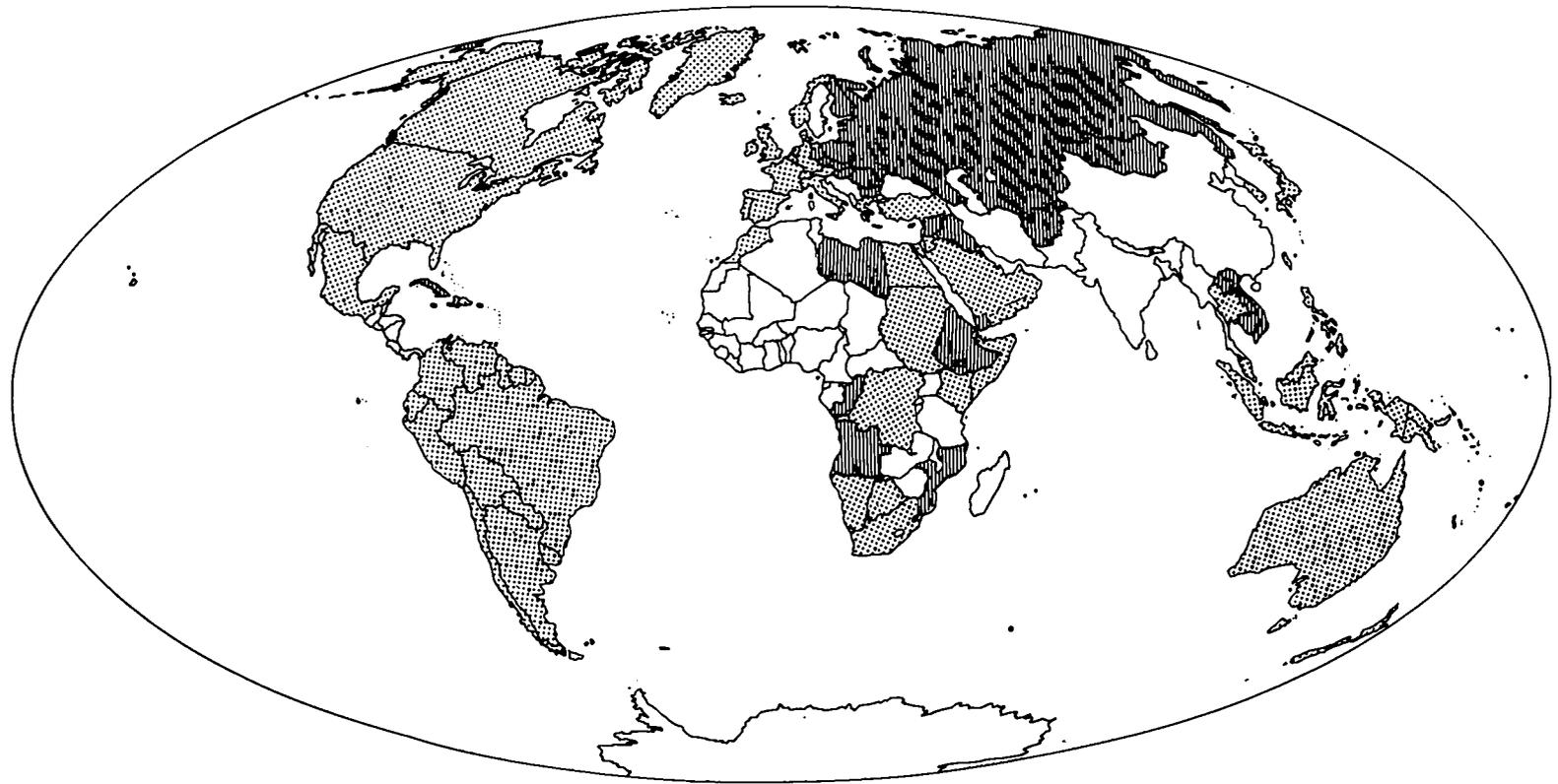


Figure 1c

SPHERES OF WESTERN AND SOVIET INFLUENCE, 1980



15

Figure 1d

But the economic growth and national wellbeing of most of the developing nations outside OPEC, particularly the poorer nations, have been sustained only by massive increases in borrowing. The trade deficit of the non-OPEC developing nations grew from 6 billion dollars in 1965 to 51.1 billion dollars in 1979. Most of the deficit arose following the massive oil price increases of 1974 and 1979.* A few of the more wealthy non-OPEC developing nations are continuing to prosper despite this economic problem and the other social and population problems that plague almost all of the Third World.

Military expenditure and probably military power in the Third World also grew from 1969 to 1978 relative to the developed world. But more than half of the military spending increase was concentrated in the oil exporting nations. Some of these countries, such as Saudi Arabia, Libya, and Indonesia, have become regional powers of consequence. A few of the wealthier non-oil developing countries, such as Taiwan, South Korea, and Brazil, also fit this category.

Governments. In the twelve months ending in November, 1980, there were 41 separate elections or other changes of government in the world.** Several of these, including the coups in Afghanistan, Bolivia, the Central African Republic, El Salvador, and Liberia, the assassination of President Park in Korea, and the death of President Tito in Yugoslavia, had important ramifications for international affairs.

In several states there are now impending or threatened leadership changes that are significant for United States interests and plans. Perhaps most ominous is the situation in Saudi Arabia. Following the revolution in Iran and the Iran-Iraq war, petroleum from Saudi Arabia has taken on even greater importance to the industrialized free world. But the stability of Saudi Arabia and the reliability of its oil supplies are not guaranteed. The large number of claimants to the Saudi throne and uncertainty in the impending succession to King Khalid, the destabilizing influence of Moslem fundamentalism (as seen in the takeover of the Mecca mosque in 1979), the general deterioration of the former balance of power in the Persian Gulf since the fall of the Shah, the continuing tension over oil pricing and the Arab-Israeli issue, all are pressures that contribute to unsteadiness in the Saudi government.+

Of even greater weight, but perhaps less potential for rapid change in the international situation, is the impending transition in leadership in the Soviet Union. The recent retirement and subsequent death of Premier Kosygin at age 75 is only the beginning of what must soon be a wholesale change in Soviet leadership, due to superannuation.

*Jimmy Carter, Economic Report of the President, 1980, pp. 169-174.

**Defense and Foreign Affairs, November 1980, p. 23.

+"Saudi Arabia, Democracy's Itch," The Economist, April 5, 1980, pp. 30-31;
"Power - And Sometimes Corruption - Reside in the House of Saud," Washington Post, June 5, 1980.

TABLE I
MEMBERS OF THE SOVIET POLITBURO

	<u>Born</u>
Leonid Brezhnev	1906
Yuri Andropov	1914
Konstantin Chernenko	1911
Viktor Grishin	1914
Andrei Gromyko	1909
Andrei Kirilenko	1906
Alexei Kosygin (Died Dec. 1980)	1904
Dinmukhamed Kunayev	1912
Arvid Pelshe	1899
Grigori Romanov	1923
Mikhail Suslov	1902
Validmir Scherbitsky	1918
Nikolai Tikhinov	1905
Dimitri Ustinov	1908

Most important, President Brezhnev is in ill health. No one around him is an obvious successor to supreme power. Informed opinion in the United States expects there to be a transitional period after Brezhnev following which some member of the new (under 65) generation of leaders will come to power. There is considerable uncertainty about the policy inclinations of this largely unknown generation of Soviet politicians, but at least one report indicated that American intelligence officials "are now convinced that the Soviet Union's next leaders will be even more hawkish than the current lineup."*

In several other states, power changes of some importance are possible in the next few years. The leadership in China is still in transition; the next generation of leaders will have to decide how far to carry the departure in Chinese policy from the radicalism and anti-modernism of Mao Tse-tung, and how close a relationship to develop with the West. The government of Iran is under strain because of internal problems, and the invasion by Iraq. Many observers expect a civil war to ensue between the left-radicals and the Moslem fundamentalists who make up the present uneasy coalition under Ayatollah Khomeini. Syria, Libya, Egypt, Zimbabwe, and El Salvador are other nations where internal pressures threaten the incumbent governments, and where changes could have damaging effects on American security. The recent unrest in Poland could challenge American policy toward Eastern Europe if it or similar problems in other Soviet satellite states lead to a repressive Soviet response.

Alliances and Alignments. The nations of the world are tied together by a large network of military, economic, and consultative alliances which are designed to improve security or prosperity or further other national aims.

*U.S. News and World Report, Jan. 21, 1980, p. 16; The Economist, February 16, 1980, pp. 49-50.

The most prominent of these are the military treaties of the United States and the Soviet Union, but there are a number of multilateral organizations to which neither of the superpowers belong. Some of these are regional groupings which have defense functions or mutual defense implications.

ASEAN, the Association of Southeast Asian Nations, was formed in 1967 by Indonesia, Malaysia, the Philippines, Singapore, and Thailand. While it presently has only economic functions, there has been increased speculation since the collapse of South Vietnam and the expansion of unified Vietnam that ASEAN may eventually assume overt mutual defense functions.*

Other regional treaty organizations include the Andean Group in northern South America, the Arab League, the Organization of African Unity, and several economic alliances. While possibly forming a nucleus from which a defensive alliance could evolve, none of these organizations has yet taken on important military responsibilities.

Of the current economic treaty organizations, the Organization of Petroleum Exporting Countries is the most prominent. Its actions since the 1973 oil embargo have demonstrated its potential to affect international security and prosperity. The petroleum exporters have manipulated supply and price to accomplish both economic and political ends. In light of this demonstration, concern has been voiced that new cartels may be formed by the exporters of other key commodities which could be equally powerful and disruptive.

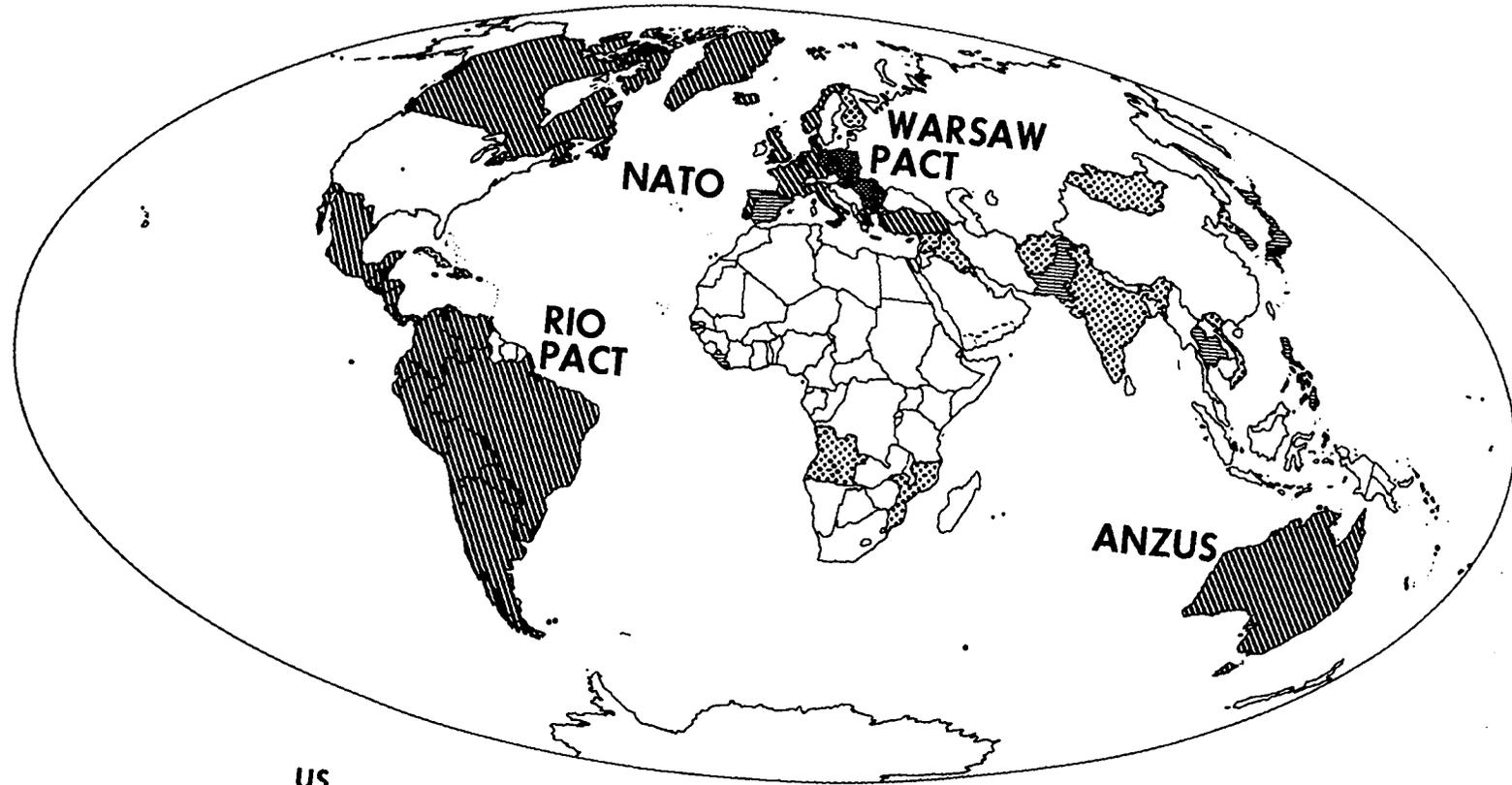
The United States and the Soviet Union participate in both military and economic treaty organizations. The major security treaty networks of the two superpowers are shown in Figure 2.

NATO and the United States. The primary United States security treaty is the North Atlantic Treaty Organization (NATO), formed in 1949 by the United States, Canada, Iceland, Norway, and the Western European nations (with the exception of West Germany, which joined in 1955). In 1966 France stopped participating in the formal military organization. NATO has undergone several periods of self-doubt, largely arising from the different perceptions and security requirements of the European as opposed to the North American partners in the alliance. Another of these periods is now afflicting NATO, caused in part by the general growth of Soviet military capabilities, by doubts about the American strategic nuclear "umbrella", and by European worries about new Soviet long-range nuclear delivery systems. The effort by NATO to counter this Soviet deployment with NATO long-range theater weapons has met with a massive Soviet political and propaganda counteroffensive designed to prevent the deployment. Doubts among some NATO members have caused a near-rift in the alliance. The decision to deploy the long-range

*"ASEAN Faces the Prospect of a Military Alliance," Defense and Foreign Affairs, August 1980.

US AND USSR SECURITY TREATIES

19



US
[diagonal lines] MULTILATERAL TREATIES
[horizontal lines] BILATERAL TREATIES

USSR
[solid black] MULTILATERAL TREATIES
[checkered pattern] BILATERAL TREATIES

Figure 2

Source: International Institute for Strategic Studies, *Military Balance, 1980-1981*; John Collins, *U.S.-Soviet Military Balance, 1960-1980*.

missiles has been particularly controversial in Belgium and Holland, where both governments have put off a final decision. In Britain the Conservative government has not wavered in its endorsement of the new weapons, but the annual conference of the opposition Labour Party has reacted by calling for unilateral British disarmament and the banning of all nuclear weapons from British soil.*

A second point of difference between the United States and its allies concerns the general approach toward the Soviet Union. The United States, following the invasion of Afghanistan, has advocated measures such as economic restrictions and the Olympic boycott to punish the Soviets for their adventurism. The other NATO countries have been hesitant to damage their relations with the Soviet Union. They have pressed on with trade agreements. Some have even raised the possibility of an exclusively European arms limitation agreement, should the United States continue to refuse to ratify SALT II or to move on to SALT III (which is supposed to include European-based nuclear weapons).**

Other threats are on the horizon for NATO. These include the need by alliance nations to secure access to essential raw materials, which may bring them into conflict with one another; possible growth in the United States of the opinion that the European NATO states are not "pulling their own weight" in a time when their economies are more prosperous than the American economy; and the possible emergence of a new isolationism in the United States. At the same time, the European countries could decide that a more "evenhanded" policy toward the superpowers is in their interest, both militarily and economically.

Besides NATO, the United States has a multilateral defense treaty with most Central and South American nations (the Rio Pact). Almost no defense preparations have been made in the context of this treaty, and it is doubtful that it could now serve as a framework for mutual defense. The United States does have a firm treaty with Australia and New Zealand (ANZUS). Finally, the Southeast Asian Treaty Organization with Australia, France, New Zealand, the Philippines, Thailand, and the United Kingdom, established in 1955, was terminated in 1977. Bilateral treaties between the United States and Thailand and the United States and the Philippines have filled the resultant gap. Congressional resolutions express American determination to preserve the freedom of Taiwan, the Middle East, and Berlin, and forbid the stationing of nuclear weapons in Cuba. Executive agreements cover Iceland, Denmark, Spain,

*Aviation Week and Space Technology, October 13, 1980. p. 22. Although a Leftist was elected Labour Party leader in November, the policies of the Labour conference are not binding on Labour MPs.

**Significantly differing descriptions of the seriousness and nature of the alliance's present problems, and how to solve them, can be seen in David Watt, "The Atlantic Alliance Needs Leaders Who Face the Facts," The Economist, Oct. 11, 1980, and in Walter Laqueur, "Europe Astray," Defense and Foreign Affairs, April 1980.

Canada, Liberia, Iran, Turkey, Pakistan, and the Philippines, while policy declarations indicate American interest in the independence of India and Israel.

What the United States does not have is flexible alliance commitments which would allow for allied action to safeguard those areas outside Europe that are of vital interest to the United States or its allies. Suggestions have been made that such arrangements will be needed to deal with areas such as the Middle East in the coming decade.

The Warsaw Pact and the Soviet Union. The primary military alliance of the Soviet Union is the Warsaw Pact. Since the allies of the Soviet Union in the Pact are its satellite nations, which enjoy much less independence of action than do America's NATO allies, the Warsaw Pact is a more integrated, centrally directed alliance. However, the reliability of the armies of Russia's Pact allies in a war against NATO remains suspect. Some armies, such as those of Bulgaria and East Germany, are thought to be quite reliable. Others such as those of Poland and Czechoslovakia are thought to be unlikely to participate actively in such a war. But while making this point about current Pact reliability, a recent study did note that "Most observers generally see the Eastern European armed forces playing a more important, if limited, role [than in past years] in a future NATO-Warsaw Pact confrontation."*

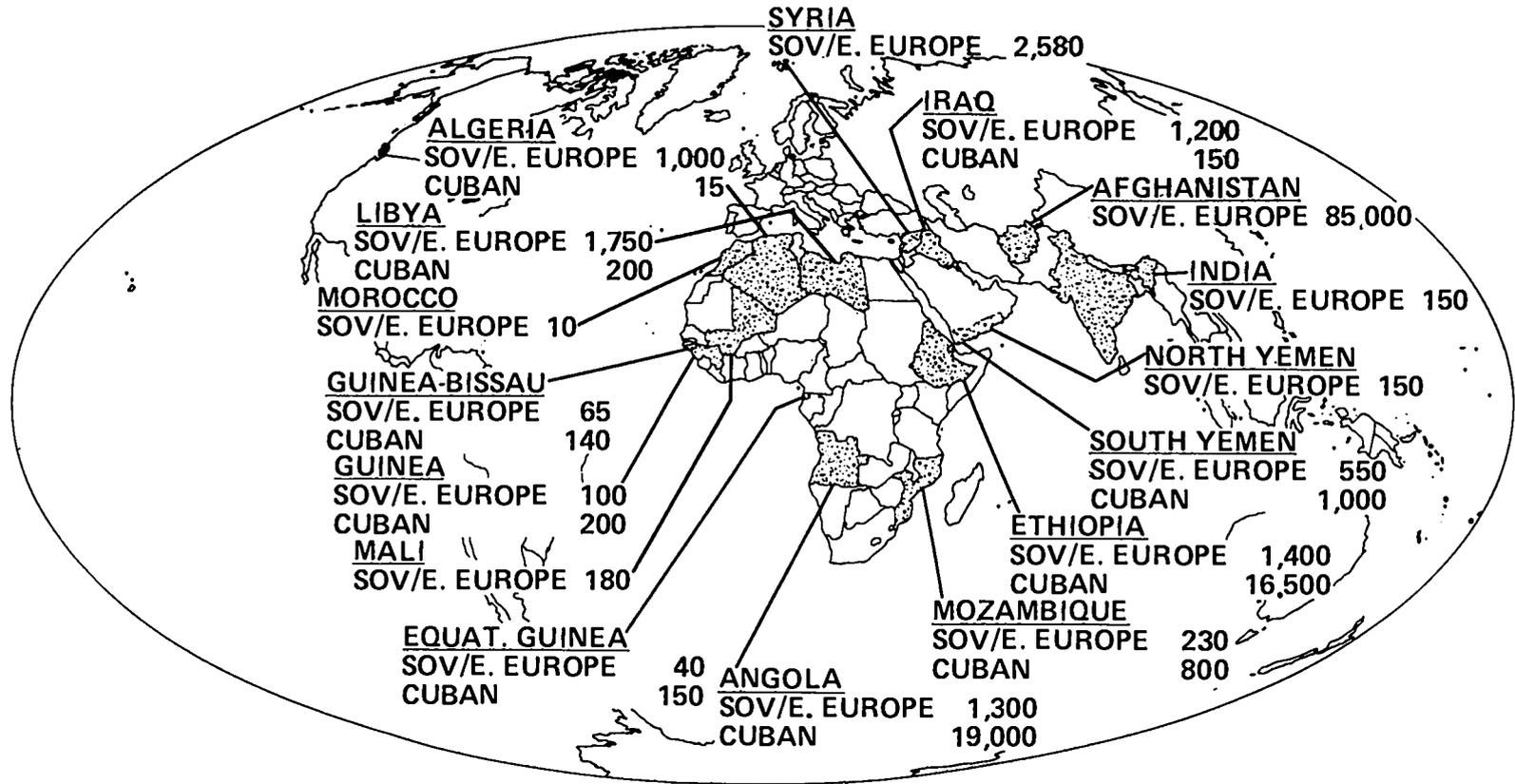
The Soviet Union has established bilateral treaties with several states outside the Pact as well, although these are not accompanied by the integrated military organization of the Warsaw Pact. Bilateral treaties exist with Afghanistan (1965), Angola (1976), India (1971), Iraq (1972, 1976), North Korea (1961), Mongolia (1966), Mozambique (1977), and Syria (1980). A mutual assistance pact was signed with Finland in 1948. While the relationship that led to these treaties has in some cases cooled, the treaties are still in effect and can be the basis for renewed associations (e.g., India).

The Soviet Union has also been supporting the overseas excursions of its satellites, Cuba and East Germany, both of which have been supporting revolutionary Third World movements in the past few years. The Soviets also have sent varying numbers of advisors and military personnel to client states, and have supported the activities of select terrorist groups, including some under the Palestine Liberation Organization umbrella (see Figure 3).

The Soviet Union also is the central power in COMECON, the East bloc's counterpart to the West's European Economic Community. COMECON includes the Warsaw Pact states, plus Cuba, Mongolia, and Vietnam. Non-member participants are Angola, Ethiopia, Laos, South Yemen, and Yugoslavia. Cooperative agreements have been signed between COMECON and Finland, Iraq, and Mexico.

*Herspring and Volgyes, "How Reliable are Eastern European Armies?" Survival, Fall 1980, pp. 208-218.

SOVIET, EAST EUROPEAN, AND CUBAN PERSONNEL OVERSEAS, 1980



TOTAL
SOV/E. EUROPE 96,205
CUBAN 38,640

Figure 3

Source: Defense and Foreign Affairs, September 1980.

China's Non-aggression Pacts. The Peoples' Republic of China negotiated non-aggression treaties with most of its neighbors in the early 1960s, and also with Guinea, Indonesia, Ghana, South Yemen, the Congo, Mali, and Tanzania. Since 1959, and particularly since the death of Mao, China has followed a policy vocally hostile to the Soviet Union while urging the West to increase its defense preparations against the Soviet Union. The "Four Modernizations" program presumably includes greater military spending by China herself, although analysts are not in agreement that China actually is making increased defense efforts. Following the Soviet invasion of Afghanistan there was some talk in the United States of an alliance with the Chinese against Soviet aggression, but it is not yet clear how far China means to carry its opposition to the Soviet Union, or if the real purpose of China's policy is to divert the Soviets' attention to their western flank.

Trends in Developing Areas. As Figure 4 shows, the loci of current world conflict are in the developing nations on the periphery of the Eurasian landmass and in Africa. Over the past decade much of the increase in world armaments expenditures has been in the developing nations. Arms imports in North Africa and particularly in the Middle East-Persian Gulf area have been very large. While many conflicts reflect purely local rivalries, the major powers often have taken a close interest in their outcome. Many of the nations which are potential nuclear weapons states -- Israel, Iraq, Pakistan, Libya, Japan -- lie in this peripheral zone.

The withdrawal of Western forces from some of these areas -- the United States from Southeast Asia and Britain from the Persian Gulf -- and the recent incursions of Soviet power into these areas have contributed to some degree to the increase in their instability. Figure 5 shows trends in armaments imports into the developing regions. In every case but East Asia, there have been very sharp increases during the 1970s.

Critical Materials. A variety of materials necessary for the operation of industrial economies are frequently cited as potential national security concerns. The United States, the European Economic Community, and Japan are all major importers of a number of strategic minerals. The Soviet Union is heavily dependent on imports for only a few minerals, and is a net exporter of many. Figure 6 shows the countries of origin of many of the key minerals that are imported to the United States. Some of these source countries are unstable, and the supplies from them could be cut off under a variety of imaginable circumstances. The concentrations of chromium, manganese, and cobalt in Zaire, Zambia, and South Africa have been of particular concern.*

The interruption of the supplies of any of these minerals for prolonged periods could damage the industrial production of the mineral-dependent nations, and could cause dislocations like those accompanying the oil shutoffs. But if the developing countries which export many of these minerals

*See "Minerals Emerge as a Campaign Issue," Aviation Week and Space Technology, October 20, 1980, p. 115.

CURRENT WORLD CONFLICT

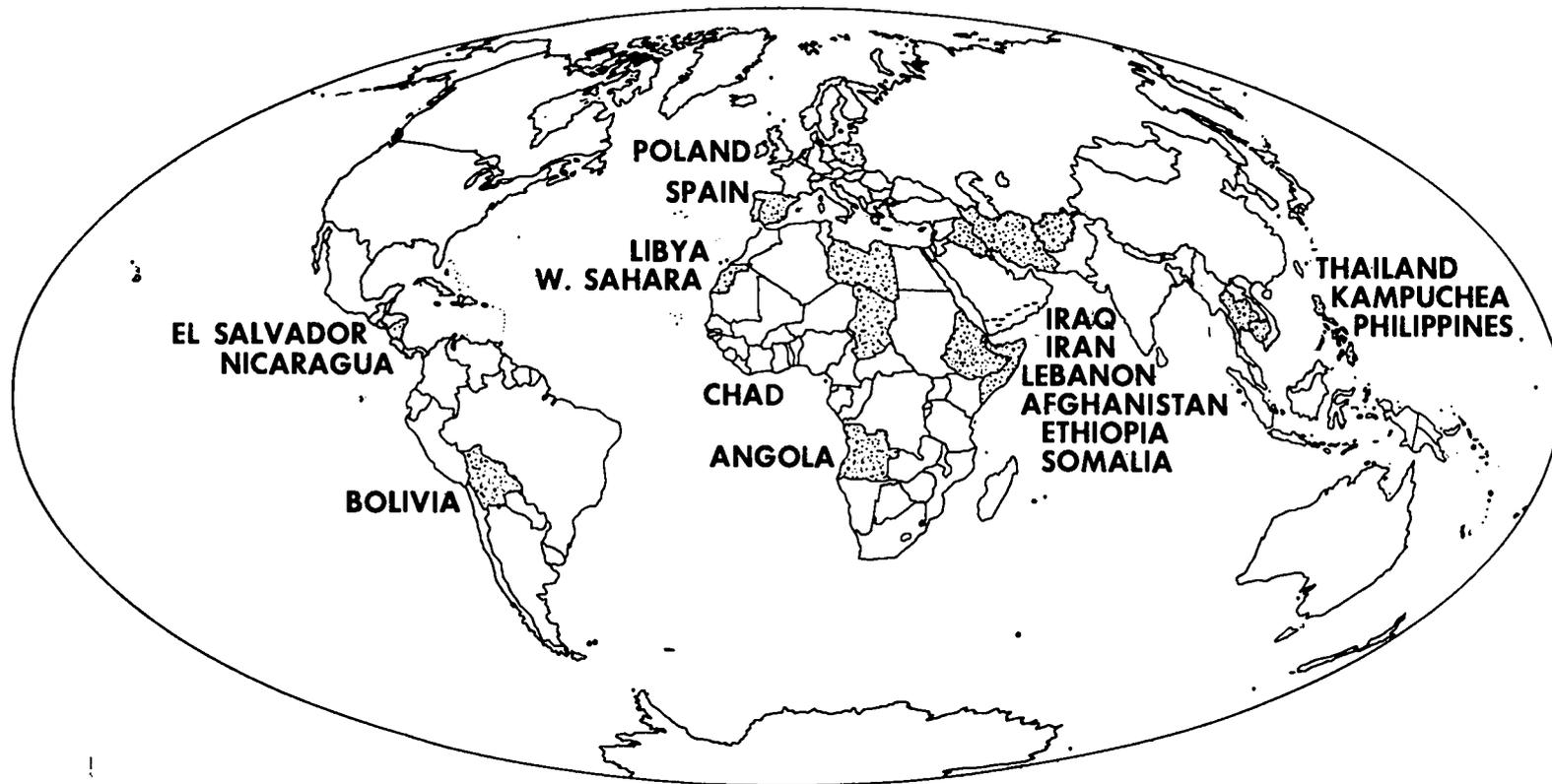
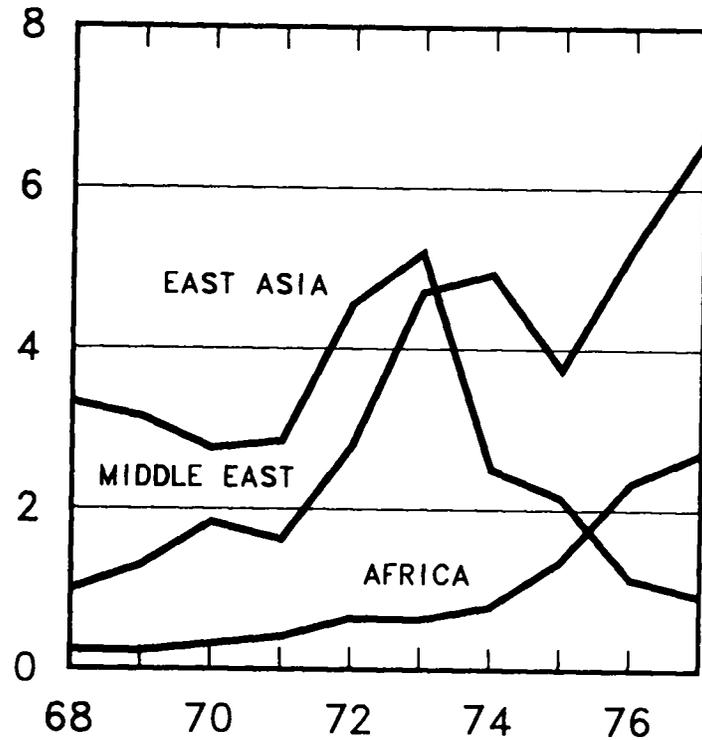


Figure 4

Source: Defense and Foreign Affairs, November 1980.

ARMS IMPORTS

\$ BILLIONS (constant 1976)



\$ MILLIONS (constant 1976)

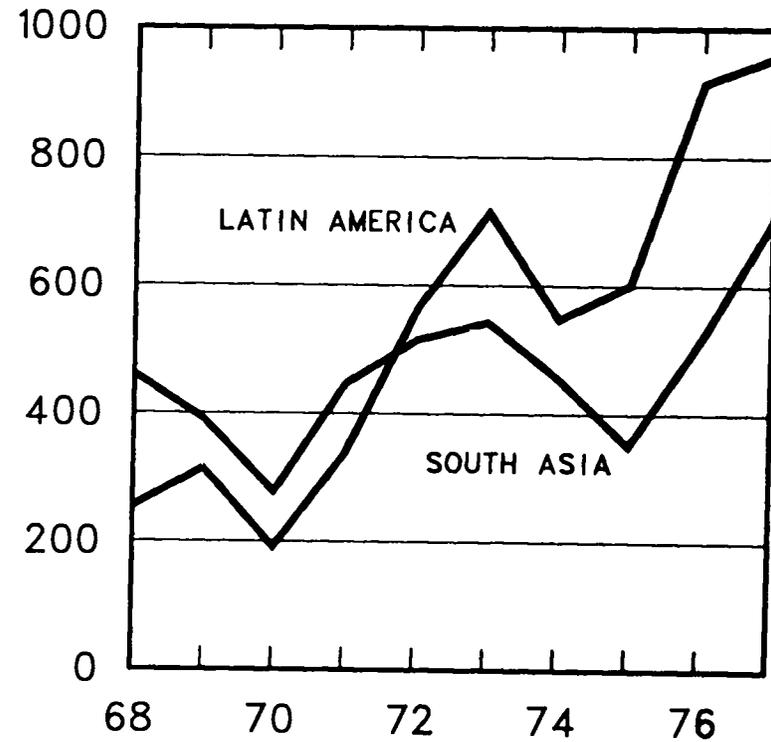


Figure 5

Source: U.S. Arms Control and Disarmament Agency, World Military Expenditures and Arms Transfers, 1968-1977.

KEY US MINERAL IMPORTS

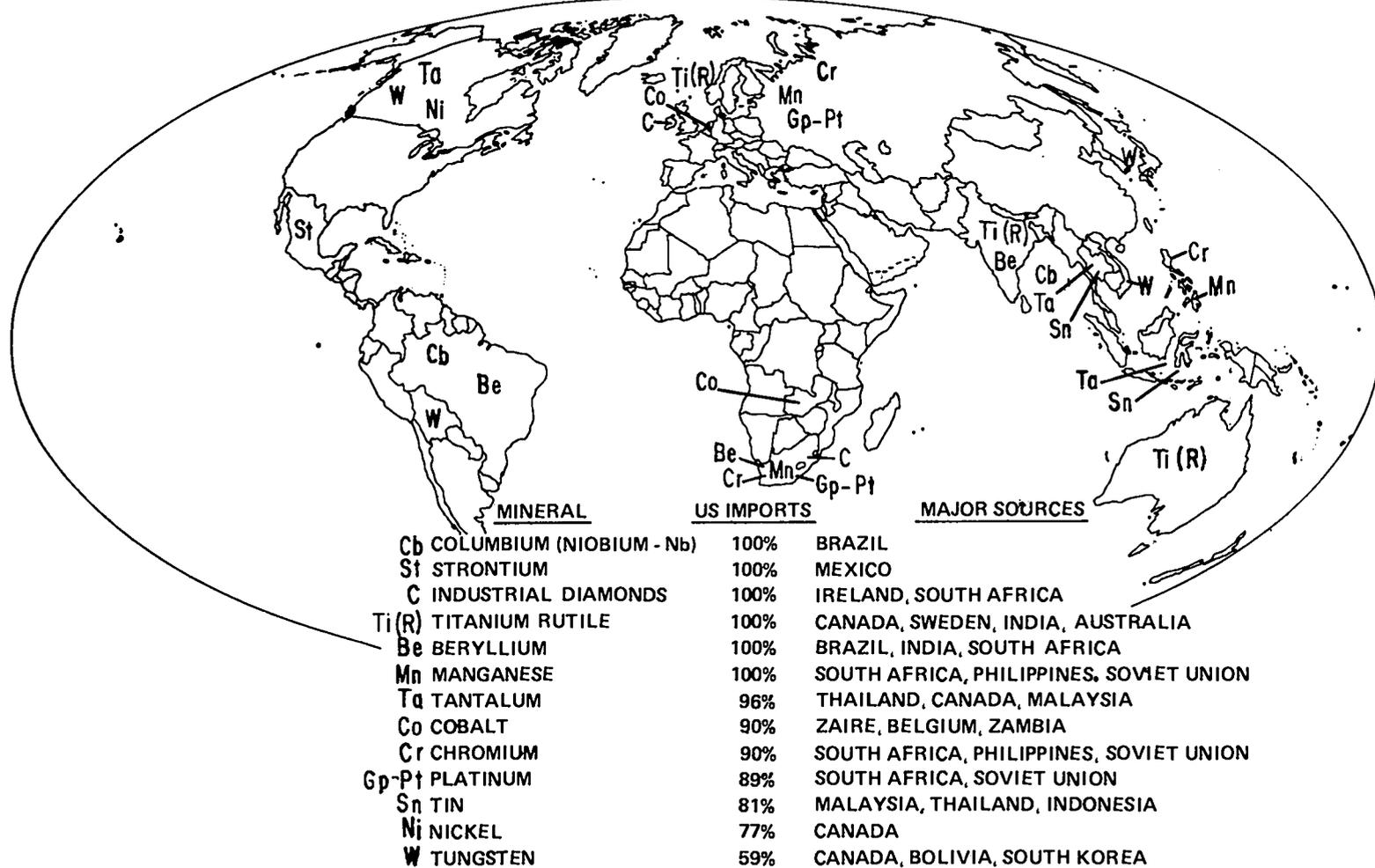


Figure 6

Source: Aviation Week and Space Technology,
 May 5, 1980; Newsweek, November 10,
 1980.

want to continue to develop, they can usually ill afford a long term interruption of sales.

The strategic minerals problem is not closely analogous to the oil problem. The minerals problem is much more amenable to solution. In general, these minerals are less bulky and are used in much smaller quantities. A longstanding American program has called for the stockpiling of strategic minerals. This program has fallen into arrears in past years, however, so that now about half of the stockpiles are deficient to some degree.

A long-term shutoff of minerals could lead to more serious problems, but here too remedial steps could be taken. In some cases low-grade ores are available in the United States; these could be mined, given suitable incentives. Other minerals could be recovered by recycling processes, although again at a high cost. In other cases, new manufacturing processes and alternative materials technologies may reduce requirements for certain minerals, or generate substitutes for them.

Military Trends

In the past decade military spending by the traditional military powers among the industrialized democracies and Communist nations has declined in relation to the developing world. In 1968 about 85% of the world's military spending was by the developed countries. By 1978 this had fallen to about 78%. Increases in military spending in the Third World were concentrated in the oil exporting countries, South Africa, and among a few other countries. In several areas regional powers have now developed the capability for a creditable self defense against the power projection military forces of the major powers and their alliances.

Considerable attention in the United States had been focused on the balance of military forces between the United States and the Soviet Union, particularly since the mid-1970s. The strategic forces of the two sides are the easiest to compare because they are primarily aimed at each other. But even these are not very comparable because of differences in operational doctrine, likely war aims, force employment, and a number of other factors. When comparing conventional, chemical, and theater nuclear forces, a variety of other dissimilarities must be taken into account. These include the different geographical situations of the two powers: the Soviets have potential enemies on both borders; the United States is separated by thousands of miles of ocean from the places where it would need to employ its forces.

By almost any standard, however, the military capabilities of the Soviet Union, nuclear and conventional, are growing faster than those of the United States and its allies. Certainly the Western Alliance has been improving the quality and in some cases the quantity of its forces, but these increases have not begun to match Soviet force growth. This point is no longer disputed by most analysts. What is disputed is how many and what type of forces the Western Alliance needs in order to accomplish its purposes. Judging by military budget increases in recent years and by the larger increases planned for the coming years the United States government intends to increase its

military strength to meet the Soviet force expansion. But the question "how much is enough?" is a defense policy question which will be addressed in the following section of this paper.

National Expenditures. In military expenditures the Soviet Union and the United States, the leaders of the world's two major alliances, overshadow the other nations (see Figure 7). The Department of Defense estimated Soviet spending in 1980 at about \$200 billion, and United States spending at about \$125 billion. And while United States spending on defense has declined in real dollars since 1960, that of the Soviet Union has grown steadily and rapidly. Figure 8 compares Soviet and American spending over those years. Considerable controversy surrounds Western estimates of Soviet defense spending.* The Defense Department figures used here are about midway between the high and low figures. The trend line for the Soviet Union may be low, and the projection almost certainly is low. The United States Central Intelligence Agency now estimates real increases in Soviet defense spending at 4-5% per year, rather than 3%. Spending by America's NATO allies appears to cover the spending gap between the two alliances. However, the projections will not be realistic if the Soviets achieve more than 3% growth, and NATO continues to fall short of its target growth rate of 3% per year (see Figure 9).

The composition of defense spending by the two powers is also different. The major decline in American spending has been for general purpose and support forces, leading to the problems with projection forces and readiness that have surfaced in American armed forces in the past year. Soviet growth has been primarily in these two segments. In both countries, strategic forces have received about constant sums over the years. However, the Soviets have always spent a much larger percentage of their total defense budget on strategic forces -- more than three times as much in 1978. Cumulatively this has allowed them to fund the very large expansion and qualitative improvement programs of the 1970s (see Table II).

When we consider too that the gross national product of the United States is almost twice that of the Soviet Union, the magnitude of the national effort the Soviets are making comes into view. Figure 10 compares ten year trends in defense spending as a percentage of GNP for the NATO alliance, the Warsaw Pact, the United States, the Soviet Union, and China. If, as the CIA now believes, Soviet defense spending is growing at 4 or 5% rather than 3%, the Soviet trend line should bend upwards slightly. The steady decline in Chinese defense effort over this decade is also interesting, since Chinese distrust of its Soviet neighbor was presumably increasing.

*See, for example, W. T. Lee, The Estimation of Soviet Defense Expenditures, 1955-1975: An Unconventional Approach; and Air Force Magazine, December 1980, p. 70.

LEADING COUNTRIES IN MILITARY EXPENDITURES AND ARMED FORCES

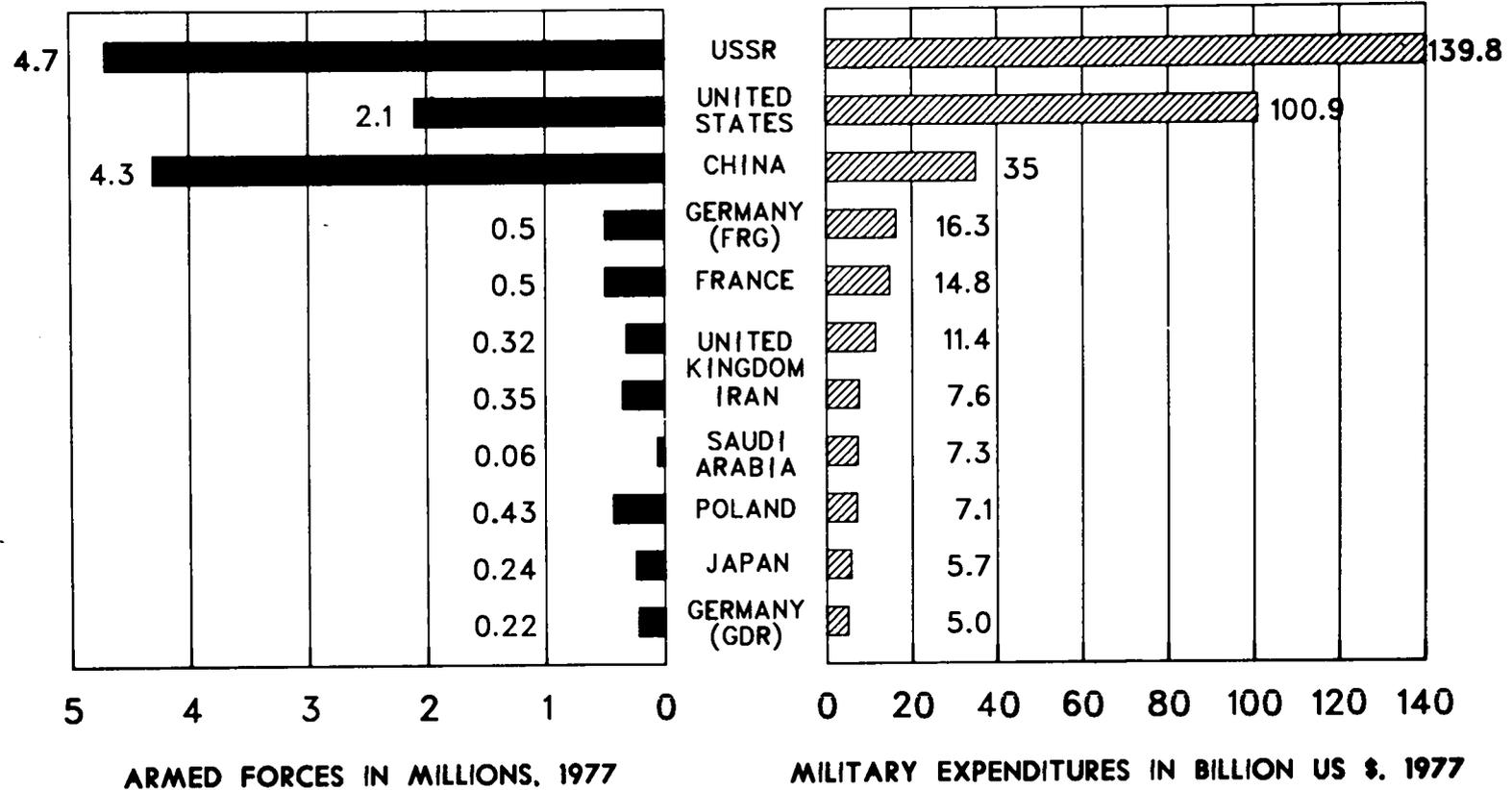


Figure 7

Source: U.S. Arms Control and Disarmament Agency, World Military Expenditures and Arms Transfers, 1968-1977.

COMPARISON OF U.S. DEFENSE OUTLAYS AND ESTIMATED
DOLLAR COST OF SOVIET DEFENSE PROGRAMS

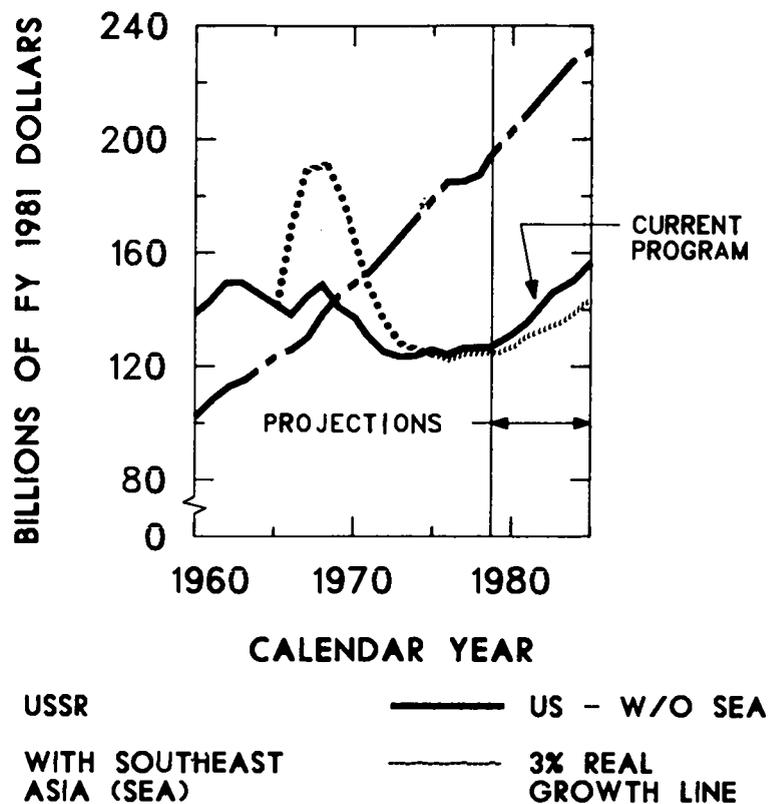


Figure 8

Source: Harold Brown, Department of Defense Annual Report, FY 1981.

COMPARISON OF NATO & WARSAW PACT TOTAL DEFENSE COSTS

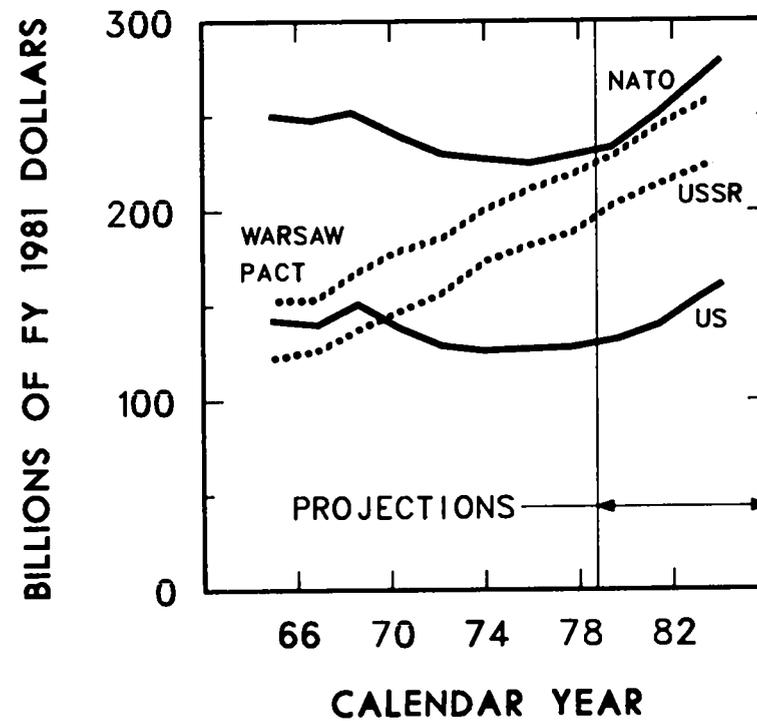


Figure 9

Source: Harold Brown, Department of Defense Annual Report, FY 1981.

MILITARY EXPENDITURES AS A % OF GNP, 1968-1978

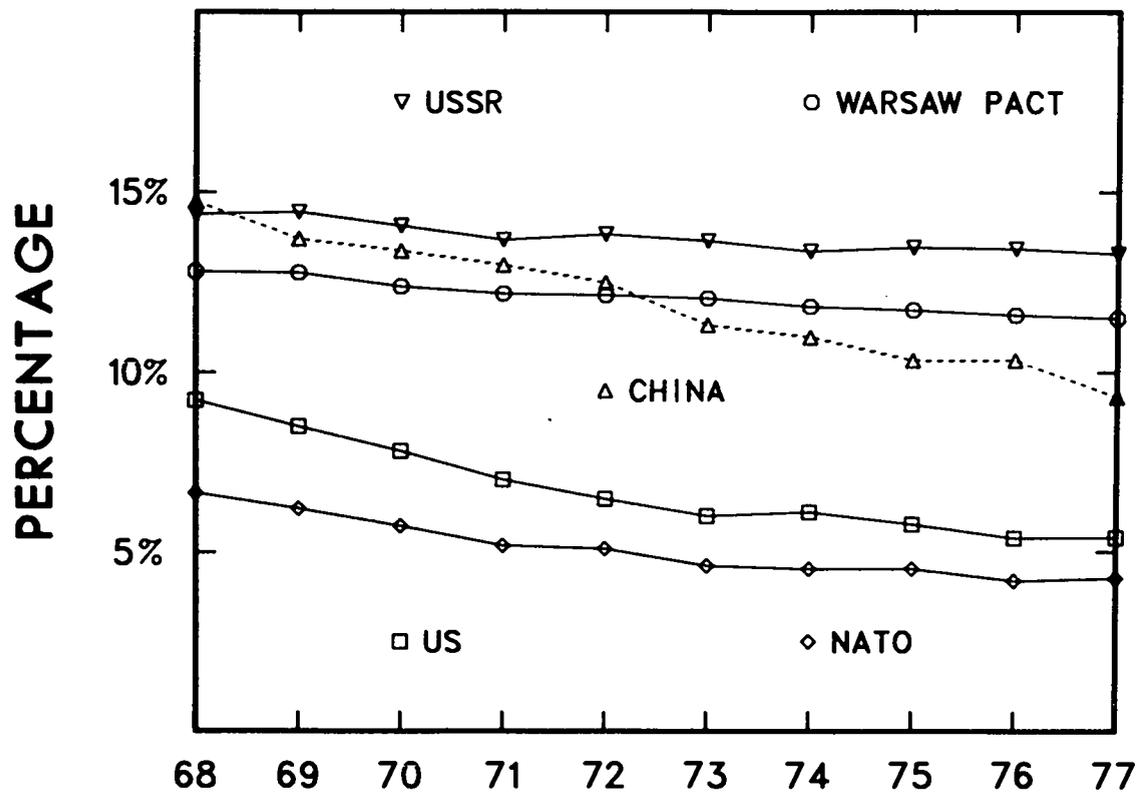


Figure 10

Source: U.S. Arms Control and Disarmament Agency, World Military Expenditures and Arms Transfers 1968-1977.

TABLE II
SOVIET DEFENSE MISSIONS AS A PERCENT OF COMPARABLE US DEFENSE OUTLAYS*

	1978	1968-78 Total
Strategic forces	330	270
General purpose forces	170	135
Support forces	95	70
Total (excluding RDT&E)	145	110

National Forces--Strategic Forces. Only China, France, the United Kingdom, the United States, and the Soviet Union possess independent nuclear arsenals. The number of theater and strategic nuclear delivery vehicles each country possessed in 1980 are seen in Figure 11.

Both France and the United Kingdom recently embarked on major modernization programs for their strategic nuclear forces. These forces of both countries appear to be designed primarily to deter nuclear attacks on their homelands. The new programs are intended to increase the reliability, survivability, and penetrability of those forces.**

The People's Republic of China first deployed medium-range nuclear missiles in 1970; it now has about 200 missiles able to strike the Soviet Union or targets in Asia. By 1980 the Chinese had completed testing an intercontinental range missile which could strike the United States, and they were thought to be developing a submarine-launched missile as well. But the number of these long range missiles is expected to remain quite small in relation to American inventories.+

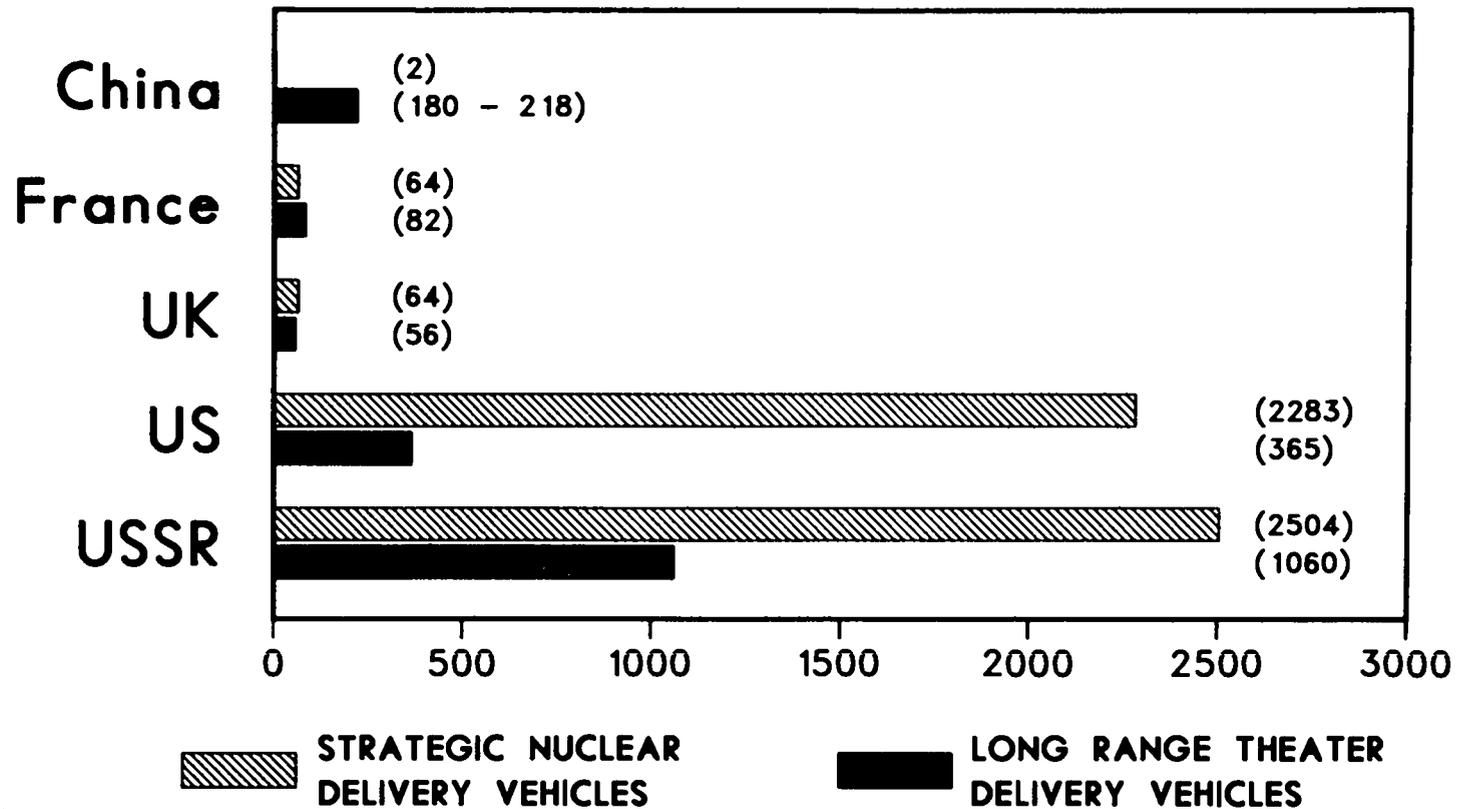
Trends in the balance of strategic nuclear forces between the United States and the Soviet Union are significant. The Soviets came from a position of substantial numerical and qualitative inferiority 15 years ago to reach parity in the mid-1970s and then to achieve superiority in most measures of strategic capability by the early 1980s. They deployed a new generation of strategic missiles beginning in 1974 and are now completing development of a fifth generation of missile systems. Much of the improvement in the Soviet Union's strategic position comes from its recent development of highly accurate, independently targetable warheads.

*Harold Brown, Department of Defense Annual Report, FY 1981. See also, "Soviet Military Spending Still Rising," International Defense Review, August 1980, p. 1185.

**Aviation Week and Space Technology, June 16, 1980, pp. 263-169; July 21, 1980, pp. 23-25; and July 28, 1980, pp. 15-16.

+International Defense Review, August 1980, pp. 1190-1192, and Aviation Week and Space Technology, August 25, 1980, pp. 16-17.

NUCLEAR DELIVERY VEHICLES, 1980*



*Missiles and bomber aircraft:
U.S. figure includes 225 B-52
aircraft in storage.

Figure 11

Source: Based on International Institute for Strategic
Studies, The Military Balance, 1980-1981.

Figure 12 shows changes since 1966 in the levels of major American and Soviet strategic forces. These figures do not indicate the impressive changes in force quality that have occurred during this period.

All of the Soviet fourth generation land-based ballistic missiles (SS-17, -18, and -19) have a multiple, independently-targetable warhead capability and sufficient yield and accuracy to be hard-target killers -- that is, they can destroy United States ballistic missile silos with high confidence. The range of Soviet submarine-launched ballistic missiles has been increased, and the Soviets have introduced independently-targetable multiple warheads on one submarine-launched missile. The United States has introduced a small number (450) of hard-target capable, multiple-warhead ballistic missiles (Minuteman III), and has several multiple warhead submarine-launched missiles as well.

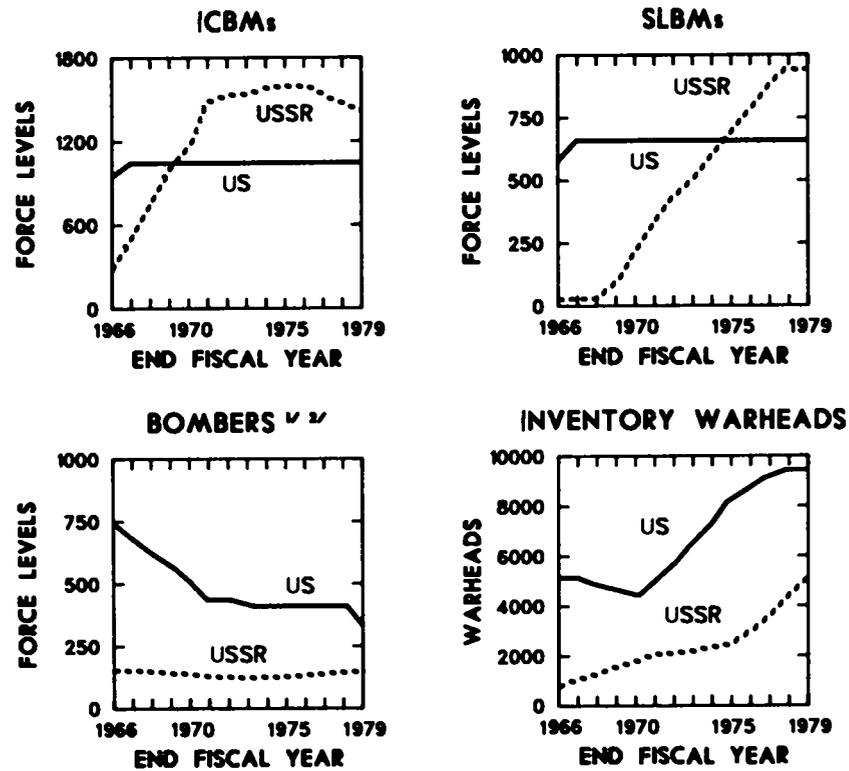
Figure 13, estimating numbers of hard target killers, illustrates the superior Soviet capability for quick destruction of hardened military targets, a superiority developed over several years. Land-based ballistic missiles, which account for the larger part of the launchers, warheads, and warhead weight of Soviet strategic nuclear systems, are the key to the Soviets' quick-destruction capability. The larger part of the American force, on the other hand, is currently in submarine launched missiles and heavy bombers (see Figure 14). The present American submarine-launched missiles have limited potential against hardened military targets because of their small yields and rather poor accuracies. Our bombers can destroy such targets after a long flight over Soviet territory. But whether these manned aircraft could survive a Soviet pre-emptive strike and overcome Soviet air defenses is doubtful. The composition of American forces reflects the United States tendency to limit the size of its capability against hardened Soviet military targets, including land-based missiles. Recently announced alterations in American strategic doctrine may lead to an increase in such weapons in the United States arsenal.

The United States has planned a number of strategic force additions and improvements which are designed to close the strategic nuclear gap that has emerged, and re-establish parity at about SALT II levels. If completed as planned, these additions will begin to close the "window of opportunity" created by Soviet strategic superiority by about 1987 -- assuming American estimates of Soviet intentions are accurate.

American and Soviet strategic defensive forces also reflect the different concerns of the two nations. Ballistic missile defensive forces of both nations are currently limited by the Anti-Ballistic Missile Treaty of 1972. That treaty is due for review in 1982. Both countries are allowed one missile defense network of up to 100 interceptors. The United States has dismantled its one site, leaving only the attack characterization radar in operation. The United States does, however, maintain a fairly comprehensive network of early warning sensors against Soviet ballistic missile attack.

The Soviet Union has retained one site defending Moscow, employing rather aged Galosh high altitude interceptors. Reports indicate that the system has recently been reduced from 64 to 32 interceptor missiles. Development of

CHANGES IN US/USSR STRATEGIC LEVELS

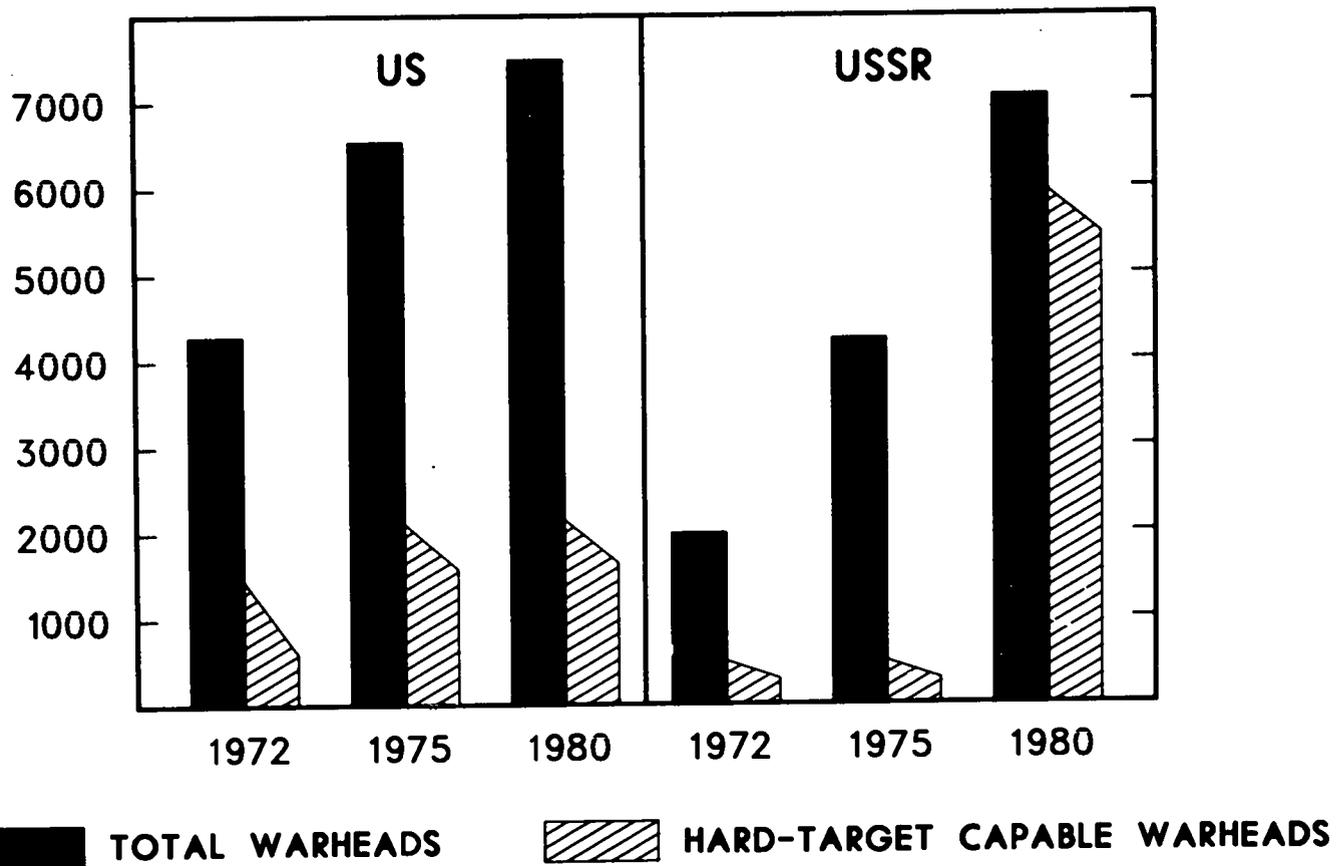


1/ FB-111 and BACKFIRE are excluded
 2/ Excludes approximately 220 B-52s in deep storage

Figure 12

Source: Harold Brown, Department of Defense Annual Report, FY 1981.

**NUMBER OF TOTAL SOFT AND HARD-TARGET
WARHEADS ON ICBMs AND SLBMs: 1972-1980***



37

*Hard target warheads are those with a CEP \leq lethal radius. U.S. silos are calculated at 300 and 1500 psi, Soviet at 500, 1000, and 3000 psi.

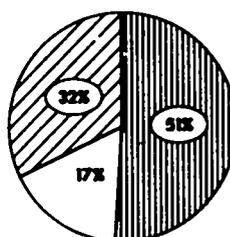
Figure 13

Source: Missile and silo characteristics are from Roger D. Speed, Strategic Deterrence in the 1980s.

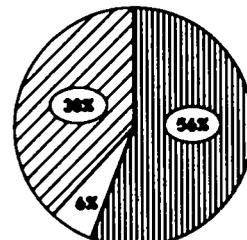
1980 COMPOSITION OF U.S. AND SOVIET FORCES

MISSILE LAUNCHERS & HEAVY BOMBERS.

1/ The number 2283 includes approximately 220 B-52s in deep storage, but these bombers are not considered in the chart percentages.

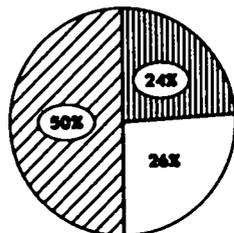


2283^{1/}
U.S.

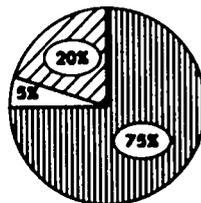


2504
USSR

TOTAL WARHEADS

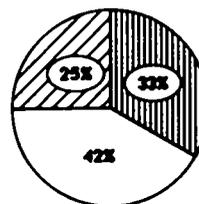


9200
U.S.

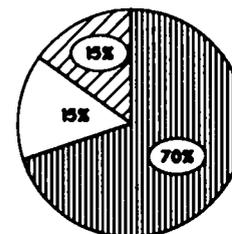


6000
USSR

THROW-WEIGHT



7.2 Million Lbs.
U.S.



11.8 Million Lbs.
USSR

Figure 14

Source: Harold Brown, Department of Defense Annual Report, FY 1981.

anti-ballistic missile technology is proceeding in both countries. We have had reports of Soviet tests of new interceptor missiles, air defense radars in anti-missile modes, and directed energy weapons for ballistic missile defense applications.* The United States is continuing technology development of low- and high-altitude interceptor missiles, and directed energy weapons, but has refrained from system development or prototyping.

Following the signing of the Anti-Ballistic Missile Treaty the United States allowed its strategic air defenses to continue to decline from their already low levels. Current United States air defenses consist of 108 active Air Force and 273 Air National Guard interceptors, and some modern Tactical Air Command fighters that may be diverted to this role. United States air warning assets are aging. Over-the-Horizon-B radars which can detect low-level attackers are not yet deployed, and the older high-altitude radar coverage has many gaps. American plans are to augment present radar coverage with Airborne Warning and Control aircraft in times of emergency.

Soviet air defense assets are compared with those of the United States in Figure 15. The Soviets currently deploy 2,725 interceptor aircraft and 9,300 surface-to-air missiles for the defense mission.** They have a very large network of ground based radars, and supplement it with the limited air warning capability of their MOSS aircraft. They are also deploying a "look-down, shoot-down" capability on some interceptor aircraft to fill the low altitude gap in their strategic air defense.

Command, control, communications, and intelligence (C³I) requirements for strategic forces are particularly exacting because of the unprecedented requirements of nuclear war. Nuclear warfighting requires the ability to communicate with and command nuclear forces, possibly in an environment of nuclear explosions with their severe effects, and to communicate with one's adversary to control or terminate the war. The nation that strikes first may avoid some of the degradation of command and control at least for the initial phase of the war.

United States policy is to be able to absorb any first nuclear strike and be able to reply in a restrained and appropriate way. Consequently the Secretary of Defense recently said that "the survivability, flexibility, and endurance of the C³I systems should be at least comparable with that of our strategic forces. . . . At present, our ability to meet these objectives falls considerably short."† We are now pursuing a number of programs to improve the survivability of our strategic nuclear forces.

Theater Nuclear Forces. All five of the world's present nuclear powers have theater nuclear forces (see Figure 11). The theater nuclear forces of

*See Goure, Hyland, and Gray, The Emerging Strategic Environment: Implications for Ballistic Missile Defense, pp. 19-26.

**John Collins, U.S.-Soviet Military Balance, 1960-1980, pp. 463-466.

†Harold Brown, DoD Annual Report FY 1981.

AIR DEFENSE FORCES

Statistical Summary - 1977

40

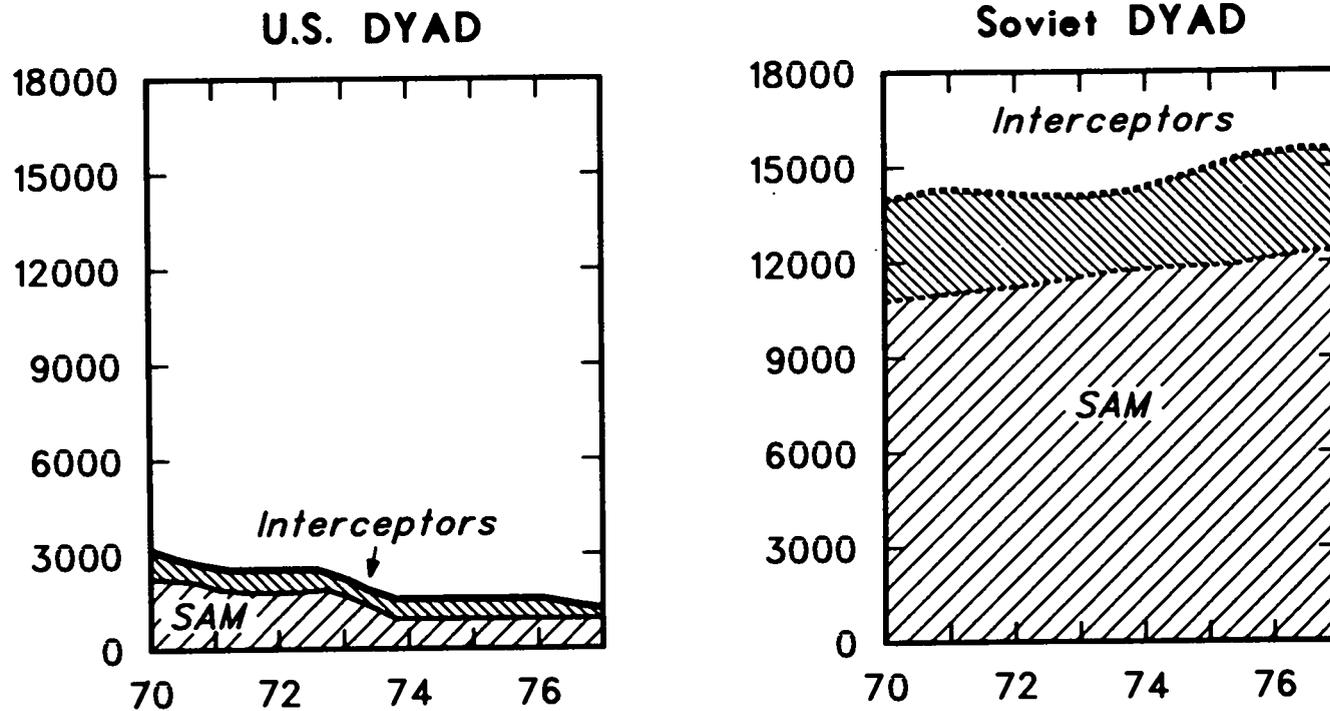


Figure 15

Source: Harold Brown, U.S. Department of Defense Annual Report, FY 1981.

Britain and France are so small as to pose only a limited retaliatory threat, while the larger forces of China are still overshadowed by Soviet theater nuclear forces in the Sino-Soviet border region.

The balance and trends of NATO and Warsaw Pact theater nuclear forces in Europe has been much discussed recently. The Soviets have been deploying the new SS-20, -21, -22, and -23 missiles, and the Backfire bomber. NATO has agreed to deploy new long-range nuclear systems able to reach into the Soviet Union (Pershing II ballistic missile and the Ground Launched Cruise Missile). These deployments and plans have set off a major debate on NATO defense strategy.

NATO defense was long predicated (at least in theory) on the early and effective use of theater nuclear weapons to stop a Soviet breakthrough, and failing that, on the central strategic deterrent of the United States. Strategic force trends have, over time, reduced the credibility of American escalation to central nuclear war to redress impending defeat in Europe.* The balance and trends in theater nuclear weapons are similarly disadvantageous to the United States. In terms of both theater nuclear weapons and delivery systems the Warsaw Pact outnumbered NATO in 1980. Recent analyses by the International Institute of Strategic Studies, which assess the utility, survivability, reliability, and penetrability of the various systems of both sides, show that system utility figures favor the Warsaw Pact in 1980 by almost three to one. Only if Poseidon submarine-launched missiles are added to the totals (and a few Poseidons are allocated to the allied supreme commander in Europe) does NATO begin to approach the Pact figures.** Figure 16, which shows Defense Department projections of growth in United States and Soviet theater nuclear weapons, indicates that the Soviet advantage will continue to grow, despite our modernization program.

Chemical and Biological Warfare. Although the first use of chemical weapons is formally banned by the 1925 Geneva Protocol, numerous reports indicate that the Soviet Union has used lethal chemical weapons in Afghanistan. Other reports suggest that the Vietnamese used similar, Soviet-supplied weapons in Laos and perhaps Kampuchea.†

The Soviet Union is believed to possess a very large chemical warfare stockpile. It may be up to eight times as large as that of the United States. Half of the Soviet munitions in Europe may be filled with chemicals. The Soviets have about five times as many chemical delivery systems as the US, and on the order of 80,000 to 100,000 chemical troops, as opposed to 2,200 for the United States.††

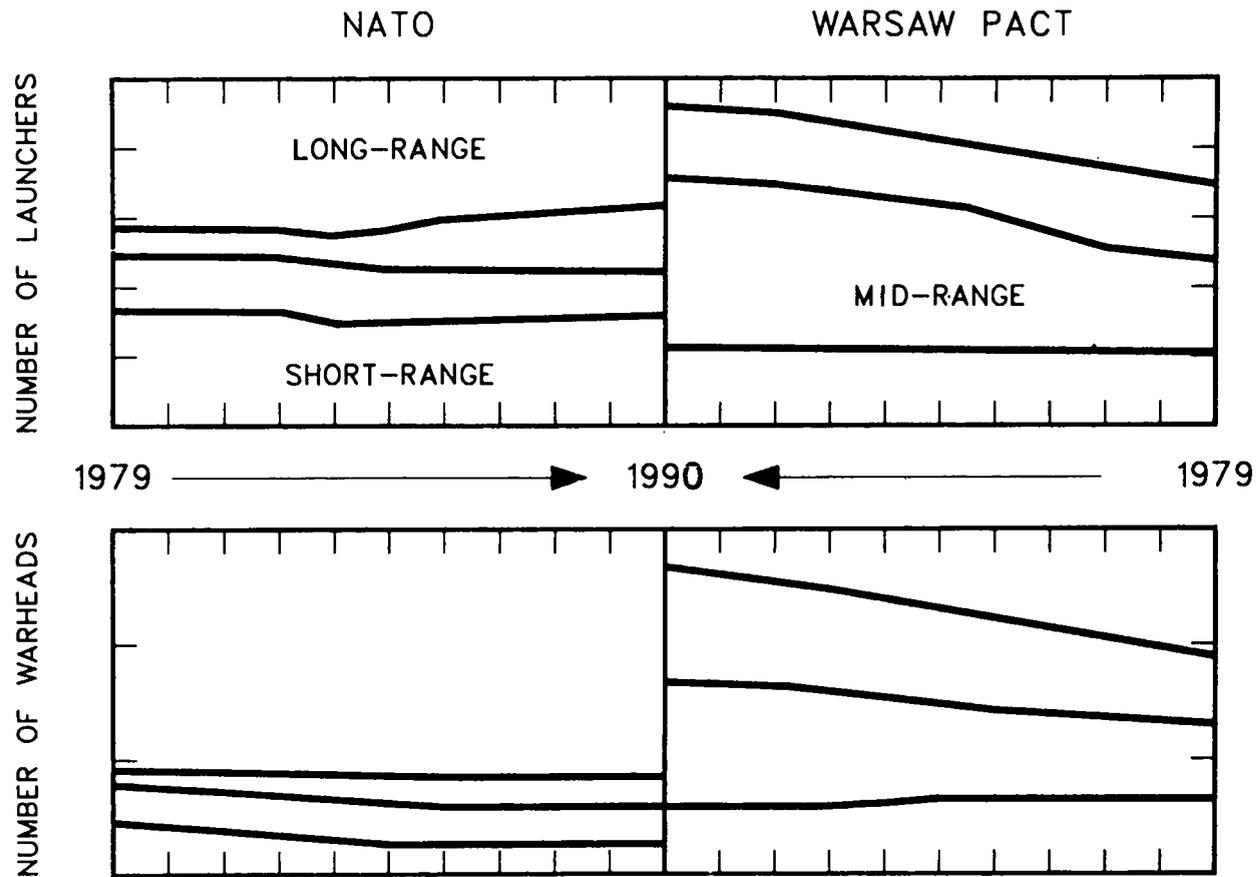
*See the speech by Henry Kissinger to a NATO conference in Brussels, 1 Sept. 1979, and the response by European officials and newspapers.

**Compare "The Balance of Theater Nuclear Forces in Europe," in IISS, Military Balance, for 1979-80, and 1980-81.

†"State Dept. Wants UN Probe of Soviet Chemical War Use," Albuquerque Journal, April 25, 1980, p. A-8.

††"CB Winds of Change," Defense and Foreign Affairs, July 1980.

TRENDS in THEATER NUCLEAR FORCES LAUNCHER BALANCE



TRENDS in THEATER NUCLEAR FORCES WARHEAD BALANCE

Figure 16

Source: William Perry, FY 1981 Department of Defense Program for Research, Development, and Acquisition.

Although the Soviet Union has denied that it possesses or intends to use chemical weapons, some analysts think that the Soviets would not hesitate to use them where they would be tactically advantageous. Most such employments would probably be for tactical operations -- suppressing anti-tank defenses, neutralizing airbases and nuclear weapons storage facilities, and preparing for breakthroughs. In conditions where nuclear strikes are ruled out, chemical attacks could also be used for disabling larger urban targets such as ports and command and control centers.*

The American response will be to increase substantially its chemical defense equipment procurement, and research and development. In addition, both the United States and France hope to deter Soviet use of chemical weapons by retaining a capability to retaliate. In 1980 Congress authorized the production of binary nerve gas and new chemical munitions, the first such production since 1969, but most of the funds for the new plant were finally cut from the budget.

The United States and the Soviet Union are parties to a 1972 Convention that bans the development of biological weapons. In 1969 the United States destroyed its biological weapon stocks, thinking they had little operational utility. However, unconfirmed reports indicated that in March, 1979 the Soviets had a biological weapon accident near the city of Sverdlovsk. The release of "weapons-strain" anthrax at a nearby military village reportedly killed hundreds of people. Other biological agent accidents have been suggested since.** The Soviets denied that the Sverdlovsk incident involved biological warfare agents. Little else has been revealed about Soviet biological warfare capabilities or intentions.

Conventional Forces. Conventional forces (or general purpose forces) may be used for a wide range of military operations, including combat on a nuclear battlefield; limited, conventional, theater wars; and commando or clandestine operations.

Conventional forces in the Third World almost certainly have been growing in relation to the developed world. Libya, Saudi Arabia, Iran (before the revolution), Taiwan, and Vietnam are examples of nations which have developed important conventional military forces. In all cases, however, these forces are restricted to national defense tasks or regional offensive operations. In several cases they have become large enough and sophisticated enough to pose a major obstacle to conventional offensive operations by the projection forces of the major powers.

Comparison of United States and Soviet spending on general purpose forces (Figure 17) shows that a large gap has developed since the late 1960s. Except

*John Erickson, "The Soviet Union's Growing Arsenal of Chemical Warfare," Strategic Review, Fall 1979.

**"Incident at Military Village No. 19," Nature Vol. 284, 27 March 1980.

GENERAL PURPOSE FORCES

A COMPARISON of OUTLAYS WITH ESTIMATED DOLLAR COSTS of SOVIET ACTIVITIES

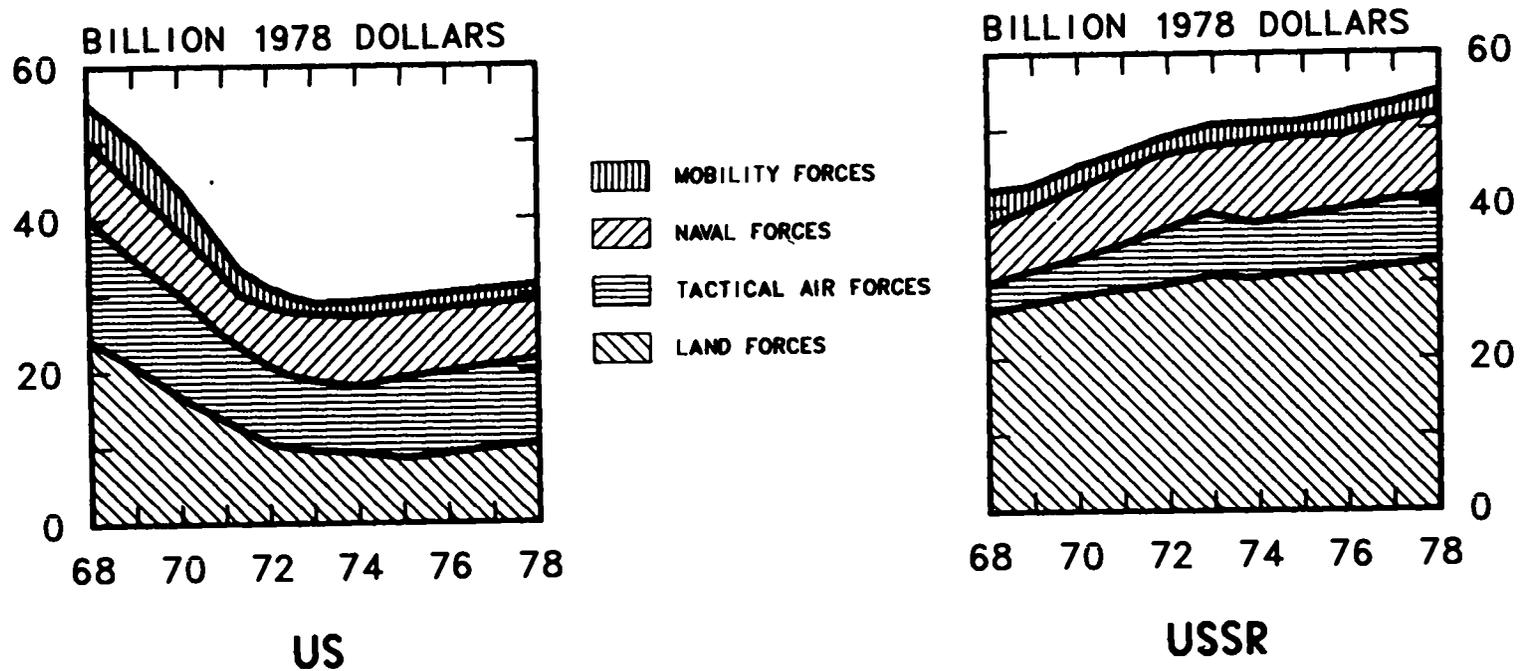


Figure 17

Source: Harold Brown, Department of Defense Annual Report, FY 1981.

for high-mobility forces, spending on all conventional Soviet forces has grown during this period. Soviet spending on general purpose forces by 1978 was nearly twice that of the United States. The major decline in United States spending has been on ground and high-mobility forces. Much attention is given in the 1981 budget to improving the capabilities of the high-mobility forces of the United States. General purpose force requirements of the two superpowers are, however, very different. This may explain some of the difference in levels of general purpose forces, if not the trends. The Soviets maintain forces to fight simultaneously in Europe and on the Sino-Soviet border. The United States maintains forces for the European theater, plus mobile forces for less-massive overseas commitments.

Figures 18a and 18b compare the present status and recent trends in general purpose forces of the United States, the Soviet Union, and their principal allies in the European theater. Again, there is a marked increase in Soviet and Pact forces over recent years, which is not matched by United States or NATO forces. These data compare only measurable factors, but various strengths and weaknesses may be experienced by either alliance under the threat of war. However, various NATO observers fear that, because of deployments, lack of operational depth, and low readiness the NATO front could readily be penetrated by an unanticipated Soviet attack using only conventional forces plus chemical weapons.

Figure 19 compares differences in average annual production of major military equipment by the Warsaw Pact and NATO nations, from 1974 to 1979. Cumulatively, these advantages result in very large Pact superiority in equipment holdings over the years.

The general trend towards greater Soviet comparative military capability is evident in ground, air, and naval forces. Comparison of Soviet and American ground force maneuver units since 1970 shows a gradual buildup of Soviet divisions to 90 in 1980, while American divisions have remained at no more than 19. Separate United States brigades and regiments have fallen in number by one third. It must be emphasized that Soviet and American combat units are dissimilar. Soviet units are smaller, with less logistical "tail" but more firepower. The Soviets have increased the size and heavy combat firepower of their divisions over the past several years. Soviet and American ground force deployments, showing the heavy Soviet commitment to the European and Asian fronts, are shown in Figure 20.

Military manpower is the material from which conventional forces are built. Figure 21 shows manpower reaching military age annually in selected countries. The Soviets utilize a very high percentage of this manpower as trained reserves. Trends indicate that they may have trouble in future years finding adequate manpower for their very large active and reserve forces. The manpower pool may fall short as early as 1985.*

*See John Collins, U.S.- Soviet Military Balance, 1960-1980. pp. 95-97.

TRENDS in GENERAL PURPOSE FORCES in EUROPE, 1970 - 1980

NORTH and CENTRAL EUROPE

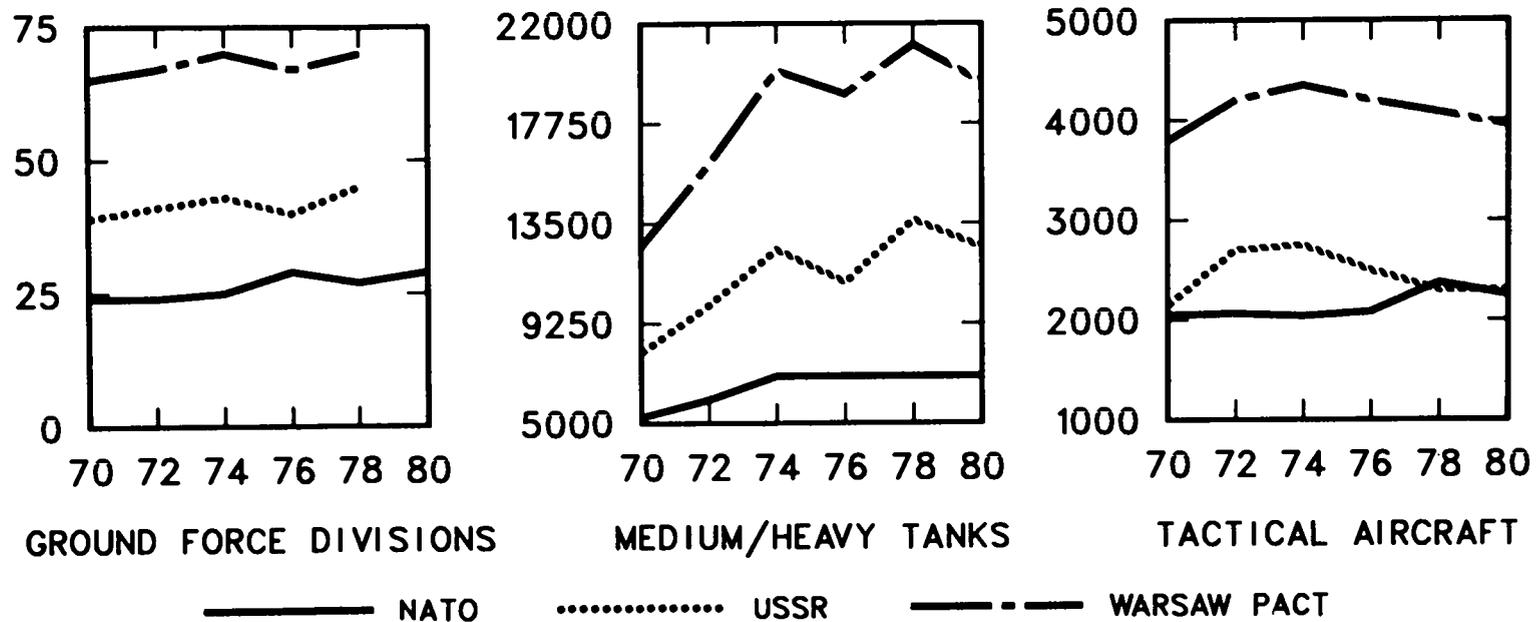


Figure 18a

Source: International Institute for Strategic Studies, Military Balance, 1969-70 to 1979-80.

TRENDS in GENERAL PURPOSE FORCES in EUROPE, 1970 - 1980

SOUTHERN EUROPE

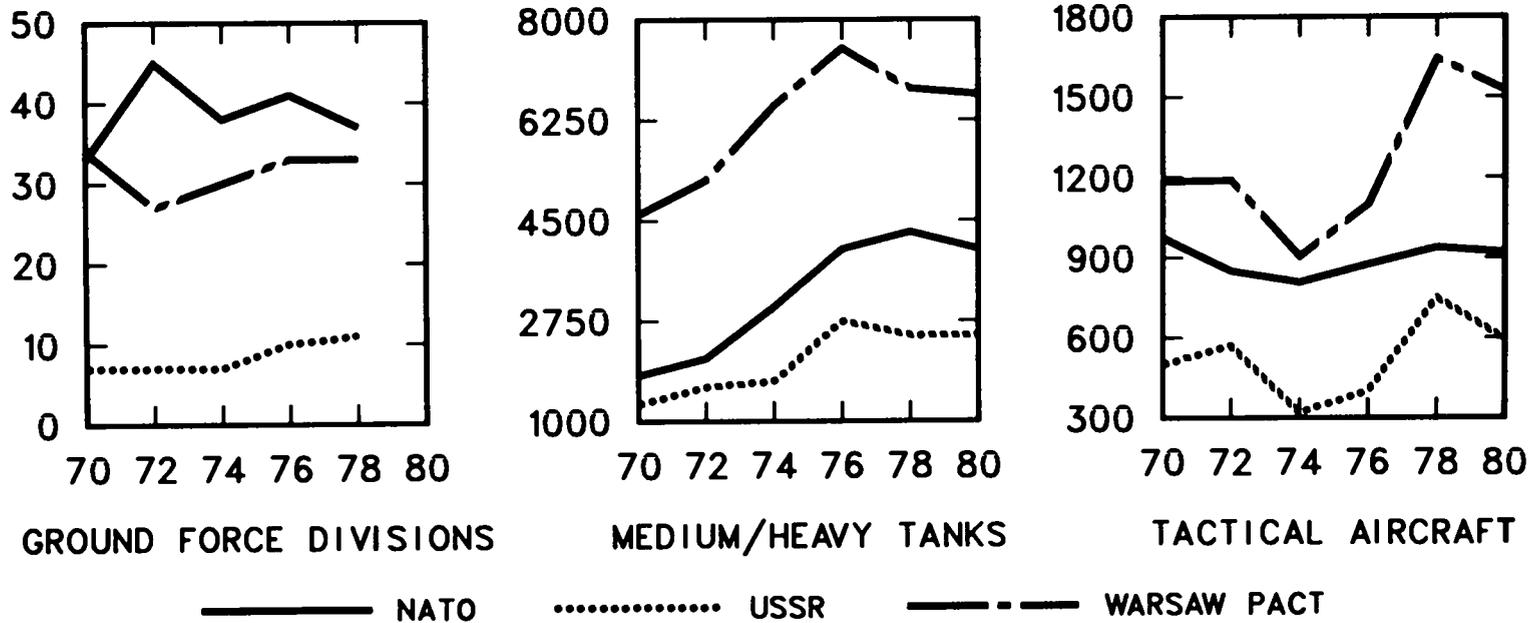


Figure 18b

Source: International Institute for Strategic Studies, Military Balance, 1969-70 to 1979-80.

RATIO of 1974-1979 AVERAGE ANNUAL PRODUCTION of SELECTED WEAPONS by WP and NATO COUNTRIES

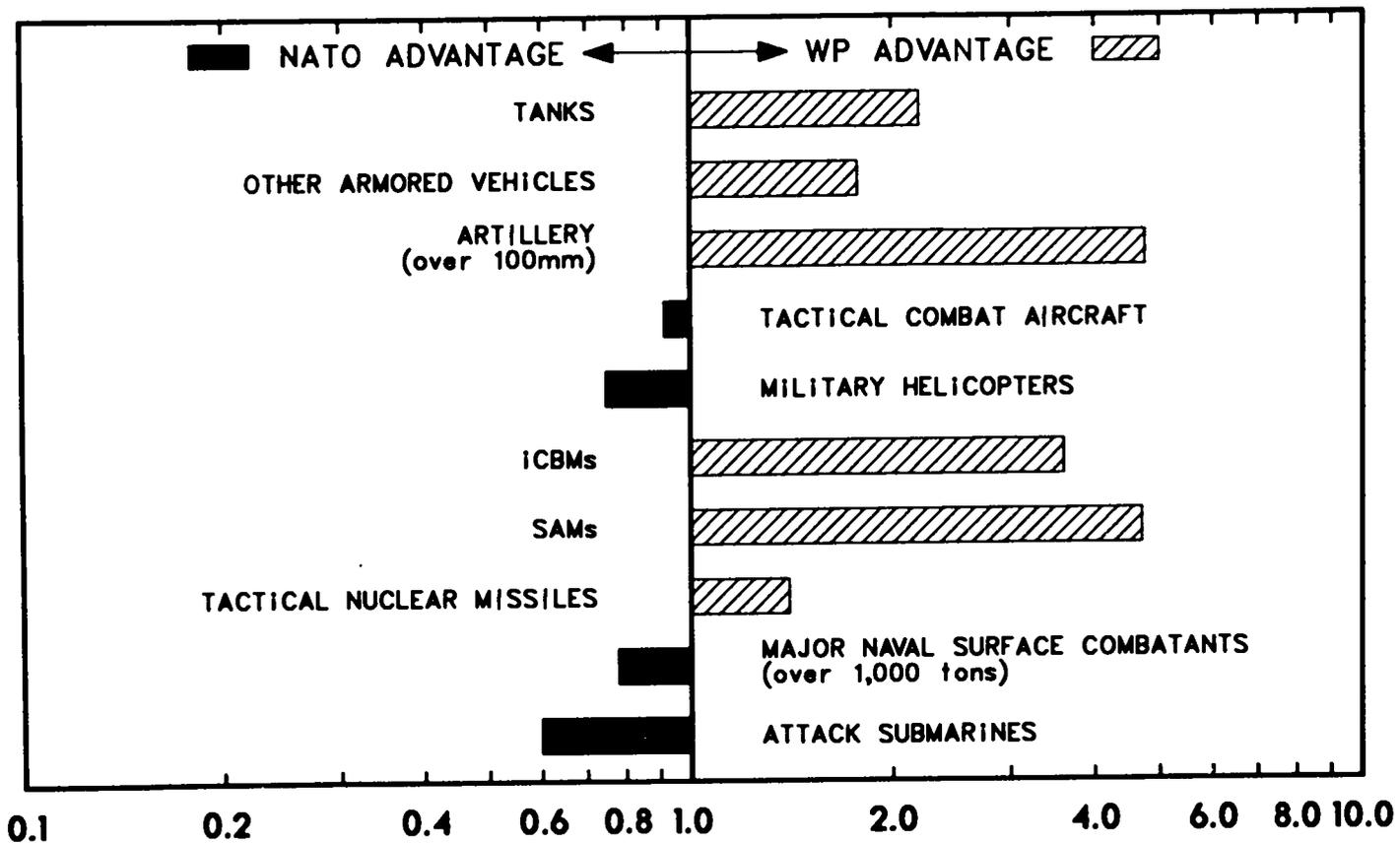
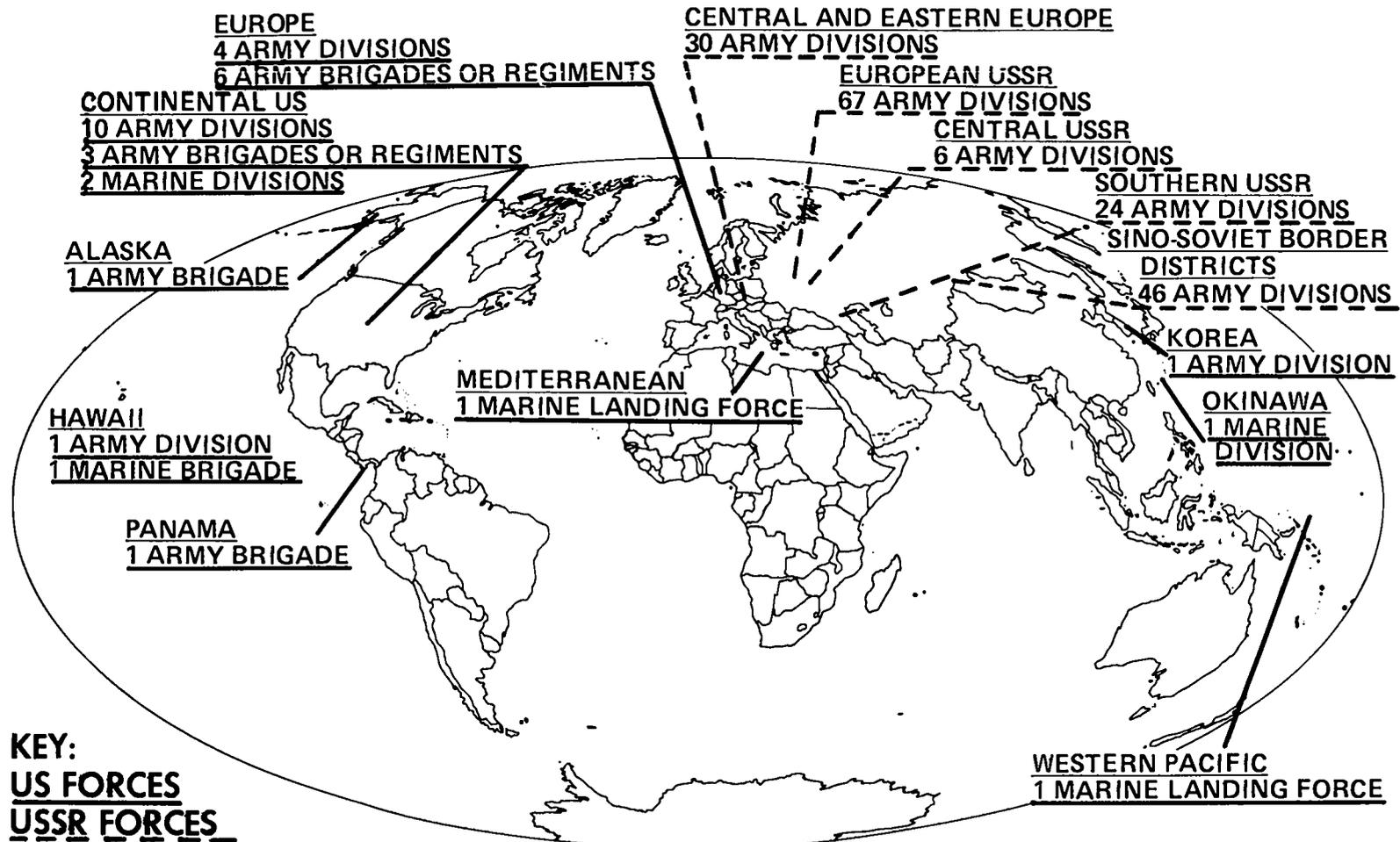


Figure 19

Source: William Perry, FY 1981 Department of Defense Program for Research, Development, and Acquisition.

US AND USSR GROUND FORCES DEPLOYMENTS, 1979



49

Sources: General David. C. Jones, United States Military Posture for FY 1980; John Collins, U.S.-Soviet Military Balance Since the Cuban Missile Crisis; International Institute for Strategic Studies, The Military Balance, 1980-1981.

Figure 20

MANPOWER REACHING MILITARY AGE ANNUALLY

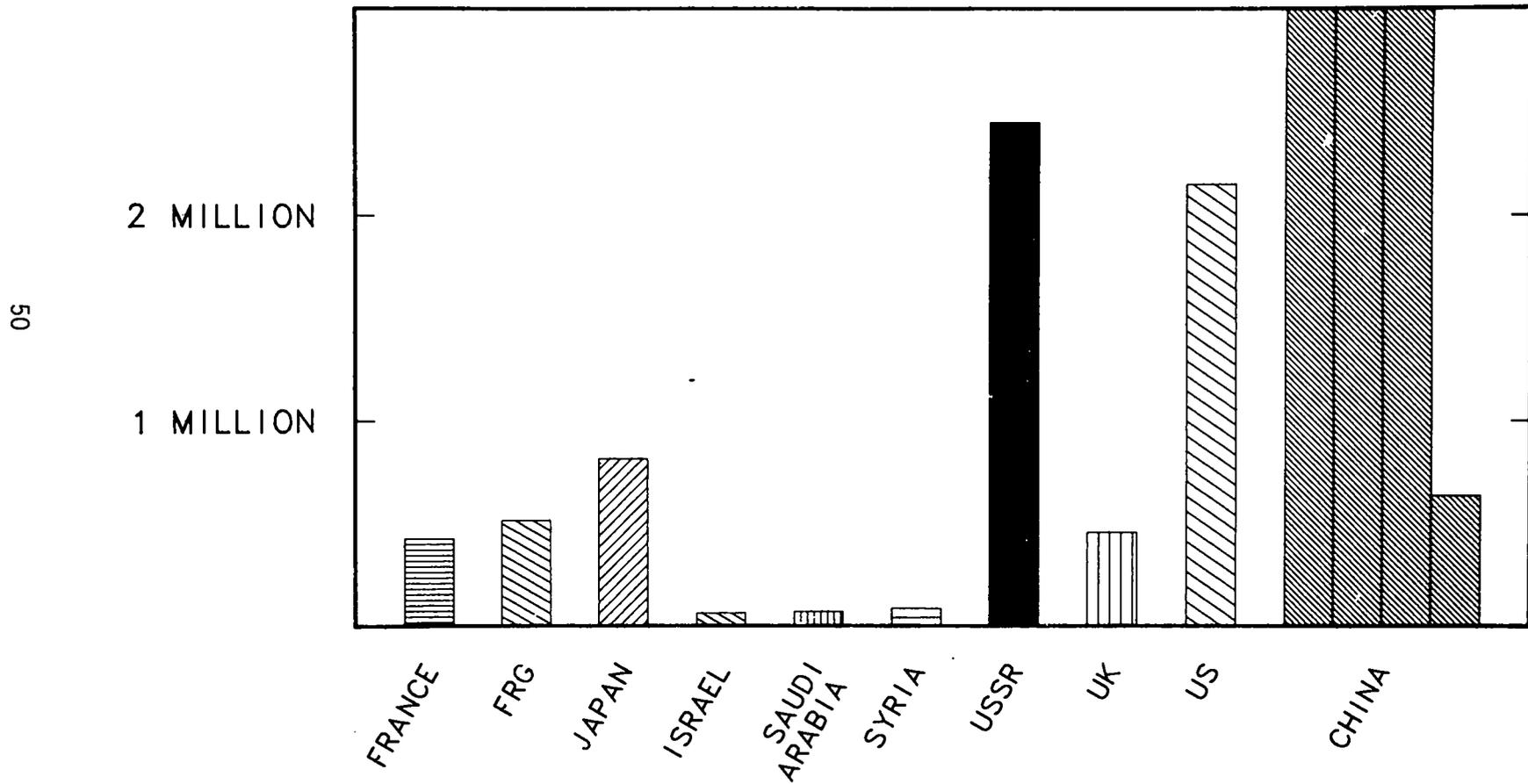


Figure 21

The composition of the future Soviet population also may present a serious problem to Soviet military leadership.* Of necessity the non-Russian republics will become the largest incremental source of able-bodied manpower in both civilian and military sectors. This manpower will consist primarily of rudimentarily-educated Moslems who lack fluency in Russian, lack the technical skills for both Soviet industry and military, and are considered ethnically inferior by the dominant Russian group. Table III indicates the high growth rates of Soviet non-Russian populations.

TABLE III
GROWTH OF ETHNIC POPULATIONS
IN THE SOVIET UNION

Demographic statistics for the USSR by republic and region 1950-2000^a

		<u>1950</u>	<u>1960</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>
Russia (RSFSR) ^b	Increase (%)	16.8	15.8	5.9	6.5	2.4	0.1
Transcaucasia (Georgia and Armenia)	Increase	19.4	28.0	17.4	18.1	17.6	14.2
Kazakhstan	Increase	25.9	30.6	17.4	19.3	17.6	14.2
Central Asia Republic	Increase	22.9	32.6	27.3	30.5	32.3	29.1

^aFeshback and Rapowy, "Soviet Population and Manpower Trends and Policies," in Soviet Economy in a New Perspective, p. 123.

^bRSFSR - Russian Soviet Federated Socialist Republic.

*See, for example, Lt. Col. Dalace Meehan, "Ethnic Minorities in the Soviet Military--Implications for the Decade Ahead," in Air University Review, May-June 1980.

Trained reserves comprise the near-term surge capacity of ground forces. They are particularly important for a slow buildup in tensions where mobilization of military potential is possible, or in the event of a protracted war. The large numbers of reservists in the Soviet Union make it possible for that nation to fill out quickly its reserve divisions for deployment -- as was done in the case of the invasion of Afghanistan. Over the past ten years Soviet reserve divisions have grown from 74 to 83, while the United States has maintained 9 reserve divisions and 25 separate brigades and regiments.

The Soviet Union possesses almost twice as many tactical air combat aircraft as does the United States and the gap has been growing in recent years as a result of additions to the Soviet air fleet. American aircraft generally have been superior to Soviet aircraft in the past and the most recent American aircraft also are considered superior to their Soviet counterparts. The Soviets, however, have deployed more of their new aircraft. They have also been shifting away from a very heavy proportion of air defense interceptors and toward ground support and interdiction aircraft.

The composition of naval forces is peculiarly tailored to the international requirements of individual nations. The United States, for example, must have naval forces which can keep open the sea lanes to Europe in times of crisis if it is to carry out its responsibility of reinforcing NATO ground forces. A powerful Soviet interest supported by appropriate naval forces may be to deny this ability to the United States. Figure 22a shows current United States and Soviet naval deployments. Other nations may see different prime responsibilities of their naval forces, for example repelling seaborne attack. As a consequence, statistical comparisons of naval assets between nations are of limited use.

On the average, the Soviet Navy is composed of much newer ships than the United States Navy. Like Soviet ground forces, however, the Soviet Navy lacks an extensive logistic infrastructure of the type the United States employs. As a result, it may be less flexible in utilization. Overall, the Soviet fleet is growing, while that of the United States has shrunk very rapidly. The composition of the Soviet fleet has changed as well. In the last few years the Soviets have deployed their first two antisubmarine aircraft carriers and a third is on the way. In 1980 they launched their largest surface combatant, a heavy missile cruiser in the 35,000 ton class.* Also in 1980 they launched their first Typhoon-class ballistic missile submarine which displaces about 30,000 tons, making it nearly twice the size of the largest American missile submarine, the new Trident. Finally, in 1980 the Soviets launched the first Oscar-class cruise missile submarine of about 30,000 tons, which at 55 knots is also the fastest submarine at sea.** Together, these

*A description of the massive armament on the Kirov is in International Defense Review, August 1980, p. 1185.

**Air Force Magazine, December 1980, p. 26.

US AND USSR NAVAL DEPLOYMENTS, 1979

53

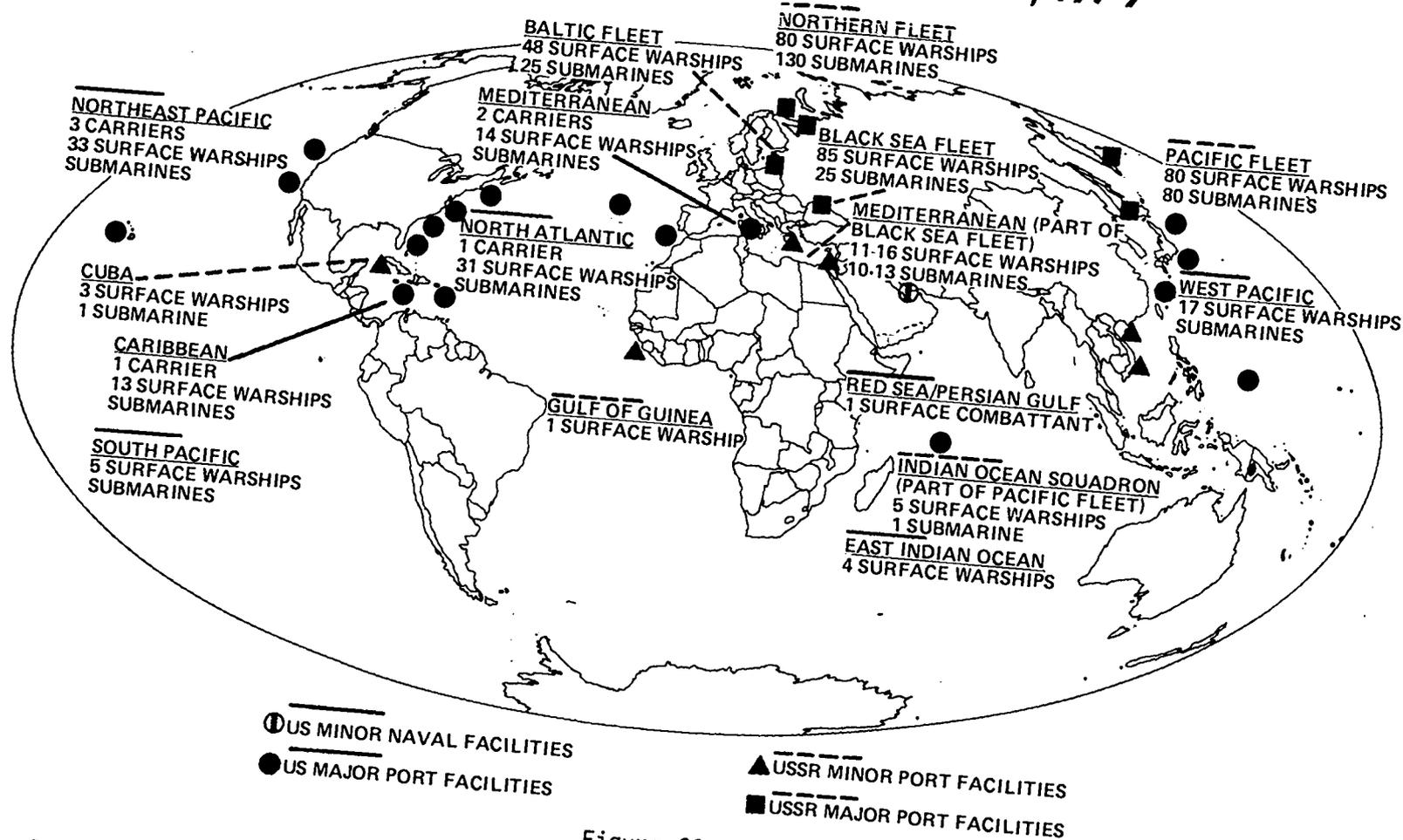


Figure 22a

Sources: General David C. Jones, *United States Military Posture for FY 1980*; John Collins, *U.S.-Soviet Military Balance Since the Cuban Missile Crisis*; International Institute for Strategic Studies, *The Military Balance, 1980-1981*.

developments indicate the qualitative improvements in the Soviet fleet that have moved it well beyond its former status as a coastal protection force. Naval analysts now perceive the Soviet navy as posing a serious threat to the United States Navy in the Mediterranean, the northern Pacific Ocean, and the Indian Ocean.

Technology Balance. For many years the Western allies have relied on the technological superiority of their military equipment to make up for Soviet superiority in numbers. Most of the trends noted above indicate that the numerical gap continues to grow steadily. Technological quality is difficult to measure but it is clear that the Soviet Union is spending more money on military research and development than is the United States. In a number of areas of military technology and in many types of military equipment, the Soviet Union is now superior to the United States. In many other areas, the Soviet Union is rapidly closing the technological gap.

Table IV shows two different attempts to assess the technological balance between the United States and the Soviet Union. Both indicate that the Soviets have done much to eliminate the Western technological advantage. Figure 22b shows the ten-year trend, and a five-year projection of American and Soviet defense spending on military research and development. These data and projections do not take into account American research and development in private industry which often proves to have defense applications, nor do they consider the research and development efforts of the NATO allies, which are not matched by Soviet Warsaw Pact allies.

Ideology and Religions

Nationalism and religious fanaticism, as well as the more familiar political ideologies such as Communism, are some of the forms in which highly organized sets of ideas currently are transmitted into the lives and actions of nations. For some nations ideology and religion remain essentially peripheral and unimportant. For others they constitute a central determinant of national behavior, as in the cases of Nazi Germany in the 1930s and Iran in 1979. In the present world, ideology and religion are prominent, often destabilizing factors affecting the relations among states.

Trends and Developments--Free World Ideology. Ideology was one of several elements that contributed to the decline in national assertiveness and military capability that occurred among most Western nations during the 1960s and early 1970s. The most pervasive forms of anti-establishment ideology in Western nations were one or another form of Marxist-Leninist (but not necessarily Communist) thought and the even more radical anti-capitalist and anti-bourgeois Marxism. Holders of these ideologies directed a persistent attack upon the American defense and foreign policies of that period. This ideological critique combined with the much larger body of public opinion which opposed American policy on non-ideological grounds to encourage the United States to draw back from its forward posture overseas in the 1960s and early 1970s. The lingering effects of this retrenchment prevented any speedy response on the part of the United States to the buildup and eventual expression of Soviet power in the mid- to late-1970s.

TABLE IV
TWO ESTIMATES OF THE US-USSR TECHNOLOGICAL BALANCE†

General	Specific	Basic Technology Areas	Technology Level in Deployed Systems
United States Clearly Superior		United States Clearly Superior	
"Black box" electronics Computers Integrated circuits Microtechnology Night vision Small turbofan engines Space technology Submarine noise suppressants Terrain-following radar	Aircraft Air-to-air missiles Artillery ammunition ECM, ECCM Look-down shoot-down systems Precision-guided munitions Remotely piloted vehicles Strategic cruise missiles Survivable submarines	Automated Control Computer Military instrumentation Electro-optical sensor Hydro-acoustic Intelligence sensor Manufacturing Signal processing Software Telecommunications	Bomber Fighter/attack aircraft Air-to-air missiles Precision guided munitions Air lift
Soviets Closing Gap		Soviets Closing Gap	
Aerodynamics Composite materials Inertial instrumentation	MIRVs Missile accuracy Satellite sensors Tactical nuclear systems	Guidance and Navigation Materials (light weight and high strength) Optics Propulsion (aerospace)	SSBN/SLBM Artillery Attack helicopters Anti-submarine warfare Sea-based Air Amphibious assault Communications Surveillance and Reconnaissance Early Warning
Soviet Union Clearly Superior		Soviet Union Clearly Superior	
Cast components Commonality of components Ease of maintenance High pressure physics Magneto-hydrodynamic power Rockets and ramjets Simple systems for common use Titanium fabrication Welding	Air defense missiles Anti-ship missiles Armored fighting vehicles Artillery/rocket launchers Chemical/biological warfare Cold weather equipment Gas turbines for ships ICBM payloads, yields Mobile ballistic missiles Ship size vs firepower Tactical bridging		Surface-to-air missiles Ballistic missile defense Anti-satellite Tanks (US closing the gap) Infantry combat vehicles Chemical warfare Mine warfare
Status Uncertain		US/USSR Equal	
Acoustics Adaptive optics High explosive chemistry Inductive storage and switching systems for pulsed power control Reduced drag for submarines	Antiballistic missiles Antisubmarine warfare High energy lasers Satellite-borne radars	Aerodynamics/fluid dynamics Directed energy Non-acoustic submarine detection Nuclear warhead Radar sensor	ICBM Surface-to-air missiles (tactical) Anti-tank guided missiles Theater ballistic missiles Nuclear attack submarines Naval surface combatants Naval cruise missiles Command and control Electronic countermeasures

†From: John Collins, American and Soviet Military Trends, and William Perry, FY 1981 DOD Program for Research, Development, and Acquisition

MILITARY RDT&E PROGRAMS: A COMPARISON of U.S. RDT&E COSTS WITH ESTIMATED DOLLAR COSTS of SOVIET RDT&E

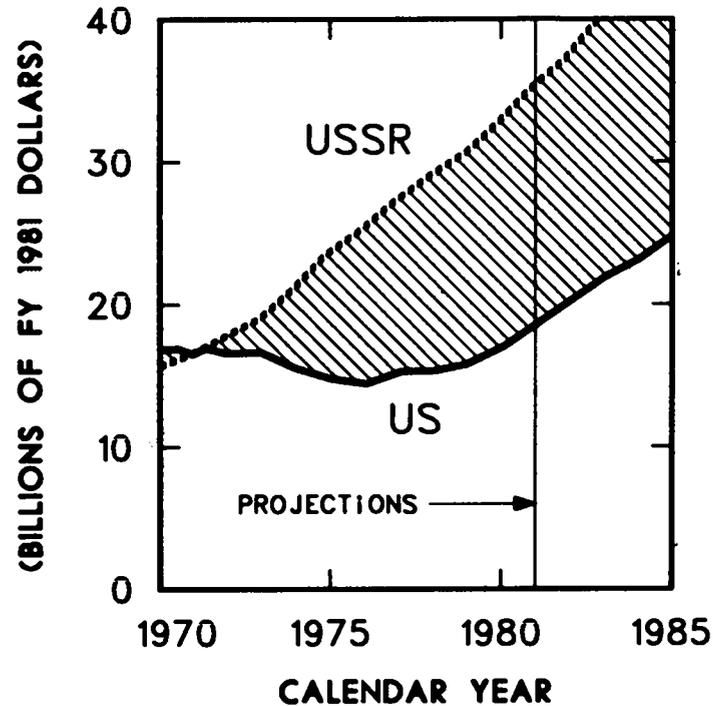


Figure 22b

Source: William Perry, FY 1981 Department of Defense Program for Research, Development, and Acquisition, p. II-34.

The 1960s and 1970s saw similar ideological attacks within most of the industrialized democracies. Before 1965, there was a general consensus in these nations that the West represented the bastion of liberty, prosperity, and national self-determination. Since then, this consensus has declined steadily, partly because of the criticisms focused on the weaknesses of Western European "bourgeois" society by the left, especially the indigenous Marxist-Leninist left, and partly because of their criticisms of America's "illegal," "exploitative," and "imperialistic" foreign policy.

Soviet Bloc Ideology. For the Soviet Union and her allies and clients, the recent past has witnessed the gradual decline of Soviet-style Communism as an attractive model for revolution and post-revolutionary government. Few citizens of any Soviet-dominated state can any longer believe that a new, prosperous, egalitarian social order is developing there. In its stead they see a permanent, impoverished, bureaucratic authoritarianism under the umbrella of an official state ideology. And incipient illusions about the evolution of personal freedom in such societies are quickly dispatched by the routine repression of any and all social critics.

Nonetheless, Communist ideology remains the influential force in Soviet life and national policy. Every important policy, domestic or foreign, must be explicated in terms of the official ideology and, accordingly, comes to be understood to some degree in those terms. Moreover, Communist ideology serves as the prime legitimizer of the authoritarian rule of the Communist Party of the Soviet Union and the whole hierarchy which effects that rule. As such it is and must remain deeply important to the perpetuation of the regime and those in power. It is needed also to justify the rule of the Soviets over their satellites. It has the most importance where it has the least credence in those satellite nations where Communist ideology has never made much headway against indigenous national values (for example, against Catholicism in Poland and tribalism in Afghanistan).*

Third World Ideology. In the Third World during and following the decline of the Western empires, ideology has expressed itself primarily in the form of anti-colonialism. In the past, many Third World revolutions took the form of Marxist-Leninist national liberation movements and drew publicly upon Soviet support. Most such revolutionary movements still are hostile to the West and are primarily Marxist-Leninist in character. At the United Nations, at "non-aligned" nations' gatherings, and in other settings, the Third World nations have shown a growing propensity to act as a group in sharp opposition to the policies of the West in general and of the United States in particular. At the same time, these revolutionary movements and Third World governments have become less closely aligned with the Soviet Union, coinciding with the loss in credibility of the Soviet Union as a revolutionary model. Still, these movements and governments are more likely to seek support from the Soviet Union, with its official revolutionary principles and flexible

*Leopold Labedz, "Ideology and Soviet Foreign Policy," Adelphi Papers, No. 51, (1979)

policies, than from the bourgeois Western nations. This Soviet affinity is strongest among nations and groups struggling against post-colonial regimes supported by the West.

The Current Situation--Pax Americana. The beginning of the 1980s has seemed to mark a change in the basic views of the West. In the United States, past uncertainty about the activist American role in the world appears to be giving way to concern about the authoritarianism and expansionism of Soviet Communism, and the harshness and intolerance of some of the indigenous nationalisms emerging in the Third World. This comparison casts Western liberalism and the Pax Americana, despite their flaws, into a more favorable light. The overt challenge to American interests and principles in Iran and Afghanistan has stimulated some resurgence of American nationalism. Among other Western nations as well there has been some revival of nationalism. From the American point of view the return of Western European nationalism may not prove helpful. Some of these nations apparently are reviewing the utility of their heavy reliance on the United States and whether, in light of rapidly growing Soviet power and an unsteady, unpredictable American response, a further accommodation with the Soviet Union might serve their interests better. On the other hand, Marxist movements (e.g. Eurocommunism) are on the wane in Europe, which may indicate a growing dislike in Western Europe of Soviet-style Communism.

Soviet Expansionism. The Soviet Communist world remains ideologically stable, despite the hopes of some observers that Communism's failure to fulfill its promise will cause a weakening of the ideological character of Soviet policy. In fact, Soviet Communism has proved to be well-suited to an expansionist, opportunistic national policy. Virtually any policy or any sudden departure from policy (e.g. the sudden shift of Soviet support from Somalia to Ethiopia) can be said to have been dictated by the requirements of a revolutionary policy, which is free of bourgeois moral considerations and sentimental attachments. Among the Soviet satellites, there is certainly ample dislike of Soviet-dominated Communism, but this has not yet been the basis for major anti-Soviet unrest. It is important to note that the recent Polish unrest has centered primarily on economic grievances, and to a lesser degree on political ones. There was very little criticism by the strike leaders of the Communist system per se. Some analysts argue that even within the Soviet Union the hold of Communist ideology will gradually weaken. As non-Russian nationalities increase in numbers and power in the Soviet Union, they suggest that Communism may be replaced by an assertive Great Russian nationalism. Given the traditional expansionist tendencies of the Russians, such a development still leaves the Soviet Union a major threat to its neighbors.

Revolutionary Third World. The most visible inroads of ideology in international affairs are Third World countries. There, national revolutionary movements espousing Marxist-Leninist principles are still prevalent, for example, in Nicaragua, El Salvador, Indonesia, and Ethiopia. But recently such movements have been supplemented by more dominantly nationalist- and religious-inspired revolutionary movements in several nations

such as Iran. Right across the "arc of crisis" that sweeps around the periphery of the Eurasian landmass -- from Southern Europe and North Africa through the Middle East to Southwest and Southeast Asia -- the instability of the Third World is increased by the growing importance of ideology and religious fanaticism and the withdrawal of Western power and influence.

Policy Issues. It is still uncertain in which direction the renewed assertiveness of the West will lead the present NATO countries and Japan. Continued American weakness, vacillation, or a turn to isolationism could stimulate a modus vivendi between those nations and the Soviet Union. It could equally encourage them to provide more fully, and more independently, for their own defense. Eventually this could mean the development of nuclear weapons by Germany and Japan, at least, and perhaps the development of regional military or political alliances (via the European community or ASEAN). On the other hand, reassertion by the United States of its interest in defense could cause the NATO allies to recommit themselves to the alliance, perpetuating the scheme of the past decades.

Continued unrest in the Third World is almost certain to cause periodic doubts about the availability of vital resources, and so may encourage the development by resource-limited nations of projection forces to secure those resources if necessary. The high chance of regional conflicts among Third World states may also lead a few to develop nuclear weapons.

The risk of recurrent local wars across the arc of crisis is considerable, and during the next two decades it is very likely that in some of them nuclear weapons will be brandished if not actually used. Both the presence of vital resources in some of these regions and the fact that the superpowers' interests tend to clash routinely at the Eurasian littoral suggest that superpower involvement in several of these conflicts is a real danger. Any major shift in the world balance of power, especially continued, unchecked expansion of Soviet power projection forces, could cause some of these nations to fall more firmly into the Soviet camp. Similarly, so-called "non-aligned" Soviet clients like Cuba and Vietnam may continue to expand their role as centers for regional non-aligned groups of nations which have sympathy with and receive support from the Soviet Union or, at any rate, are inhospitable to American interests.

UNITED STATES STRATEGIC POLICY: EVOLUTION AND ISSUES

The beginning of the 1980s may mark a turning point in broad United States world aims and in specific military strategies that are related to them. The United States seems to be at the point of returning to its post-World-War-II aim of attempting to contain the sphere of influence of the Soviet Union. This policy was first established following a brief, unsuccessful effort to reach an accommodation with the Soviets at the end of World War II. Over the years, and through many alterations in strategic military policy and weaponry, this basic aim remained. The decision by the United States in the early 1960s to allow the Soviet Union to attain strategic military parity and to rely on mutual assured destruction rather than our strategic superiority as the moderating factor marked the first step away from containment.

The policy of detente in the early 1970s aspired to more. We attempted to establish a genuine, enduring accommodation with the Soviets. By the end of the 1970s, that effort had clearly failed. The Soviets, instead of becoming less militant when they reached strategic parity, continued their military increases without letup. Meanwhile, they cited the resulting shift in the world "correlation of forces" as allowing them a more aggressive, expansionist policy such as they have displayed in the late 1970s. Thus strong reaction in the United States to the Soviet invasion of Afghanistan may presage an American effort to reconstitute forces and reinstitute the containment policy in the 1980s.

The Evolution of United States Strategy

The first significant shift away from containment came under Secretary of Defense McNamara in the early 1960s. He briefly espoused the policy of "flexible response," that was designed to allow the United States to respond to challenges across a wide spectrum, particularly low-intensity aggression. In Europe this resulted in the establishment of the "NATO triad" doctrine. This triad, a combination of conventional, tactical nuclear, and strategic nuclear forces, was supposed to be capable of deterring or defeating aggression at any level of military intensity. The "linkage" of each level to the next was meant to be a warning that the central strategic forces could be brought in, if needed, to correct the failure of lower level defensive forces.

Soon flexible response was replaced in its turn by the doctrine of assured destruction. The change was prompted by the Soviet development of strategic forces largely secure (for the time being) from a United States nuclear attack. The doctrine, while perhaps sufficing to deter Soviet strategic nuclear forces, was of questionable value in preventing lower intensity warfare. The establishment of mutual assured destruction as the Soviets completed their own second strike capability meant that the United States also would probably be deterred from using or threatening to use its strategic arsenal except to prevent the Soviets from using theirs.

The arms control agreements of SALT I codified mutual assured destruction as American policy; the Anti-Ballistic Missile Treaty in particular was thought to mark acceptance of assured destruction by both the United States and the Soviet Union because it guaranteed a "free ride" to their targets for the ballistic missiles of both sides. Following those agreements, however, the Soviets continued to expand the size and capabilities of their strategic forces. They vastly increased the throw-weight of their land-based missiles by deploying the SS-17, -18, and -19 generation of missiles. They moved quickly to multiple, independently targetable warheads. And they rapidly improved their warhead accuracy. By the mid-1970s it was argued in the United States that these force improvements, which also included modernization of the ballistic missile submarine fleet and new theater nuclear forces, would give the Soviets a considerable first-strike counterforce potential and accordingly a significant damage-limiting, or warfighting, capability.

A partial response to this shift in the strategic balance was announced in 1974 by then-Secretary of Defense Schlesinger. The United States, he

announced, intended to improve its capability to use its strategic nuclear forces in a limited, selective way as opposed to the very large strikes that were usually envisioned -- and to some degree necessitated -- by limited United States command and control capabilities. Under the shadow of Soviet parity, or more, this doctrine of Limited Strategic Options was designed to improve the credibility of American strategic forces; limited options would give the United States a plausible option of responding with limited strategic strikes to severe provocations or imminent defeat in limited areas. Thus we might delay or if possible prevent escalation to mutual attacks on cities and industries that would clearly be catastrophic to the United States. This doctrine required plans to strike a wide spectrum of Soviet targets, including military forces and command and control centers.

The Current Situation

The "Countervailing Strategy." In 1979 and 1980 President Carter announced a new American nuclear strategy designed to address the new realities which some policymakers believe have been created by Soviet military expansion. This "countervailing strategy" is supposed to give the United States the capability to fight a nuclear war at any level of intensity and to strike a wide variety of military and political-control targets. In this way credibility is to be restored to the United States deterrent. Should deterrence fail, the new strategy is designed to give the United States some chance of fighting a nuclear war to an acceptable and meaningful conclusion. According to reports in the press, this new policy was set forth in several Presidential Directives, and includes the following points. (The Directives are presented in reverse chronological order).

Flexible Response and Nuclear Targeting (PD-59). Adding flexible response options to the assured destruction capability in July 1980 is the culmination of a trend started in the 1970s. New priorities were set (reportedly) for targeting enemy strategic forces, political control (leadership and its command, control, and communications facilities), other military targets, and war supporting industries. An enduring secure reserve is to be withheld by the United States to provide an assured destruction deterrent to enemy escalation to urban attacks.

Continuity of Government (PD-58). Policies and measures to assure continuing Presidential leadership and the continuity of government in case of nuclear warfare were issued in June 1980. They stress the importance of national telecommunications.

Mobilization (PD-57). New policies for industrial and manpower mobilization were issued in March 1980, renewing emphasis on this area of federal emergency management.

National Security Telecommunications Policy (PD-53). In November 1979 a new national security telecommunications policy was established with two key features: national security and continuity of government requirements should receive major attention; common carrier telecommunications networks should be interconnected and government networks should be interoperable.

Arms Control (PD-50) Policies were established in August 1979 to harmonize arms control initiatives with national security objectives. They require the examination of arms control proposals in the context of defense policy, future force goals, and foreign policy aims as well as their effect on arms competition.

As Table V indicates, however, none of these Presidential Directives has been implemented fully and there is reasonable doubt that all can or should be. The technical risk of implementing the new strategy is high, political support for it is questionable, the cost is likely to be high, and the impact on other high priority national programs could be large. Nor has the theory of deterrence primarily by retaining the ability to destroy the Soviet economy and population been disproved -- as indeed it could only be disproved if it fails.

At the same time, examination of military trends demonstrates that the Soviet Union has achieved a quantitative, and perhaps a qualitative edge in the strategic balance over the past two decades. There is growing and influential doubt in the United States that reliance on assured destruction alone as a deterrent will be credible in coming years.

Arms Control and Verification. Since the early 1960s, when we adopted the mutual-assured-destruction doctrine, the United States has attempted to complement strategic policy with negotiations to limit strategic nuclear weapons. Since a rather small number of nuclear weapons should be sufficient to achieve "assured destruction" of the enemy's population and economic recovery capability, the United States sought an agreement to reduce American and Soviet nuclear arsenals closer to those low levels. With such an agreement both countries could reduce their defense spending. This curtailing of the "arms race" might also lead to a reduction of tensions between the two nations.

Critics of the arms control process in the United States, particularly since the signing of SALT I, have argued that the Soviets have manipulated the negotiations and exploited American optimism as one means to gain a marked strategic advantage over the United States.

As Table VI shows there have been three phases of arms control agreements. The first, in 1963 and 1964, included an agreement designed to reduce the risk of accidental war and a treaty to re-introduce limitations on nuclear weapons tests. The second series of negotiations culminated in 1972 in the SALT I package of agreements limiting both strategic offensive and defensive armaments. Two subsequent treaties on nuclear test explosions, signed in 1974 and 1976, have not been ratified, although both sides have stated that they would abide by these limitations.* The final set of

*Several recent reports suggest that the Soviets have exceeded the treaty limitations on several occasions. See International Herald Tribune, Sept. 24, 1980, p. 4 and Sept. 27/28, 1980, p. 1.

TABLE V

EVOLVING STRATEGIC NUCLEAR POLICY

MAJOR POLICY DECISIONS	ARMS CONTROL PD-50 AUGUST 1979	STRATEGIC COMMUNICATIONS PD-53 NOVEMBER 1979	MOBILIZATION PD-57 MARCH 1980	CONTINUITY OF GOVERNMENT PD-58 JUNE 1980	EMPLOYMENT POLICY PD-59 JULY 1980
MAIN THEMES	COORDINATE ARMS CONTROL AND DEFENSE PLANNING	ENDURANCE. RELY ON COMMON CARRIERS	ACCELERATE PLANNING	MOBILITY/ DISPERSAL OF NCA	PROLONGED WAR TARGETING FLEXIBILITY IMPROVED C ³ I
ACTION TAKEN		PLANNING INITIATED	LITTLE	PLANNING INITIATED	SOME ADJUSTMENT IN PLANS
MAJOR PROBLEM AREAS	LACK OF A MECHANISM	CONFLICTING POLICIES FUNDING SOURCES NEEDED	RESPONSIBILITIES NOT FIXED	FUNDING PLANNING SLOW	VULNERABILITY OF C ³ I LACK OF OSD FOCAL POINT

negotiations resulted in the SALT II agreements, which have not been submitted to the United States Senate for ratification.

A number of arms control negotiations are presently in progress. Depending on relations between the United States and the Soviet Union during the next few years, several of them may be concluded; these will affect American defense doctrine and programs.

Chemical Disarmament. The United States and the Soviet Union are negotiating a multilateral treaty banning the development, production, stockpiling, or other acquisition or possession of chemical weapons. While some progress was made towards such a treaty during 1979, at least three major points remain to be negotiated.

1. Should research and development on chemical weapons, and preparations to fight chemical war be allowed?
2. Should verification of the treaty include systematic on-site checks?
3. Should confidence-building measures be arranged before the activation of the treaty?*

Radiological Weapons. In 1979 the United States and the Soviet Union submitted an essentially complete treaty text to the Committee on Disarmament which would ban the development, production, stockpiling, acquisition or possession of radiological weapons -- weapons other than nuclear explosive devices which use radiation to cause death, injury, or destruction.

Inhumane and Indiscriminate Weapons. Initial discussions were held in 1979 on a treaty to ban certain conventional weapons deemed inhumane or indiscriminate in their effects. Weapons to be prohibited are incendiary weapons (particularly napalm), mines and booby-traps, and fragmentation weapons. In 1980 the treaty was approved by the 36 nation Committee on Disarmament, and during 1981 it will be opened for signatures.**

Comprehensive Test Ban. The Carter Administration undertook a major initiative to secure a three-year ban on all nuclear explosions, including those underground. After twelve negotiating sessions an agreement has not been reached and the negotiations are in recess. Opposition to the proposals developed in Congress and the Executive Branch while the negotiations proceeded.

The next effort in the nuclear test ban area will probably be ratification of the Threshold Test Ban Treaty. A careful review and redefinition of American test ban objectives, in light of developments since 1974, will be appropriate before reconsideration of ratification.

*Stockholm International Peace Research Institute, World Armaments and Disarmament Yearbook 1980, pp. 365-369.

**Soviet Aerospace October 14, 1980, p. 48.

SALT III. The SALT II Agreements, still unratified by the United States Senate, include a description of future arms control negotiations. At the time of the signing of SALT II the following priority arms control tasks for SALT III were agreed upon by the two sides: quantitative reductions in strategic offensive arms; qualitative limitations, including limitations on research, development, and modernization; measures to reduce the risk of surprise attack; cooperative measures for treaty verification; and resolution of the SALT II Protocol items (mobile ICBMs and long-range cruise missiles).* Both of these last items are key elements of the current American strategic improvements program.

Eurostrategic Weapons. The Soviet Union is pressing for a European disarmament conference which would address the question of long-range theater nuclear weapons. After originally insisting that the NATO countries reverse their decision to deploy the Pershing II and Ground Launched Cruise Missile before opening negotiations, the Soviets subsequently dropped this condition and now ask only that all forward-based systems be included in the negotiations (these include nuclear-capable tactical aircraft).

NATO for its part first suggested arms limitation discussions at the time it decided to deploy new, long-range theater systems. But the NATO countries rejected the precondition imposed by the Soviets. The United States and the other NATO countries have reacted favorably to the latest Soviet proposal, but the United States does not wish negotiations to begin before carefully coordinating a NATO position.**

Issues for Negotiation. Important arms control issues will arise in the next few years. Certain to arise is the question of the Anti-Ballistic Missile Treaty, which is scheduled for regular review in 1982. The growth of Soviet strategic offensive capabilities has thrown into doubt the original premises of the Treaty -- that it guaranteed the retaliatory capabilities of both sides, and that it ensured the adoption of mutual assured destruction. At the same time, ABM technology may have matured sufficiently to be able to contribute significantly to assuring the survival of retaliatory missiles, or to providing area defense. Those developments could lead to re-negotiation of the Treaty, or its abandonment.

Eurostrategic weapons limitations also will probably become a major issue. The Soviets and several European governments have shown a strong interest in negotiating limits on these weapons, and the Soviets may also see such negotiations as a means to further their long-term aim of loosening the ties between the European NATO countries and the United States. Whether in the form of multilateral negotiations between the Soviet Union and NATO, as part of SALT III discussions, or in a separate European disarmament conference, this matter is almost sure to receive attention in the next few years.

*US Department of State, SALT II Agreement, Vienna, June 17, 1979.

**See Current Digest of the Soviet Press, Vol XXXII, No. 30, pp. 12-13; and The Economist, Aug. 23, 1980, p. 42.

TABLE VI

MAJOR ARMS CONTROL AGREEMENTS IN EFFECT OR PENDING RATIFICATION

<u>Date Signed</u>	<u>Bilateral US/USSR Treaties</u>
June 20, 1963	"Hot Line" Understanding
April 20, 1964	Simultaneous Statements on limitation of fissionable materials production
Sept. 30, 1971	Prevention of Accidental Nuclear War Agreement
May 25, 1972	Prevention of High Seas Incidents Agreement
May 26, 1972	Anti-Ballistic Missile Treaty
May 26, 1972	SALT I Interim Agreement
May 29, 1972	Agreement on Basic Principles of Relations
Dec. 21, 1972	Understanding on SALT Standing Consultative Commission
June 21, 1973	Agreement on Principles for Strategic Arms Limitations Negotiations
June 22, 1973	Agreement on the Prevention of Nuclear War
July 3, 1974	Threshold Test Ban Treaty (not ratified)
Nov. 24, 1974	Statement on Further Strategic Arms Limitations (Vladivostok Agreement)
May 28, 1976	Peaceful Nuclear Explosion Treaty (not ratified)
June 18, 1979	SALT II (not ratified)
June 18, 1979	Statement of Principles and Guidelines for Subsequent Arms Limitation Negotiations

<u>Date Signed</u>	<u>Multilateral Treaties</u>
Dec. 1, 1959	Antarctic Treaty - Antarctic to be used only for peaceful purposes.
Aug. 5, 1963	Partial Test Ban Treaty - bans nuclear tests in atmosphere, outer space, underwater
Jan. 27, 1967	Outer Space Treaty - prohibits weapons of mass destruction in space
Feb. 14, 1967	Treaty Prohibiting Nuclear Weapons in Latin America (Treaty of Tlatelolco)
July 1, 1968	Nuclear Non-Proliferation Treaty
Feb. 11, 1971	Sea-Bed Treaty - prohibits stationing weapons of mass destruction in the sea-bed
April 10, 1972	Biological Weapons Convention
May 18, 1977	Environmental Modification Treaty

Verification is an issue that affects several arms control agreements -- chemical disarmament, strategic offensive and defensive arms limitations, and a nuclear test ban in particular. Verification depends on measurements, and any measurement may be in error. The political consequences of lack of confidence in verification data can be considerable. First, democracies like the United States may be very reticent to allege possible treaty violations, especially if the evidence is ambiguous. One party could gain considerable advantage from exploiting verification uncertainties. On the other hand, without reliable, credible verification procedures, nations may come to doubt the actions and motives of other treaty parties, leading them to terminate or withdraw from treaties. A nation that suspects another of cheating on its treaty obligations might refuse to participate in future negotiations or engage in armaments programs that negate the intended effects of the treaties. A recent Soviet nuclear test, for example, was reported by some sources to have exceeded the 150 kiloton test limitation of the Threshold Test Ban Treaty, which the Soviets have pledged to observe. In consequence, the United States reportedly considered conducting a test of its own that would exceed the treaty limitations.* Similarly, questions about Soviet observance of the missile defense treaty have led to suggestions that the United States spur on its own missile defense development.

Verification of nuclear tests is crucial for any nuclear test ban or limitation. Soviet nuclear testing has increased greatly over the past few years (see Figure 23). But American figures on Soviet testing activity must presently depend on our own measurements, not Soviet announcements, and there has always been a question whether we know about all of their tests in any given year. The importance of adequate verification capabilities was also emphasized in 1979 when an atmospheric nuclear test may have taken place in the South Atlantic. A dying American verification satellite system almost by accident provided initial evidence of the possible test. This satellite system will not be replaced until at least 1985. Without verification capabilities in which treaty signatories can have very high confidence, arms control agreements may actually be counterproductive to arms control aims. They may even magnify the very competition and suspicion between nations which such agreements are intended to eliminate.

New Directions

United States defense policy is at a turning point in the early 1980s. The growth of Soviet military power and the relative decline of American and NATO strength at all levels has created a gap between the interests of the United States and its allies and their capabilities to

*See Walter Pincus, "US Concerned by Soviet Nuclear Test," International Herald Tribune, Sept. 24, 1980, p. 4.

TRENDS in US and USSR NUCLEAR TESTS SINCE the SIGNING of the PARTIAL TEST BAN TREATY

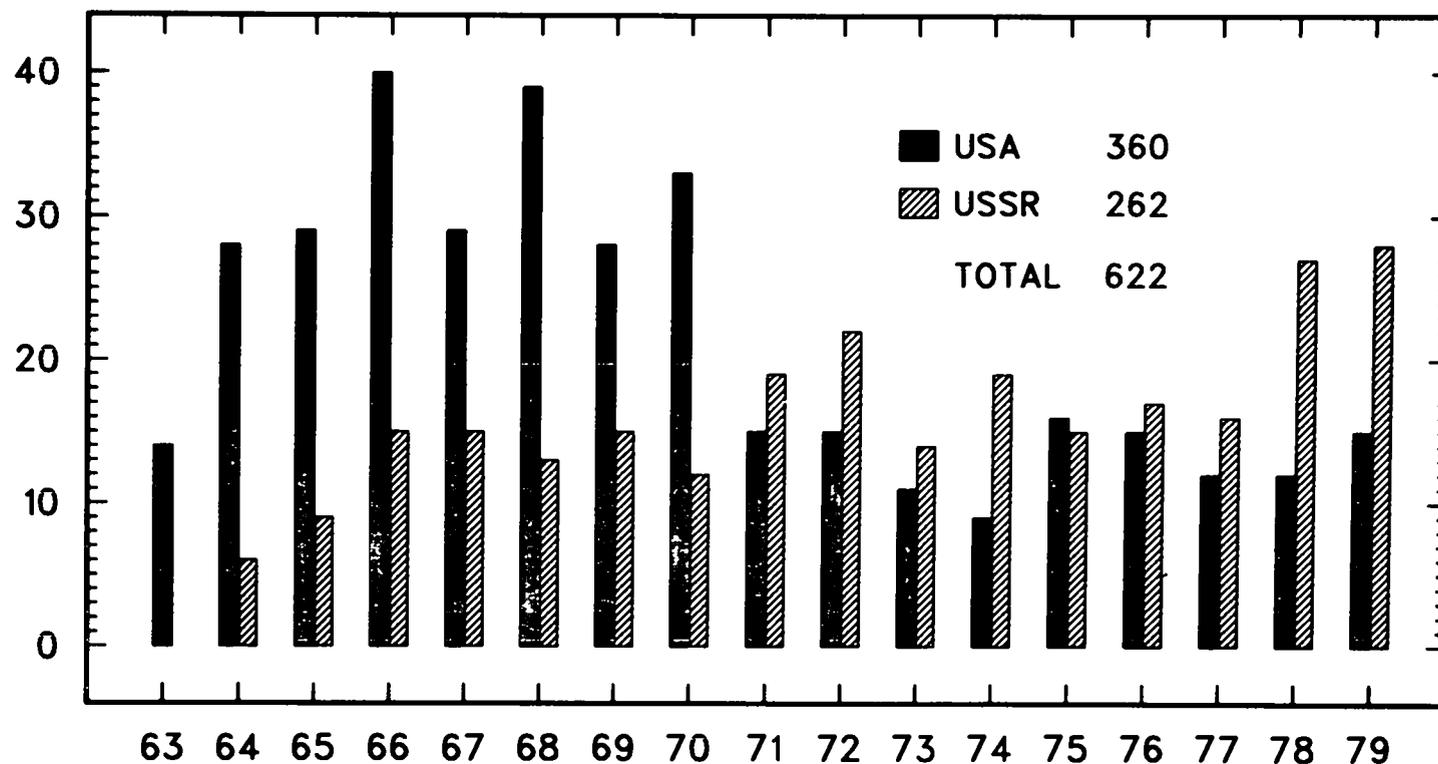


Figure 23

Source: Stockholm International Peace Research Institute, World Armaments and Disarmament Yearbook, 1980.

protect those interests. Growing turbulence and independence in the Third World also requires more military power if nations determine to use their own might to protect their interests.

This gap between interests and capabilities can be met in two ways -- by drawing back interests as far as possible or by increasing capabilities. The United States faces this choice in relation to all three levels of military force -- strategic, theater nuclear, and conventional.

It is conceivable at the strategic and theater nuclear levels that arms control agreements rather than armament programs could halt the slippage in comparative United States capability. But it is difficult to show examples of Soviet inclination to forfeit advantages they have gained, unless forced to do so.

The United States strategic policy envisioned in the Presidential Directives of 1979-1980 may be another way of responding to the slippage in America's strategic capability. If adopted and fully implemented, it could provide the United States a new, distinctly different national defense policy. Implementation of the new strategy would in time bring about considerable alterations in American strategic forces. These would probably include greater hard-target kill capabilities, major improvements to strategic command, control, communications, and intelligence capabilities and survivability, and more interest in defending against Soviet strategic weapons (via ABM, anti-submarine warfare, and strategic air defense). Also suggested by the new flexible response targeting doctrine and by the Secretary of Defense in recent statements is the possibility that the United States could adopt a policy of launching its land-based ballistic missiles on warning of a Soviet attack. This policy is not generally thought to be attractive because it may increase the risk of accidental war while reducing the capability for a measured response to a limited attack. If adopted, launch-on-warning will require improvements in the speed and accuracy of ballistic missile early warning information and in command and control of the ICBM force. A change from deterrence primarily by the threat of assured destruction to deterrence supported by a realistic, measured warfighting option could give impetus to theater warfare improvements and to rethinking NATO doctrine on the use of theater nuclear forces. Finally, should the United States move in the direction of the new strategic doctrine, there may be need for development of a war mobilization base in the United States, particularly for the production of new systems that could be used either to restore the strategic balance or to implement the new strategic policy.

The progressive stationing at sea and in space of major Soviet and American military assets creates the possibility of detached war against these assets. Attacks conceivably could be isolated to these deployment areas, assuming neither side chose to use an attack as a reason to resort to all-out war -- a reasonable assumption if something like strategic parity or mutual assured destruction prevails. However, the outcome

of such detached battles could affect the military balance and could in fact be decisive by itself (e.g. by eliminating the early warning assets of one combatant). The ability to fight such battles could become a major interest for United States defense planners.

Whatever the choice about strategic nuclear policy, efforts by the United States to bolster its conventional military capabilities for use away from the centers of conflict with the Soviet Union are likely to continue. This would include continued efforts to acquire forward bases, and to build up the Rapid Deployment Force.

Reliance by the United States on natural resources from abroad and on unhindered foreign trade will continue. These interests will keep the United States involved in developing, conflict-prone regions in which the Soviet Union has also expressed an interest. Accordingly, the generation of forces capable of operating in these regions will retain a high priority, even if the United States does not choose any active involvement.

Allied to some extent with this problem is terrorism. Terrorism, especially that sponsored by or responsive to nation-states, will become an attractive and perhaps common method of conducting war. Since the risk from a direct military confrontation has increased by the development of more destructive weaponry, low-level coercion such as terrorism, especially if intelligently directed for maximum political effect, takes on greater importance. Transnational or "stateless" terrorism may wane, to be replaced by terrorism which serves as a vehicle for major state interests.

DEFENSE TECHNOLOGY REQUIREMENTS

Historically defense needs have stimulated major and dramatic advances in industrial technology, particularly during times of conflict. Less obvious but of equal importance is the effect on the technology of warfare that is exerted by expanding research and development capabilities. Nothing foreseeable on the international scene is likely to change this mutual relationship, or diminish the pervasive importance of technology to defensive posture and warfighting capabilities.

Strategic Nuclear Forces

Strategic Offensive Technologies. Strategic offensive capabilities will continue to be dominated by and keyed upon nuclear weapons systems. A new development in explosive capability, which is likely to have a significant impact if it can be developed, is the pure fusion bomb. Improvements in delivery systems for weapons will tend to blur even further the distinction between assured destruction and warfighting capabilities, since almost any weapon may eventually have the capability to destroy very hard military targets as well as to inflict area damage. There appear to be no insurmountable obstacles to refining ballistic missile guidance ultimately to zero circular-error-probable accuracy,

perhaps using terminal homing guidance technology. Such a development would maximize the hard-target-kill capability of strategic warheads and encourage further warhead fractionation. However, the principal current accuracy improvement program is not being strongly supported, indicating that the decision to continue improving accuracy may not be taken. But given this decision, only extreme target burial depths or treaty initiatives will confound this trend. Full implementation of the recent Presidential Directives could lead to pressure to develop weapons capable of destroying very hard, buried command and control centers. It also might require development of systems able to locate, follow, and destroy mobile military units. Countermeasures to anti-ballistic missile defenses -- maneuvering reentry vehicles, infrared and radar decoys, and, for the longer term, means to defeat directed energy weapons -- are likely to assume growing importance.

At sea, a possible threat to ballistic missile submarines is a constant worry. A breakthrough in anti-submarine warfare could decisively tip the strategic scale. American efforts to keep ahead of probable anti-submarine warfare developments will continue. If the United States decides to improve its countermilitary offensive capabilities, it may also require more effective means to locate and destroy enemy ballistic missile submarines in their sanctuaries.

The air-breathing component of the offensive triad may also receive more attention if ballistic missiles continue to be affected by the development of countermeasures, or if radar evasion technology provides new penetration capabilities. American efforts will probably be stepped up to develop means to overcome "stealth" technology in anticipation of similar Soviet developments.

Another probable development involves basing important components of the strategic offensive force complex in space.* This is particularly attractive as a means for safeguarding vulnerable command and control assets from prompt destruction, but it could also provide a location for long-reaching, selective strategic weapons systems (directed energy weapons are the prime example).

Defensive Technologies. A major portion of the American defense community now believes that continued credibility of the United States nuclear deterrent requires ICBMs which are more survivable under attack. The MX missile is expected to replace or supplement the Minuteman force in some form of multiple-aimpoint basing. However, it is not certain that such systems can survive in the long term, since a breakdown in concealment would make the entire force vulnerable to defeat. It may also stimulate the Soviet Union to multiply its warheads to cover all of the aimpoints. Lower-cost, stable strategic options are preferable

*The actual weapons of mass destruction cannot, under the terms of the Outer Space Treaty, be based in space.

since they would permit resources to be diverted to the acquisition of expanded conventional forces, sorely needed for dealing with non-nuclear aggression and terrorism.

Strategic systems employing ballistic missile defense with technologies now in development appear to offer the needed economy and stability as well as elements of strategic damage limitation otherwise inconsistent with arms limitation goals. If such systems can be implemented and the technologies developed, decreased nuclear weapon inventories are a real possibility. Several specific technologies would have to be developed further for conventional missile defense. These include fast, high capacity computer capabilities based on large-scale circuit integration; highly accurate infrared detection and discrimination capabilities; technical means to operate a system of great overall complexity; and means to integrate missile defense into an already strained national command, control, and communications network.

For the future, the technical prospects for directed energy ballistic missile defense weapons, both surface and space-based, appear quite promising. If their development proceeds and their potential contribution to active defense of both strategic weapons and economic/population resources is fulfilled, revolutionary changes in deterrent strategy can be expected. The entire long-range nuclear weapons base of strategic deterrence may have to be reviewed.

If military assets are increasingly moved to space, more attention will be given to defending them from anti-satellite weapons of both conventional and directed energy types.

Several strategic force trends, and in particular any decision to defend against ballistic missiles, will raise the question of strategic defense against bomber aircraft. The present American interception and detection capability is very limited. Attention must also be given to defending against close-in submarine launched ballistic missiles, perhaps launched on depressed trajectories.

Strategic Command, Control, and Communications. Integrating increasingly complicated offensive and defensive weapon systems into a reliable warfighting complex will put severe demands on command, control, communications, and intelligence technology. Command and control will be built upon increasingly cost-effective computer technology, but growing demands will continue to challenge our ability to acquire, organize, and assimilate large quantities of information in real time. Sensor technology, data processing, communications links, and the human interface present problems that must be solved if the strategic systems are to remain an effective deterrent force. The requirement for command and control to operate reliably in a harsh nuclear environment, perhaps for extended periods as envisioned in recent United States strategic doctrine, increases the difficulty of resolving these technological problems.

Particular challenges may be raised by PD 59 (flexible response targeting). One is the surveillance requirement to detect, track, and quickly target mobile enemy military units. A second could be the need sufficiently to improve the accuracy and yield of submarine-launched ballistic missiles to give them effective hard-target kill characteristics and at the same time to develop a command and control system adequate to allow those missiles to be employed against time-urgent targets.

Theater Warfare

Land and Air Warfare Technologies. On land both employment doctrine and associated technical requirements for nuclear weapons in a supporting role require attention.

Major developments can be expected in three areas of non-nuclear technology:

Sensor and information technology; command and control. As it is in the strategic arena, command and control is a major problem for tactical warfare. Technology for secure and reliable communications heads the list. Also important is a better capability to sense and interpret the changing military situation through the "fog of war", and to target critical, often mobile enemy assets from remote locations.

"Smart" weapons. As computer hardware becomes cheaper and more compact, there will be additional emphasis on giving individual weapons sensor and decision-making capabilities to simplify troop responsibilities in target acquisition and aiming, and to allow "over-the-horizon" combat.

Chemical and biological warfare. The United States will have to respond to the growing Soviet chemical threat with improved defenses and probably an offensive capability. Research will emphasize detection, destruction, and decontamination of chemical agents, and will employ very high technology.

Sea Warfare Technology. Naval warfare can still be expected to accompany any major war, and to aim at the classical purposes of sea control or denial, and force projection. Attempts to develop and emplace a satellite-borne, all-ocean surveillance system should be expected. Defense of surface ships against increasingly lethal weapons -- missiles of all types and smart weapons -- will continue to be a key concern.

Projection Forces/Quick Response Forces. Projection forces, accompanied by appropriate seapower, will be increasingly necessary to counter threats that arise to American interests in remote areas. The recent instability in the Persian Gulf has emphasized this problem. While advanced technology in areas such as sensors, communications, and stand-off weaponry could be useful here, the important problems appear to be in logistics and in command of largely conventional forces.

It is an open question whether nuclear weapons have any role to play in low-intensity warfare. Nuclear weapons are relatively inexpensive and capable of delivering enormous destructive power. This power, however, is usually viewed as out of proportion to the problem. It also may entail risks of escalation even if used in very selective contexts.

Unconventional Warfare Technologies.

Unconventional warfare -- including terrorism -- is seen by some as the conflict growth area for the 1980s. As attacks (and attackers) operating in this mode become more sophisticated, technology for intelligence and countermeasures will become increasingly important. Surveillance, detection, and weapon neutralization, along with communications and institutional planning, will be of high importance when force or counterforce is to be applied.

In all types of warfare, but particularly in low intensity warfare, the full panoply of national resources can be employed to accomplish national objectives. This includes economic, political, and technological as well as military resources. In low intensity conflicts the use of these other resources may often prove most appropriate and effective.

ENERGY TRENDS AND TECHNOLOGY

The second major area of Los Alamos National Laboratory effort is applied research in energy supply technologies. Energy supply is of concern to Los Alamos because it has become an issue of security for the United States. The economic health and the defense capabilities of the nation and many industrial democracies are becoming increasingly vulnerable to price and supply policies of oil-exporting governments. In coping with this vulnerability, the United States and its allies face a number of policy decisions concerning short-term management of oil supplies and long-term development of substitutes for oil as the basic energy input.

INTERNATIONAL ENERGY TRENDS AND PROJECTIONS

Past Trends: Oil-Rich to Oil-Poor

Supply and Demand for Oil. World consumption of energy has grown rapidly since the end of World War II. This growth was stimulated largely by rapid economic growth in the industrialized world, the beginnings of industrial development in the less developed countries, and the availability of a cheap world oil supply (Figure 24). Population growth, combined with a greater per capita energy consumption associated with industrialization, has also contributed to this dramatic increase in energy usage.

In the United States, in the Organization for Economic Cooperation and Development (OECD),* and in other developed nations, most of this increased consumption was supplied by oil (Figures 24 and 25). During the period 1960-1978, oil accounted for two-thirds of the increased energy use in the OECD and almost all of the increase in several important nations (Figure 26a). Currently, oil supplies more than 50% of the total energy consumed in the OECD (Figures 26a and 27), which accounts for about two-thirds of world oil consumption (Figure 25).

Three recent trends in the energy supply system have significant implications for United States national security and the security of the members of the Western Alliance. First, the United States is becoming increasingly dependent upon imported oil, especially from OPEC countries (Figure 28). Second, imported oil is becoming very expensive. Third,

*The OECD members are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

WORLD ENERGY CONSUMPTION BY REGION, 1960 - 1990

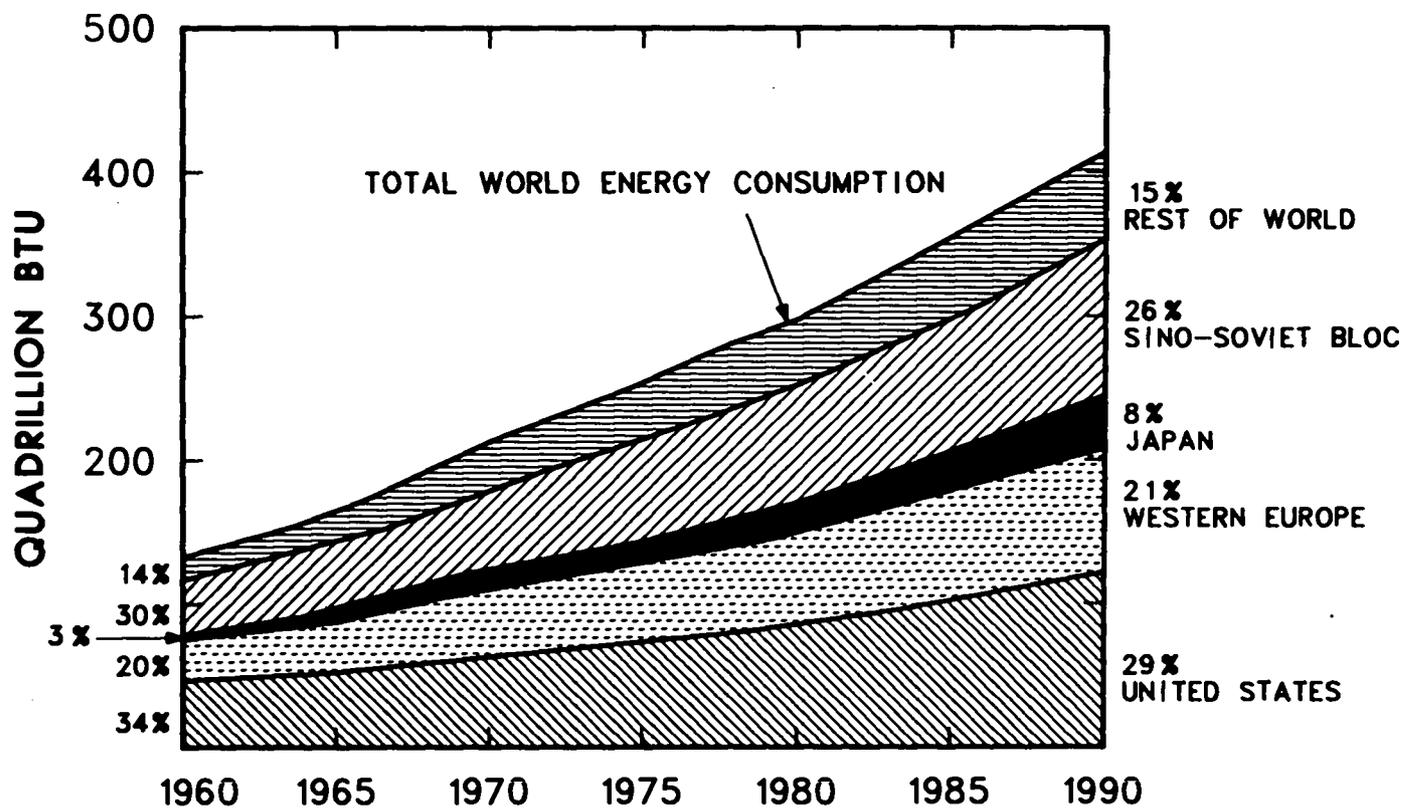


Figure 24

Source: U.S. Department of the Interior, Energy Perspectives, February 1975.

Apparent Consumption of Refined Petroleum Products, 1978

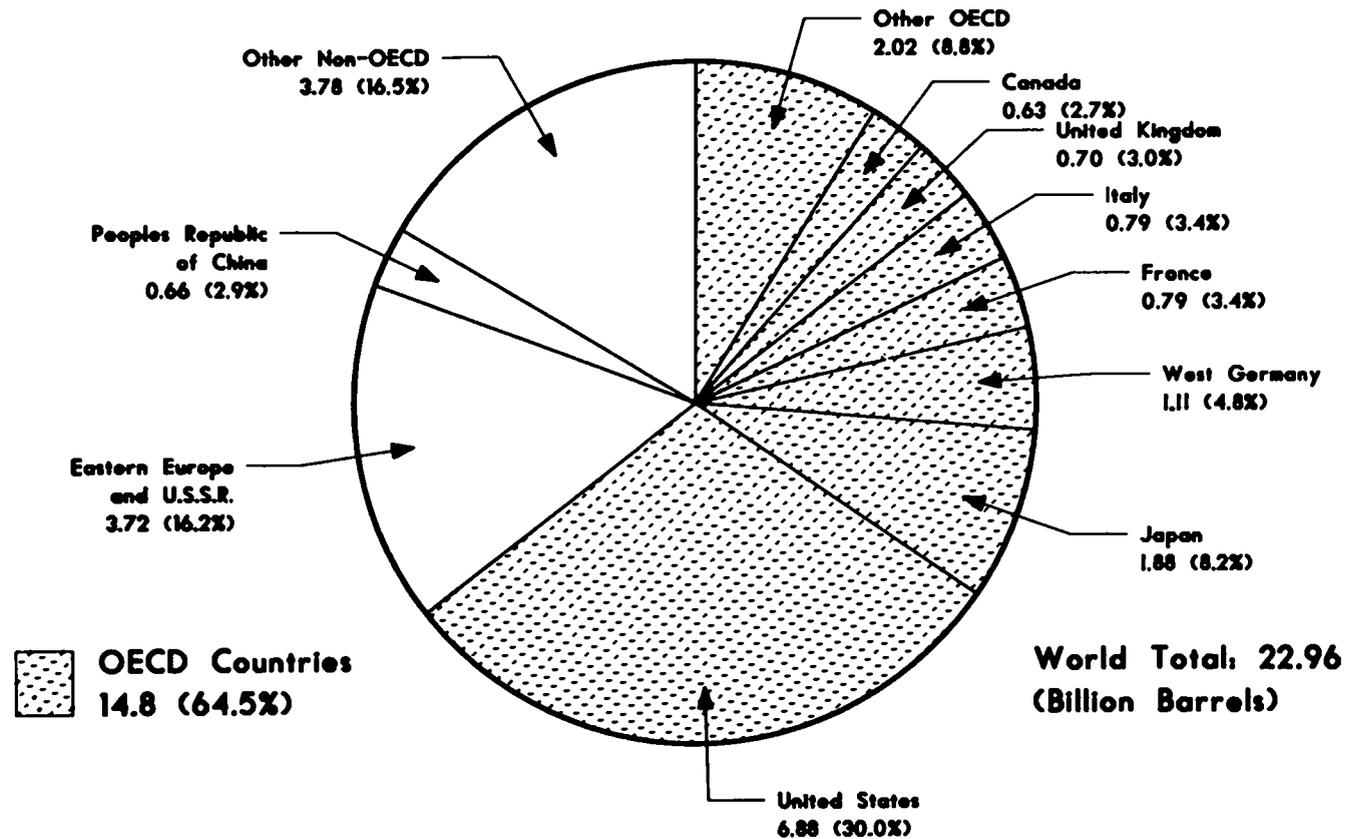


Figure 25

Source: Energy Information Administration, Annual Report to Congress, 1979, Volume Two: Data.

OIL'S SHARE OF THE INCREASE IN ENERGY USE - TOTAL OECD AND SELECTED COUNTRIES (1960-1978)

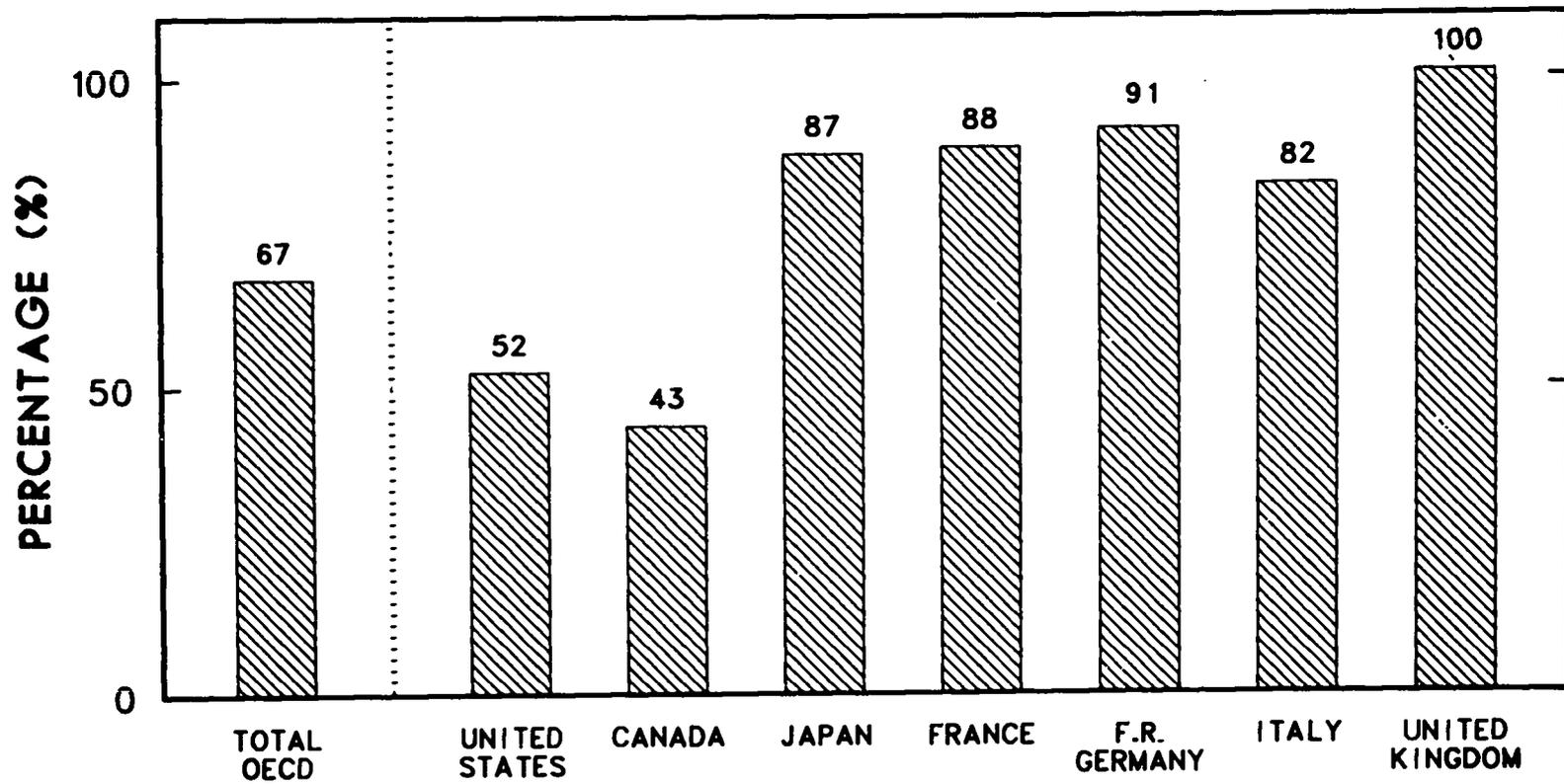


Figure 26a

Source: International Energy Agency.

TOTAL OECD ENERGY USE (1960 - 1978)

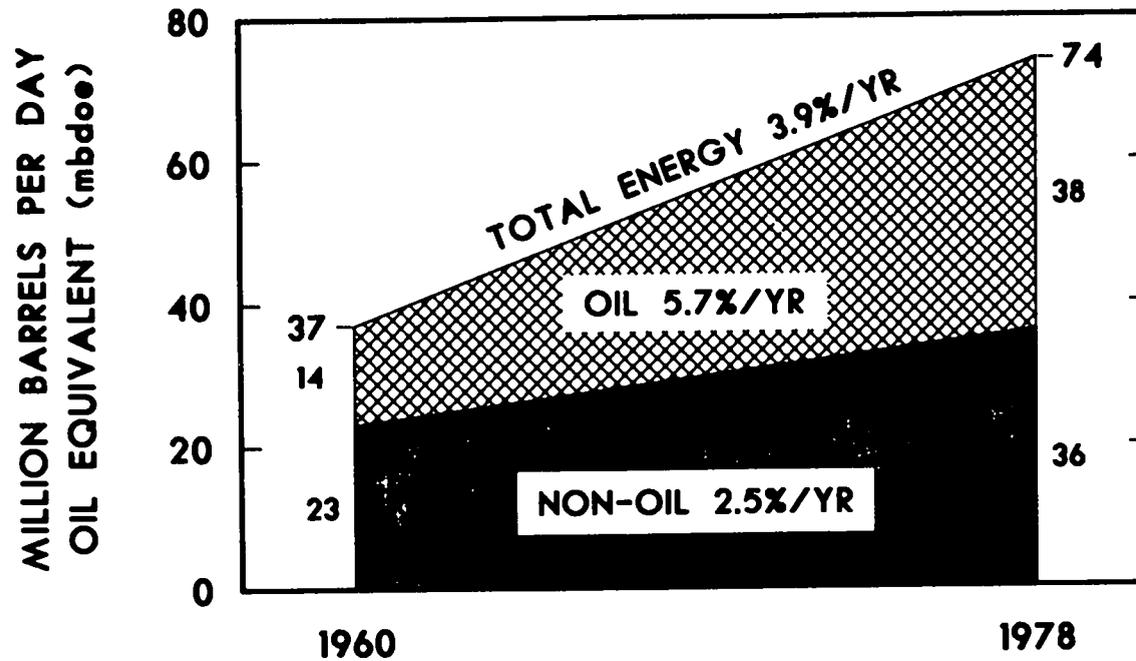


Figure 26b

Source: International Energy Agency.

IEA ENERGY INDICATORS
(Quadrillion Btu)

COMPOSITION OF ENERGY DEMAND

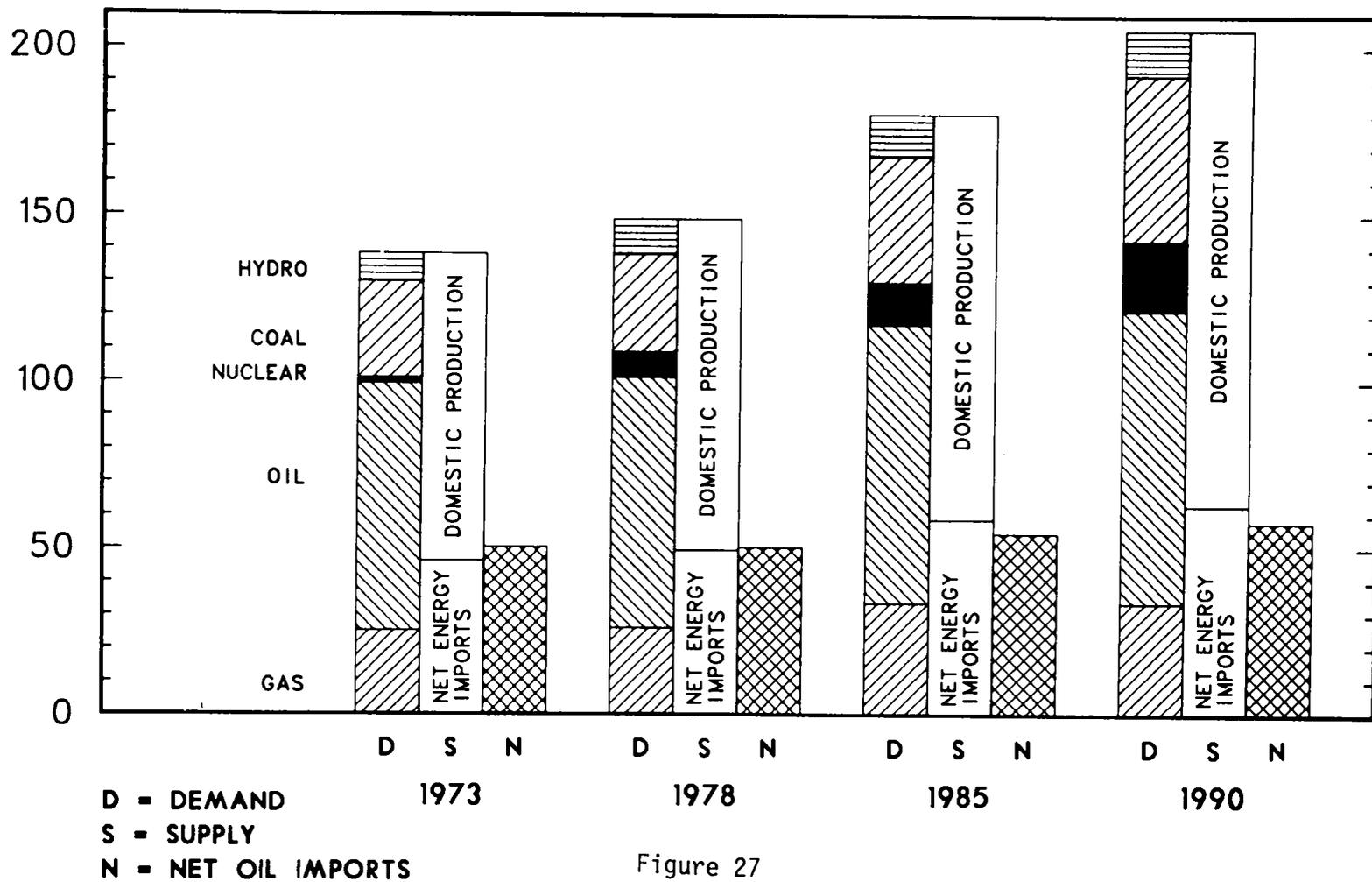


Figure 27

Source: International Energy Agency.

PETROLEUM IMPORTED DIRECTLY FROM OPEC COUNTRIES

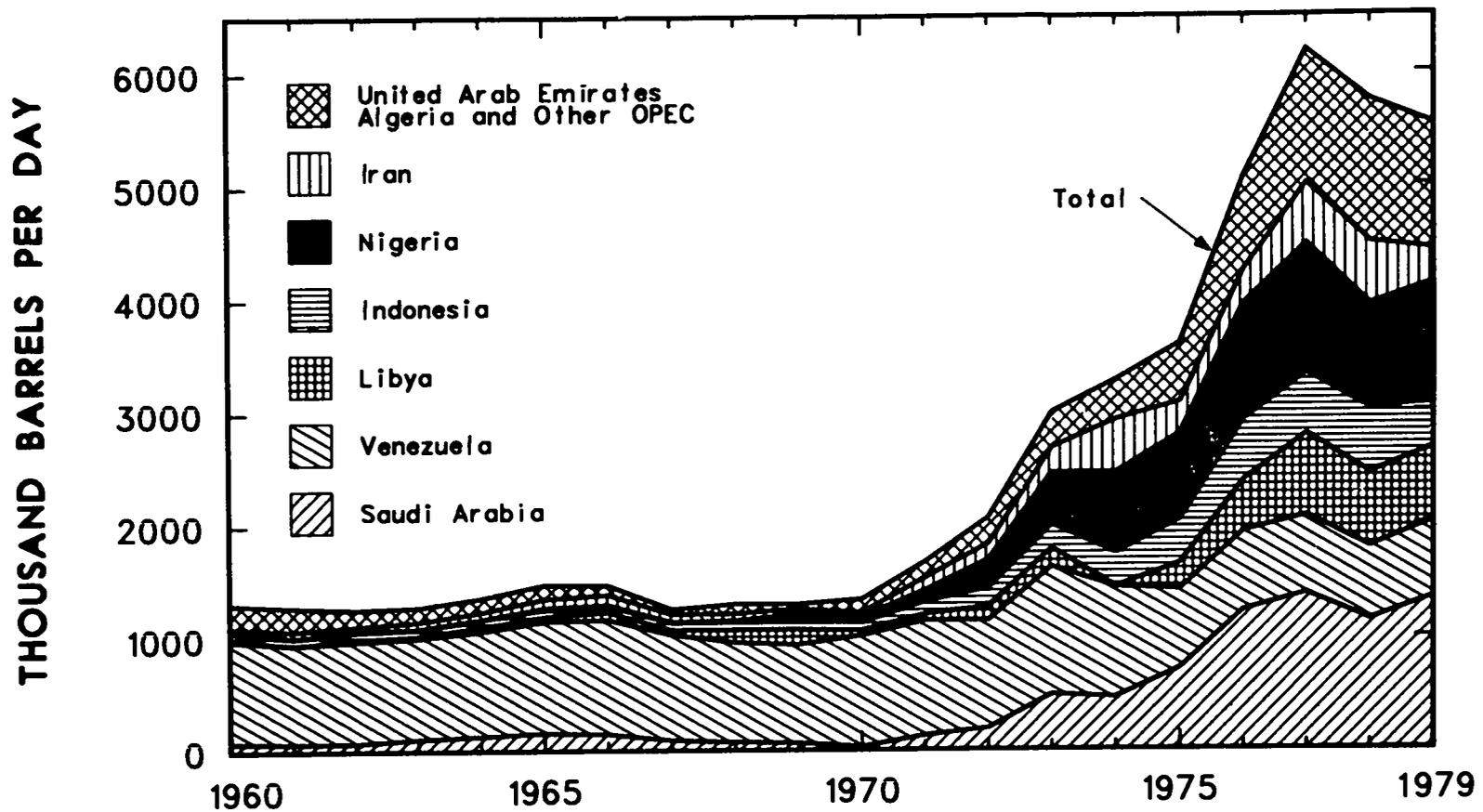


Figure 28

Source: Energy Information Administration, Annual Report to Congress, 1979, Volume Two: Data.

the interruption of oil imports, an interruption leading to oil shortages (which we in the United States call the "energy crisis"), is becoming an increasingly likely adjunct to various regional conflicts. The oil embargo imposed on Western nations by the Arab OPEC members in 1973 in response to geopolitical problems in the Middle East resulted in heating oil shortages and lines at gasoline stations. These were the first manifestations of this energy crisis. Later, in the winter of 1978 and through the summer of 1979, severe regional shortages of gasoline and home heating oil reinforced the idea that the nation in fact had a problem in energy supply.

In 1980, however, a "mini-glut" of crude oil existed on the world market, and gasoline was plentiful at American service stations. Some observers interpreted this as indicating that the energy crisis was easing and justifying their belief that the crisis is really just a set of artificial shortages being created and manipulated by oil companies or other villains in order to raise oil prices and oil company revenues and profits.

This view ignores several realities of American and world economic, resource, and energy predicaments. The present world oversupply of oil is largely due to a recession in several major industrial nations. The balance of world oil supply and demand could return to normal, with world oil production only marginally able to meet world oil demand as world economic conditions improve. In the United States, demand for oil products continued to grow after the 1973 embargo and is now met by importing about 50% of the oil we consume. This compares with import levels of about 35% at the time of the 1973 embargo; in other words, our import dependence has grown steadily.

This continuing dependence on foreign oil imports is a major security concern for the United States. The combination of slack world demand and the willingness of the United States to import more and more oil over the years gives the short-term illusion of a plentiful oil supply; however, the reality is that over the course of the next two decades, domestic oil supply from conventional sources will level off and then decline. This means that the nation's economy, and its national defense capability, may become extremely vulnerable to shifts in availability of world oil supplies. Within the last 24 months we have seen the withdrawal of Iran, at one time the second-largest world oil exporter, from the world oil market, and by the end of 1980 we have seen the major Iranian oil production and refining areas in the hands of Iraqi troops. And the Iran-Iraq border war has threatened to spill over into other parts of the oil-rich Persian Gulf. Nothing could give starker emphasis to the importance of dealing with the transition away from oil imports.

Geopolitics of Energy Supply. The basic issue is larger than just the question of possible shortages in the world oil market. A significant change has occurred in the structure of that market, a change that has received inadequate attention in analyses of United States energy policy.

Before the decade of the 1970s, the world oil market was dominated by a small number of giant, vertically integrated international oil companies.

They had assured relatively secure supplies for oil-consuming nations, and had operated under relatively stable agreements with governments of oil-producing nations. This market arrangement was encouraged by American foreign policy. While in retrospect it may not have been desirable to have such an important resource completely dominated by the "Seven Sisters,"* the result still was that oil was in adequate supply for decades and at a declining real price before 1973.

The world market changed radically with the advent of the OPEC cartel.** OPEC governments have replaced the international oil companies as the primary provider of crude oil to the world market. The first obvious results have been the attempts to control levels of oil supply and to raise world prices arbitrarily and by unpredictable amounts. These market changes in themselves have had profound impact on the United States and its allies. However, perhaps even more important is the fact that economically motivated oil companies have been replaced by politically motivated governments as suppliers of the world's basic energy commodity. These governments have increasingly imposed noneconomic terms on their willingness to provide oil supplies to the West. They have felt free to change the terms of oil contracts retroactively, arguing that sovereign nations have the unencumbered right to control the use of their natural resources. The United States has never challenged these arbitrary actions. One international oil expert has characterized the current period as one of "lawlessness" in international oil affairs, a period in which producing nations can and do demand "practically any economic or political terms" for providing their product without regard to any accepted business or political protocols.+

Thus the basic energy problem (for the United States) is not just that of world oil supply and demand, in itself a critical matter; the other part of the problem is the interjection by oil-producing nations of escalating political objectives into the oil supply equation. Imposing a solution to the Palestinian question is one example; others include various political postures requiring political quid pro quo on the part of the consuming nations in order not to be shut off from oil supplies. It is this political aspect of how the world oil supply is allocated that will have the most serious implications for American national security, as long as we and our allies continue importing as much oil as we can get from OPEC suppliers.

Further, the precarious energy supply situation of several of our most important allies gives opportunities for geopolitical initiatives on the part of the Soviet Union. West Germany imports much of its natural gas and some of its uranium from the Soviet Union. It also imports coal from Poland (as do

*The seven major international oil companies are British Petroleum, Exxon, Gulf, Mobil, Shell, Socal (Chevron), and Texaco.

**Members of OPEC are Algeria, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela.

+See Walter J. Levy, "Oil and the Decline of the West," Foreign Affairs, Summer 1980.

other Western European countries). A major new gas pipeline from the Soviet Union to Western European countries has just been announced. One analyst has suggested that the Soviets may attempt to isolate the West Germans and the French from the Western Alliance by convincing them that in such matters as energy supply they might "see advantages in negotiating in partnership with the Soviet Union rather than as an opponent."*

Global Impacts of Energy Supply Policies. The worldwide nature of the energy challenge must also be emphasized. It is not just the United States and its allies that have suffered from the unpredictable price increases dictated by OPEC; the developing world has suffered greatly as well, and perhaps more than the West. Major industrial and agricultural development projects have been cancelled or delayed because Third World countries required the funds to pay the enormous increases in their bills for imported oil. As rates of economic growth have slowed, the aspirations of the developing world for a better standard of living have been thwarted. On a worldwide scale the effects of the OPEC oil price increases have been readily apparent and massive: little or no economic growth, increased unemployment, and inflation.

The major impacts of OPEC oil price policies on the economic and security interests of the United States and our principal allies can be seen clearly in Figures 29, 30, and 31. The tremendous changes in the United States balance of trade caused by OPEC's price policies and our continued willingness to import large quantities of OPEC oil are readily apparent, as is the macroeconomic impact of the 1973 jump in world oil price on the member nations of the International Energy Agency (IEA),** an agency created with major goals of countering shortages caused by OPEC and cooperating to find alternatives to imported oil from OPEC. Figure 31 points out that our dependence on oil from Middle Eastern OPEC sources also exposes our supply to possible interdiction on its way through various waterways to the Arabian Sea, the Indian Ocean, and around the Cape of Good Hope. Thus the impacts on our trade balance, the health of our economy and those of our allies, the political prices we are being asked to pay for oil supplies, and the highly vulnerable oil delivery system are all elements of the world energy crisis.

United States Policy Response. How has the United States responded to this world crisis so far? As many analyses have pointed out, the United States is blessed with a relative abundance of energy resources; it has choices about how to handle its energy problems and about whether it wishes to become a leader in solving the world problem.

Conservation. A number of federal programs are being formulated to conserve oil, either by reducing consumption or by substituting other energy sources for oil. Efficient energy use is being promoted through creation of

*See Paul H. Nitze, "Strategy in the Decade of the 1980s," Foreign Affairs, Fall 1980.

**The members of the IEA are the same as the OECD except that Finland, France, Iceland, and Portugal are not members of the IEA.

VALUE OF U.S. PETROLEUM IMPORTS 1949 - 1979

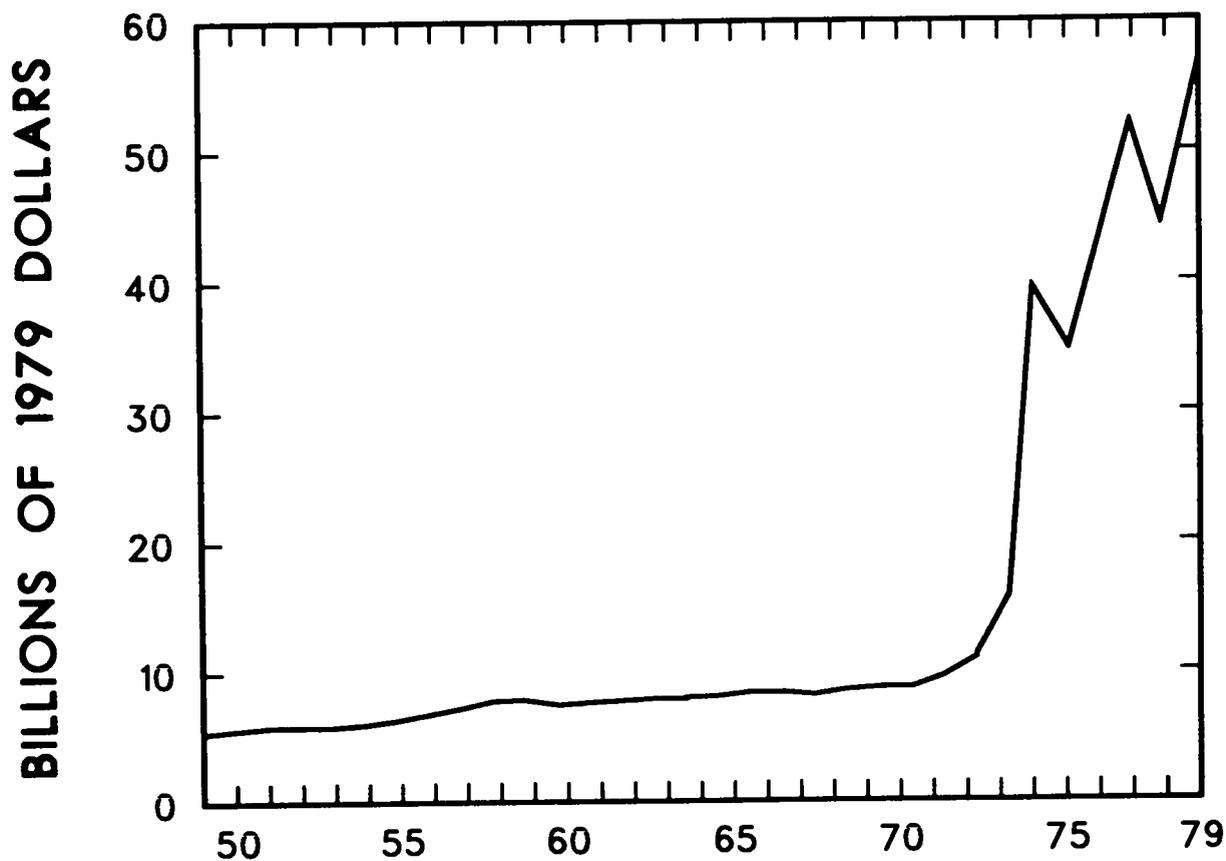


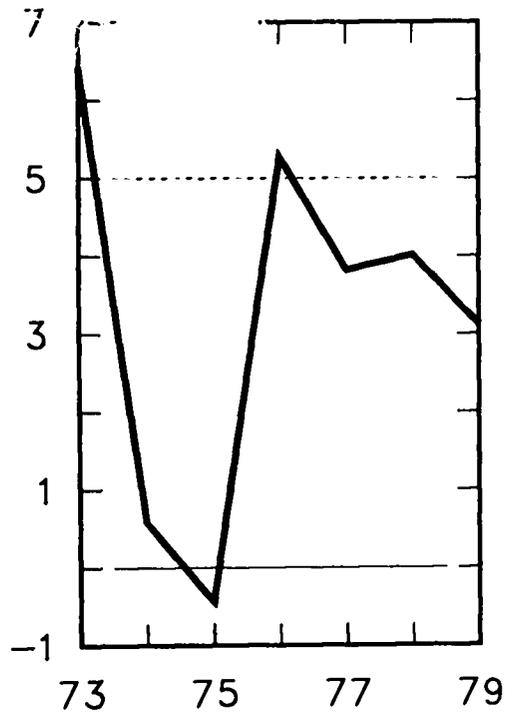
Figure 29

Source: Energy Information Administration, Annual Report to Congress, 1979, Volume Two: Data.

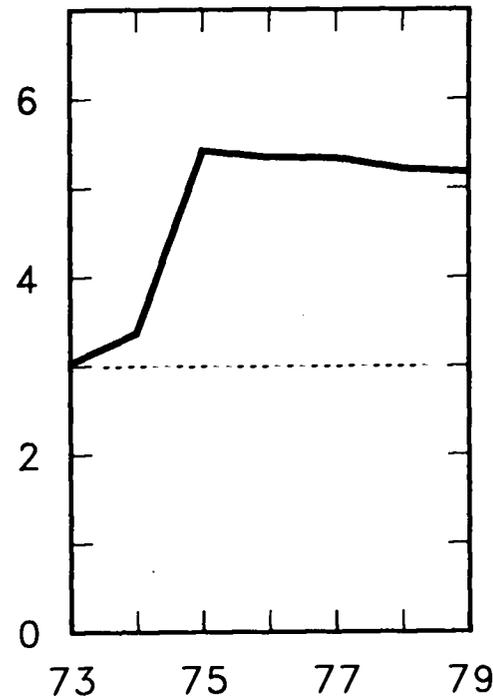
ECONOMIC PERFORMANCE

----- 1963 - 1972 AVERAGE

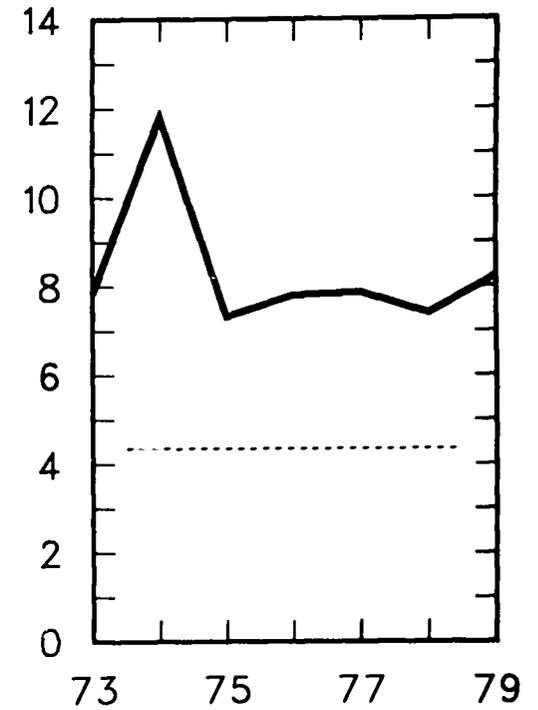
85



GROSS DOMESTIC
PRODUCT
(PERCENT CHANGE)



UNEMPLOYMENT
RATE
(PERCENT)

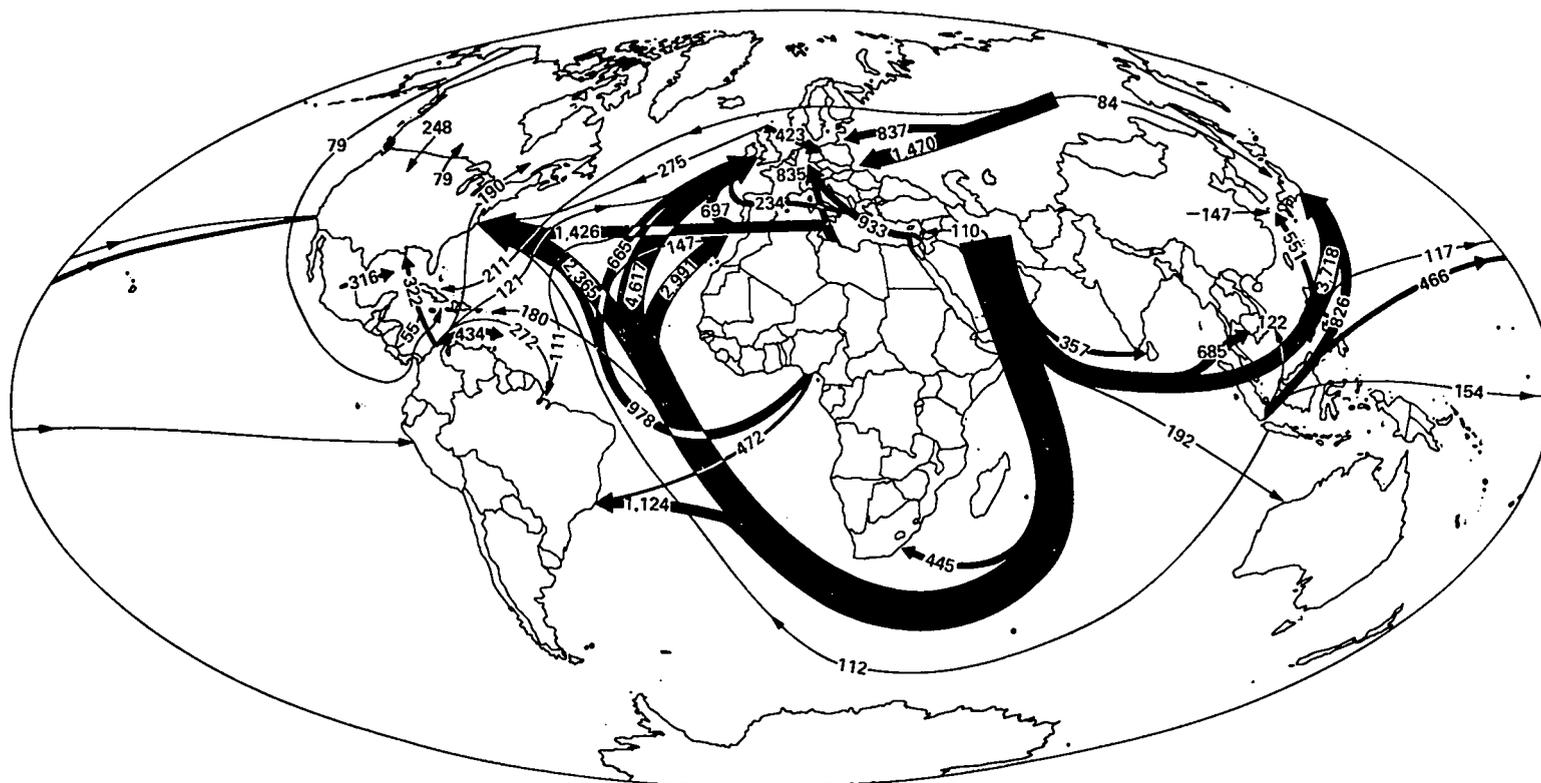


INFLATION RATE
(PERCENT)

Figure 30

Source: International Energy Agency.

INTERNATIONAL CRUDE OIL FLOW, 1978 (THOUSAND BARRELS PER DAY)



NOTE: ARROWS INDICATE ORIGIN AND DESTINATION
BUT NOT NECESSARILY SPECIFIC ROUTES

SOURCE: ENERGY INFORMATION ADMINISTRATION, ANNUAL REPORT
TO CONGRESS, 1979, VOLUME TWO: DATA

Figure 31

Source: Energy Information Administration, Annual Report to Congress, 1979, Volume Two: Data.

efficiency standards for construction of buildings and appliances. Households are encouraged to save energy through insulation tax credits, and to switch away from oil through tax credits for solar and other renewable energy resources. Electric utilities and industries may be encouraged to switch to alternate fuels through oil back-out programs and tax incentives. Perhaps most important, domestic oil and gas prices are being deregulated on a phased schedule; consumers thus can receive correct price signals about the true current market value of oil and adapt their consumption accordingly. In addition, the President has announced a quota on the amounts of oil we will import.

The nation has begun to conserve overall energy use in response to these incentives; especially notable has been the leveling off and slight decline in gasoline use in 1979-1980. However, the United States economy is in recession, and it is not yet clear that energy use will continue at reduced levels if several major industries (automobile manufacturing, primary metals, housing), and subsidiary industries they support, return to normal productive levels. Further, long-term conservation programs require massive changes in capital stocks (buildings, tools, houses, automobiles, transport systems, etc.); these changes have been slow to start.

Oil Supply. Deregulation of the domestic oil industry and accelerated leasing of oil tracts on federal lands (including the Outer Continental Shelf) have begun, and exploratory activity has increased as a result. The decline in domestic oil production may be slowed as a result. However, we have not developed a clear policy about what to do with the extensive amounts of conventional light crudes that remain in existing fields and that might be extracted through enhanced recovery techniques. We have also remained indecisive about how to exploit our deposits of heavy crudes. Similarly, we have created and are staffing a Synthetic Fuels Corporation, and we are to commit to several demonstration plants for the production of liquid fuels from coal and oil shale. But the low production levels expected from this synthetic fuels industry, as currently forecast by the Department of Energy, will come nowhere near meeting future liquid fuel requirements if oil imports are to be contained or reduced.

Other Energy Supplies. The President has announced a goal of 20% of American primary energy input for solar energy by the year 2000, a goal which is extremely ambitious and probably unattainable.* Alcohol fuels have become a

*See Robert Stobaugh and Daniel Yergin, Energy Future (New York: Ballantine Books, 1979) for a typical study that advocates a solar solution through extensive Federal programs of purchase guarantees, required fuel switching, and incentives. A less optimistic view is that of the National Academy of Sciences Committee on Nuclear and Alternative Energy Systems, U.S. Energy Supply Prospects to 2010 (Washington, D.C.: National Academy of Sciences, 1979), which projects extremely small solar use by 2000 under normal conditions and less than 5% of domestic energy production from solar even assuming enhanced implementation.

controversial topic, with advocates insisting they should play a major role in American energy supply strategies; however, no program yet announced would displace a major portion of current United States oil consumption. We have continued to reduce support for our domestic nuclear power programs. We have continued to pursue an international nuclear policy that calls for no fuel reprocessing. And we have continued to deny a near-term need for the breeder reactor. Our allies, on the other hand, are proceeding with reprocessing and breeder reactor technologies.

Emergency Measures. International allocation policies to be followed in the case of significant oil shortages have been worked out with our allies through the International Energy Agency. But one of the most effective ways of mitigating the effects of a shortage, an emergency stockpile, has been a complete failure; the Strategic Petroleum Reserve exists but is unfilled.

Other Policies. Nationally, we have created such a lengthy and complex network of regulation and licensing requirements on energy projects that frequently they can not be brought on-line quickly enough to be fully effective. Internationally, we have not gone beyond cooperative measures to manage shortages, to develop an effective, positive response to cartelization of oil supplies. In other words, while we seem to be taking some good first steps, the overall impression of current United States energy policy is that it is one more critical example of insufficient United States determination to protect a vital national interest.

International Projections

Turning to the future, what are some of the most significant trends that we may expect to emerge, and how should they influence our energy policies?

Basis for Projections. A number of extensive analyses and projections of the world energy outlook have been completed within the last few years. The bases for these projections range from complex models to intelligent guesswork. However, regardless of the complexity of the analysis, it appears that just a few key assumptions tend to drive the projections toward their findings:

- o the possibility of substituting decentralized for centralized technologies (or, "soft" for "hard" technologies)
- o reducing energy consumption without reducing economic growth to an unacceptable level
- o the growth of the nuclear electric power industry
- o conservation and substitution in the uses of petroleum
- o the future role of coal, both for direct use and as a new source of liquid and gaseous fuels
- o how fast a new technology can penetrate energy markets.

Generic Types of Forecast. Given the range of forecasts possible from these different assumptions, there is surprising uniformity in many of their main aspects. In fact, just two basic types of forecasts emerge from the studies. Figures 32a and 32b show projected future quantities of primary energy sources produced and consumed in an equilibrium or market-clearing energy system,

GENERIC TYPE 1 ENERGY FORECAST

68

QUADRILLION BTU

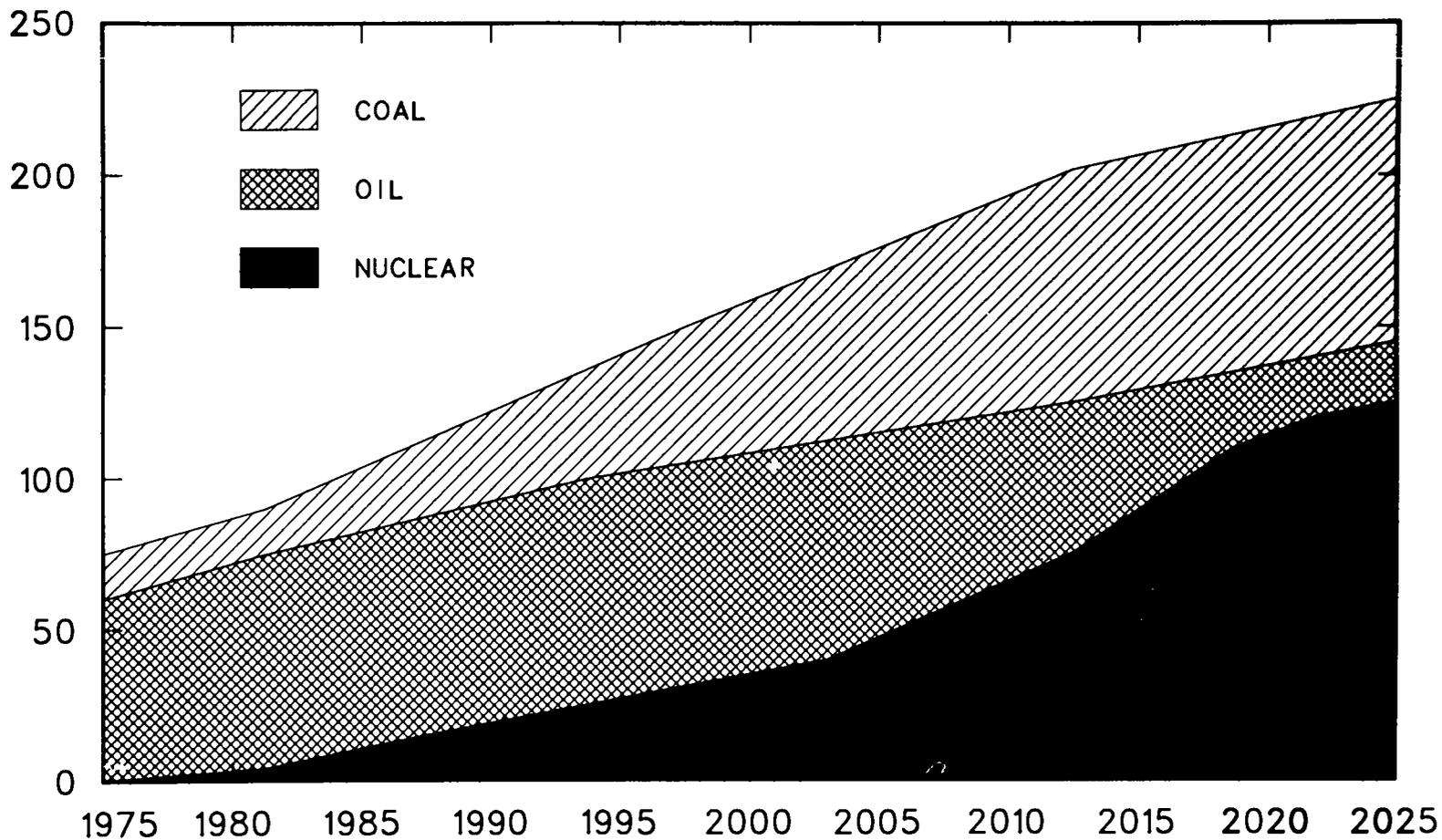


Figure 32a

Source: Amory Lovins, "Energy Strategy: The Road Not Taken," Foreign Affairs, October 1976.

GENERIC TYPE 2 ENERGY FORECAST

06

QUADRILLION BTU

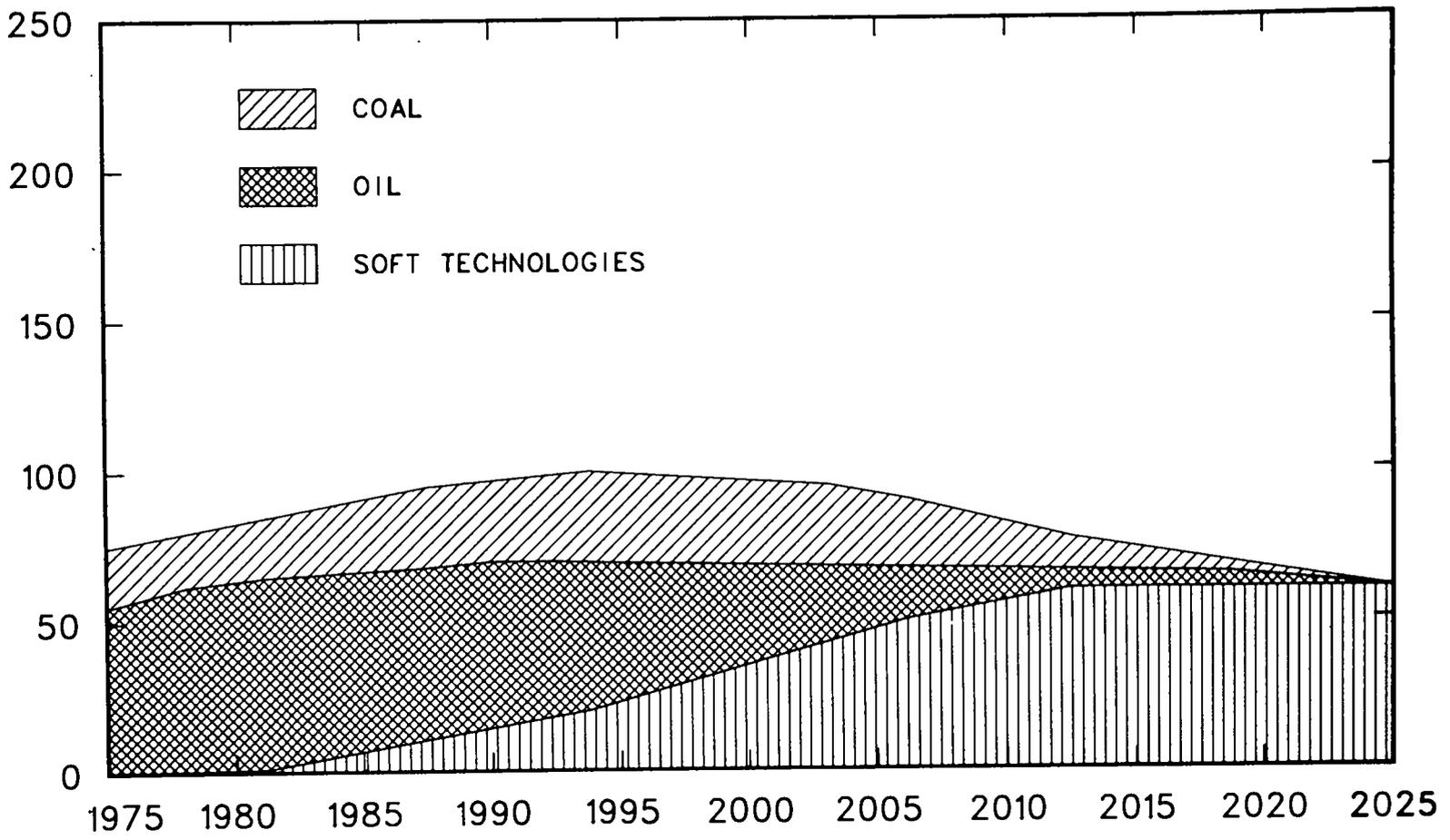


Figure 32b

Source: Amory Lovins, "Energy Strategy: The Road Not Taken," Foreign Affairs, October 1976.

according to these generic forecast types. (These examples are of forecasts for the United States roughly in the time period 1980-2020; world forecasts show similar characteristics.) Forecast I might be called the "standard" forecast: it assumes that no radical changes are made in the primary energy resources utilized to meet demand, nor any radical changes in the ways in which resources are processed, converted, and distributed to final consumption. This forecast is typical of most energy analyses. Forecast II represents the typical result of the alternative forecasts that call for commitment to radically different energy systems as a matter of public policy. The share of "other" primary energy sources is substantially increased (exactly how much may vary between forecasts, but the increase is always large), and the share of conventional energy sources (in particular, nuclear) is substantially reduced (again, exactly how much may vary, but the reduction is always large).

The differences in the two types of forecast are obviously in the role of other primary energy sources and in the overall level of energy consumption. To achieve a forecast of type II, the analyst assumes that conservation measures and rising prices will reduce demand for energy (price elasticity of demand is large); that new, "other" technologies (typically, solar and renewable) will substitute for standard technologies (elasticity of substitution is large); that the nuclear industry is largely phased out of existence; that reliance on coal is reduced by substitution of other resources and technologies; and that dependence on petroleum is further reduced by shifting use of oil and gas to only transportation and possibly feedstock uses.

In contrast, the standard forecast assumes, first, that conservation and price effects will reduce overall energy demand somewhat, but that continued growth in demand for energy will characterize the future (price elasticity of demand is small); and, second, that the rate of substitution of new, other technologies will be slow and expensive (elasticity of substitution is small). It further assumes that the demand for liquid and gaseous hydrocarbon fuels will remain about constant in some sectors (residential, commercial, and transportation) and continue to grow in others (industrial), yielding a continued demand for petroleum and a growing demand for liquid and gaseous fuels from coal and oil shales. It assumes that nuclear and coal will be the primary sources of electric power generation for the intermediate future, that, while the energy/gross national product ratio may be reduced, the reduction will not be radical, and that substantial new energy resources will be required to sustain acceptable levels of economic growth.

A world characterized by Forecast II would involve substantial changes not only in energy systems but in industries and personal habits as well. Most forecasts do not view this kind of world as achievable in the intermediate future; rather, they forecast some variant of Forecast I. So, we examine next major features of a type-I forecast for the world and the United States.

International Forecasts. Several studies have taken a longer term world view. The Workshop on Alternative Energy Strategies projected future levels of demand for the non-Communist world and compared these against estimates of

potential supply that would probably be available.* The International Institute for Applied Systems Analysis, in its World Energy Project, has made similar projections for the entire world. For the Western nations, the International Energy Agency has made medium-range forecasts of energy balances.**

Figures 33 through 37 illustrate several critical findings from these international studies. First, the non-Communist world will remain dependent on petroleum for large portions of its energy throughout this century; much of this petroleum is projected to come from OPEC imports. Second, the Alternative Energy Strategies study in particular concluded that if healthy economic growth in the non-Communist world is to continue, even with vigorous policies to replace oil with other fuels, oil demand will remain extremely strong through the end of the century. Available world oil supply will begin to decline in this period. Enhanced oil recovery and use of oil shales may slow this process,⁺ but the generic result will be the same. Before 1990, demand for oil will begin rapidly to outstrip available supply (Figure 36).

The Alternative Energy Strategies analysts did not attempt to find ways to eliminate the "gap" between supply and demand for world oil. They pointed out that in the absence of some coherent policy to find either additional oil supplies or substitutes for oil, the consequences of encountering an actual shortfall between supply and demand could be severe in their effects on world economic stability: severely reduced world economic growth, sustained worldwide inflation, significant worldwide unemployment, severe balance-of-payments problems.

It is important to note that these results were obtained in the mid-1970s and assumed orderly world oil markets; thus the gap they project reflects the operation primarily of economic factors. If political uses of world oil supplies play an increasing role in determining availability of supply, the projected gaps may be larger and may occur sooner than anticipated.

The International Institute for Applied Systems Analysis World Energy Project has also made projections of future energy supply and demand. Whereas the Workshop on Alternative Energy Strategies group simply tried to point out gaps between energy supply and demand that must somehow be "filled," the World Energy Project constructed a world energy and economic modeling system that balanced the two.

*Workshop on Alternative Energy Strategies, Energy: Global Prospects 1985-2000 (New York: McGraw-Hill, 1977).

**International Energy Agency, A Group Strategy for Energy Research, Development and Demonstration (Paris: Organisation for Economic Cooperation and Development, 1980).

⁺For example, Figure 35b shows a typical result assuming use of these methods and resources. See Ray Dafter, "World Oil Production and Security of Supplies," International Security, Vol. 4, No. 3 (Winter 1979/80).

PRIMARY ENERGY DEMAND by FUEL TYPE. WOCA

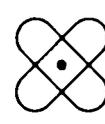
Assumptions:
 High Economic Growth,
 Rising Energy Price,
 Vigorous Policy, and
 Coal as Replacement Fuel



Oil



Nat.
Gas



Nuclear



Hydro



Coal

Geothermal
and others

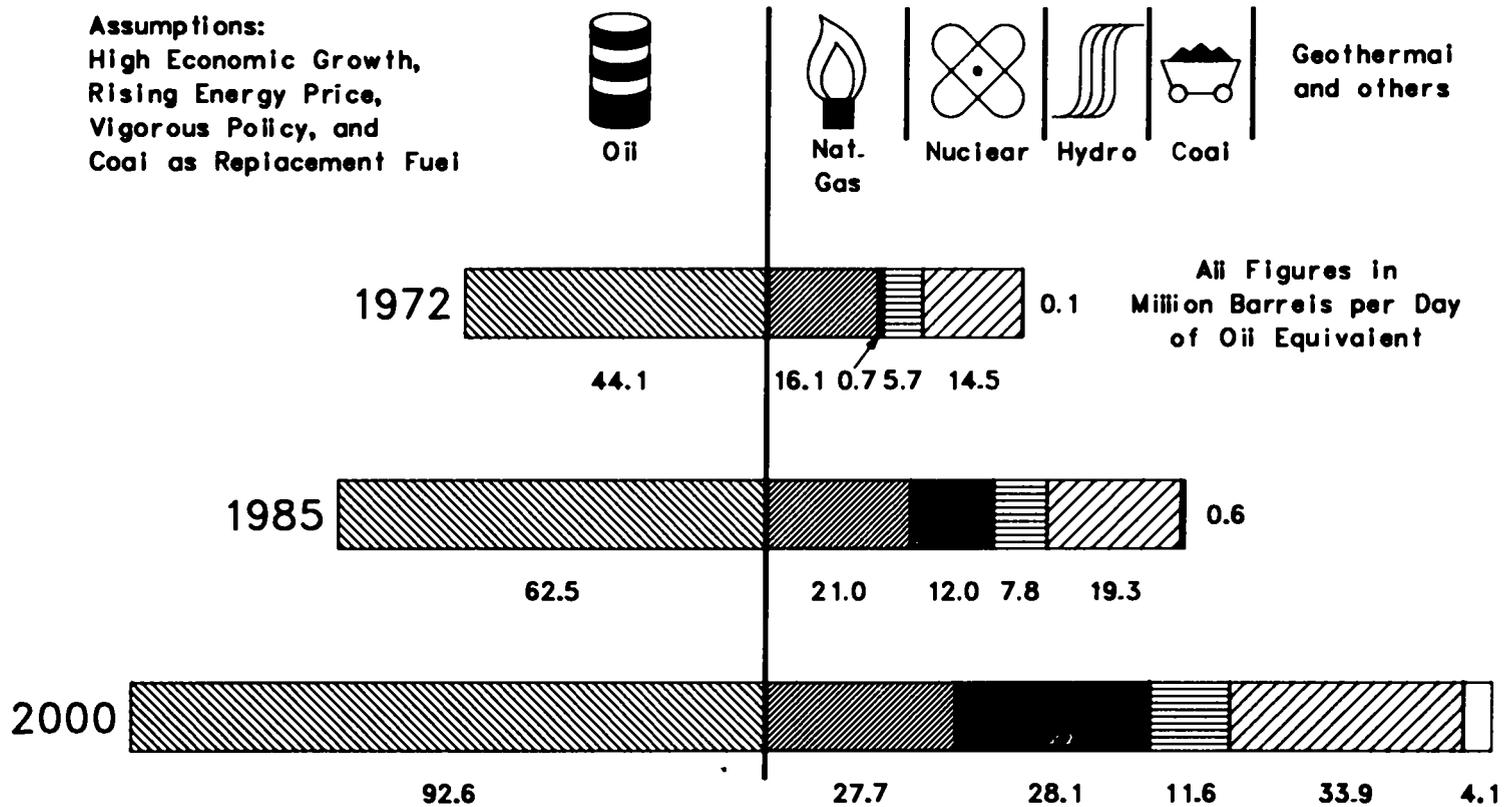


Figure 33

Source: Workshop on Alternative Energy Strategies,
 Energy: Global Prospects 1985-2000, (New
 York: McGraw-Hill, 1977.

POTENTIAL FOSSIL FUEL SUPPLY

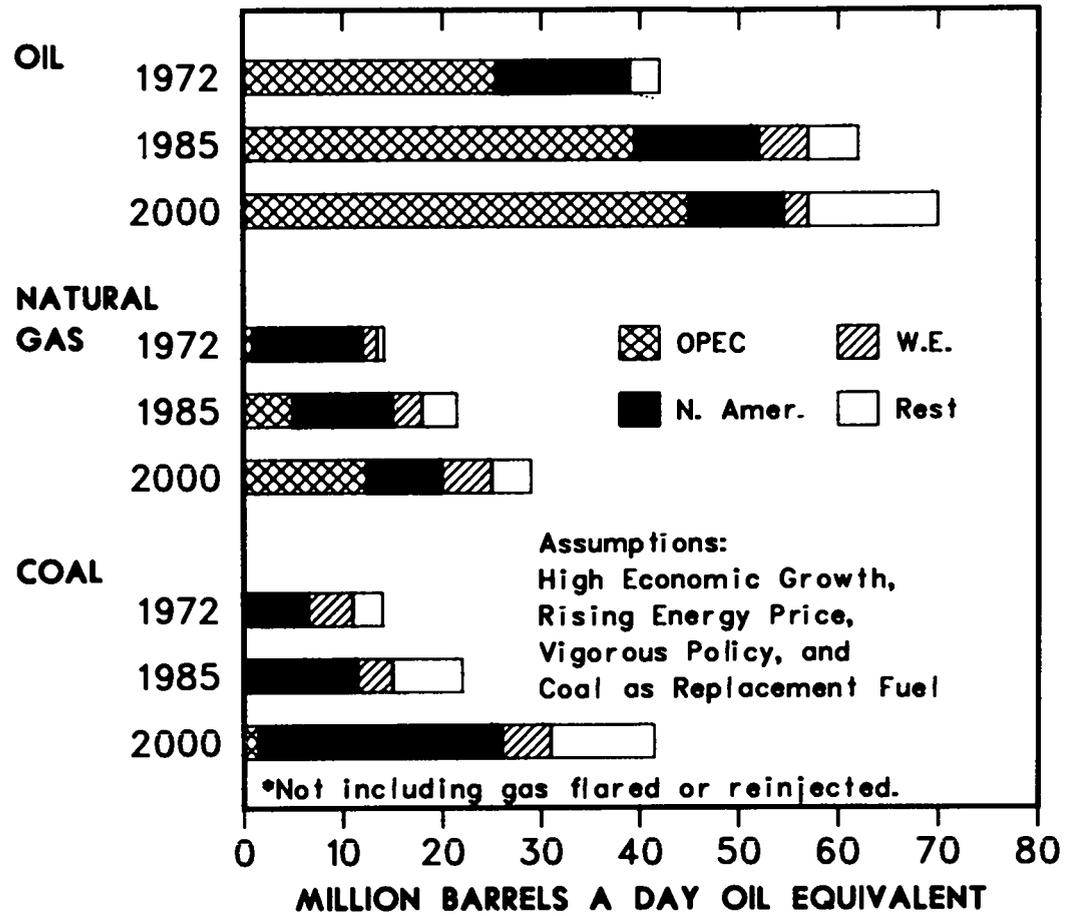


Figure 34

Source: Workshop on Alternative Energy Strategies, Energy: Global Prospects 1985-2000 (New York: McGraw-Hill, 1977).

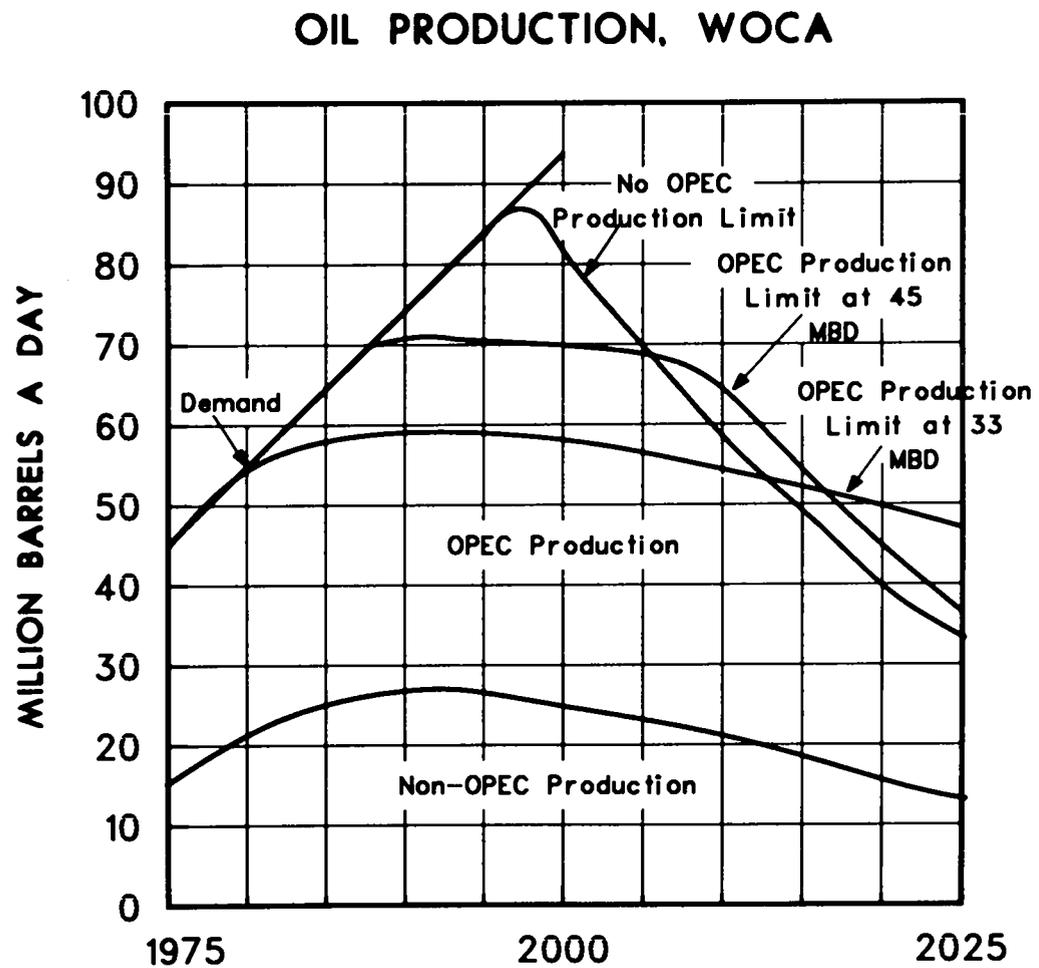


Figure 35a

Source: Workshop on Alternative Energy Strategies,
Energy: Global Prospects 1985-2000, (New
 York: McGraw-Hill, 1977.

ESTIMATE OF COMPLETE CYCLE OF WORLD OIL PRODUCTION A MORE OPTIMISTIC VIEW

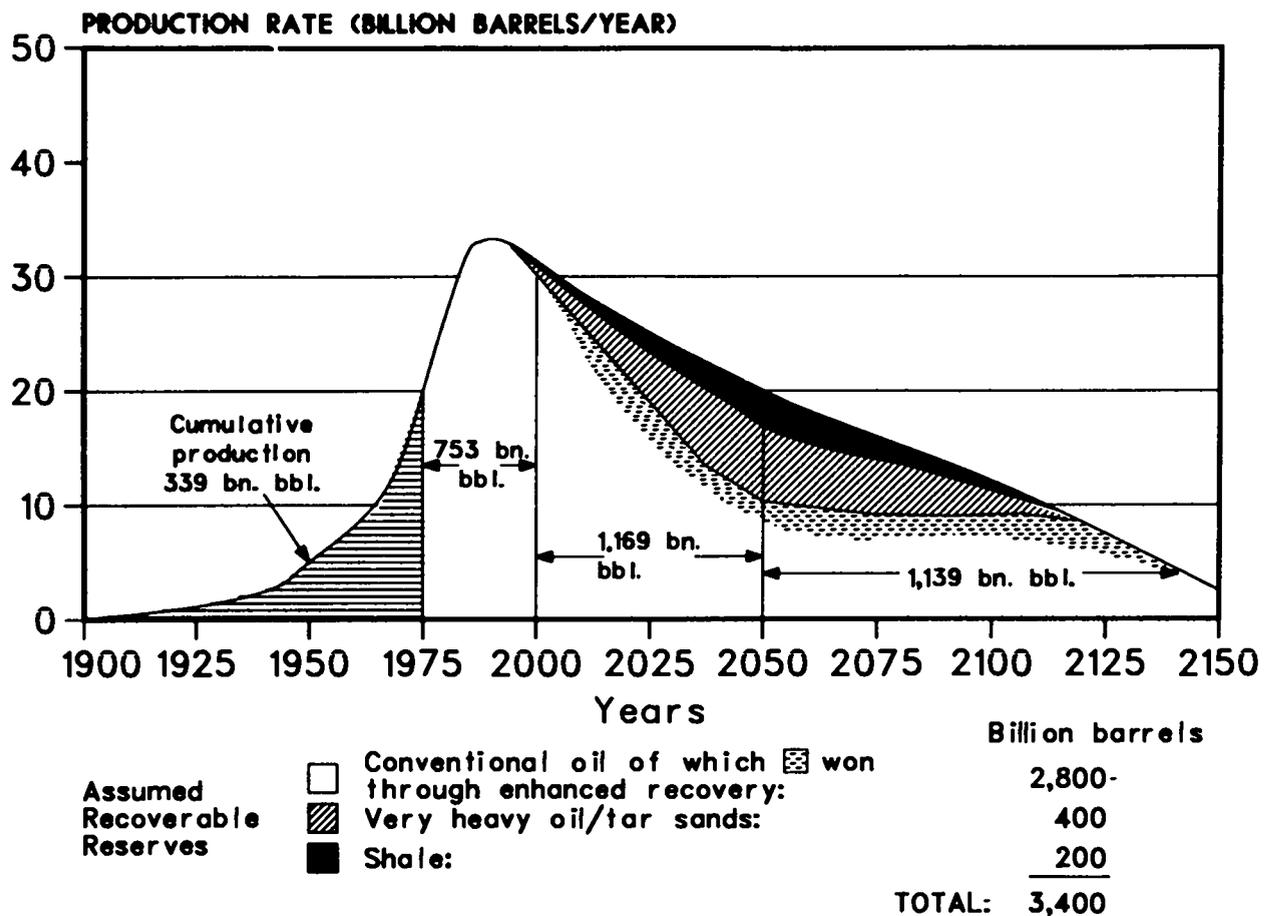


Figure 35b

Source: Ray Dafter, "World Oil Production and Security of Supplies," International Security, Winter 1979/80.

POTENTIAL OIL SHORTFALL, WOCA

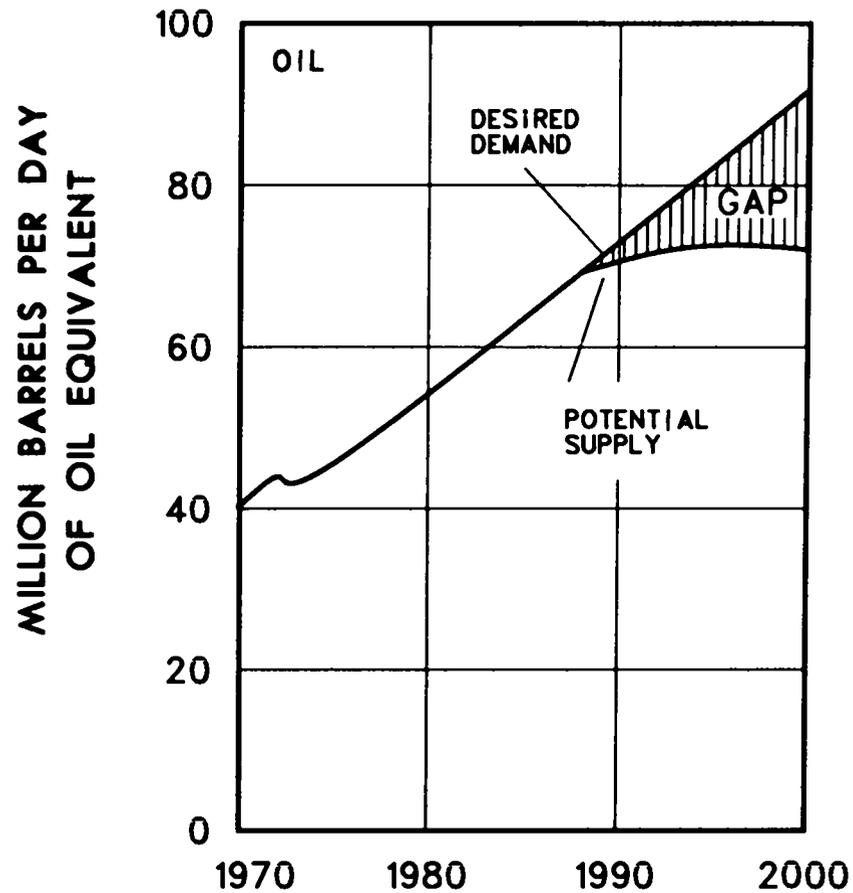
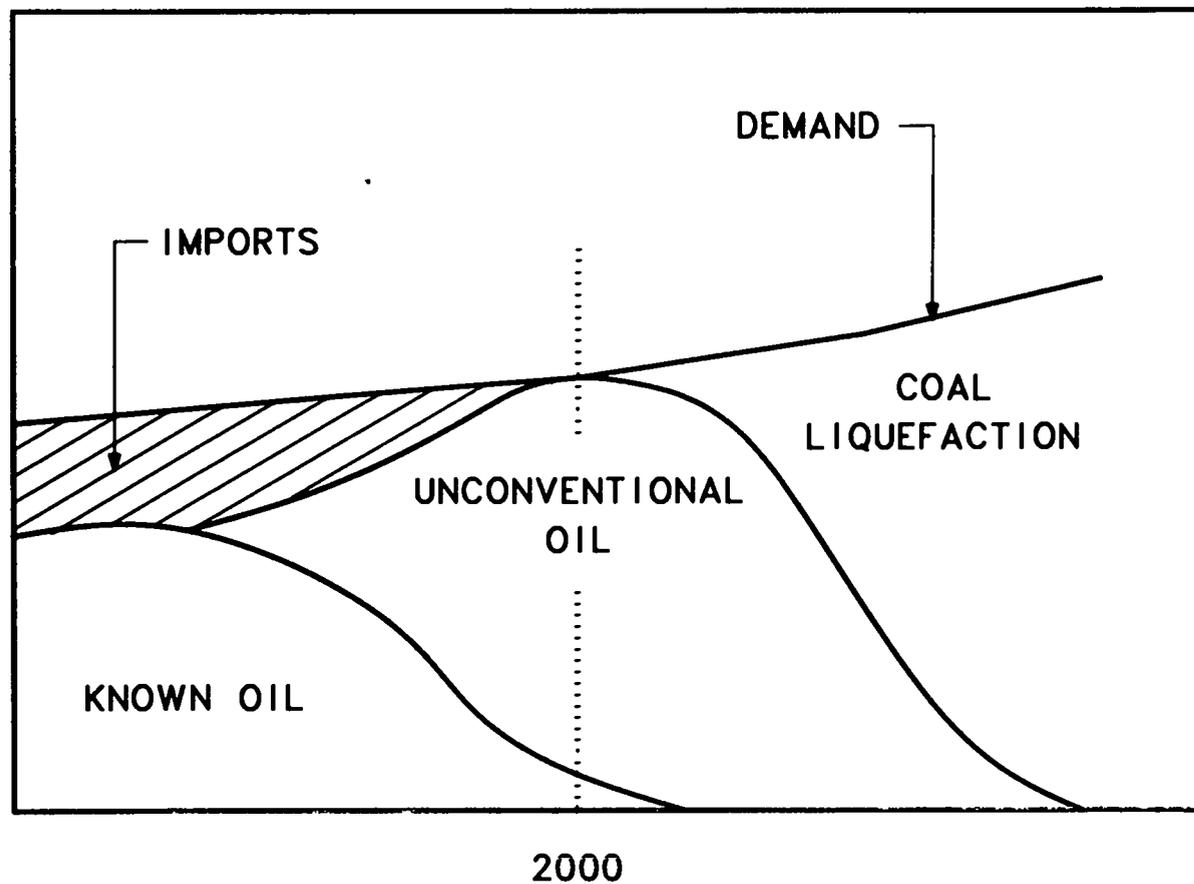


Figure 36

Source: Workshop on Alternative Energy Systems, Energy: Global Prospects 1985-2000 (New York: McGraw-Hill, 1977).

SOURCES OF LIQUID FUELS



86

Figure 37

Source: International Institute for Applied Systems Analysis.

Figure 37 shows the fundamental result of the World Energy Project work. As do most other analyses of world oil supply, the World Energy Project shows world oil production (even including unconventional recovery methods) peaking very soon. In this system, world demand for liquid fuels continues to grow, especially as the underdeveloped world attempts to industrialize. Like the Energy Strategies study, the World Energy Project concludes that world oil supply and demand become unbalanced fairly soon; this occurs in this projection beginning about 2000. The result is that an alternative source of liquid hydrocarbon fuels must be found and, on a worldwide scale, only coal exists in sufficient quantity to meet the projected demand. Thus, the study forecasts a massive synthetic fuels industry based on coal resources found mostly in the United States, the Soviet Union, and China. The figure shows how the World Energy Project sees North America meeting its demand for liquid fuels over time. This massive increase in coal use is in addition to, not in substitution for, a greatly enlarged nuclear electric power industry. The geographical distribution of coal resources is such that a few nations could substitute coal (via direct combustion or conversion to electricity or liquid fuels) for most of their energy requirements, if necessary, but this is not generally true. Many nations in the forecasts--notably Germany, Japan, and France--must rely upon imported fuels and a nuclear industry.

For the Communist world, the critical factor is the level of Soviet crude oil production. In the long run crude oil from China may become a significant factor in world and Communist-area energy supply, but there are no indications that the Chinese leadership is planning for massive development projects for exporting oil.

Natural gas and coal supplies can meet a significant portion of energy demand in Communist countries. As already noted, the Soviet Union is a significant exporter of natural gas to both Eastern and Western Europe, and countries such as the Federal Republic of Germany are attempting to gain more long-term supply commitments from the Soviets. However, demand for liquid fuels is just as critical in these countries as it is in the West. Soviet oil production for some time has met both domestic demand and significant portions of demand in other Communist countries, especially in Eastern Europe, Cuba, and Southeast Asia. If Soviet crude oil production were no longer able to meet all these demands, it is possible that several of these countries would enter into the competition for world oil supplies (it would not necessarily be the Soviet Union itself).

Because the Soviets have restricted data on their oil reserves and oil development activities for a number of decades, it is not possible to project their future supply with the same degree of accuracy as for the United States. However, the Central Intelligence Agency has been forecasting since the early 1970s that Soviet crude oil production may peak in the early 1980s and then decline. Figure 38 shows projections made by the CIA in 1977.

The impact this might have in the short term is indicated by Figure 39, which indicates that by as early as 1982 (according to CIA analyses) the Communist countries as a whole may move from a position of being a net

SOVIET CRUDE OIL PRODUCTION

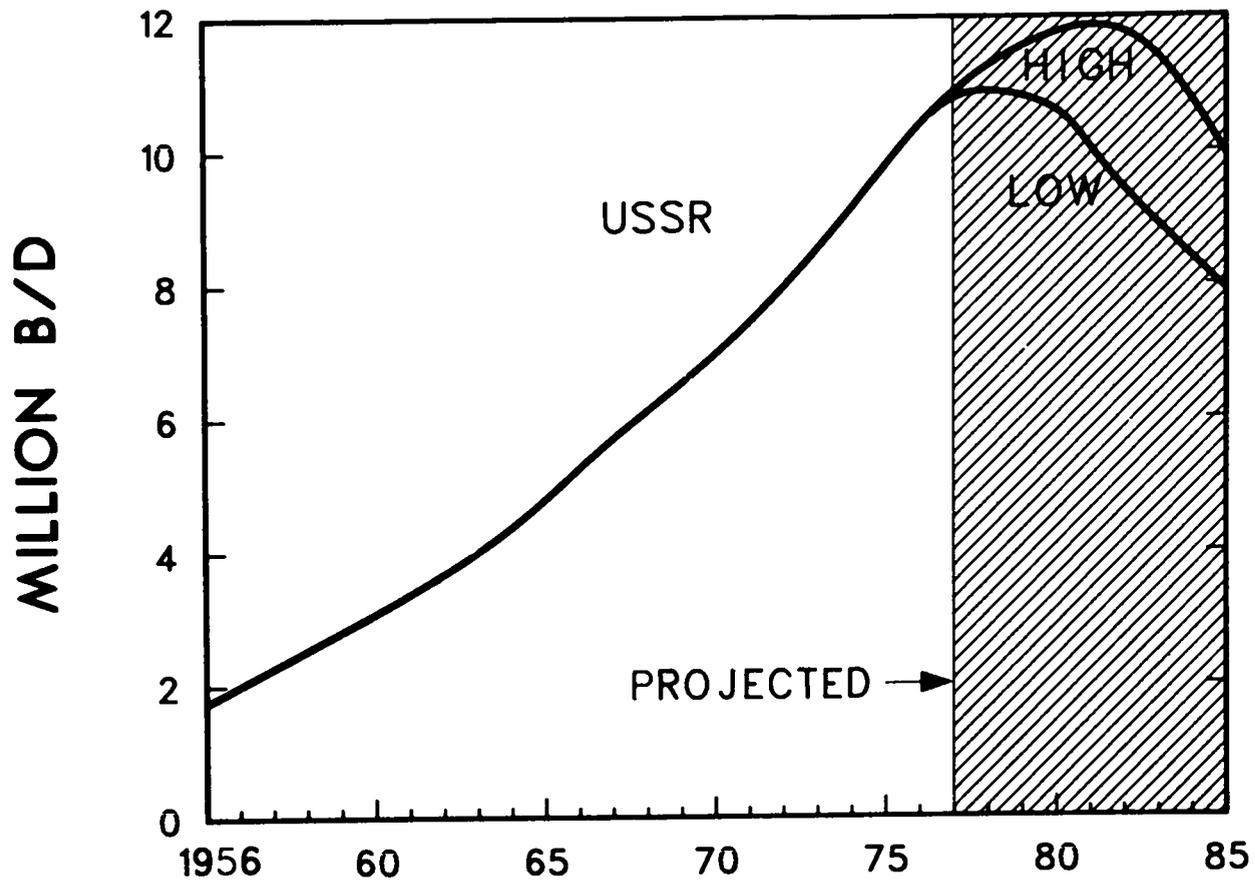


Figure 38

Source: Central Intelligence Agency, The World Oil Market in the Years Ahead, August 1979.

COMMUNIST COUNTRIES: NET OIL TRADE

Million b/d

	1978	1982
Net exporters		
USSR	3.2	2.0
China	3.0	1.7
	0.2	0.3
Net importers		
Eastern Europe ¹	-2.2	-2.7
Other ²	-2.0	-2.4
	-0.2	-0.3
Balance	1.0	-0.7

¹ Including Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, and Yugoslavia.

² Including Albania, Cuba, Kampuchea, Laos, Mongolia, North Korea, and Vietnam

Figure 39

Source: Central Intelligence Agency, The World Oil Market in the Years Ahead, August 1979.

exporter of about 1 million barrels per day, to being a net importer of about 700,000 barrels per day. If continued, this trend would place a critical burden on the ability of the world oil supply to meet total world demand for oil.

United States Projections

Energy Forecasts. The energy outlook for the United States has been subjected to many exhaustive analyses; again, there is surprising uniformity in the findings. The Energy Information Administration Report to the Congress is quite representative of the standard kind of energy forecast made for the United States. Figures 40 through 45 illustrate the critical findings. The first figure demonstrates that consumption of oil and gas will remain an important part of American energy consumption for some time, even though they decline in the percentage of supply that they provide. Of the growing energy supplies, the two most important primary energy sources for which consumption increases most dramatically are coal and nuclear. United States consumption of liquid fuels shifts substantially to fuels from synthetic sources, rather than crude petroleum. Finally, all other primary energy resources consumed are at best a small portion of total consumption.

The second figure in this group shows that the Energy Information Administration forecast is by no means deviant from other forecasts. The figure shows a comparison of five independent attempts to make systematic forecasts of American domestic energy consumption.* The degree of similarity in findings is remarkable; there seems to be no qualitative difference in the projections.

Figure 42 displays projections about energy consumption in particular end-use sectors. It reveals that residential, commercial, and transportation uses show almost no growth in consumption; almost all total energy consumption growth occurs in the industrial sector. A significant substitution of electricity for oil occurs in the residential and commercial sectors, but oil consumption in industry and for transportation remains about constant (reflecting feedstock uses and realities of United States transportation systems and industrial processes). Almost all increased energy consumption involves either electricity (produced primarily by coal- and nuclear-fueled generating plants) or direct combustion of coal or its transformation to a liquid fuel.

Figures 43, 44, and 45 confirm trends implicit in the other figures. First, nuclear and coal are the overwhelmingly dominant sources of electricity. Further, the conversion of coal to synthetic fuels becomes a major source of United States energy supply after 2000, representing potentially one-fourth to one-half the entire energy consumption of the United States. Liquid fuels, which remain a very substantial part of domestic energy

*US Dept. of Energy, Energy Information Administration, A Comparative Assessment of Five Long-Run Energy Projections, DOE/EIA/CR-0016-02, December 1979.

LEAP MODELING SYSTEM PRIMARY ENERGY CONSUMPTION

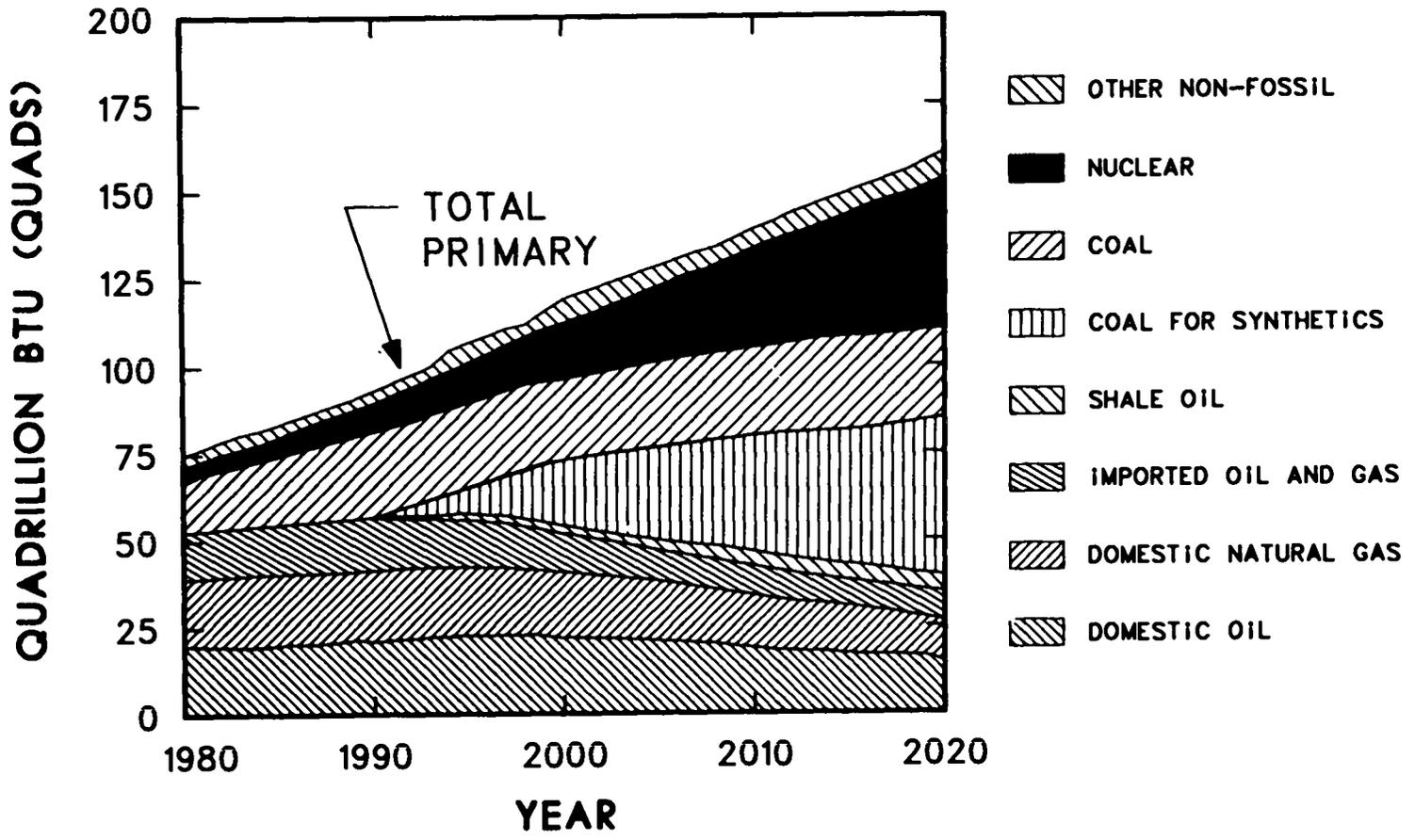


Figure 40

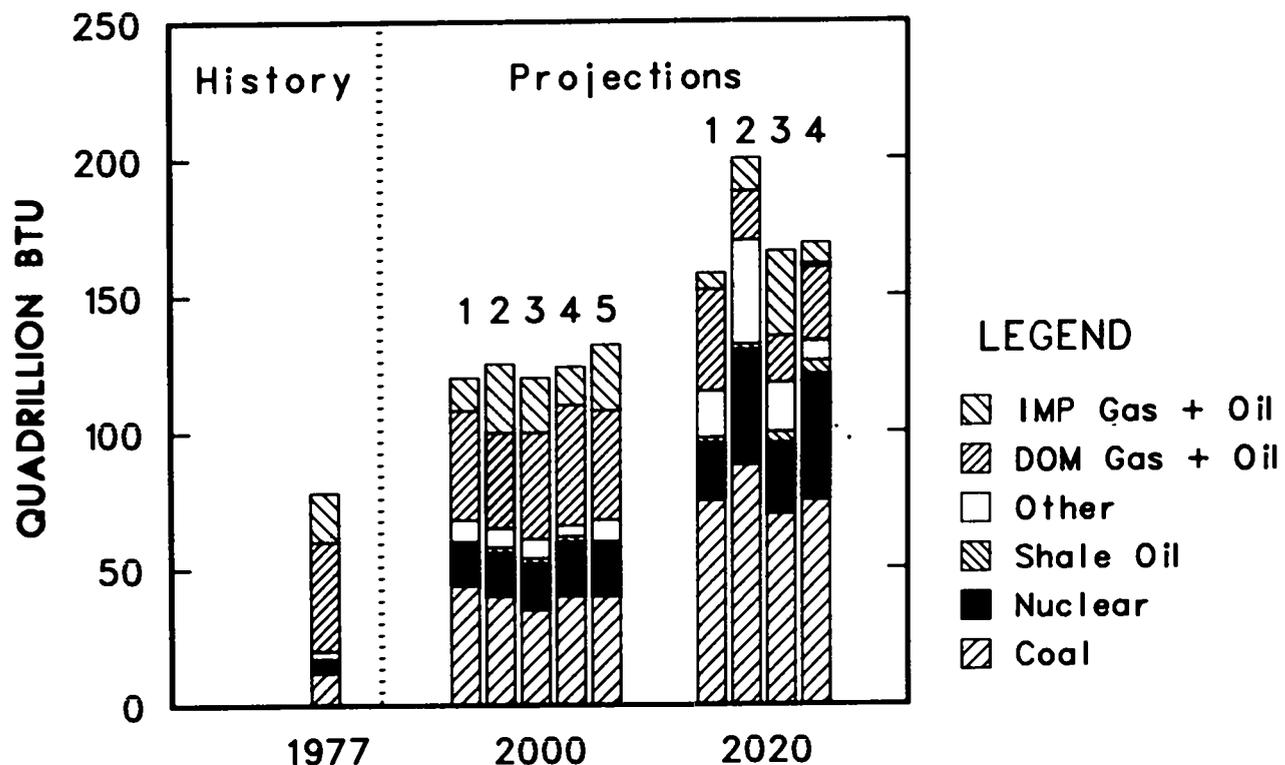
Source: Energy Information Administration, A Comparative Assessment of Five Long-Run Energy Projections, December 1979.

COMPARISON OF PRIMARY ENERGY CONSUMPTION PROJECTIONS

104

KEY

- 1 BNL/DJA
- 2 ETA/Macro
- 3 Fossil 2
- 4 Leap
- 5 Pilot



LEGEND

- IMP Gas + Oil
- DOM Gas + Oil
- Other
- Shale Oil
- Nuclear
- Coal

Figure 41

Source: Energy Information Administration, Annual Report to Congress 1978, Volume Three: Forecasts.

END-USE ENERGY CONSUMPTION by SECTOR and FUEL

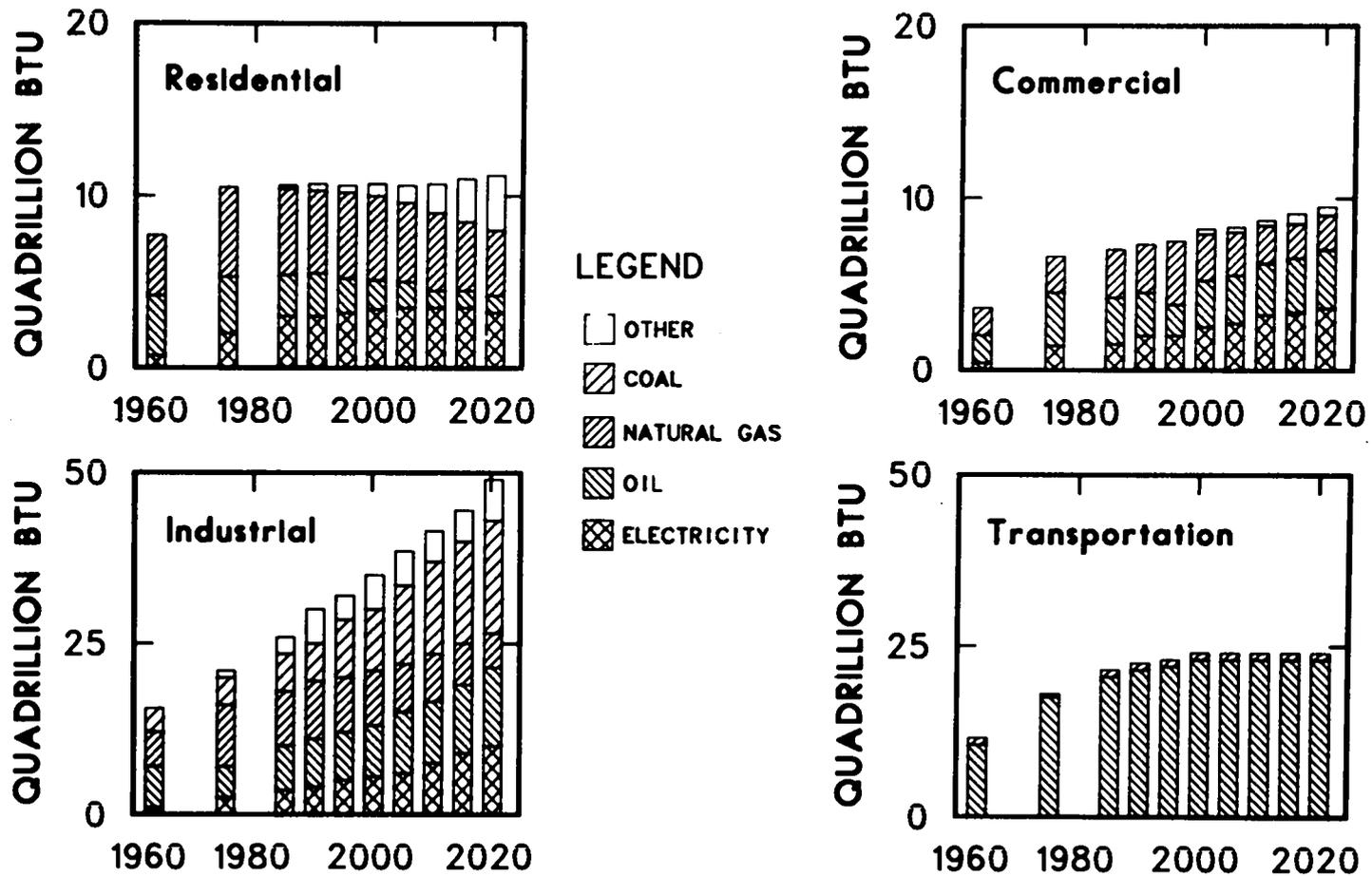


Figure 42

Source: Energy Information Administration, Annual Report to Congress 1979, Volume Three: Projections.

U.S. UTILITY FUEL DEMAND

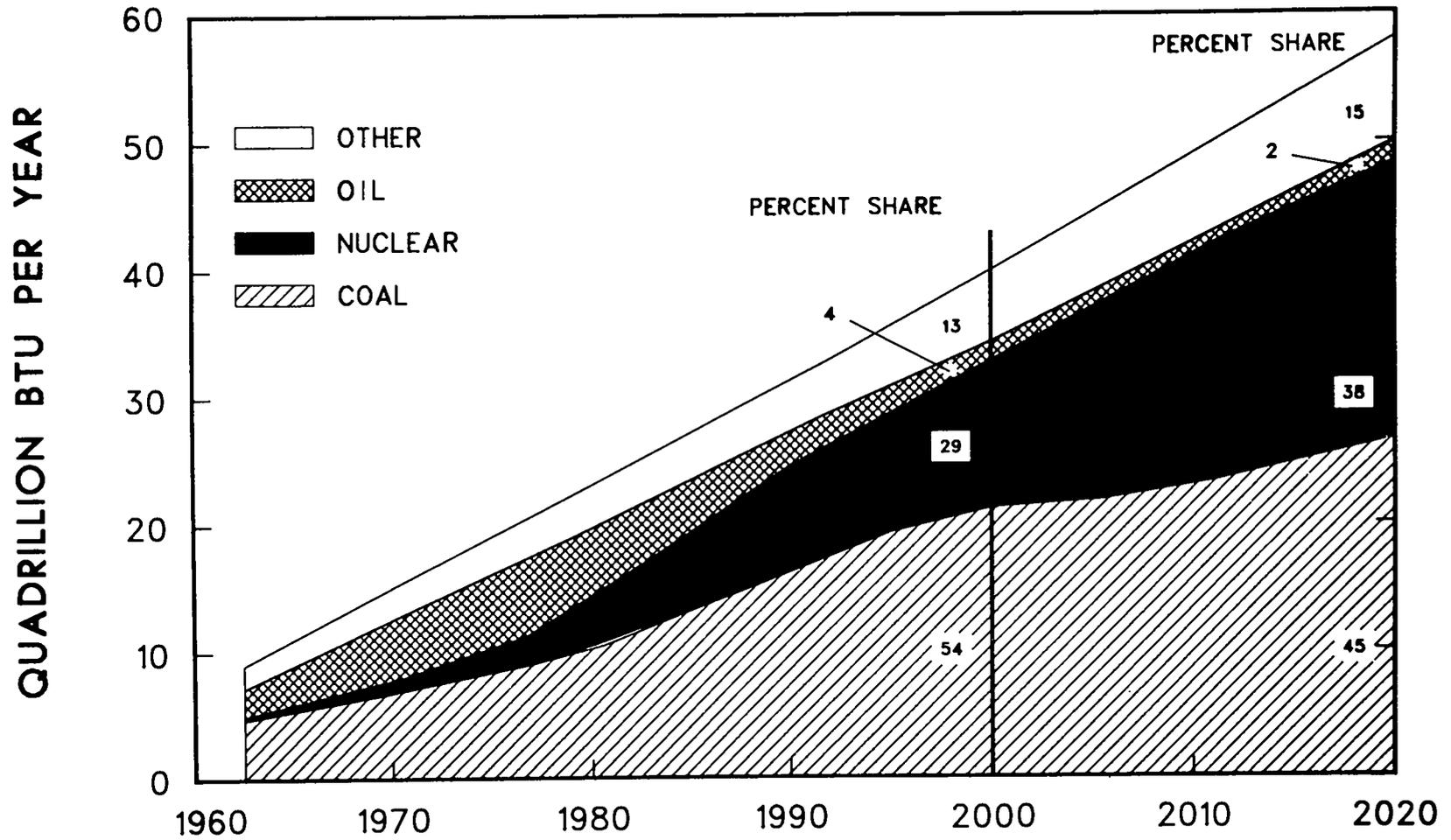


Figure 43

Source: Energy Information Administration, Annual Report to Congress 1979, Volume Three: Projections.

TOTAL COAL and COAL to SYNTHETICS

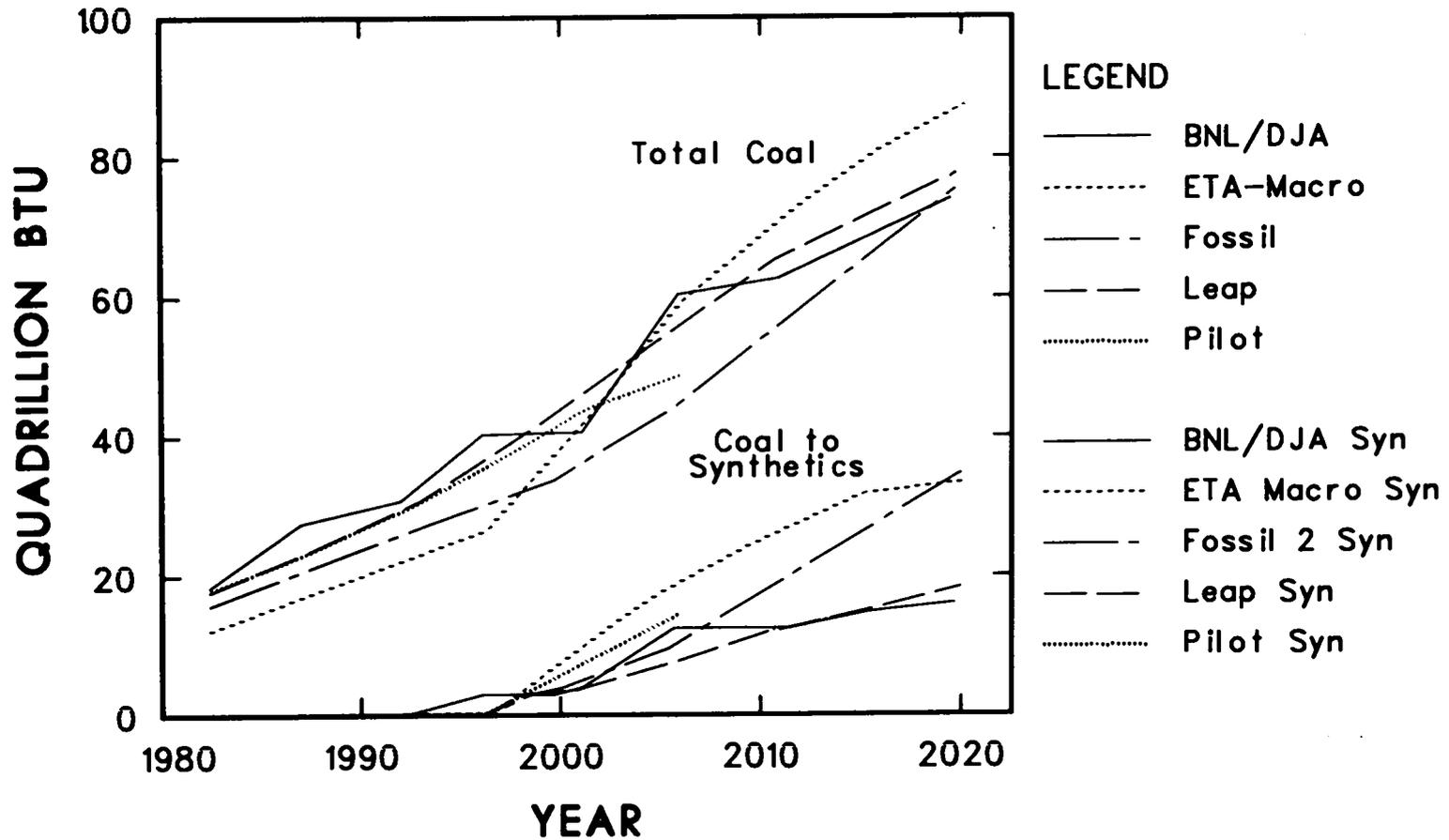


Figure 44

Source: Energy Information Administration, Annual Report to Congress 1978, Volume Three: Forecasts.

PETROLEUM LIQUIDS SUPPLY

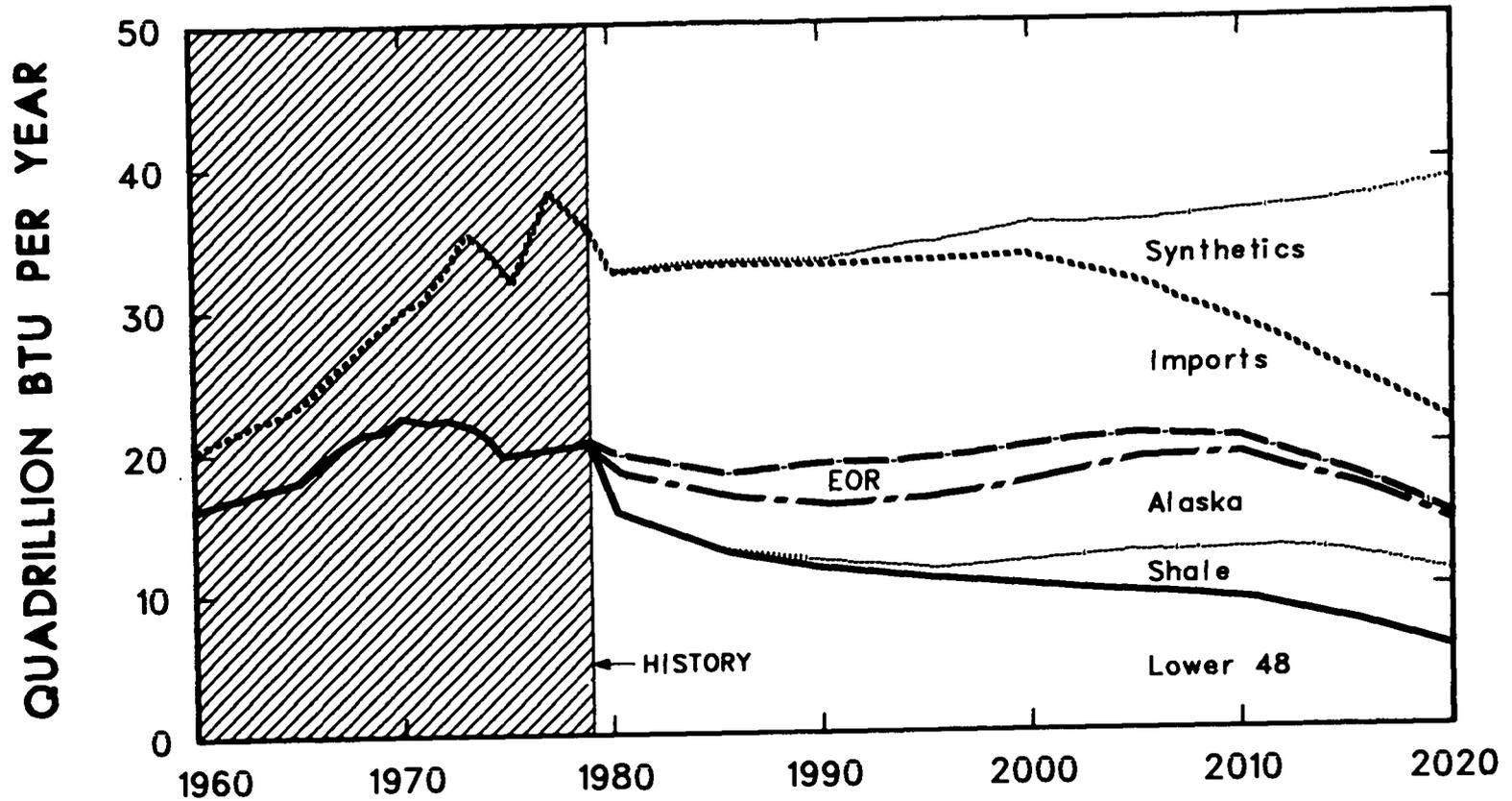


Figure 45a

Source: Energy Information Administration, Annual Report to Congress 1979, Volume Three: Projections.

TOTAL LIQUIDS SUPPLY by SOURCE

	1962	1977	2000	2010	2020
Conventional Oil and NGL					
Continental United States	17.1	19.8	13.8	9.6	6.6
Alaska	-	-	4.0	4.3	3.9
Enhanced Oil Recovery	-	-	5.4	5.7	4.8
Oil From Shale	-	-	1.8	3.6	5.1
Synthetic Coal Liquids	-	-	2.6	7.2	11.0
Total Domestic Production	17.1	19.8	27.5	30.4	31.3
Net Oil Imports	4.2	18.2	11.0	8.6	7.4
Total Liquids Supply	21.3	38.0	38.5	39.0	38.7

Figure 45b

Source: Energy Information Administration, Annual Report to Congress 1978, Volume Three: Forecasts.

consumption, increasingly come from synthetic sources (both coal- and shale-based) and enhanced recovery, and less and less from conventional production and imports.

Major Findings from Global and United States Forecasts. We may summarize the conclusions reached in these energy projections for the world and the United States in the following ways.

Critical Findings about Energy Quantities. We have noted, that while the individual forecasts and analyses differ as to detail in numerical projections, there are several central similarities in conclusions in the studies.

- o Conventional oil and gas resources may be consumed to a lesser extent than now, but they remain a central primary energy resource for the foreseeable future.
- o Conservation measures and increased efficiency of energy end use are necessary and will reduce the size of the problem somewhat, but they do not change the basic nature of the problem: a potential shortfall of the most economically desirable energy resources.
- o Coal resources, especially United States coal resources, have the potential of becoming tremendously important in the United States and the world energy supply system and economy. In order of decreasing importance of use, the three primary coal end uses may become
 - o feedstock for synthetics fuels,
 - o electric power generation, and
 - o industrial uses.
- o In industrialized economies similar to that of the United States, major substitutions include the replacement of oil consumption by electricity consumption in several sectors (not transportation or industrial feedstocks) and the reduction of oil consumption by capital expenditure on conservation in all sectors.
- o The United States-focused studies tended to find ways for clearing energy markets (balancing supply with demand); they seem to have done this by allowing imported oil to fill any gaps. However, when the worldwide situation was examined, the problem seemed much different: the world as a whole may suffer a shortfall of upwards of 20 million barrels of oil per day by the 1990s. No longer should United States analysts assume the oil imports will be there in the quantities required to meet United States demand.
- o Several major alternatives to a worldwide oil shortfall seem to exist: radical political changes in the ownership and allocation of oil resources; drastically reduced economic growth in both developed and developing countries, caused by rapidly increasing world energy prices and reduced energy supplies; or the emergence of a truly

massive synthetic fuels industry based on coal, with the United States as a prime producer and exporter to the rest of the world. A major policy concern is whether such an industry can be generated in time to meet projected demand.

- o Given the potential worldwide demand for coal and the potential substitution of electricity for oil, it is difficult to achieve a world forecast that balances supply with demand for electricity without a substantial nuclear power industry (whether LWR, breeder, advanced converter, or others) installed in a significant number of fuel-poor nations.

Critical Findings about Policy Variables. The various studies contain a vast array of policy conclusions and recommendations, some of a very general nature and many of a very narrowly focused nature. Our view is that almost all the important policy statements can be subsumed within one of the following dimensions.

1. The role of markets versus planning for the future. There are two quite different ideological viewpoints apparent in these studies; any particular study tends to emphasize either one or the other. The first takes the view that normal economic market forces are sufficient to adjust the changing energy supply/demand situation. The second viewpoint differs in that market processes are viewed as necessary but not sufficient, additional specification of future energy goals is required, and planning for means of achieving these goals must be engaged in.

The viewpoint that promotes reliance on market responses to "solve" energy "problems" relies on certain key assumptions: that there are considerable primary energy resources still in the ground, that under appropriate economic conditions these resources will be produced, and that they will enter the world energy supply system freely and be accessible to all consumers. It assumes that conservation in energy use (reduction in demand) is most efficiently achieved, and will be achieved, as the real price of energy rises. It assumes that changes in energy consumption patterns (substitution between fuels and in end uses) is most efficiently achieved, and will be achieved, as the real price of energy rises.

Obviously this is the view of the economist, and several of the studies use this viewpoint as the basis of their forecasts and recommendations. From these principles, we get these typical recommendations

- o Rapid deregulation of energy markets so that the real prices of energy commodities can be established and consumers can make efficient individual adjustments.
- o Removal of hidden and visible subsidies from the energy-consuming sectors.
- o Removal of barriers to private entrepreneurs who wish to produce more conventional energy resources or develop new ones.
- o Use of government intervention only when markets fail.

The planning perspective, in contrast, tends to resemble the analysis of the engineer or research and development program manager in that it does not assume that the changes projected by the market viewpoint will occur automatically, efficiently, or in time to make a difference. Rather, this viewpoint assumes that adjustments to price changes in energy commodities occur with significant time lags, with the danger of significant shortfalls between demand and supply as a result. It assumes that imperfect foresight and planning will prevent industry from accounting for declining resources soon enough to adjust and generate the required substitutes. It assumes that research and development on alternative energy supplies, especially those requiring development of new technologies, requires lead-times so long that normal market considerations will not bring forth the required level and timing of investment in research and development. Therefore, in addition to freeing energy markets, this viewpoint calls for the use of other measures to meet future desired levels of energy production and consumption. These include

- o incentives,
- o subsidies,
- o regulations, and
- o promotion of research and development programs.

This approach also contends with noneconomic requirements such as security of supply.

2. Centralized versus decentralized energy systems. Several studies argue that radical alternatives to the present system of energy production and distribution could reduce the demand for oil and gas, coal, and nuclear power. The central assumptions are that severe conservation measures, adoption of decentralized solar power systems for space heating, water heating, and residential and commercial power generation, and reliance on unconventional and renewable sources for power generation and transportable fuels will bring about a supply system that will meet future needs. (As noted, the standard forecast differs from this dramatically in that it forecasts continued, fundamental reliance on petroleum, natural gas, coal, and nuclear power.) Most of the urgency in recommending political intervention to bring about investment in solar, biomass, etc. depends on whether the analyst believes the alternative energy system can make major substitutions for the three principal conventional energy resources in relevant time horizons. These studies seem to posit an alternative energy system that is not only more efficient but morally superior, justifying political changes and solutions.

3. The role of energy technology research and development. Most of the studies make pro forma statements that research and development has an important role to play in managing transitions to different energy supply and consumption systems. However, there are several differences of opinion about the details, and some important unresolved issues.

The studies that advocate a radically new energy supply system for the United States and the world tend to be extremely optimistic about the ability of the research and development community to produce a broad range of new energy technologies, which will be economically competitive with existing technologies. This is especially true of the solar alternative, which will

require orders-of-magnitude improvements in technical performance and cost reductions before photovoltaics, for instance, can supply sufficient electricity at economic rates.

On the other hand, standard analyses tend to display a lack of vision (or confidence) about what may be possible in using conventional energy resources. The technologies analyzed for such processes as coal conversion and combustion, and nuclear power generation, seem usually to be technologies that are now known. The forecasts typically assume no advance in technology in these potentially fruitful research and development areas. Further research and development is not required to begin implementing these technologies, but it is needed to provide for improved efficiencies and reduced costs.

No particular discrimination seems to be involved in choosing priority areas for research and development investment, except in the studies that advocate solar power. There is little discussion of how to focus research and development to achieve specific energy ends. A blanket endorsement of all areas of research and development will probably not provide the appropriate technologies when they are needed. Similarly, blanket approvals of research and development do not clarify the different roles that basic research, applied development, and demonstration of results can play. Perhaps most crucially, there seems to be no specific discussion of the timing of the need for new technologies and associated deadlines for starting up required research and development programs.

International Energy Agency Policy Response

The International Energy Agency, through its Committee on Energy Research and Development, has since 1976 considered the implications of the above findings and posed the following questions.

1. What new energy production, conversion, and end-use technologies will Agency countries as a whole need over the next several decades?
2. What energy contributions can be expected of these technologies?
3. How might the total of energy research, development, and demonstration programs in individual Agency countries be structured in order to maximize the chance of actually having the technologies when they are needed?*

Concluding that there will not be sufficient time for a smooth and gradual transition away from oil, the International Energy Agency has developed a new strategy for group energy research, development, and demonstration. The primary objective of the strategy was to find a set of priorities so that member countries can rapidly become more rational and efficient in energy use and to find alternatives to rapidly depleting and increasingly costly oil supplies.

*This is described in detail in International Energy Agency, A Group Strategy for Energy Research, Development and Demonstration (Paris, OECD, 1980).

To establish these priorities, a 3-year-long systems analysis was carried out with widely used energy modelling techniques. The energy system (supply, distribution, end-use) of each of 15 Agency countries was simulated over a 40-year time period. This provided a detailed and systematic analysis of levels of possible energy supply contributions from selected new technologies. Two major policy thrusts constrained the analysis: the need to minimize overall costs of energy systems and the need to minimize imports of oil. Trade-off analyses between these two goals were also made. The key assumptions in the analysis were: modest and gradually declining economic growth rates; continually increasing real prices for oil and other energy; and substantially reduced growth of end-use energy requirements (through increased end-use efficiency).

Several policy scenarios were examined. Figure 46 shows the level of imports under four useful scenarios. It is apparent that requirements for imported conventional oil can be made to decline in the 1980-2020 period. But, at today's pace of energy technology research, development, demonstration, and commercialization, import reduction is very gradual and would continue to leave member nations seriously vulnerable to supply disruptions. Under minimum cost considerations alone, accelerating technologies can alleviate this somewhat. But the really substantial import reductions come under scenarios that impose the goal of reducing imports as a matter of national security. This accelerates current energy technology even further and also tends to bring new technologies into the supply systems faster.

These are the major observations and conclusions important to research, development, and demonstration planning that were drawn from the Agency analysis

- o During the 1980-2020 period IEA oil imports by member nations are projected to decline. In the first 20 years this is due mainly to conservation and to expansion of existing technology. In the second 20 years, new liquid fuels technologies become significant.
- o The current pace of energy research, development, demonstration, and commercialization efforts results in oil import requirements that leave the IEA too vulnerable to supply disruptions. Accelerated introduction of new energy technologies is important to achieve reduction in oil demand before the year 2000.
- o The impact of new conservation technologies is very important, and it may equal the contribution from new supply technologies in some nations.
- o Major growth in primary energy production occurs in coal and nuclear power in virtually all member countries.
- o Electricity growth continues to exceed total energy growth in all cases studied.

**IEA ENERGY RD & D STRATEGY PROJECT
NET CONVENTIONAL OIL IMPORT UNDER FOUR SCENARIOS**

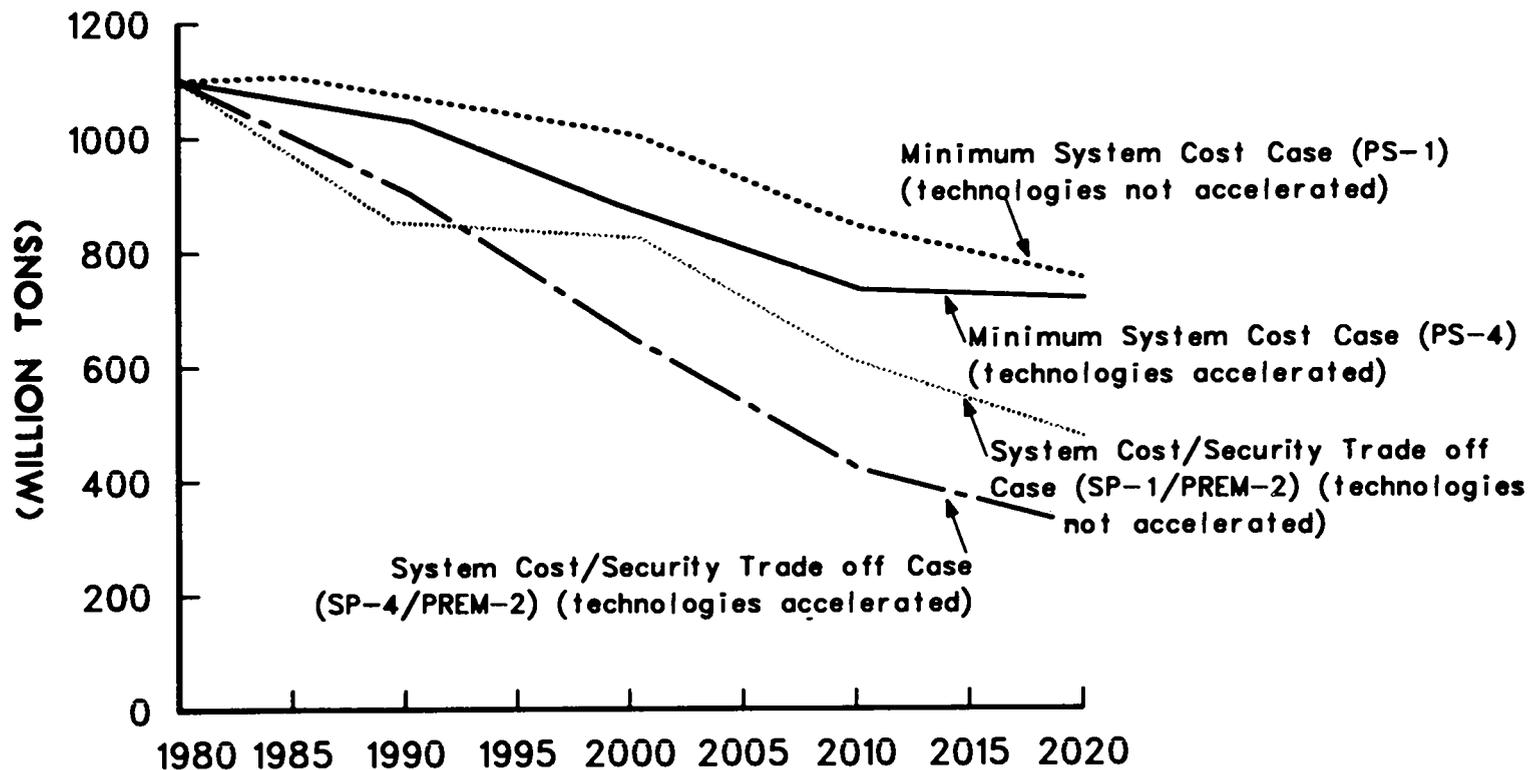


Figure 46

Source: International Energy Agency, A Group Strategy for Energy Research, Development and Demonstration (Paris: OECD, 1980).

- o Nonrenewable technologies are still called upon to provide the major fraction of energy needs even in a scenario of accelerated efforts to introduce renewables.
- o Research, development, and demonstration efforts on renewables should be focused on the most promising technologies, rather than giving equal emphasis to all.
- o Limitation on the growth in use of fossil energy will produce major effects on economies and energy costs. Aggressive research, development, and demonstration programs focusing on environmental control technologies for coal are needed to prevent this future.
- o Limitation on the growth of nuclear power would engender the need for a broad variety of higher cost technologies, not just a few replacement technologies.

Strategic planning judgments were applied to these analytic results to develop a strategy for developing new technologies. A priority system was established to be used as a guide for national priorities and funding designed to support a policy directed toward security energy supply. All important new generic technologies were divided into four priority categories, with top priority going to technologies most likely to contribute the most to net energy supplies--particularly energy that substitutes for oil. This priority grouping is displayed in Figures 47a and 47b, where the cross-hatched bar segments show the appropriate next step.

UNITED STATES ENERGY POLICY ISSUES

Given these major strategic trends in energy security, what are the major issue areas demanding immediate policy attention? The following groups of issues seem most crucial.

Domestic Oil Supply and Conservation

Conservation of oil must be one of our top priorities; however, oil conservation must be distinguished from energy conservation in general and national policies should be better focused on the real priority, oil. We must decide as an urgent matter whether it is in the national interest to establish an acceptable limit on oil consumption and imports. If it is, we must enforce this limit.

Considerable domestic petroleum reserves exist in the form of unrecovered light crudes available through enhanced recovery methods, and heavy crudes. We must decide how important these reserves are to the near-term security of the nation and proceed accordingly for their recovery.

We must determine the costs of a synthetic fuels industry sized to make a really significant contribution to national liquid fuels supply, in contrast to conducting expensive demonstrations that contribute only tiny amounts of fuel. Possible foreclosure of other energy alternatives by Federal funding of such an industry poses serious questions for national policy.

IEA ENERGY RD & D GROUP STRATEGY

GENERIC TECHNOLOGY PRIORITIES ⁽¹⁾	INDICATIVE ACTIONS			
	EXPLORATORY R & D	PILOT SCALE TESTING	DEMONSTRATION	COMMERCIALIZATION
PRIORITY 1				
*END-USE				
CONSERVATION - AUTOMOTIVE TRANSPORT SYSTEMS			///	
CONSERVATION - BUILDING EQUIPMENT (MAINLY HEAT PUMPS)				///
INDUSTRIAL CONSERVATION				///
RESIDENTIAL AND COMMERCIAL			///	
SOLAR HEATING AND COOLING				
*PRODUCTION				
ENHANCED GAS RECOVERY				///
ENHANCED OIL RECOVERY				///
TAR SANDS AND OIL SHALE				///
*CONVERSION				
ADVANCED CONVERTER NUCLEAR REACTORS			///	
ALTERNATIVE TRANSPORT FUELS			///	
BREEDER REACTORS			///	
COAL LIQUEFACTION			///	
*KEY SUPPORTING TECHNOLOGIES TO MAKE FULL USE OF EXISTING ENERGY SYSTEMS				
ENVIRONMENT-PROTECTING COAL TECHNOLOGIES (INCLUDING ATMOSPHERIC FLUIDIZED BED)				///
COAL MINING				///
NUCLEAR REACTOR SAFETY				///
NUCLEAR FUEL CYCLE				///

117

Source: International Energy Agency, A Group Strategy for Energy Research, Development and Demonstration (Paris: OECD, 1980).

Figure 47a

IEA ENERGY RD & D GROUP STRATEGY

GENERIC TECHNOLOGY PRIORITIES ⁽¹⁾	INDICATIVE ACTIONS			
	EXPLORATORY R & D	PILOT SCALE TESTING	DEMONSTRATION	COMMERCIALIZATION
PRIORITY 2				
*PRODUCTION GEOTHERMAL (HYDROTHERMAL)				///
*CONVERSION COMBINED CYCLE (INCLUDING LOW CALORIC GASIFICATION AND PRESSURIZED FLUIDIZED BED) FUELS FROM BIOMASS HIGH CALORIC VALUE GASIFICATION	///	///	///	///
PRIORITY 3				
*END-USE ELECTRIC AUTO	///	///		
*PRODUCTION GOEPRESSURIZED METHANE WIND POWER	///	///		
PRIORITY 4				
*PRODUCTION HOT DRY ROCK - GEOTHERMAL OCEAN POWER (TIDAL, WAVE, OTEC ⁽²⁾) SOLAR ELECTRIC	///	///	///	
*CONVERSION FUEL CELLS FUSION ⁽³⁾ LOW-MEDIUM CALORIC GASIFICATION MAGNETOHYRRODYNAMICS NON-FOSSIL HYDROGEN PRODUCTION SYSTEMS UNDERGROUND COAL GASIFICATION	///	///	///	///

118

Source: International Energy Agency, A Group Strategy for Energy Research, Development and Demonstration (Paris: OECD, 1980).

Figure 47b

Energy Technology Research, Development, and Demonstration Priorities

We must first and foremost focus our near-term energy research, development, and demonstration efforts on those technologies and resources that can really make a difference in the near-term future; these include

- o support for enhanced recovery techniques and projects,
- o synthetic liquid fuels processes,
- o clean coal utilization, and coal mining safety, and
- o nuclear power safety, and fuel cycle security.

We must establish relative priorities for long-term alternatives, such as solar, fusion, and geothermal energy and the breeder reactor, and we must decide whether it is in the national interest to accelerate these technologies to immediate engineering demonstrations or whether further intensive research is required before committing to expensive, risky demonstration plants.

Economic and Regulatory Policies

We must support the rapid deregulation of domestic oil and gas prices, but we should not misinterpret what deregulation will achieve. It is primarily a measure to achieve efficiency in allocation and conservation in end use, not primarily a supply-increasing measure. Deregulation has already stimulated increased exploration for oil and gas; natural gas supply will increase as shut-in capacity is brought to market. But oil supply is subject to many factors in addition to price, in particular the geophysical effects of reservoir depletion. The major impact of deregulation may be to slow the rate of decline in oil production rather than to increase domestic production.

As for heavy crudes, tar sands, and synthetic fuels, they are already (for the most part) priced at world market prices, unlike domestic light crudes, which were regulated to below-market prices. We should not expect to see sudden production of heavy crudes owing to oil price deregulation alone.

A totally free market in oil is unlikely. Traditionally, regulation intervened in the oil market to keep oil prices low for consumers. This intervention was justified with arguments based on equity. Now, considerations of national security and Western Alliance strategy may cause the United States to intervene in the oil market again. The objective this time would be to stimulate more oil production, sooner, from enhanced recovery, heavy crudes, tar sands, and synthetic fuels than would come about from pure market considerations. Thus the old intervention may be replaced by a new intervention that will keep regulated prices high so as to maintain high production levels.

The ability of the financial community in the nation and in the world to manage the recycling of OPEC surplus funds must be assessed, and appropriate support mechanisms must be established.

We need to determine whether it is in the national interest to be able to accelerate certain projects in their path through the regulatory and licensing process.

Environmental Constraints on Energy Development

National energy development plans must recognize that the nation will continue to support the effort to provide clean air and water and a reasonably safe environment for all citizens. Energy development plans must include specific strategies for achieving such environmental goals as

- o clean air, through the use of best available control technologies to comply with new source performance standards on all point-sources of emissions
- o clean water, providing for waste-water cleanup of all toxic materials, including waste streams from huge synfuels facilities
- o public health and safety, including a rapid resolution of the nuclear waste disposal issue.

Several global environmental issues must be more intensively examined, if not resolved. These include

- o long-range effects of the CO₂ buildup from fossil fuel consumption, especially if major synfuels industries are created
- o effects of acid rain caused by increased coal combustion and conversion.

Strategic Materials

In recent years it has become obvious that the availability of strategic raw materials must be factored into the process of materials selection for energy technologies. Material availability will be governed by basic resource availability, processing capabilities, economics, and politics. An adequate supply of industrial materials can be assured only through a coordinated effort of materials exploration, improved resource recovery, conservation, material substitution, and novel processing techniques designed to minimize or eliminate the use of strategic materials.

We must initiate a vigorous materials program, recognizing that materials will play a central role in whether or not we meet the technological challenge of the energy problem. In all energy technologies, materials contribute to the cost of basic energy supplies. Materials also affect reliability, which is becoming increasingly important as energy systems become larger, more complex, and more expensive, and as they must operate in hostile environments. In many technologies, materials limitations control the efficiencies of energy conversion processes. In some technologies, development of suitable materials determines the very feasibility of the process.

International Strategies

The Organisation for Economic Cooperation and Development and its energy policy agency, the International Energy Agency, are the policy-coordinating bodies of the free market economies, and the United States will be constrained by their energy policy. Our attempts to align oil consumption and distribution policies with our allies are not yet fully effective; we must realize that continuing uncoordinated national policies only serve OPEC's goal of increased control over oil supplies. We must work with our allies to

achieve common goals and strategies, especially implementation of the International Energy Agency research, development, and demonstration strategy.

Because of our current nonproliferation policies, several nations critical to our economic and military alliances are seeking advanced nuclear technology and nuclear fuels elsewhere, including uranium purchases from the Soviet Union. This raises several policy issues: loss of United States leverage on facilities that may lead to proliferation; loss of leadership in international strategies for controlling weapons-grade materials; loss of credibility with our allies as a consistent supplier of nuclear fuels; and loss of opportunity for American business in an important, emerging worldwide industry.

In addition, since several European governments and Japan have decided to proceed with independent nuclear fuel reprocessing, we must change our basic policies with respect to proliferation, reprocessing, and the breeder reactor technologies, and reestablish our technology leadership position in the nuclear power field.

We must recognize that coal resources, including United States coal resources, will constitute one of the major alternatives to continued reliance on Middle Eastern oil and we must begin to lay the technology and policy groundwork for a major expansion of the coal production industry in this country, including the possibility of major exports of coal and such coal products as methanol and synthetic oil and gas. This would include substantial investments in coal transportation and port facilities.

If coal is to be used as the basis for liquid fuels for export, we must establish the kinds of end uses of the fuels. Current world oil supplies are almost perfectly interchangeable, but man-made products from coal can be varied to suit different uses. Particularly important is the decision to produce either methanol or synthetic crude oil from coal. Current Department of Energy plans lean heavily toward production of synthetic crudes by direct liquefaction. This decision requires more analysis of potential technologies to use coal products, including discussion of standardization of product quality.

Investment in heavy-crude recovery techniques may be marginal economically in the United States, but investment in and transfer of such technology to other countries may be a sound international policy if we wish access to these products. A prime example is Venezuela, rich in heavy crudes in the Orinoco belt, and with rapidly declining light-crude reserves. There are substantial problems in extracting these crudes, removing the heavy-metal contaminants from them, and making them compatible with existing refineries or refining technologies. These would all be prime areas of research and development investment for the United States, cooperating with Venezuela.

Decisions need to be made on how to handle the problem of the increasing debt of underdeveloped countries that is due to oil consumption. These decisions need to include programs of technical assistance on alternatives to oil. Within the International Energy Agency framework, decisions need to be made on whether and how to establish coordinated oil import limitations, to assure the security of supply of member nations and to eliminate competition among them during periods of shortage.

ENERGY RESEARCH REQUIREMENTS

Domestic Research and Development

The search for solutions to the energy shortage has clearly affected the national research and development picture. Since 1975 the rates of both federal and industry research and development expenditures for energy programs have increased. These have accounted for about 40% of the increase in the total federal research and development obligations and about 20% of basic research expenditures by industry.* Industry's energy-related research and development spending has risen at an average annual rate of 26%, or 18% in constant dollars since 1972. This growth occurred primarily in funds provided by the Department of Energy, and from petroleum and electrical equipment companies' own funds. Federal energy-related research and development spending in constant dollars has risen at an annual rate of 19% since 1972. Industry's prime research and development emphasis has been on fossil fuels, particularly oil and coal, whereas federal emphasis has been on nuclear energy development, although solar energy, conservation, and synthetic fuels programs have recently received substantial percentage increases.

The large increases for energy research and development have been needed to support a growing number of expensive pilot and demonstration plants, which will be forerunners of commercial-scale facilities. At the same time it is clear that the energy problem will create new demands on both short-range and long-range energy supply technology research and development, and an increased need to support the technical base in terms of instrumentation capability, computer modeling, materials development, and environmental and life sciences so that commercial introduction of new energy supply technologies can be accelerated. A few of the most crucial areas of research merit special attention.

Alternative Liquid Fuels. The need to reduce national dependence on imported oil clearly indicates high priority for research and development on alternative liquid fuel production technologies for the next decade. Four candidates dominate at the moment: (1) extraction of heavy crude oils; (2) extraction of kerogen from oil shales; (3) liquefaction of coal to a synthetic crude oil; and (4) conversion of coal to methanol. Heavy crudes and oil from shale could make the largest contribution to domestic synthetic fuel supply in the next decade, since technologies for production are further toward commercial application. No large-scale coal liquefaction plants are planned for the next 10 years, reflecting uncertainties over which process to select for commercialization. The strong appeal of converting coal to methanol is due to the number of optional uses of this fuel. It can be burned directly as a motor fuel or boiler fuel, blended with gasoline, refined into a fairly high octane gasoline, and used as a chemical feedstock.

*Cf. National Science Foundation, Science and Technology Resources 1980, NSF 80-308, (Washington, D.C.: March 1980).

The principal areas of research need for both heavy crudes and oil from shale are the extraction and processing of the products. For heavy crudes, ability to characterize reservoirs and optimize drilling and mining techniques is required, as is research and development on efficient ways to heat reservoirs such as RF or microwave radiation or downhole steam generators and combustors. Behavior of reservoirs when subjected to heat, gas, or alkaline floods, and polymer or surfactant injection must be understood. Product characterization after extraction, and alterations required in refining techniques to handle special properties of heavy crudes are a high priority.

Oil shale technology also requires research and development on extraction and product-preparation technologies. Study of physical flow and chemical reactions in packed beds of variable porosity is required, as are three-dimensional models of retorting and in situ processing, remote instrumentation to monitor retorting processes, scaling analysis from field tests to commercial plants, and analysis of the chemical kinetics and physical properties of oil shale. Further study of the rheology of oil from shale, and mechanisms for preventing product deteriorations in storage are required.

Coal liquefaction involves catalytic cracking in all direct methods; improvements in these methods could be used for upgrading heavy oils as well. Characterization of the properties of liquefaction products, conversion of residues, and design and scale-up of the heavy equipment components of coal conversion plants all require further work.

The Department of Energy currently leans heavily toward technologies for the direct liquefaction of coal. Effort should also be spent evaluating indirect coal liquefaction technologies since they can produce chemical feedstocks as well as substitutes for crude oil. Fifty years ago, coal was the resource base for most chemicals--ammonia, benzene, toluene, xylene, naphthalene, methanol, and glycol. Currently, natural gas, crude oil, and then coal are used for feedstocks reflecting the increasing processing difficulty and the lack of specificity of the product slate. With diminished availability, Middle Eastern natural gas has been displaced by oil to some extent, and as oil prices rise coal may displace oil.

Coal brings with it problems of a relatively unfavorable hydrogen-to-carbon ratio, mining and handling difficulties, substantial quantities of ashing minerals, and the inability to crack directly to ethylene and other desirable light olefins. It has the advantage of being able to offer a fairly extensive slate of products tailored to specific end uses. In particular, attention should be directed to methanol since processes for making it are very selective and commercially proven and synthetic gas from any C,H source is acceptable. Many routes to hydrocarbon fuels and chemicals can proceed through this simple intermediate step. Methanol can be used itself as a primary fuel for transportation. In addition to gasoline substitutes, olefins, such as ethylene and propylene, can be produced from methanol under selected conditions.

Inexhaustible Energy Supplies. In addition to the pressing need for research and development in liquid fuels to address the short-range aspect of the energy problem, there is a requirement to intensify applied research efforts on long-range energy resources and technologies: advanced fission reactors, breeder reactors, and fusion, geothermal, and solar energy. These technologies produce thermal and electrical energy rather than liquid fuels and thus will never be a complete substitute for transportable petroleum fuels. In addition, it is unlikely that one technology will dominate the future energy supply system; it is necessary to understand the characteristics of each of them to determine which mix of them and liquid fuels is best.

While fission reactors using uranium and thorium do not offer the magnitude of potential resource that others do, further research and development on reactors can significantly increase available world energy supplies. Advanced converter reactors, alternative fuel cycles, and safeguards methods are prime areas of research. Testing breeder reactor technologies on full commercial scale, as the French nuclear program is doing, will probably raise areas for further research and development. A number of confinement schemes and fuels have been proposed to achieve magnetically confined fusion. Several major demonstration facilities will be built and operated in the next decade; the nation needs to determine whether even more intense effort is required in fusion and whether fusion is a viable technology for commercial applications.

Geothermal resources are immense, but like oil shale and heavy crude oil, there are significant problems of extraction to be solved. How the resource is distributed, converted, and used requires substantial research and development as well.

Whether solar electric applications are viable energy alternatives depends largely on the technical feasibility and costs of several known but unproven technologies. Basic scientific questions, such as the nature of selective coatings, amorphous semiconductors, and crystal growing techniques, must be investigated before the feasibility of solar applications is decided.

Materials. In many areas of technical innovation, the bounds on what is ultimately achievable are always established by the properties of the materials available. Research and development have long focused on improving known materials or devising new materials with special properties needed for new applications. The results have been spectacular, leading to entire new industries, such as plastics, synthetic fabrics, and semiconductors. Now that we are in an era of growing global interdependence, energy shortages, and strong environmental concerns, we can anticipate strong motivation toward finding effective substitutes for materials now filling essential roles but otherwise environmentally unacceptable, or too costly in energy use, or perhaps in short supply. Major research and development areas for information and communication will include continued semiconductor development, magnetic bubble memories, fiber optics, and sensor technologies. Energy-related materials efforts will include research and development of metal alloys for high-temperature, high-stress environments, ceramics for corrosion resistance, and composite materials for replacing metals in automobiles and trucks to achieve significant weight reduction and fuel savings.

Diagnostic and Monitoring Techniques. Application of advanced diagnostic and monitoring techniques can provide valuable support services to both short-term liquid fuel and long-term inexhaustible energy technology research and development. In many cases high-speed, high-accuracy observation techniques are required to understand the processes and measure the parameters of crucial physical phenomena. Prominent examples would include the chemical kinetics in a variety of synthetic fuel processes, the physical flows in in situ conversion processes, such as fluidized-bed coal combustion and oil shale retorting, and the behavior of materials properties under dynamic conditions of high temperature, high pressure, and hostile corrosive environments. We should support further development and application of nondestructive techniques, such as laser monitoring, x-ray and gamma-ray radiography, optical techniques of interferometry and ultra-high-speed photography, electron and x-ray microscopy, flash x-ray generation, and seismic and atmospheric monitoring.

Computers and Information Processing. No area of technology presents a history of more explosive growth; since World War II, the stored-program computer has undergone rapid development and use under government sponsorship for a variety of essential national purposes. Integrated circuits began a dramatic expansion in the realm of computing. Chip technology, beginning with one single transistor per chip in 1964, has doubled the number of components per chip every year since, with very little increase in chip cost. Techniques for chip manufacture continue to be important areas of material science research. Ultimately, circuit density will be limited by heat dissipation and tolerable electric field strengths. At present, the size of circuit elements is limited by the optical resolution of photoetching systems, and therefore fundamentally by the wavelength of light, to the order of one micron.

Of growing importance will be the design of algorithms to attack present problems more efficiently and to allow increasingly powerful computing machinery to be brought to bear on ever more complex problems. Modeling of complex systems and technological processes offers an effective and economic means for making design and policy choices. Given sufficiently powerful computers, such models can incorporate enough detail to allow a very accurate description of reality. The rapidly falling cost of computation will intensify research into methods allowing the replacement of detailed programming with more abstract approaches and into problems of overall program structure and management of very large data bases. This new discipline of program analysis and optimization should continue to grow rapidly.

Environment. Environmental questions and issues touch on all energy options and resource utilization technologies. The likelihood of large increases in coal use, both as feedstock for synthetic fuels but also directly for power generation and heat supply, presents the nation with formidable environmental concerns. Coal is by far the most destructive fuel in ecological and health terms. We need further research into economic means for removing sulfur and providing combustion under conditions that suppress formation of nitrogen oxides. Solutions are complicated by the complex and variable composition of coal and the lack of detailed understanding of coal combustion. The extent

and source of acid rain and coal's role in its production must be established. There is also the CO₂ problem which overshadows all fossil fuel technology and holds serious import for human wellbeing.

Life Sciences. The success of our new energy technologies depends not only on their scientific and economic feasibility but also on the satisfactory resolution of questions concerning their public health impacts. Possible toxicological and carcinogenic threats posed by energy technologies must be identified. Solutions to such problems may well prove to be the most vital need in the entire synthetic fuels program, for example. However, a research program in the traditional regulatory mode, which is usually limited to identifying health threats, setting limits on effluents, and mandating certain engineering fixes for their control, is unlikely to solve these problems.

A common theme in evaluating the health problems concerns the functional relation of response to exposure. If the effect occurs only above a minimum-threshold exposure, it can be more readily controlled than if it is nonthreshold. As we know from epidemiological studies concerning radiation injury, it is extremely difficult, perhaps impossible, to determine the existence of a threshold from statistical data on humans. However, modern techniques of cell culture and analysis can tell us, at the molecular and cellular level, if a single damaging event can lead to an affected population of cells. It may be possible to further determine whether enzymes or other agents can repair such damage completely so that the organism is permanently harmed only when the repair mechanism is overwhelmed. Such experiments could provide much critical information bearing on the existence of a threshold for permanent damage. It might even lead to the clinical identification of individuals who are damage-resistant or damage-prone.

CONCLUSION: IMPLICATIONS FOR LOS ALAMOS

From the above analysis of strategic trends, it is clear that several areas of science and technology research and development deserve increased emphasis in order that Los Alamos fulfill its mission of carrying out work on problems of critical interest to national security. We briefly reiterate them here, organized under the general rubrics of defense and energy.

NATIONAL DEFENSE

Nuclear Weapons

The mission of maintaining the science and technology base sufficient to sustain the credibility of the American nuclear deterrent remains central to the purpose of Los Alamos. From our analysis of strategic defense trends, two areas seem deserving of special effort. First, the nation may soon require the capability for disabling hardened targets such as command and control centers, in order to implement Presidential Directive 59 concerning targeting of political and strategic centers. Second, we may require enhanced safety, security, and command and control for United States projection forces that may deploy with tactical nuclear weapons.

Directed-Energy Weapons

This technology calls for special initiative, since it may be the key to our ability to defend our progressively space-based military assets against a "detached" war. Directed-energy weapons may be critical in protecting space-based communication and verification satellites, as well as satellite-based weapons systems. Further, directed-energy weapons systems could provide the upper level of a highly effective anti-ballistic-missile defense system.

Chemical and Biological Weapons

There is sufficient reason to believe that the United States may be involved in chemical or biological war in the future. We need the capability first to detect chemical and biological agents, and second we need the ability to defend against them. This will require extensive research in the chemical and life sciences.

Verification Technologies

It is highly probable that there will be continued efforts to reach arms control agreements that serve the security interests of the United States. Upgrading of aging verification systems, especially satellite observation systems, and creation of new verification technologies are required to assure that arms control agreements are being kept.

ENERGY

Liquid Fuels

The immediate national need is for substitutes for or new supplies of liquid fuels, largely for transportation requirements. Intensive research into the most effective ways of producing these fuels from domestic oil shale, coal, and heavy crude resources is urgently required. Technologies for indirect versus direct liquefaction of coal need to be extensively investigated and compared as to feasibility, costs, and suitability of end products. The possibility of shifting to other forms of energy, such as using electric power for transportation, need to be investigated rapidly.

Nuclear Fuel Cycle

It is highly likely that a very extensive world nuclear power industry will soon emerge, providing, with coal resources, the major energy alternative to petroleum in the intermediate future. Both the economic and the national security interests of the United States would be well served by continued research on the nuclear fuel cycle, in particular safeguarding of nuclear facilities, assuring safe operation of plants and safe disposal of nuclear waste, and the design of more efficient, less proliferation-prone reactor and fuel processing technologies.

Inexhaustible Energy Resources

For the long term, the alternatives to the current energy supply system will probably be magnetic fusion, solar, breeder reactors, and geothermal resources. Opportunities exist now to make significant contributions to national welfare by intensive exploration of the scientific feasibility of these technologies. This is especially true for alternative magnetic confinement schemes and fuel cycles for fusion, and the basic physics underlying solar photovoltaic processes.

Supporting Sciences and Technologies

Several areas of scientific research are critical to a successful transition to alternative energy resources. Most critical are the environmental and life sciences, since all resources and technologies proposed as alternatives to petroleum involve risks of environmental degradation and injury to human health. This is most serious for coal, but is true for other technologies as well, including solar and fusion. Materials research, for the extraction, conversion, and use of energy from these new technologies is required if they are to be implemented. Finally, the ability to numerically model and optimize the design of new energy systems will greatly benefit from enhanced computing capability, both for pure numerical processing and algorithmic analysis as well.

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