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ENERGY SECURITY IN THE POST-COLD WAR ERA: IDENTIFYING FUTURE COURSES FOR CRISES

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SCOPE NOTE

This paper addresses U.S. energy security in the post-Cold War era for a conference on energy security jointly sponsored by the Department of Energy and the National Defense University. It examines the evolving nature of energy security based on analysis of past crisis-inducing events and discusses potentially important geopolitical, environmental, regulatory, and economic developments during the next twenty-five years.

The paper steps beyond the traditional economic focus of energy security issues to examine the interplay between fundamental economic and technical drivers on the one hand, and political, environmental, and perceptual phenomena, on the other hand, that can combine to create crises where none were expected. The paper expands on the premise that the recent demise of the Soviet Union and other changing world conditions have created a new set of energy dynamics, and that it is imperative that the United States revise its energy security perspective accordingly. It proceeds by reviewing key factors that comprise the concepts of "energy security" and "energy crisis" and how they may fit into the new world energy security equation.

The study also presents a series of crisis scenarios that could develop during the next twenty-five years, paying particular attention to mechanisms and linked crisis causes and responses. It concludes with a discussion of factors that may serve to warn analysts and decision makers of impending future crises conditions.

The crisis scenarios contained in this report should be viewed only as a representative sample of the types of situations that could occur. They serve to illustrate the variety of factors that can coalesce to produce a "crisis."

This study focuses primarily on the following issues:

- Geopolitical and regional developments affecting the stability of major energy-producing states;
- International energy consumption patterns and international energy production among major producer blocs;
- Financial markets and their role on the price and availability of energy products; and
- The effects of environmental regulation on energy security.

This paper views the role of petroleum in the world energy security equation as primary. While other energy fuels such as coal, natural gas, nuclear, or renewables remain important, fewer concerns are attached to the security of their supply or pricing. Thus, it is real or

perceived interruptions in the supply of oil, and the associated consequences that would accompany such developments, that are expected to be the principal focus of U.S. energy security for the next quarter century.

EXECUTIVE SUMMARY

Energy security will be a key national security issue during the next twenty-five years. This paper presents the case that in the post-Cold War era, the traditional concept of energy security requires modification in order to facilitate effective recognition, management, and deterrence of future energy crises. Our reconsiderations take into account the wide array of changes that have occurred since the 1973 energy crisis, and the need to adjust the U.S. energy security focus accordingly. Based on an examination of the dynamics of past crisis situations and the possible direction of future crises outlined in this paper, we have developed an approach that broadens the scope of energy security and thus establishes a foundation on which to help direct future analyses concerning U.S. energy security in the 21st century. The following is a summary of our major findings:

- It is the interaction of crisis stimulating events and responses to these events that together generate energy crises. The total state of a recognized "energy crisis" cannot be attributed to a single occurrence, such as an energy resource supply disruption. Crisis initiating events and responses to those events are intrinsically linked. Real or perceived supply disruptions or threats to supply are a main source of crisis stimulants. Responses to such stimulants are linked via positive feedback mechanisms, and thereby snowball as a result of fear or uncertainty on the part of governments, producers and consumers. These, in turn, create and often exaggerate a state of crisis conditions. Perceptions play a critical role in the advent of crises.

- The end of the Cold War and collapse of the Soviet Union has dramatically altered the international environment in which energy security is sought. Many states are now largely free of superpower constraints, and seek to pursue their own national interests, not those of a patron state. This evolving situation heightens the prospect of regional conflicts, including potentially destabilizing conflicts over natural resources such as water, agricultural land or petroleum in energy-producing regions.

- Energy security is an international issue. It is difficult to isolate many of the energy security interests of the United States from those of other major energy-producer and consumer states. Interdependence between producers and consumers and their joint desire to provide long-term unimpeded access to energy products provides a basis for establishing global energy security. The international character of the petroleum industry along with the interaction of and the sharing of perspectives between producers, consumers, and markets can help foster stability. Despite these convergent interests, pure political and other non-energy related interests will remain primary determinants for the policies and actions of many states.

- Past experience demonstrates that unpredictable international circumstances have the potential to stimulate energy crises, and are likely to develop with minimal warning. Ensuring effective energy security therefore resembles risk management. The United

States should have an infrastructure in place to conduct crisis management and mitigation actions on short notice. Defusing misperceptions is central to crisis avoidance. This might entail ensuring the distribution of accurate energy information to financial markets or other large consuming states in the event of geopolitical developments, or establishing better ways to utilize strategic petroleum reserves.

- The fuel of primary importance to U.S. energy security during the next twenty-five years will continue to be petroleum, primarily as the result of the large and growing transportation sector throughout the world which is wholly reliant upon petroleum. As domestic supplies of petroleum are depleted, American reliance on imports will grow, thus making the U.S. susceptible to international developments that might affect the price and availability of oil.

- The Middle East will remain the most important international source for petroleum resources due to its large petroleum reserves, the quality of those supplies, and the relative ease with which its oil can be produced. This region also will continue to exhibit political instability related to the Arab-Israeli conflict, the spread of Islamic extremism, territorial disputes, and other issues. Political developments in this region will remain unpredictable.

- Portions of the former Soviet Union (FSU) show significant promise for development as alternative suppliers of fossil fuel energy resources. But serious concerns exist regarding the issue of political stability. The need to attract capital and technology for the ailing FSU energy sector heightens the risk associated with projected reliance on those resources as a major source of supply.

- Turkey is expected to play a growing role in the international energy security equation because of its strategic geographic location vis-a-vis the development and export of petroleum reserves in Central Asia.

ENERGY SECURITY IN THE POST-COLD WAR ERA:
Identifying Future Courses for Crises

A NEW CONCEPT NEEDED

The meaning of energy security for the United States in the post-Cold War era will be different than previously conceived due to changes in politics, economics, technology and the environment on a global scale. These changes have altered the forces that might create future energy crises and the context within which such crises might arise. These changes have also altered the appropriate path U.S. policies should follow to address potential future crises. Traditional concepts developed during the past, therefore, require modification in order to respond to fundamental changes on the international scene.

The collapse of the Soviet Union has significantly changed external military threats to energy-producing regions on which the United States has traditionally depended, and created conditions wherein some of the newly independent states of the FSU might become major exporters of energy resources to world energy markets. Yet, there are serious questions concerning burgeoning economic and political instabilities throughout the FSU and whether the FSU's energy sector will be able to obtain the Western capital and technology it needs to modernize and compete on a global scale.

While unique circumstances surrounded its creation, the establishment of the Gulf War coalition following Iraq's 1990 invasion of Kuwait demonstrated the growing shared interest and interdependence between major energy-producing and consuming states and their ability to cooperate in seeking mutually acceptable conditions for energy security. The Iraqi incursion also demonstrated how in the post-Cold War era, the absence of superpower constraints over client states may enhance the prospects for regional military conflict involving energy resources. In addition, while diplomatic progress on the Arab-Israeli peace front shows promise to remove a principal cause of tension in the energy resource-rich Middle East, political turbulence there will persist, creating obstacles to energy security.

There is a growing worldwide recognition of the importance of the environment and the need to include ecological considerations in plans for economic growth and industrial development. Concerns over environmental degradation are influencing the development of existing and emerging alternative sources of energy. Growing public sensitivity to the environmental impacts of energy production, transportation, storage, and use have led to broadened regulatory oversight that influences our ability to achieve energy security.

Interdependence between energy-producing and consuming nations has grown as the result of the globalization of financial energy markets, and the increasing involvement of large producers in downstream activities. Meanwhile, technological advancements in energy resource extraction and recovery have improved the ratio of known energy reserves to production. Deep water drilling techniques, for example, are now able to profitably access

reservoirs of oil previously untapped because of excessive cost.

The concept of an energy crisis must move beyond the comfortable and simplistic analytical framework that focus almost exclusively on singular events resulting in supply-side disruptions of crude oil (e.g., protecting U.S. access to Persian Gulf oil). The next world energy crisis might, indeed, have its roots in sudden geopolitical developments in the volatile Middle East, leading to concerns over the availability of energy resources. But it is equally plausible that a crisis might develop from turbulent political developments occurring simultaneously in several other world regions or build gradually and less visibly as the result of the interaction of more subtle forces, perhaps revolving around economic conditions or environmental concerns.

It is our contention that the key to recognizing and avoiding future crises lies in understanding their complex nature and underlying dynamics, and in being aware of how less obvious forces (frequently within our control) combine to create crisis circumstances.

A primary theme of this paper is that energy crises may have no single cause or villain, but rather evolve from the confluence of crisis-initiating events and the coupled responses to and perceptions of those events. Supply disruptions of crude oil (either real or perceived) frequently play an important role but are not the sole cause of crises. Actors such as the U.S. Government, other major energy consuming states, private industry, financial markets, and the general public respond to this uncertainty, frequently driven by fear over the future availability of that resource. Recognizing and monitoring response mechanisms helps illuminate the recursive dynamics that precipitate energy crises, and the inherent linkage between crisis causes and responses in the crisis "state." Understanding this process will allow for the development of remedial or avoidance measures that will form the basis of future energy security policy.

Achieving energy security for the United States during the next twenty-five years will require a broadened approach to the topic. The revised rationale will not rely solely on market externalities, but rather the need to monitor, assess and take decisive action to preclude inappropriate responses from the variety of market actors. Such an approach may have more in common with the practice of risk management of complex systems than with traditional notions of security oriented toward specific threats from a fixed set of sources. Unforeseen events can be expected to develop in the future from a wide range of sources with the potential to precipitate crises. The ability of the United States to view unfolding developments within the proper perspective and to take appropriate corrective measures (in unison with other nations) will facilitate the effective management or deterrence of severe crises.

Oil will remain the energy resource of greatest importance for the immediate future, and the United States and the consuming world are likely to remain heavily reliant on the Middle East for much of their energy needs. Without the development of alternative major supply sources from other world regions, this dependence will only grow with time. Thus,

sensitivity to destabilizing political developments in the Middle East -- especially the Persian Gulf -- will remain intense. Reduced dependence on the Middle East as a primary source for oil, or diplomatic initiatives that help stabilize that region as a secure energy producer, would enhance the prospects for future energy security. The development of large energy resources for export from Russia, Azerbaijan, and Kazakhstan would be an immense benefit. However, internal strife, ethnic conflicts, and political and economic instability throughout Russia and the FSU may also introduce new uncertainties into the world energy supply balance.

The end of the Cold War and depolarization of the world has ushered in changes that will effect global energy security. Foremost among these are the removal of many outside superpower constraints imposed on client states. Nations are now freer to pursue their own national interests. One related outgrowth could be the increased proliferation of nuclear weapons programs by developing states seeking prestige and protection against regional adversaries. Proliferants may seek to establish secret nuclear weapons programs under the guise of peaceful nuclear power generation activities. A related concern is the possible diversion of nuclear technology, fissile materials, or even a nuclear device from the FSU to proliferant states. In addition, conflicts previously suppressed by superpower intercession could escalate when the interests of states clash, such as those related to the control of energy resources. Competing claims over oil deposits in the South China Sea between China and Vietnam could be one such flashpoint. While a greater United Nations role in coming years may help moderate some of these conflicts, the inability of that world body to achieve consensus on divisive issues may undermine its ability to intercede decisively.

Developing a new framework for energy security in the changing post-Cold War era requires a fresh approach to the subject commensurate with the complexity of the post-Cold War world, while at the same time building on lessons learned from the past. While this does not invalidate all prior energy security concepts, it does require that they be adjusted against world conditions that have changed significantly since their inception. This means refocusing of our efforts; moving away from the analysis of singular events toward an understanding of the world energy situation as a whole, and the dynamic forces that shape it.

Disruptions in the supply of oil have normally been seen as the root cause of energy crises, although it has become apparent that the dynamics of recent energy crises have been driven as much by perceptions or fear of potential long-term energy shortages, as by meaningful actual shortages of significant duration. Most resource appraisals addressing global crude oil availability estimate abundant resources for more than the next twenty-five years (for example, see Miller 1992; Barnes 1990; Masters 1993; Houghton et al., 1993, and Attanasi and Root 1994). Therefore, a key component of energy security in the post-Cold War era is recognizing that most potential supply shortages are likely to be of temporary duration and that the ability of the United States and other major consuming nations to rapidly tap into alternative energy sources will enhance our energy security posture. Crises, almost by definition, are transient events.

DEVELOPMENTS IN ENERGY MARKETS

While the major thrust of this paper is to view energy security from a broader perspective than just the economic one, economic issues cannot be ignored. It is important to consider the relationships between oil inventories, prices, and the demand and supply of oil as it affects energy security. These topics have a familiar and fundamental importance in analyses of oil supply disruptions, and the continued dependence of the United States on foreign oil to meet its energy needs. First, the United States derives 38 percent of its energy needs from oil, and this is not likely to change substantially over the next decade. Second, traditional relationships between oil stocks, prices, and demand/supply, have evolved to keep pace with the institutional changes in the structure of oil markets, and these changes are important to understanding how prices may respond during crises. Third, oil supply sources have changed dramatically over the last two decades, bringing new opportunities to diversify America's import energy basket, and reducing the risk of oil supply disruptions on the American economy. Finally, the reality of continued dependency on foreign oil, now 41 percent of total U.S. petroleum consumption, warrants some consideration of what our demand for foreign oil means to other countries, and what foreign demands for oil mean to the U.S. economy. Detailed discussion of these factors appear in Appendix A.

TOWARD A NEW ENERGY CRISIS PARADIGM

Typically, crises develop when an unanticipated shortfall (or perceived shortfall) of energy resource occurs and the "ramp-up" time for replacing the supply is compromised by excessive cost or time delay. Total demand at any given time is served by a number of sources. The loss of any one or more sources may create an immediate shortfall. The time and cost of the replacement from either the current source or additional new sources and the market responses to these times and costs constitute the depth and severity of the "crisis." That is the fundamental, **economic** side of the crisis. This precipitating event may then be complicated by a series of factors.

For example, the Iranian Revolution in 1978-79 removed approximately 3.7 million barrels of oil per day for six months. The cost of the make-up from other sources, allocation difficulties, and concern regarding political instability in the Persian Gulf led to panic buying, gas lines and price surges. While increased Organization of Petroleum Exporting Countries (OPEC) production made up for approximately half the Iranian shortfall, supply tightened further because there was not an adequate system to disseminate accurate market information and assuage panic buying. As a contrast, the Iraqi invasion of Kuwait in 1990 removed 5.4 million barrels of oil per day for 10 months, and yet, in part because of rapid source make-up from Saudi Arabia, and widespread publicity associated with mobilization of the Desert Shield/Desert Storm alliance, the market crisis that occurred was of limited duration. One major difference between the Iranian Revolution and Gulf War circumstances was the widely held perception that the relationship between the Kingdom of Saudi Arabia and the United States had changed. The two states were able to work cooperatively in 1990.

The Saudis announced that they would make up the shortfall, and their ability to do this was guaranteed by American-led protection against an Iraqi incursion into the Saudi oil fields.

Energy crises germinate through a sequence of interwoven events and responses based on perceptions, not through any singular objective external event. Actions by the U.S. Government, private industry, and the general public may exacerbate these effects, thereby fostering crisis conditions. Further, the interaction of several seemingly unrelated events over time, none of which alone would facilitate a supply restriction, have also generated crisis situations through mutually-reinforcing mechanisms. In the literature on analyses of accidents occurring in highly complex technical systems, this process of converging and amplifying system effects has come to be called the "normal accident" because of its pervasiveness. Under analogous conditions, an energy crisis forms just as does a cascading failure in a complex technical system.

Perceptions of current developments and anticipated future influences in the international energy marketplace are taking on greater importance. Futures trading activities in oil, now an important component of the international energy security equation, is at times driven by psychological pressures derived from fears and uncertainty over provocative international developments. For example, the confrontation between the international community and North Korea over Pyongyang's apparent nuclear weapons program has helped force up the price of oil futures, leading at least one petroleum market specialist to note the importance of "psychological pressures" and "anxiety" in the market.[1]

Given the fact that rapid changes have altered the complexion of the post-Cold War world, and that reactions and perceptions to real or perceived supply shortages contribute to the onset of crisis conditions, a more expansive concept of today's energy security equation is needed. This framework should be based on the ideas that:

- Economics alone cannot explain energy crises. Economics, politics, and other factors such as technology and the environment need to be considered in unison.

- Energy crises are transient in nature; the price increase associated with market response will encourage forces that lead to an end to the crisis.

- Discussions concerning energy security should recognize that despite the interdependence of energy-producers and consumers, states develop and maintain legitimate and unique national interests based upon their own particular social, political, and economic needs. Understanding such differences will help avoid misperceptions which can promote or exacerbate potential crises.

- Energy crises are promoted by the same drivers underlying the "tragedy of the

[1] Myerson, A. June 16, 1994. "Oil Price is Highest in a Year." *The New York Times*.

commons," whereby nations acting in their own self-interest attempt to maximize gains while competing for scarce resources. [2]

Energy Crises as Linked Components

Traditionally, energy security has focused on supply-side analysis of Middle East oil and on preventing the former Soviet Union from gaining undue control or influence in the region. But under current evolving conditions, expectations over future energy costs, resource availability, and the environmental impacts of energy resource use are displacing these pre-existing concerns. In the post-Cold War era, bipolar models of political influence are no longer relevant, and the nature of friendly and adversarial relations are increasingly ambiguous. Outside superpower influences that previously constrained the actions of states embroiled in the East-West conflict have largely been removed, allowing these states increased liberty to pursue their own self-interests. This will result in a less predictable international environment, where numerous opportunities will exist for states to clash over conflicting interests.

Accordingly in the post-Cold War era, energy crises will result from a combination of events, perceptions, and the subsequent actions or reactions of independent governments, private industry, and the general public. It is these "linked components" that in unison act to produce a crisis. Thus:

1. Energy security concerns the overall state of a country's energy system in terms of its production, transmission, storage, and consumption activities that enables energy markets to function as efficient mechanisms for allocating energy resources, **but also promote or constrain the scope of the nation's independence of action.** The fundamental economic indicators of energy security include:

    a) technical performance and efficiency in resource availability, and in energy production, transmission, storage, and use;
    b) the presence of energy resource and capacity constraints, and ongoing efforts to develop alternative or substitute sources of energy; and
    c) the strategic end-use of energy by source, location, and type.

These factors must be monitored to understand the fundamental movements in the energy markets over the long term and to uncover the precursors to crisis conditions.

2. Energy security is jeopardized by a loss of perceived control over energy product availability, and/or distribution, and/or delivery that:

    a) starts with a specific event and subsequent responses to the event (e.g., panic

[2] Hardin, G. 1968. "The Tragedy of the Commons." Science, vol. 162.

buying, regulatory controls or halts in futures market trading);

b) expands through public oversimplification and uncertainty concerning these events and responses;

c) impairs the ability of the United States and/or other key states to function militarily, politically, or economically; and

d) is a transient condition, although the impact(s) may linger.

Clear information about what is happening to demand as well as supplies in the short term, and clear communication of this information to the public will help control the more egregious perception problems that force governments to intervene in energy markets or in political disputes when vital interests are not actually at stake.

3. Energy security in the post-Cold War era necessitates:

a) movement away from the idea that only supply-side disruption events generate crisis conditions;

b) more recognition of how perceptions promote behavioral responses which magnify energy crises; and

c) the realization that energy crises arise through initiating events, but subsequently depend on the responses and interactions of various political, financial-economic, technical, and environmentally-centered forces.

Enough is now known concerning many of the demand-side economic reactions and political reactions to permit governments to devise strategies and tactics to respond appropriately not only to perceived supply disruptions, but to the constellation of other reactions that surround them.

4. The behavioral response components of an energy crisis highlight the roles of key players in the U.S. energy security equation. Particularly important roles include:

a) government responses such as the regulation of domestic energy production, distribution, and consumption; the importation of oil and the use of import tariffs and price regulation; and the use of a full range of economic, political and even military sanctions;

b) market responses, such as panic buying and selling of energy-related commodities, and their respective futures and options markets;

c) industry responses, such as changes in energy production, consumption, exploration, and R&D activities as well as profit-taking and other opportunistic market-trading activities; and

d) responses by the general public and/or special interest groups such as outcries over environmental accidents (e.g., Three Mile Island or the Exxon Valdez) and unpopular regulatory measures (e.g., gas rationing and tariffs).

Awareness of the interactive nature of these key players and their response actions is central

to understanding how crises develop and, subsequently, how crises can be recognized in their formative stages and their effects diminished or mitigated.

The interlinked roles of initiator and response that may create an energy crisis was illustrated following Iraq's invasion of Kuwait in August of 1990. Following the invasion, the spot price of oil leapt from $16 a barrel to around $36 a barrel. Market mechanisms had responded rapidly to the *perceived threat* to Persian Gulf oil supplies. In the United States, releases from the Strategic Petroleum Reserve (SPR), which was at an all-time high, did not occur until shortly after the air war against Iraq began in late January of 1991. This was a slow-acting response; not to the perceived threat of short-term shortages, but to the high spot price of oil. Subsequent economic analyses of the period have criticized this delay as being "too little, too late" to blunt the impact of the price rise produced by the market's sharp response to the initial situation.

In the above sequence of events, no single cause of the temporary energy crisis can be isolated. The perceived threat to Middle East oil supply was a contributing factor, as was the rapid response by the market to perceived future scarcity. Another contributing factor may have been the failure of the United States, as the world's largest consumer of foreign oil, and other International Energy Agency (IEA) members to help stabilize the market sooner through the release of strategic petroleum reserves.

The cause of energy crises rests in the interaction of a cascading sequence of initiators and multiple responses to them. The actions of people, markets and nations do not occur in a direct sequence, such as an automobile production line. The interaction of responses on different levels of the social scale, with different delay times due to the mechanisms by which they operate, are affected by unintended feedback, and are mostly uncoordinated. They rely on different information sources and become sources in turn for subsequent actions. In combination, however, these responses exert significant influences, greater than the sum total of their respective impacts. This collective set of evolving conditions all contribute to the set of conditions labeled "a crisis." Just as importantly, in the middle of these conditions, governmental decision makers frequently lack an overarching, comprehensive view of the situation, which hampers their ability to take decisive actions.

High speed telecommunications and responsive information systems have resulted in the world being much more densely connected, so that news of potential threats to energy stability and reactions to them now proliferate much more rapidly through financial markets, responsible government agencies and public awareness. This makes it inevitable that energy security in the 21st century will have much more in common with risk management of complex systems than it will with traditional notions of security, oriented around specific threats from a fixed set of sources. The effective management of response mechanisms will help facilitate more accurate perceptions in world energy markets, and therefore reduce distortions and minimize over-reactive, crisis-inducing behavior.

SEEING THE FUTURE IN THE PAST: HISTORICAL SKETCHES

The following review of key historical events sheds light on the genesis of past energy crises and how the interaction of initiating events and responses precipitated crisis conditions for the United States and others. While many of these crisis events are thought to have been caused by simple supply disruptions or technical system failures, the following review illustrates the importance of systemic crisis dynamics. As previously noted, these dynamics will play an even greater role in energy security and crisis management and avoidance in the changing post-Cold War world environment.

The 1973 Arab Oil Embargo

A series of diplomatic misperceptions and unanticipated consequences of U.S. support for Israel during the October 1973 Yom Kippur War led Arab members of OPEC to cut production and halt shipments of oil to the United States, South Africa, Portugal, and the Netherlands. The embargo was accompanied by decreased OPEC production, during a time when there was minimal excess production capacity elsewhere in the world. For the United States, the embargo occurred at a time of rising demand, increasing imports, and declining domestic oil production. This resulted in short-term shortages (gas lines) and dramatic price increases.

These events occurred despite the fact that at the height of the six-month embargo, the net loss of supplies was 4.4 million barrels per day, or only about 9 percent of the total 50.8 million barrels per day that previously had been available in the "free world" (Yergin 1991). To some degree, international oil companies were able to reroute oil from other exporters to the embargoed countries (Fried and Trezise 1993). However, the embargo's effects were magnified by tremendous uncertainty about how much oil actually was available. Confusion in the market, coupled with widespread uncertainty about the future supply of Middle East oil, led to panic buying, further exacerbating the shortage.

One of the lessons learned from the 1973 embargo was that energy supply shocks can be significant and psychologically enduring despite being measurably small and transitory. In part, this may be owed to rising world consumption of oil (7.5 percent a year) at the time of the shock (Yergin 1991). The 1973 embargo also demonstrated how dangerously reliant the United States had become on foreign petroleum sources, without an accompanying knowledge of the ramifications of this vulnerability. This lack of understanding was partly the result of perverse government incentives of taxing domestic oil and gas production, while simultaneously subsidizing oil imports. Regulatory responses also bore much of the blame, as an allocation system had been introduced just prior to the embargo. This system, meant to ensure even nationwide supply, had the opposite effect, preventing redistribution of the supply to points of need. Thus, the reduction of supply, small in comparison to that withdrawn from the market as a result of Iraq's 1990 invasion of Kuwait, was not the sole cause for the severity of the crisis. Rather, it was the responses of markets, producers, and regulators that exacerbated conditions.

The 1978-1980 Iranian Revolution and Outbreak of the Iran-Iraq War

The Iranian Revolution began with protests and violent acts directed against the Pahlavi monarchy in 1978. By late that year, a strike by oil workers virtually shut down production and halted exports. While the signs of serious political instability were building in Iran throughout 1978, the United States was distracted by other foreign policy issues, such as the Camp David peace accords between Israel and Egypt, strategic arms negotiations with the Soviet Union, and normalizing ties with China. World supplies appeared to be tight, as the winter demand surge was beginning while the inventories of international petroleum companies were low (Yergin 1991). Despite this fact, significant levels of lost Iranian production were offset initially by increased production by other OPEC members (primarily Saudi Arabia). A total deficit in supply of 2 million barrels per day ensued initially, or 4.3 percent of consumption in the oil-importing countries (Fried and Trezise).

However, panic spread following the fall of the Shah in January 1979. The Iranian monarch had been considered the strongest proponent of American and Western interests in the region. His ouster was both unexpected and traumatic. It was feared that the new regime would indefinitely halt Iranian oil production and that its radical, anti-Western Islamic doctrine might spread to other Muslim countries, particularly the Arab oil-exporting states of the Persian Gulf. This precipitated panic buying in the West and by Japan. Spot market prices increased and oil companies scrambled to build stocks in anticipation of further price increases. OPEC then raised official prices, precipitating a further upward price spiral. The rush to build oil company stocks, reinforced by heightened consumer demand and intense uncertainty regarding political conditions in Iran and elsewhere in the Middle East, resulted in an artificial increase in world demand of 3 million barrels per day above actual consumption, further exacerbating the sense of crisis (Yergin 1991).

In September 1980, Iraq invaded Iran, producing yet another serious disturbance in the Persian Gulf. Iraq gained control of portions of the key Iranian oil province of Khuzestan and struck at and damaged Iranian oil production and transportation facilities. Iran retaliated in kind, inflicting significant damage on Iraq's oil production and transportation infrastructure. Crude oil prices remained high throughout the early stages of the war, as concerns mounted that the conflict might escalate and that the resulting instability in the Gulf might prompt a total shut-down of exports from the region. Many Gulf producers reduced output, while oil companies and governments began to stockpile oil to build reserves (EIA 1993). Those combined actions put upward pressure on prices, which rose from $14 per barrel at the start of 1979 to more than $35 per barrel in January 1981.

The back-to-back nature of these two events in 1978-1980 magnified uncertainty and speculation regarding the future availability of Persian Gulf oil, as did the continuation of the Iran-Iraq war throughout much of the 1980s. **The creation of additional "demand" in excess of actual world consumption requirements also demonstrated how crisis responses feed on one another, making circumstances appear worse than they actually are.**

The 1979 Three Mile Island Release Incident and the 1986 Chernobyl Nuclear Reactor Explosion

In March 1979, a small pressure relief valve in the primary feedwater system in Unit 2 of the Three Mile Island (TMI) Nuclear Plant stuck open, causing a loss of coolant and eventual depressurization of the reactor. The crew and managing teams from the Nuclear Regulatory Commission did not assess the state of the plant and the ongoing processes correctly, and the water level dropped until the nuclear core was partially exposed and severely damaged. A meltdown of the core was narrowly avoided. Three Mile Island resulted in a total release of radioactivity of 2.4 million to 13 million curies, of which only 13 to 17 curies of radioactive iodine were released to the environment. The negligible physical consequences outside the plant were overwhelmed by the social and psychological impact on the U.S. public, where faith in the safety of nuclear power was badly shaken. Independent assessments afterwards concluded that the causes were mostly compounded "human error" because of inadequacies in equipment design, information presentation, emergency procedures, and training.

In April 1986, operators at Unit 4 of the V.I. Lenin four reactor complex near the village of Chernobyl in the Ukraine were conducting an experiment, running the reactor with the emergency water cooling system deliberately turned off. After a series of human errors, an explosion occurred, releasing about 50 million curies of Strontium-90 and Cesium-137 which dispersed throughout Europe and North America. Some reports indicate that as many as 10,000 people in the FSU may have died from the associated effects of radiation poisoning. Another 10 million probably were contaminated.

The impact of these incidents transformed public attitudes about the safety of nuclear power and threatened support for the global nuclear industry and its acceptance as an alternative energy source. This is especially significant because the large-scale adoption of nuclear power had been seen as the United States' technological solution to the energy supply disruptions of the type occurring during 1973 oil embargo. Other countries had also perceived the advent of nuclear power as the answer to their lack of fossil fuel deposits or the technologies needed to cost effectively recover them. Combined with the as yet unsolved technical problem of long-term storage of radioactive wastes, these highly publicized accidents served to alter the public's image of nuclear power.

Although some have argued that nuclear power must return to the United States to meet the next century's demands for increased electrification, one lesson of the last twenty years is that a solely technical solution of shifting demand to an alternative energy source is unlikely to provide a stable solution to questions of energy security. Furthermore, serious safety concerns remain over the continued usage in the FSU of nuclear power reactors similar or identical to the flawed and unstable Chernobyl reactor design. The

danger remains that another disaster could disperse radioactivity across much of Europe.[3]

The 1988 British Piper Alpha Oil Platform Explosion

In July 1988, a gas leak at the $3 billion British Piper Alpha offshore oil drilling platform in the North Sea caused an explosion which demolished the structure and killed 167 workers. The oil industry's worst disaster caused a disruption in oil recovery of about 400,000 barrels a day over a period of two months, and raised serious safety questions concerning deep sea oil drilling. Accident reconstruction analyses showed design flaws in the platform. The Piper Alpha explosion was widely used as an example of how time pressures in the exploitation of petroleum resources from the North Sea had led to an unusually high rate of industrial accidents. This, in turn, stimulated a continuing argument of productivity versus safety in offshore drilling operations that has slowed the licensing and sitting of such platforms and increased the cost of recovering North Sea oil. As with accidents in the nuclear industry, the design and operations of offshore oil platforms are being challenged. Another major accident and spill could have devastating consequences for the industry in terms of public acceptability of offshore oil drilling. **The lessons of Piper Alpha illustrate that social support for extracting natural resources becomes bound with the willingness to accept the occupational safety and health risks that accompany the enterprise.**

The 1989 Exxon Valdez Oil Spill

In March 1989, in Prince William Sound, Alaska, the Exxon Valdez tanker struck a reef and spilled 11 million gallons of her 53 million gallon crude oil cargo. The spill fouled four national wildlife refuges, a national forest, and three national parks, invading more than 1,200 miles of coastline. Extensive media coverage over the following weeks emphasized the Alaskan wilderness and its wildlife despoiled by crude oil. It was the largest and most expensive U.S. tanker spill in history, eventually costing over a billion dollars in cleanup and an estimated 100 thousand dead seabirds, plus as yet uncalculated damage to salmon and herring hatcheries and seal and sea otter populations. To date, Exxon has paid out about $3 billion in damage claims. The litigation on another $3.5 billion in damages continues, and much of the scientific evidence gathered on the effects of the spill and its aftermath is sequestered awaiting court testimony.

While the ultimate environmental effects are in dispute, there is little disagreement over the impact of the Exxon Valdez spill on the American public, whose perceptions of the environmental/technical safety of oil production were altered. This had direct adverse consequences for what is politically possible in the domestic supply arena, and could have precipitated a "crises," had the supply/demand balance been more precarious. Oil drilling and transport in ecologically pristine and fragile areas have come into disrepute, and

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[3] Jehl, D. June 13, 1994. "Ukraine Hints It Won't Close Nuclear Plants at Chernobyl." *The New York Times*.

the search for alternative energy forms has been given a noticeable boost. Major political battles have forestalled further oil drilling in Alaska, while Congress has attempted to respond with legislation requiring detailed inspection and control of tanker operations and training for crews. The oil industry has proposed to build five coastal response centers around the United States to handle future spills, while the strong environmental lobbies see the only hope to avert such future disasters is to lessen the country's oil needs. The Exxon Valdez created a highly charged image of economic-driven despoliation of the planet. The consequent public attitudes and perceptions of "big oil" are raising questions as to domestic oil production in our energy future. The same lack of public support constrains federal support for long-term petroleum research on technologies that could help recover the 100 billion barrels of oil still available, but not economically retrievable, from previously worked U.S. fields.

The 1991 Gulf War

The August 1990 Iraqi invasion of Kuwait forced the price of crude oil to rise suddenly. A United Nations embargo on all crude oil and products from both countries shortly thereafter increased fears of large shortfalls and stimulated additional price increases. Iraqi and Kuwaiti production totaled some 4.3 million barrels per day, representing almost 7 percent of world supplies (EIA 1993). World crude prices rose from $16 per-barrel in July 1990 to $36 a barrel in September of that year. In response, Saudi Arabia and other OPEC members increased production, as did non-OPEC countries in Central America, Western Europe, the Far East, and in the United States, offsetting much of the shortfall. At the time, commercial stocks in Organization for Economic Cooperation and Development (OECD) countries were abnormally high (Fried and Trezise 1993).

No apparent increase in speculation occurred in futures markets in the 90 days immediately following the invasion, as these markets did not contribute to the run-up in prices or to price volatility (EIA 1993). Prices fell following United Nations approval of the use of force against Iraq in October 1990, after only a two-month price escalation. In January 1991, the beginning of the allied air war against Iraq precipitated a record drop in world oil prices, as fears of a cut-off of Persian Gulf oil diminished. The announcement shortly after the allied offensive began of International Energy Agency (IEA) agreement to release up to 2 million barrels per day from government-held stocks also served to moderate concerns (Fried and Trezise 1993). As a result, only about one-third of the pledged IEA strategic stocks were actually sold. The release of further stocks by both Saudi Arabia and Iran also served to help calm oil markets.

The rise in price of crude oil and petroleum products immediately following the Iraqi incursion into Kuwait reflected multiple uncertainties. These included the possible spread of the invasion (south into the Saudi oilfields), the potential destruction of Persian Gulf oil installations in the event of war between Iraq and the allied forces, and the spare capacity available to OPEC and other world producers to replace lost Kuwaiti and Iraqi supplies. The success of the allied coalition to mobilize militarily and obtain the necessary political backing

to confront Iraq, coupled with the immediate battlefield success of the Operation Desert Storm offensive, helped prevent a further price escalation in world markets. Perhaps most importantly, IEA discussions on the release of strategic petroleum reserves of member states provided a psychological restraint to runaway panic buying. While the timing of the IEA intention to release stocks was geared to preempt panic in the early stages of the allied offensive, there are those that argue an earlier such announcement would have had an increased moderating effect on world markets in the run up to the conflict. **In the final analysis, the effects of the 1990-91 Gulf crisis were modest in comparison to previous crises as a result of the availability of increased and more detailed oil market information and close cooperation among major energy consumers and between consumers and major producing states.**

ENERGY CRISIS SCENARIOS: BETTER UNDERSTANDING THE PATHS TO POTENTIAL CRISES

A series of potential scenarios could induce an energy crisis during the next twenty-five years. Illustrative scenarios appear in Appendix B. These scenarios fall into the following categories, according to their primary causal mechanism:

- Political: regime changes, terrorism, civil unrest, and regional conflict, including conflicts between states arising from contested control over natural resources.

- Environmental and technical: changes in environmental regulation as a result of accidents or emerging scientific understanding, transportation disruptions due to technical failure.

- Economic: rapid and sustained economic development among the world's emerging economies, dollar devaluation, failure to fully develop FSU energy resources.

Previous energy security studies have focused on long-range prediction concerning geopolitical developments, energy resource availability, and international economic conditions and have largely failed to predict the onset of subsequent crisis conditions, which are **short-term phenomena arising out of perceptions and uncertainties and are compounded by the choice of responses based on these perceptions and uncertainties.** Many key developments affecting U.S. energy security during the past twenty-five years have been sudden and unexpected. Based on past experience, it can be assumed that previously unidentified crises types and/or well-defined crisis conditions may occur in the future with little forewarning.

As the politically volatile Middle East contains 65 percent of the world's proven oil reserves, that area will continue to merit significant attention. This is especially true of the Persian Gulf region, where the vast majority of Middle East oil is located. The importance of Middle East oil will be further magnified should future instabilities in other parts of the

world lead to an increased concentration of available world supply in that region. Large known petroleum reserves and anticipated future finds located in Russia and elsewhere in the FSU make that area an important energy region. Developments in Latin America and Asia also warrant close scrutiny as significant energy reserves are located there, as are growing energy consuming populations.

During the next twenty-five years, potential energy crises could result from single regional supply side disruptions of significant proportion. Equally likely are crisis situations evolving out of a linked series of events that individually would not result in crisis, but in unison have that effect. Finally, crises might build over a period of time, as the convergence of a variety of seemingly unrelated environmental, energy, social and technology policy consequences gradually exercises interlinked constraints on the energy system.

Political

It is essential to monitor and attempt to predict the potential for, and consequences of, conflict and geopolitical change that may impact energy security, while at the same time recognizing that international political events are inherently complicated and are frequently difficult to foresee with great specificity.

Regime Changes. Changes of central authority may occur in states precipitating a worldwide energy supply shortage and/or the destablization of energy-producing regions. Worst case scenarios envisage such changes occurring with little warning. **Unforeseen and rapid regime changes can serve to magnify associated political and economic uncertainties, resulting in unsettled public concerns regarding the long-term availability of energy products.** Sudden and dramatic regime changes are likely to have the greatest psychological impact on energy markets.

Regional Conflict/Civil Unrest. Armed conflicts or significant levels of civil unrest in major energy exporting countries might result in crisis conditions if sizeable levels of petroleum or other energy resources were kept from the market (or such a threat appeared imminent) and sufficient excess production appeared to be unavailable from other producers/regions. Were conflicts to arise in more than one energy producing region simultaneously, severe crisis conditions could result. **Increased consideration should be given to the possibility that crises may evolve from several small scale, concurrent conflicts in separate world regions.**

Terrorism. Major acts of terrorism generating widespread international publicity could help the onset of an energy crisis. **Terrorist actions resulting in extreme environmental damage and/or loss of human life could trigger societal or political responses that influence the range of acceptable alternatives for energy production.** Use of more or less oil worldwide as a consequence of such events could result (DOE 1992a).

Terrorism does not have to make sense; it just has to attract attention. As long as the United

States continues with per capita consumption of twice that of Europe and six times that of the world as a whole, the energy production, supply, and distribution facilities that support it remain tempting targets to extremist factions seeking to justify themselves to disenfranchised people everywhere. In this respect, probably the most dangerous terrorist weapon would be a small nuclear device aimed at a key juncture point in the production or supply of oil. The possible proliferation of nuclear technologies to recognized states that support terrorism thus becomes a key concern of future energy security.

Environmental/Technical

The adverse environmental effects of various forms of world energy production, transportation, and use has generated concerns in the United States and overseas, resulting in increased public sensitivity to environmental issues.

Restrictive Environmental Regulation. The growing political strength and influence of the environmental movement could lead to more restrictive activities in the future, especially should more significant environmental degradation come to pass.

Technical (Transportation). Nearly half of the 66 million barrels per day of oil consumed worldwide flows through one or more of six key tanker routes (*Oil & Gas Journal* 1994c). A disruption of crude oil or product shipments through key world shipping lanes at choke points such as the Strait of Hormuz (where 14 million barrels per day transit), Strait of Malacca (7 million barrels per day), the Suez Canal (900,000 barrels per day), Panama Canal (500,000 barrels per day), Rotterdam Harbor (600,000 barrels per day), or through the Bosporus (1.6 million barrels per day), could result in a crisis, according to an Energy Information Administration study (*Oil & Gas Journal* 1994c).

Economic

Adverse international economic conditions could develop gradually or over a short period of time, helping to precipitate crisis conditions. Understanding and learning to recognize non-obvious interactions can help establish warning signs of building crisis conditions, enabling corrective or preventative measures to be employed.

Rapid Economic Growth. Sustained and dramatic economic growth by developing countries in Asia and Latin America during the next twenty-five years could put strains on world energy markets and contribute to the onset of crisis conditions. These conditions could arise either out of the continuing development (and growing energy appetites) of the world's poorer economies, or out of an unexpectedly poor performance by the energy sector of the FSU.

Dollar Devaluation. A massive devaluation of the U.S. dollar could result in crisis should foreign energy sources become prohibitively expensive, especially should producing countries choose to benchmark the price of crude against another foreign currency.

LESSONS LEARNED: COMMONALITIES ACROSS ENERGY CRISES

These scenario types and future energy trends for the United States and the world suggest that although there are many possibilities for energy crises in the post-Cold War world, there are also commonalities and distinguishing characteristics of the conditions that create them. Awareness of these commonalities may help illuminate the early development of precursor conditions to a crisis, while also helping us comprehend how sometimes seemingly distant developments in either time or subject matter may interact to produce crisis conditions.

The preceding sections highlight the key forces and dynamics of past energy crisis situations and possible future scenarios. They illustrate that the interaction of multiple factors in response to crisis stimulating events serve to exacerbate those situations and elevate their impact. Further awareness and understanding of those factors will allow for earlier recognition of future crisis developments and/or more effective management of crisis conditions when they occur. Several of these key factors include:

- **Fear and uncertainty regarding political instability in major energy-producing regions exacerbates energy crises.** Regional conflicts are likely to grow in the post-Cold War era, and we must be prepared to manage and deflect their effects. Wherever possible, preemptive diplomacy and mediation may halt the advent of destabilizing armed conflict. Under special conditions, the use of military force may be required to protect our energy security interests.

- **Immediately available energy production, supply, and distribution information to world markets during times of perceived crisis improves policy reactions and reduces market impacts.** As demonstrated during the recent Gulf War, closer cooperation between markets and producer and consuming states helps moderate panic reactions.

- **Concern over adverse environmental impacts from energy production, transportation and use can contribute to energy supply disruption.** The proper balance must be sought between protection of the environment from irreversible damage, and the need to responsibly utilize available natural energy resources. Continued research into the use of large-scale, environmentally-friendly energy sources must also be pursued. DOE intelligence resources could be effectively utilized to help monitor and assess situations from which concerns over adverse environmental impacts emanate.

- **Every political crisis is a potential energy crisis if it occurs in a major energy-producing region of the world.** Potential energy crises may arise from the results of internal or regional instability. Border disputes, ethnic and religious strife or succession uncertainties also appear to be prime candidates for creating conditions that may occasion an energy crisis, through perceived impacts alone, if not real ones.

Particular attention should be devoted to the impact of hostilities on key energy production and distribution facilities, with developments in the Persian Gulf and FSU meriting significant monitoring.

- **Energy policy in the United States, and elsewhere, is increasingly likely to be influenced by environmental policy**. The United States leads the world in the implementation of meaningful environmental regulations, such as in the area of clean fuel emissions reduction. However, such actions have unforeseen consequences, the end results of which may increasingly put the production of energy under control of a system which is not yet well organized, and which is buffeted by significant social disputes. This serves to make prediction of energy needs and savings accruing from energy programs more difficult, driving down the comprehensibility of the energy system to the analyst. Recent delays by the U.S. Environmental Protection Agency (EPA), for example, to settle on disposal means for older fluorescent tubes, which are classified as hazardous waste due to their mercury content, caused a significant slowdown in the commercial sector's changeover to energy-efficient lamps. Similar examples in EPA's administration of the Clean Air Act amendments have caused confusion with many utilities' demand-side management programs that have raised the cost of those programs over five times earlier estimates. Projected energy savings too often assume perfect planning and implementation of the scheme, which is hardly ever realized in the real world. If those energy savings are being critically counted upon to reduce demand for an energy resource, their absence may be enough to trigger or exacerbate an energy crisis.

- **In the short run, perception is everything to the energy marketplace**. The marketplace responds to real or imagined crisis initiators with attempts by buyers to secure energy resources in the face of uncertainty. For uncertainties about supply of a resource, the ensuing response of the marketplace then acts to create the shortage in the near-term, whether or not one exists in reality.

- **Technologically and environmentally speaking, there is no "free lunch."** It is tempting to look for the solutions to future energy problems in terms of simple fuel substitutions. In 1973, nuclear power was supposed to offer the kind of energy secure future that natural gas is promised to deliver today. But all sources of energy have their costs. Hydroelectric dams interfere with salmon runs. Wind power projects are criticized for their visual and sonic impacts and their potential threat to wildlife. As the number of environmental and social concerns associated with energy projects grows to include such considerations as "environmental justice" and equitable distribution of benefits, the likelihood that any single fuel source will be able to meet all objections to its conceivable uses diminishes.

- **Transferring energy requirements from one fuel source to another does not solve an energy problem, but merely shifts it to a different sector of our energy economy**. This is especially true as regards oil and natural gas. If unforeseen

technological breakthroughs allowed a massive shift to electric cars, and the need to curtail burning of fossil fuels demanded it, there would be a concomitant energy crisis in trying to meet the electrical demand over the grid.

- **Economic policy matters because it helps control the precursors to crisis.** Economic growth of developing countries will be a major driver of national and international energy policy in the future. That development will exacerbate the potential for conflicts over natural resources, and perhaps result in increased developing country competition with the United States for foreign energy resources. The more that developing countries are encouraged and assisted to develop in a "sustainable manner," the less pressure there will be to consume non-renewable energy sources, and energy security for all will be enhanced. The health of the U.S. dollar could also be an energy issue. With our current and increasing dependence on foreign energy sources, a strong dollar on the international money markets is needed to keep the costs of foreign-obtained energy affordable.

CRITICAL FORESIGHT

Charting a course to future energy security will be gained through seeking to establish a dynamic equilibrium among the forces that can create energy crises. Maintaining the balance requires sensing the recurrent combinations of crisis conditions and reading the trends towards situations that constrain our energy-related policies and their responsiveness to crisis events.

The revised conception of energy security developed in this paper can be illustrated through use of a seafaring metaphor. In this metaphor, energy security is not a destination, it is a journey. And what has changed is the seascape on which the journey is taken.

In the past 50 years, we have sailed a course analogous to that of a journey downriver. The boundaries of the course of energy security were often well defined by the opposing riverbanks of competing world hegemonies. The very forces of history it seemed, provided an impetus to the passageway. If new energy resources appeared, like islands in the stream, the question was to which side of the channel, and thus which hegemony, they would belong to as the ship swept by.

The end of the Cold War and the dissolution of one of the world's great political empires is tantamount to the ship reaching the river's mouth and finding itself on a great, uncharted sea. Without the nearby shorelines, how will the course be discerned, what rules of steerage will be invoked, and what are the unforeseen dangers of continuing the journey?

Our scenarios show that the variety of conditions that can prompt crises, the multilevel responses the United States and other countries and world energy markets make in turn, and the associated operational timescales of the above, are much greater than before. The world

has become a much more uncertain and confusing place if not a more dangerous one. Continuing with the seascape metaphor, the following are the rules of "good seamanship" that we believe advisable when journeying on such uncharted domain.

Keep Landmarks in View

One of the basic rules of open water sailing is to keep landmarks in view if you don't have a chart. Landmarks in the energy security sense are given by clear statements and communication of priorities. These priorities need to address the degree to which the nation will decouple energy supply and consumption, and the mixed use of energy resources we will strive to achieve. If they can be clearly communicated and implemented, it will become easier to maintain awareness of the precursors of national and international circumstances that may threaten our ability to meet these goals.

Know the Indicators of Currents

The earliest open water sailors learned quickly to follow the route of the trade winds and currents if these were taking them generally where they wanted to go. Similarly, it appears that energy security may be guaranteed far more by sensing and working with emerging world drivers of energy consumption than by trying to resist them. Two of the strongest emerging drivers of energy use in the world are the environmental consequences of different fuels and the energy needs of developing countries. Charting a course that is compatible with these realities is one that is inherently more secure.

Keep Watch for Whirlpools, Icebergs, and other Surface Disturbances

To a sailor, all of the above are phenomena due to conditions beyond control of the ship's crew. But running into these is a function of steerage. In our metaphor, a "whirlpool" is formed by a conflict in at least two convergent sources of control. On the sea, these may be currents, while on a world energy surface, they may be competing religious ideologies or political rivalries in an energy producing region, or even incompatibilities in the operations of our own federal agencies.

Icebergs are what the name implies -- a major obstruction to passage that may be only partly visible from the surface. But when struck, they do not yield, and will significantly deflect a course. Public opinion and values are much like icebergs in that the depth of opposition to a proposed plan of action is often not apparent from a distance. But when aroused, public opposition can greatly change the course of energy development in a country, as the history of our nuclear industry shows.

Surface disturbances are indicators that there is something going on out of view which may mean danger for the unwitting voyager. Good sailors "read the ripples" to infer what water conditions go unseen. Similarly, effective guidance in energy matters means becoming aware as early as possible of the risks inherent in certain approaches energy security. These may

be risks in the suitability or effectiveness of proposed energy technologies, or uncertainties in the results of environmental modelling, like predicted world climate changes, that nonetheless affect energy security goals.

Be Prepared for The "Killer Wave"

The "killer wave" is a sea phenomenon that appears to come out of nowhere on clear, calm days to swamp the unfortunate boat. It is an "interaction phenomenon" caused by a chance confluence of circumstances and forces that converge at a particular point. While it is documented and real, it is relatively unpredictable in terms of the exact location and place it can strike.

Similarly, an energy crisis can occur or be amplified through the chance interaction of many smaller effects, each of which would not trigger a crisis. The Arab oil embargo of 1973, as deliberate and monolithic as it appears, in hindsight actually was occasioned in its timing and impacts by just such an interplay of relatively independent world conditions and small details that made it the "killer wave" it was for U.S. energy practice.

Although impossible to predict with exactitude, it should be possible to extract a key set of semi-independent indicators for certain types of metaphorical "killer wave" phenomena with respect to energy security. This set of indicators would combine summative conditions of world financial energy markets, trends in energy demands, concentration ratios of energy resources for certain uses, and indices of social stability to give an overall reading of the suitability of conditions for a "killer wave."

Exercise Foulweather Preparedness

No country can predict or avoid all potential energy crises. Being "foul weather prepared" means having plans in place to deal with the worst and most unpredictable of these, so that mitigating actions may be taken properly and within the time required for reactions. Just as failing to reef a sail in time can overturn a ship, effective responses to crisis conditions are not useful if they are delayed. Implementing crisis plans means having the information necessary to do the right thing at the right time. Acquiring that information and getting it to governmental and private sector decision-makers is a provision of energy security that needs to be practiced and maintained.

Know Where the Safe Harbors are on the Journey

It is said that countries do not have friends, they have interests. A safe harbor on the course of energy security is gained by knowing which countries have compatible energy interests to one's own, and how these might be built into alliances that act concertedly to remove threats to energy security. The Iraqi occupation of Kuwait was overturned by an alliance of nations that had a convergence of interests and concerns. It had to be painstakingly built over a period of time. Effective alliances are deterrents to the kind of adventurism that may

occasion energy crises. Making and maintaining these alliances is another essential part of energy security in the changed world order of the 21st century.

CONCLUSIONS

Achieving and maintaining energy security in the post-Cold War era will be both an evolutionary and an adaptive process. It will necessitate building from the advantage of hindsight and its accompanying lessons learned from past crises. It will also necessitate recognition of potential crisis-inducing developments on the international scene, reducing their likelihood where possible (e.g. by reducing dependence on foreign oil by both the United States and developing world), anticipating and planning contingency actions ("war gaming" the Strategic Petroleum Reserve, for example), and compensating for them as they occur. It will inevitably be, to some extent, a learn-as-you-go procedure.

Our review of past events illustrates that much of the excess severity of previous crises were directly attributable to reactions about perceived shortages of energy supply based largely upon fear and uncertainty over the future availability of oil, not from actual supply shortfalls. Other crises impacts were due to the combined influences of relatively minor stimulating events and the interlinked responses to them from agencies acting with good intentions but with little information or coordination. Certain past incidents that have not stimulated energy crises per se have occasioned changes in public attitudes and the regulatory environment that could become crucial in the formation of a future energy crisis. Better information and better-communicated information concerning the actual market facts, both ahead of time and during the crisis, offers a chance to better to defuse potential crises and to handle them better when they occur.

Severe energy crises appear to manifest themselves in at least three ways.

a. They arise from perceptions and psychological responses to perceived uncertainty in the future price or supply of a resource.

b. They arise from a cascading set of stimulating actions and responses in energy and financial markets and governmental agencies that tend to produce the crisis as an emergent consequence from all of the activity.

c. They build slowly and relatively imperceptibly over time, as a variety of seemingly unrelated policies, decisions and changes in the world all act to constrain effective responsiveness to a future critical incident, which then becomes a trigger for an unreasonably massive impact.

These are all aspects of a dynamic world energy security equation. The previous focus of most energy security analyses have dealt extensively with crisis stimulants, as if these were somehow enough to explain all the consequences. They are not, even when the initiating event seems to be clear and distinguishable. Rather, the so-called critical incident or initiating event always has its own history of precedents and consequences, all of which radiate outward across time and distance to collaboratively create the course of the crisis.

One thing that *is* certain in all of this dynamism is that it is not an "us against them" world, whether we think of the dichotomy as energy consumers versus producers, or one bloc of consumers against others. Energy security will not be realized by simply substituting a new oppositional thinking for the old. In the new world order, energy producing and consuming nations are both interested in avoiding circumstances that might interrupt supply and therefore threaten their respective financial/economic well being. Everyone benefits from a world energy security equation that projects smoothly and foreseeably into the future. What this means is that the energy security of the United States becomes inextricably bound with the energy (and even political) security of other nations. There is no clear boundary where distinct relevancies become apparent. Instead, the overlapping and competing interests in world energy resources bump and rebound and sometimes adhere, making for a complex and continually evolving worldset of influences.

Forecasting under such circumstances would seem to be exceptionally risky. Yet, certain of these influences also seem inevitable, because they are driven by inexorable demographics or are already in formation. China and other Asian nations will exhibit strong growth in energy consumption, particularly for transportation and electrification. So will many of the developing countries.

There will be periods of political turbulence in the FSU and in the Middle East. The former is recovering from 75 years of spent political orthodoxy, the latter from the pressures of booming population and economic growth and ongoing regional tensions.

Economic development and environmental concerns will become increasingly linked, as the industrial practices of any one nation have increasingly obvious consequences for others.

Throughout the next half century, the world will begin to look ahead to a transition to a post-oil energy economy, as the cost of remaining fossil fuels rises with an inevitable decrease in reserves and an increase in the environmental impacts of their continued use.

Issues of the safe use of nuclear power and its potential support of nuclear proliferation will have to be addressed in a consistent way on a world scale, to prevent the possibility of future Chernobyls and nuclear arms races among the developing countries.

These and other forces will create the currents that can become courses to crises. As their uncertainty and variability increase, the ability of the United States to exercise its diplomacy adaptively and flexibly becomes all the more important, as does the need to think systemically and to integrate activities across our different agencies of government. But there is no one sure route across such an uncharted sea, only practices of good "seamanship." It is hoped that this paper will help provide the stimulus for the analysis and the vision that will guide that journey.

SOURCES

American Petroleum Institute. January 1994. *Basic Petroleum Data Book, Petroleum Industry Statistics*.

Attanasi,E.D., and Root, D.H., 1994, "The Enigma of Oil and Gas Field Growth." *Bulletin of the American Association of Petroleum Geologists*, Vol. 78, No. 3.

Barnes. 1990. "The OIES Review of Long-Term Energy Supplies." *Oxford Institute for Energy Studies, Oxford*. United Kingdom.

Bohi, D.R., and Montgomery, W.D. 1982. *Oil Prices, Energy Security, and Import Policy*. Resources for the Future, Inc.

Bohi, D., and Russell, M. 1975. *U.S. Energy Policy: Alternatives for Security*. Resources for the Future.

Brauchli, M. September 14, 1993. "China's Oil Needs Outstrip its Supply." *The Wall Street Journal*.

British Petroleum, June 1993. *BP Statistical Review of World Energy*.

Clark, John. 1990. *The Political Economy of World Energy*. University of North Carolina Press.

Cremer, J., and Salehi-Isfahani, D., 1991. *Models of the Oil Market*. Harwood Academic Publishers.

Commodity Futures Trading Commission Annual Report. 1990. Chicago Board of Trade.

Conway, P. April 1994. "Kazakhstan: Land of Opportunity." *Current History*.

Curlee, T.R., and Russell, M. 1992. *Oil Vulnerability, Structural Market Changes, and the Role of the U.S. DOE*. Oak Ridge National Laboratory.

Dunkerly, J. 1980. *Trends in Energy Use in Industrial Societies: An Overview*. Resources for the Future.

Dunkerly, J. 1978. *International Comparisons of Energy Consumption*. Resources for the Future.

Doran, C., Buck, S., eds. 1991. *The Gulf, Energy, and Global Security: Political and Economic Issues*. Lynne Rienner Publishers.

Dornbusch, R. and Poterba, J. 1991. *Global warming: Economic Policy Responses*. MIT Press.

The Economist. June 18, 1994. "Survey: Energy."

Energy Information Administration (EIA), U.S. Department of Energy. 1992a. *Country Profiles: 1992*. Washington, D.C.

Energy Information Administration, U.S. Department of Energy. 1992b. *EIA Analysis Brief: The Former Soviet Republics*. Washington, D.C.

Energy Information Administration, U.S. Department of Energy. September 1993a. *The U.S. Petroleum Industry: Past as Prologue 1970-1992*. Washington, D.C.

Energy Information Administration, U.S. Department of Energy. October 1993b. *Weekly Petroleum Status Report*.

Energy Information Administration, U.S. Department of Energy. January 1994. *Monthly Energy Review*.

Energy Information Administration, U.S. Department of Energy. May 1993. *State Energy Data Report 1991 Consumption Estimates*.

French, H.E., and Lee, W.C. *Quarterly Journal of Economics*. February 1987. "The Welfare Cost of Rationing-by-Queing Across Markets: Theory and Estimates from the U.S. Gasoline Crisis."

Fried, E., and Trezise, P. 1993. *Oil Security: Retrospect and Prospect*. The Brookings Institution.

Friedman, T. April 3, 1994. "OPEC's Lonely at the Tap, but China's Getting Thirsty." *The New York Times*.

General Accounting Office. 1993. *Energy Security and Policy: Analysis of the Pricing of Crude Oil and Petroleum Products*. Washington, D.C.

Hirshleifer, J., and Glazer, A. 1992. *Price, Theory and Applications*. Prentice Hall, Inc.

Houghton, J.C., Dolton, G.L., Mast, R.F., Masters, C.D., Root, D.H. 1993. "U.S. Geological Survey Estimation Procedure for Accumulation Size Distributions by Play." *Bulletin of the American Association of Petroleum Geologists*. Vol. 77, No. 3.

International Energy Agency, Organization for Economic Cooperation and Development (OECD). 1987. *Energy Conservation in IEA Countries*. OECD.

International Energy Agency, Organization for Economic Cooperation. 1991. *Energy Efficiency and the Environment*. OECD.

Jochem, E., and Morovic, T. 1988. "Energy Use Patterns in Common Market Countries Since 1979." *Annual Review of Energy*.

Long, D. January 1991. "Stability in Saudi Arabia." *Current History*.

The Margin. November/December 1990.

Masters, C.D. 1993. "U.S. Geological Survey Petroleum Resource Assessment Procedures." *Bulletin of the American Association of Petroleum Geologists*. Vol. 77, No. 3.

McMullen, R. July-September 1993. "Ethnic Conflict in Russia: Implications for the United States." *Studies in Conflict and Terrorism.*

Miller, R.G. 1992. "The Global Oil system: the Relationship Between Oil Generation, Loss, Half-life, and the World Crude Oil Resource." *Bulletin of the American Association of Petroleum Geologists*. Vol. 76, No. 4.

McMullen, R. July/September 1993. "Ethnic Conflict in Russia: Implications for the United States." *Studies in Conflict and Terrorism.*

Oil & Gas Journal. January 10, 1994a. "Asia To Pace Growth in World Energy Demand."

Oil & Gas Journal. February 7, 1994b. "Geopolitical Trends Shape Future of World Petroleum Industry."

Oil & Gas Journal. March 7, 1994c. "EIA Cites Importance of Key World Shipping Routes."

Pavle, J. October 1989. "Gas Househeating Survey: 1988." *Gas Energy Review.*

Stanislaw, J., and Yergin, D. September/October 1993. "Oil: Reopening the Door." *Foreign Affairs*.

Time Magazine. January 28, 1991.

U.S. Central Intelligence Agency. September 1993. *Handbook of International Economic Statistics*.

U.S. Department of Energy, Office of Intelligence. June 1992a. *Identifying Vital Issues: New Intelligence Strategies for a New World. Volume 1: Vital Issues*. Washington, D.C.

U.S. Department of Energy, Office of Intelligence. September 1992b. *Identifying Vital Issues: New Intelligence Strategies for a New World. Volume 2: Critical Topics.* Washington, D.C.

U.S. Government Printing Office. 1993. *Economic Report of the President.*

U.S. International Trade Commission. June 1993. *Trade and Investment Patterns in the Crude Petroleum and Natural Gas Sectors of the Energy-Producing States of the Former Soviet Union.* Washington, D.C.

U.S. Department of Commerce. 1992. *U.S. Statistical Abstract.*

Wilhelm, K. April 17, 1994. "China's Energy Crisis: More Resources Needed to Power Economic Growth." *Seattle Post-Intelligencer.*

Yergin, D., 1991. *The Prize: The Epic Search for Oil, Money & Power.* Simon & Schuster.

APPENDIX A: IMPORTANT DEVELOPMENTS IN ENERGY MARKETS

Despite Declines in the Rate of Growth, Trends in U.S. Energy Consumption Have Made the United States Significantly Dependent on Foreign Oil

Oil has long been the major source of energy consumed in the United States, averaging 17.2 million barrels per day in 1993 (EIA 1994). But the growth in total U.S. oil consumption has slowed over the last two decades, from an annual 3.6 percent increase between 1960 and 1970 to -0.2 percent between 1980 and 1990 (see Table 1). Primarily, these trends reflect oil consumption in the transportation and industrial sectors. Over the last twenty years, the share of oil consumed in the transportation sector increased from 51.8 percent (1970) to 65 percent, an increase of 6 quadrillion Btu's (quads). Meanwhile oil consumption in the industrial sector has increased modestly from its 1970 level to approximately 8.3 quads in 1990. Because transportation and industrial end-uses account for most U.S. oil consumption, these sectors are especially sensitive to future oil supply disruptions and present-day concerns over American dependency on foreign oil.

The *EIA Annual Energy Outlook 1994* projects petroleum consumption will grow by 1.3 percent a year through the year 2010. This growth rate scenario is based on the assumptions of rapid growth in the consumption of liquid petroleum gas, and petrochemical feedstocks. Presently, the eight most energy-intensive industries (i.e. food, paper and allied products, refining, bulk chemicals, glass and glass products, cement, iron and steel, and primary aluminum), account for two-thirds of industrial energy consumption. Future energy consumption by these industries is projected to grow at an annual rate of 0.9 percent. Meanwhile, EIA projects consumption by non-energy intensive industries will grow at more than twice this rate, 1.9 percent. Metal durables are projected to grow the fastest at 2.1 percent per year. Among the more telling influences on these consumption projections will be the degree of growth in the various product markets, and the degree to which energy-intensive industries adopt more energy-efficient technologies.

The projected trends in future domestic energy consumption underscore the U.S. dependency on foreign oil, and the growing importance of global and regional energy markets in buffering future supply disruptions. The growth in foreign supply sources in the future will no doubt influence the efficiency of energy markets, and promote international trade in energy commodities, both of which could serve to augment this buffer. At the same time these prospects raise another issue, namely the prospects for increased foreign energy consumption, especially in non-OECD countries. Assuming international trade in energy commodities continues to grow, it is important to consider what U.S. demand for foreign oil means to other countries, and what foreign demand for oil means to the U.S. economy. An important element of this interdependency is an understanding of how oil markets have changed, and what effect these changes have had on responses to crises.

Institutional Changes in the Oil Market Have Had Mixed Impact: On Balance, They Have Partially Adjusted for Dependence on OPEC Oil

A number of key institutional changes have influenced the traditional relationships between oil inventories, prices, and the demand/supply of crude oil. First, is the nationalization of oil fields by oil-producing countries. By the end of 1975, all decisions governing price, output, and capacity were under the exclusive control of the oil-producing governments (Cremer and Salehi-Isfahani 1991). A second influential factor is the emergence of oil futures trading. Since 1983, these markets have been highly sensitive to oil supply disruptions, and unanticipated changes in the levels of petroleum inventories around the world. A third factor influencing world oil markets is the organization of international agreements to share petroleum reserves during crises. Since its authorization in 1974, the U.S. Strategic Petroleum Reserve has been developed and managed under the terms of these arrangements. Finally, there has been a gradual deepening of international oil spot markets as a substitute to long-term contracts for crude supplied to refiners, due to an increase in the number of sources of supply in the world spot market for crude oil.

The implications of some of these changes for U.S. energy security were discussed in a recent two-volume report by the Department of Energy's Office of Intelligence (DOE 1992a,b). According to this report, the structure of the oil market has changed in recent years in ways to make the oil market less susceptible to violent swings in price (DOE 1992a). However one notable exception may be the nationalization of crude oil fields by oil-producing countries. As oil producing governments became part owners of operating companies, they began to assert their control over production through the abrogation of oil concession agreements and/or through increased 'participation' in production. For instance in 1970, Libya cut the exports of Continental Oil by 50 percent to pressure it to pay more for Libyan oil. In 1971 Algeria nationalized the interests of Companie Francaise de Petrole, and acquired complete control over all its oil supply. And of course the Arab oil producers politicized their control over production decisions when they asked operating companies to cut production in order to force the Western supporters of Israel to modify their policies.

A second influential factor on oil markets arose in 1983 with the introduction oil futures trading (GAO 1993; DOE 1992a). By providing information on anticipated price movements and instruments for refiners and merchandisers to hedge price risks, futures trading made oil markets more efficient and lowered the costs of petroleum products to American consumers. In the process, oil futures trading has helped retail petroleum markets absorb supply shocks with less disruption than occurred in either the 1973 Arab oil embargo or the 1979 Iranian Revolution (CFTC 1990). Yet, oil futures trading became controversial following Iraq's invasion of Kuwait in 1990. This event was reflected at the New York Mercantile (futures) Exchange (NYMEX), as oil prices reached $40 per barrel on several occasions and continued to remain volatile through subsequent news from the world's major oil-producing region. Critics of futures trading argued that "unwarranted speculation" magnified the price spikes

following the invasion, and added to price volatility.[4]

The fact remains that futures trading is relevant to U.S. energy security by reflecting the price impacts of supply disruptions (actual or perceived), and inventory adjustments. Moreover, since inventory adjustments can either amplify (if too low) or dampen (if too high) the attendant price impacts of real or perceived supply disruptions, futures markets can play an important role in stabilizing world oil prices. Indeed, prices on the NYMEX futures market respond to news items that influence petroleum inventories around the globe. Similarly, the release of industry or government reports on the state of petroleum inventories in the United States and other major oil-consuming regions, e.g., Europe and Asia, advances the volume of futures trading throughout the world. Some of the more closely watched sources of information on petroleum inventories include the American Petroleum Institute (API), the DOE's Energy Information Administration (EIA), and the Organization for Economic Cooperation and Development's International Energy Agency.

A third factor that has changed oil markets was the signing of international agreements to share petroleum reserves during crises, and the consequent development and management of the U.S. strategic petroleum reserve under the terms of these arrangements. The argument that private profit motives are too "unstable and myopic" relative to the potential long-term risks associated with oil supply disruptions rationalizes the need for the SPR. However, the development and management of the SPR has been an issue of considerable controversy, particularly following the invasion of Kuwait. Many policy analysts believe the government failed to use the SPR stocks responsibly following the invasion and the subsequent outbreak of the Gulf War (Curlee and Russell 1992). While the Bush Administration did release SPR stocks at the outbreak of the Gulf War, it was criticized for not drawing them down quickly and in large enough quantities -- too little, too late (see *Time Magazine* January 28, 1991).

Some SPR critics consider the current system to be flawed in the sense of poorly defined rules and responsibilities for initiating drawdowns. They have argued that the absence of an effective "drawdown trigger" is a costly error in "pure economic terms" (Horwich 1991 and Curlee and Russell 1992). However a policy decision to tap SPR stocks in response to supply disruptions is inherently complicated by uncertainty surrounding the severity of supply disruptions, and how privately-owned stocks will be managed during disruptions. For example, at the start of the Iran-Iraq War in 1980, private stocks were large enough to buffer the resulting shock, and no actions were required by governments to restrict consumption or to draw upon SPR stocks. On the other hand, the pro-active decision to draw down SPR stocks during the 1991 Gulf War was criticized for mistaken expectations over panic buying

[4] However highlights of a study by the CFTC found this conclusion to be without foundation, since it was demonstrated that: a) most of the "open interest" at NYMEX was held by commercial operators from the oil industry; b) that speculative trading volumes were below average and actually declined following the invasion; that speculators were "net short," and stood to profit only from lower oil prices; and c) that movements in the NYMEX futures prices paralleled (and, at times, even lagged) other world oil prices in both the futures and cash markets.

and hoarding of crude oil (*Time Magazine*, January 28, 1991).

A fourth factor which has influenced the impact of oil supply disruptions is the deepening of international oil spot markets during periods of high oil prices. International spot markets for crude oil provide a viable substitute to long-term contracts for crude supplied to refiners. The deepening of these markets during supply disruptions owes much to the supply behavior of bystander oil-producing nations, i.e., nations not directly involved in the crisis-initiating event which nevertheless have price incentives to respond to the event. To the extent bystander oil producers have the requisite production/refining capacity to make up for the lost production from the affected country(ies) or region(s), the price and inventory effects that accompany supply disruptions may be relatively moderate. Figure 1 illustrates monthly spot market prices for West Texas crude over the period 1984-1993 in relation to domestic consumption and production, as well as several key events that transpired during the period.

Note, in Figure 1, how oil prices began falling sharply once Saudi Arabia committed to increase its production during 1991-1992. Just prior to the crisis, Iraq and Kuwait had a combined production of about 4 million barrels per day, about 6.7 percent of the world's total. Consequently, an upward adjustment in oil prices was needed to reduce the quantity demanded to equal what resulted in a lower quantity supplied. Allowing prices to adjust following supply disruptions is socially desirable in the sense of simultaneously encouraging production while discouraging consumption, and has important implications on the issue of supply sources and U.S. dependence on foreign oil. This issue is considered below.

Saudi Arabia is the World's "Swing Producer," but Cannot Control Oil Prices

Over the last several decades, energy economists have developed an extensive literature on the topic of U.S. energy security based on the magnitude and variability of future energy imports and the institutional stability of the countries from which these imports are obtained. The emerging framework from these studies has given due emphasis to the importance of U.S. vulnerability to "supply shocks," following events such as the 1973 Arab oil embargo, the 1980-88 Iraq-Iran War, or Iraq's invasion of Kuwait in August of 1990 (GAO 1992). In addition, there is continued uncertainty as to the influence of OPEC over market prices, and the willingness of its members to subscribe to strategic production targets (Cremer and Salehi-Isfahani 1991). These matters continue to be focal points in discussions of U.S. energy security policy.

For more than two decades, the United States has experienced wide fluctuations in the magnitude and variability of oil imported from an increasingly diverse number of foreign sources.[5] Imports from OPEC (Figure 2A) increased from 65 percent of the total U.S.

[5] The three major sources of U.S. oil imports delineated by IEA involve: 1) the "Arab-OPEC Bloc" consisting of Algeria, Iraq, Kuwait, Libya, Qatar, Saudi Arabia, and the United Arab Emirates; 2) the "Non Arab-OPEC Bloc," consisting of Ecuador, Gabon, Indonesia, Iran, Nigeria, and Venezuela; and the 3) the "Non-OPEC Bloc" made up of Mexico, Canada, United Kingdom, Angola, and Colombia.

energy basket in 1973 to over 85 percent in 1976. Subsequently this growth trend was reversed and OPEC imports declined to approximately 40 percent in 1985. From this point on, OPEC imports have remained relatively stable, occupying between 50-60 percent of the U.S. oil import market. However, since 1980, OPEC has experienced some of the most turbulent years since its formation in 1960. Between 1980 and 1985, members of the non-Arab OPEC bloc gained market share in the United States at the expense of Arab-OPEC producers. Subsequently, the tables were turned, with Arab OPEC producers recovering their U.S. market share by 1988. Thus, while Figure 2A illustrates the apparent stability of oil imports from OPEC as a whole, Figure 2B shows the relative instability of the market share held by Arab members relative to non-Arab members.

In summary, the size of the Arab and non-Arab OPEC market shares have varied considerably in the United States over two decades. The same may be said for the total OPEC and non-OPEC market shares. What is important to understand is the quickness and extent to which the various oil-producing countries are able to respond to supply disruptions, as well as how these supply responses will impact the market for crude oil imports. At a time of excess oil inventories and refining capacity, the immediate supply response of bystander oil-producing nations may be sufficient to overcome the initial deficits associated with the disruption. As a general rule, oil-producing nations have pecuniary incentives to increase supply following disruptions, and it is precisely this incentive that helps alleviate the initial price shocks and potential future scarcities following oil supply disruptions.

Figure 3 demonstrates the importance of Saudi Arabia as a "swing producer" between 1981 and 1985 following Iraq's attack on Iran; and later during the invasion of Kuwait. As the Saudis cut back production to maintain OPEC's control over the world price of crude oil, Figures 4 and 5 show the opportunistic behavior of other countries which were quick to increase their supply and U.S. market share at the expense of the Saudis. More recently the tables were turned following the invasion of Kuwait, and the Saudis' U.S. market share reached an all-time high. In contrast to these changes in supply sources, international oil markets reflect the competing demands of oil consuming countries. Therefore the following section considers trends in foreign energy consumption.

Non-OECD Countries are Replacing OECD Countries as the Principle Source of Demand. The OECD is Becoming Less Vulnerable to Supply Disruptions, the Developing World More So.

There are two facets to how energy consumption may change in the future that are relevant to this discussion. The first is the way developed economies may alter their use of energy, in particular the relationship between energy consumption and economic output. This relationship has changed radically following the first oil price chock in 1973. The second facet concerning future energy consumption is the tremendous potential for developing

countries to absorb world energy supplies. Regarding the first matter, the oil price shock in late 1973 provoked numerous studies of the relationship between energy consumption and economic output. One of the purposes, according to Bohi (1975), was to "provide insights into the prospects for long-run economic growth in an era of increasingly costly energy." Other studies examined why energy consumption per unit output had become higher in the United States than in other advanced industrialized economies, and why changes in output provoked such a wide range of responses in energy consumption (Dunkerly 1980).

Before 1973, Dunkerely (1980) observed that the trends in the energy-GDP ratios of the major industrialized countries showed a "mix of results" --increasing in some while decreasing in others (see Figure 6B). Only after 1973 did the ratios begin falling in all of the countries. Subsequently, it was noted that over the period 1973-1985 total energy demand grew by 5 percent in the major OECD countries while their GDPs grew by 32 percent (IEA 1987). This trend reflects a decline in energy intensity of 20 percent. The phenomenon of declining energy intensity is also measured by the change in arc elasticities over time - the ratio between percentage changes in energy consumption and percentage changes in GDP. These elasticities across OECD countries vary considerably over the last two decades. Up to 1973, this ratio was just over one; i.e., a one percent change in GDP growth gave rise to approximately the same percentage change in total energy consumption (Dunkerley 1980 and IEA 1987).

Since 1973, arc elasticities have decreased across all countries. Improvements in energy efficiency are commonly associated with this trend. The gains in energy efficiency across OECD countries are reviewed in *Energy Efficiency and the Environment* (IEA 1991), and *Energy Conservation in IEA Countries* (IEA 1987). These references estimate that as much as one-third of the efficiency improvements in the United States are due to shifts towards a more service-oriented economy. Meanwhile, a study by Jochem and Morovic (1988) concludes that a similar shift has taken place in Western Europe which may be responsible for as much as 20 percent of the overall improvement in efficiency in the so-called "Euro-Ten" countries. Similar trends are observed over the period 1970-1989 for Japan (28 percent), the United States (24 percent), Canada (20 percent), and the United Kingdom (34 percent). These trends indicate that future energy consumption in developed countries should reflect continued improvements in energy efficiency. However, there is a second facet to the question of how energy consumption may change in the future, namely the tremendous potential for developing countries to absorb world energy supplies.

It is interesting to note recent observations of decreasing energy efficiency in selected non-OECD countries. For example, energy intensities in China, Mexico, and the former Soviet Union have all increased over the period 1970-1989. Brazil, however, appears to have achieved a modest gain in energy efficiency. Figure 6A illustrates these trends. Note how China appears to show some gains since 1980, but this likely reflects poor GDP data. One

report estimates that less than one-third of all fuel inputs in China result in useful energy.[6] Another way to depict energy intensity is based on population levels. Under this metric, Figure 7 shows that per capita energy consumption increased between 1970 and 1989 in both China (142 percent) and the former Soviet Union (59 percent). Meanwhile consumption in Brazil and Mexico rose by 69 and 55 percent, respectively.

If similar trends in energy consumption hold for developing countries currently experiencing high growth -- say, throughout Asia and Latin America -- then IEA estimates that the share of energy consumed by all developing countries may increase from its present 1994 level of 27 percent, to over 40 percent by the year 2010 (*The Economist*, June 18th 1994). Consequently, the two factors that may explain future trade flows in the global energy markets, i.e. improved energy efficiency across developed countries, and increased energy consumption across developing countries, are working in opposite directions. The developed countries might continue to improve the efficiency with which they use energy and slow the rate at which economic growth absorbs energy supplies, while the developing world could more than breech the gap. These renewed concerns over resource scarcities are reflected by the recent energy consumption forecasts of the developing world.

The IEA's published "scenario" for energy consumption suggests that developing countries will become increasingly vulnerable to energy shortages in the years ahead. Two demographic factors that most influence this prediction are the affects of population growth and the degree of urbanization. By one estimate, a doubling of the urban populations in India and China alone would increase their combined energy demand by 45 percent above their present level, even if their national income and population levels remain the same (Jones, 1991). A third factor that influence the vulnerability of developing countries to energy shortages is their lack of "purchasing power" in world energy markets. The economic vulnerability of developing countries to energy shortages is a cause for concern in considering the overall impact of increased urbanization and population growth in the years ahead.

In contrast, the economic strength of the U.S. in world energy markets appears to mean that recurrent U.S. worries about a stable **long term** supply of imported oil during the next twenty-five years are unfounded, as our major oil suppliers are as dependent on our business as we are on theirs. While we need to be assured of a continuous supply, an organization like OPEC needs to be assured of a continuous demand. Like the oil-consuming nations, the oil-producing nations are not aided by volatility in the price markets. Uncertainties in our national energy policy or the lack of a consistent national energy policy does not aid the oil-producing nations when it comes to planning for the future demands of their customers. They need to make investments in developing their energy resources infrastructure to meet the projected needs of the United States and other major consumers. Information we use to implement a consistent national energy policy that can be shared with producers will help

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[6]"China's Energy Crisis: More Resources Needed To Power Economic Growth", Seattle Post-Intelligencer, April 17, 1994.

avoid future energy crises.

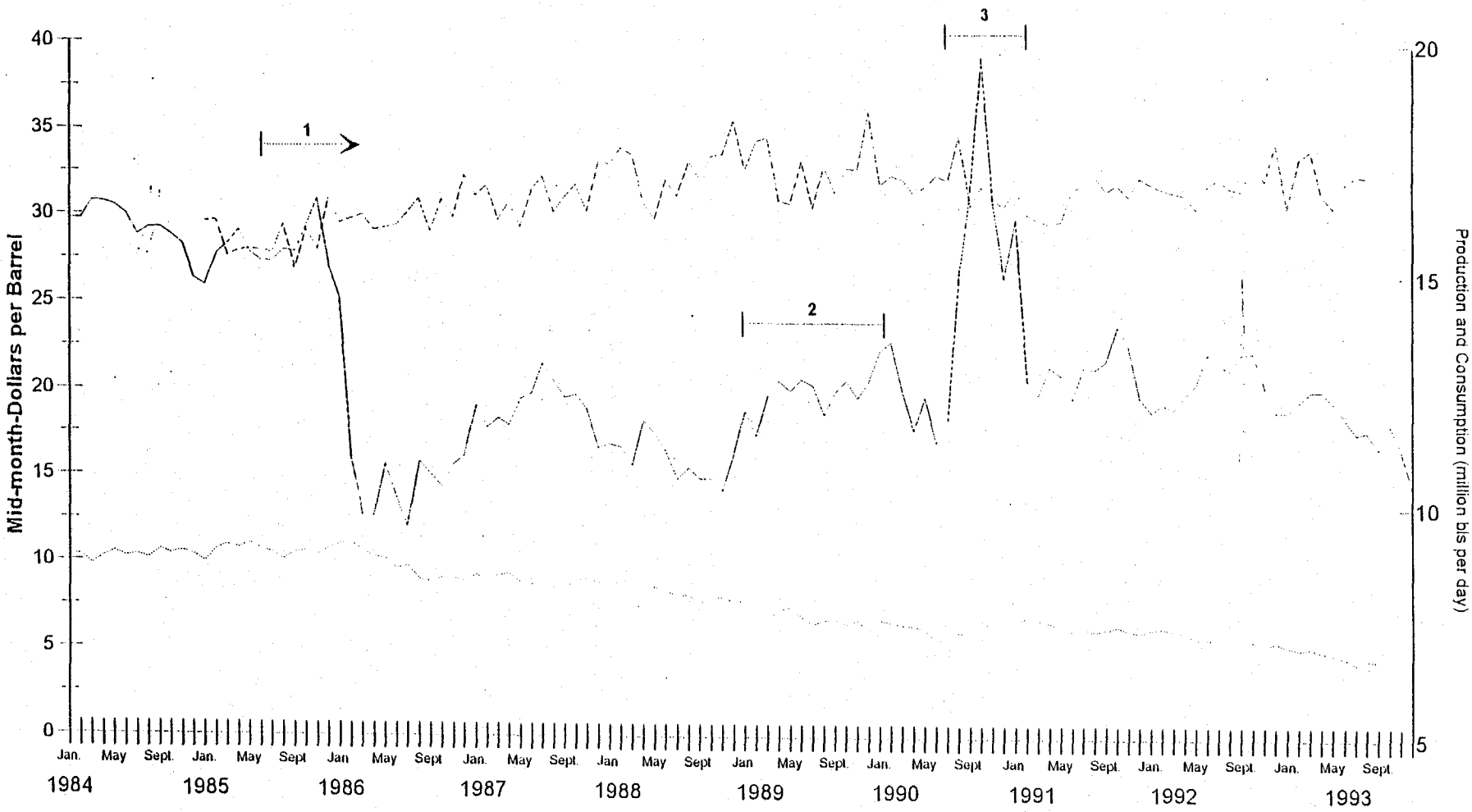
However, while the long term prospects for the world petroleum markets appear promising, energy crises can still arise in the short term because of the combination of any of a number of factors. These potential sources of disruption are discussed in the Appendix B.

Figures

Tables

Figure 1

Monthly Petroleum Spot Price, U.S. Production and Consumption (1984-1993)



Source: American Petroleum Institute

1 Saudi Arabia no longer acts as a swing producer (summer, 1985) and increased production results in a price collapse

2 Exxon Valdez Oil Spill (1989), Home Heating Oil Crisis (1989-1990)

3 Persian Gulf Crisis (Aug 1990 - Feb 1991)

Spot Price (W. Texas Crude)

U.S. Production

U.S. Consumption

U.S. Oil Import Shares From OPEC and Non-OPEC Producers

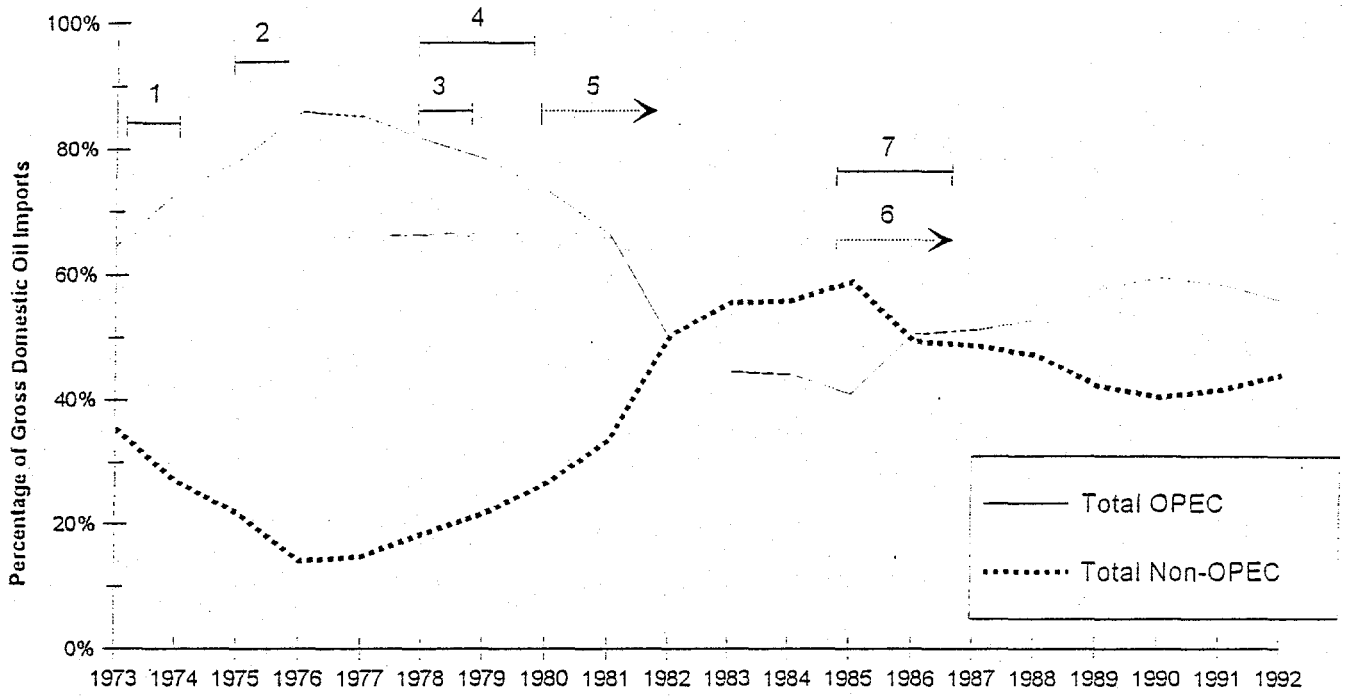
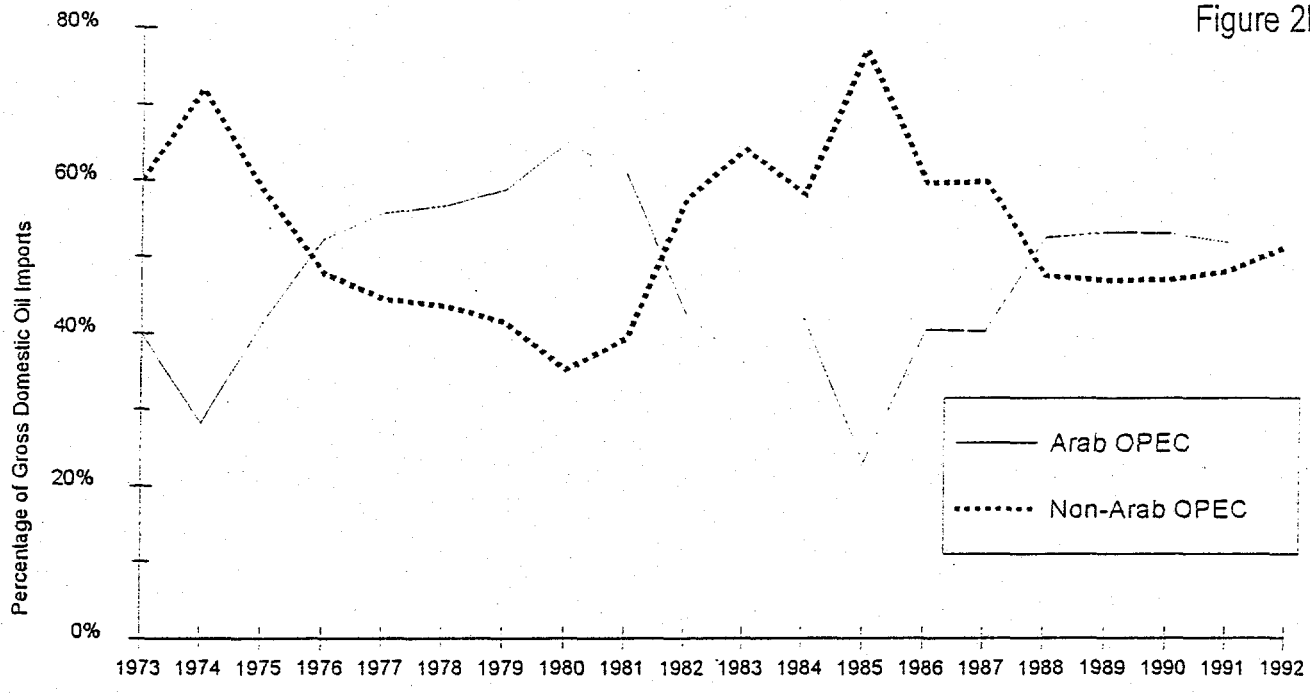


Figure 2b



1 *War in the Middle East results in U.S. oil embargo and a 5% drop in world supply*

2 Price drop of 5% due to a recession in industrialized countries.

3 Revolution in Iran - strike by Iranian oil workers.

4 Price increases due to supply shocks resulting from the strike in Iran followed by the Iran- Iraq war.

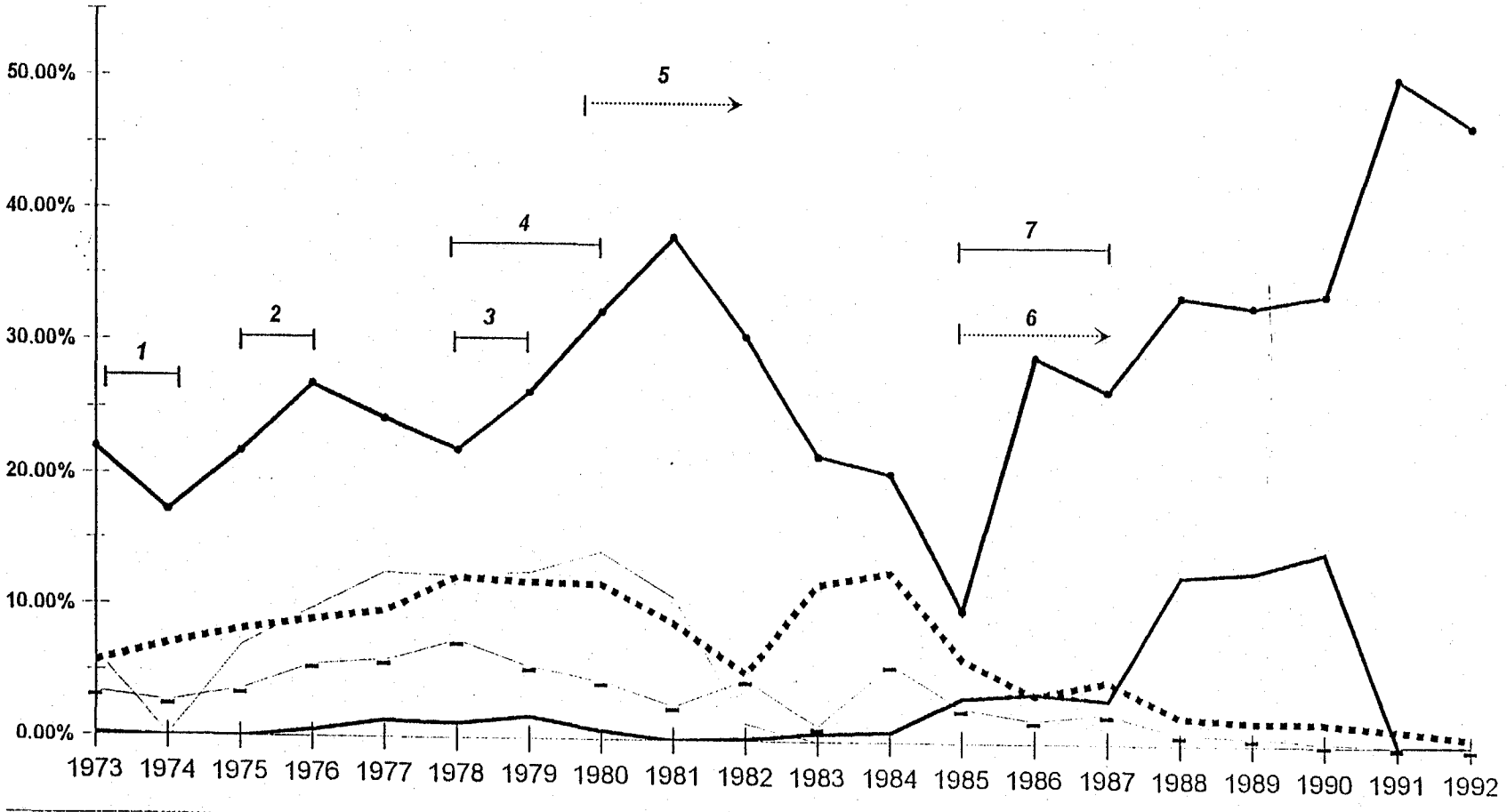
5 Iran-Iraq war - from 1980-1988. Resulted in the cessation of exports from both countries.

6 Saudi Arabia no longer acts as the swing producer (1985)

7 Internal OPEC conflicts prompt overproduction and a price drop of over $18 per barrel

Arab-OPEC Market Shares (% of OPEC Exports to U.S.)

Figure 3



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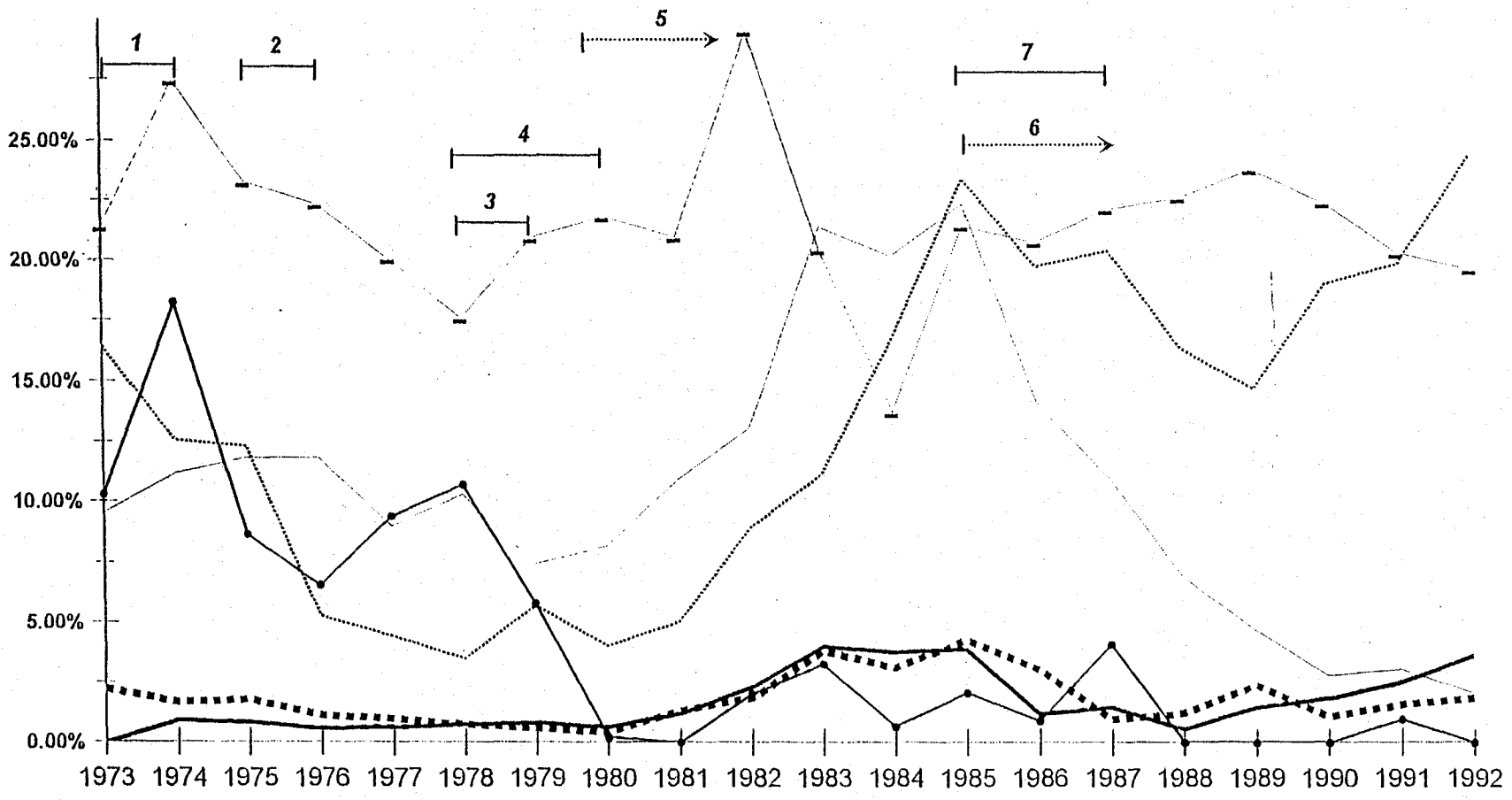
7 Internal OPEC conflicts prompt overproduction and a price drop of over $18 per barrel.

Non-Arab-OPEC Market Shares (% of OPEC Exports to U.S.)

Figure 4



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5 Iran-Iraq war - from 1980-1988. Resulted in the cessation of exports from both countries.

6 Saudi Arabia no longer acts as the swing producer (1985)

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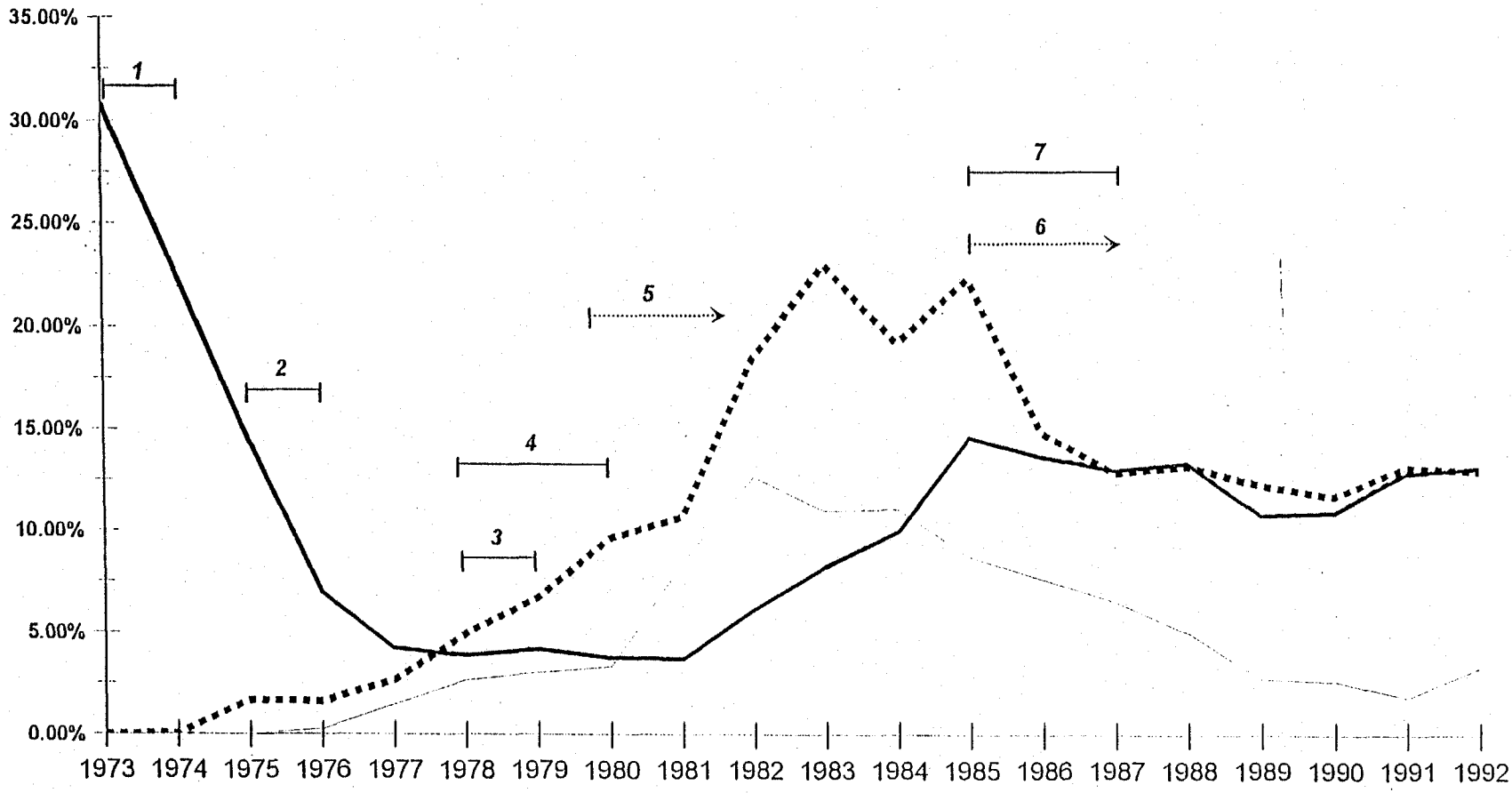
Figure 5

Non-OPEC Market Shares (% of U.S. Imports)



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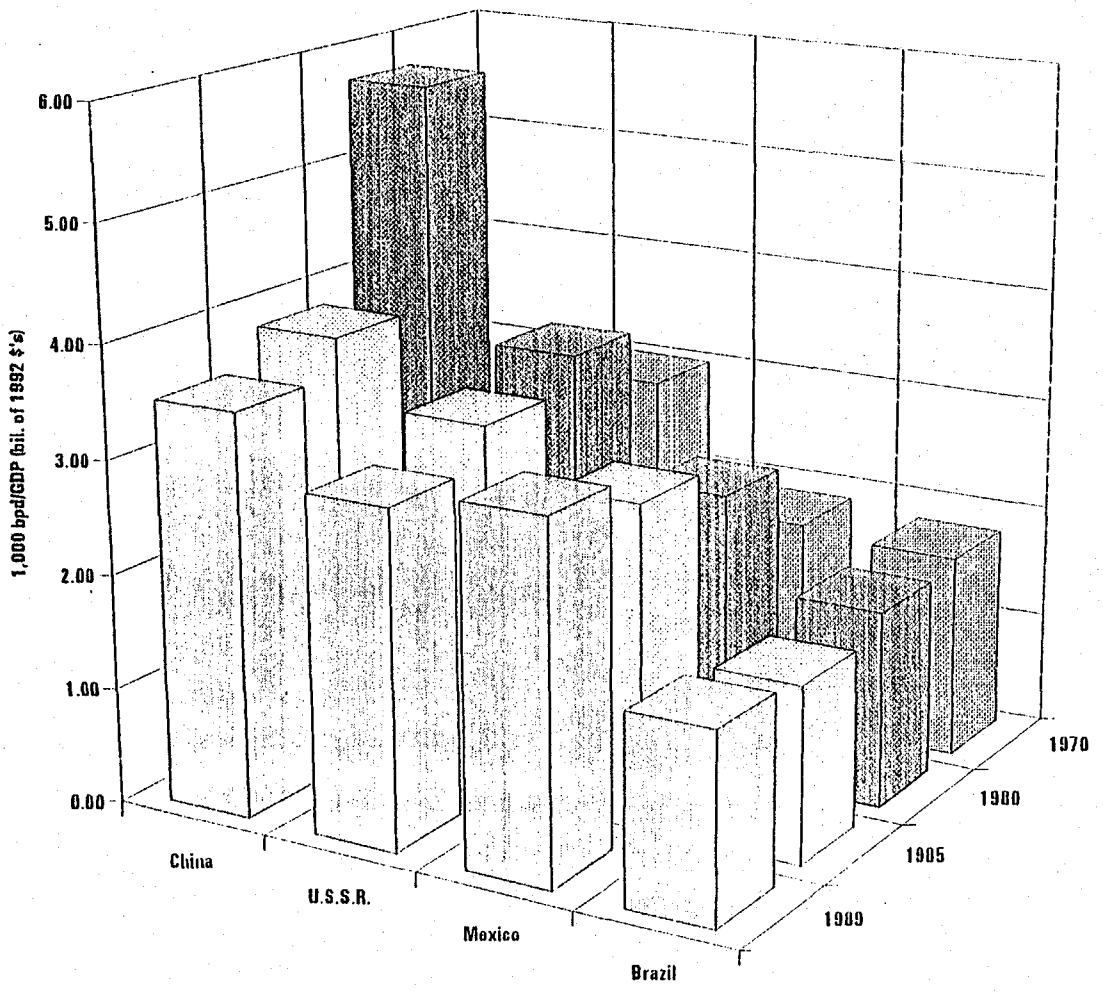
6 Saudi Arabia no longer acts as the swing producer (1985)

7 Internal OPEC conflicts prompt overproduction and a price drop of over $18 per barrel.

Figure 6a

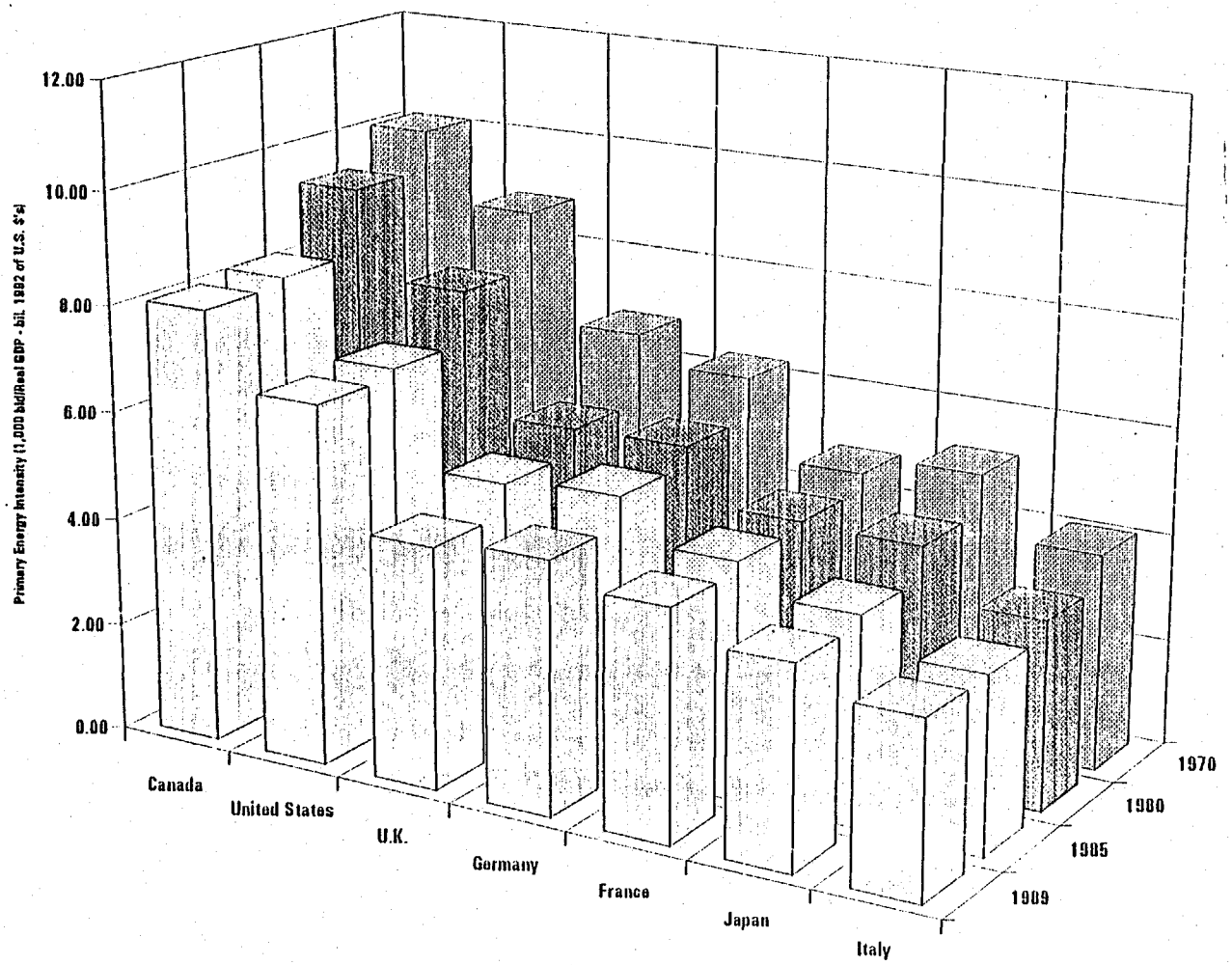
Energy Output Ratios of Non-OECD Countries (Selected Years)



Sources: Handbood of International Economic Statistics, 1993, pgs. 24 and 87; Economic Report of the President, Jan. 1993, pg. 352; U.S. Statistical Abstract, 1979, pgs. 904 and 895; U.S. Statistical Abstract, 1992, pgs. 831 and 844.

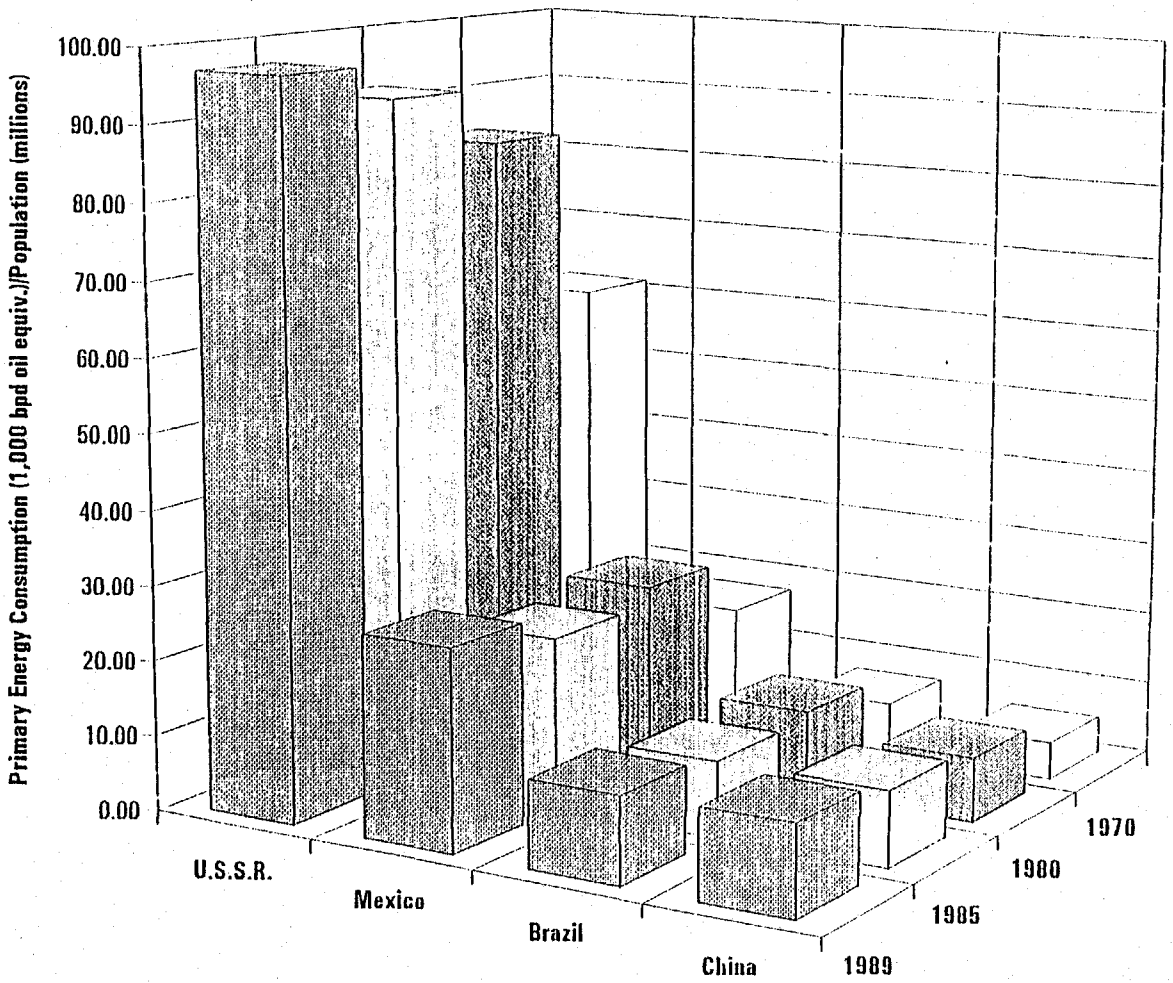
Figure 6b

Energy Output Ratios of OECD Countries (Selected Years)



Source: Handbook of International Economic Statistics, 1993; Tables 7 41.

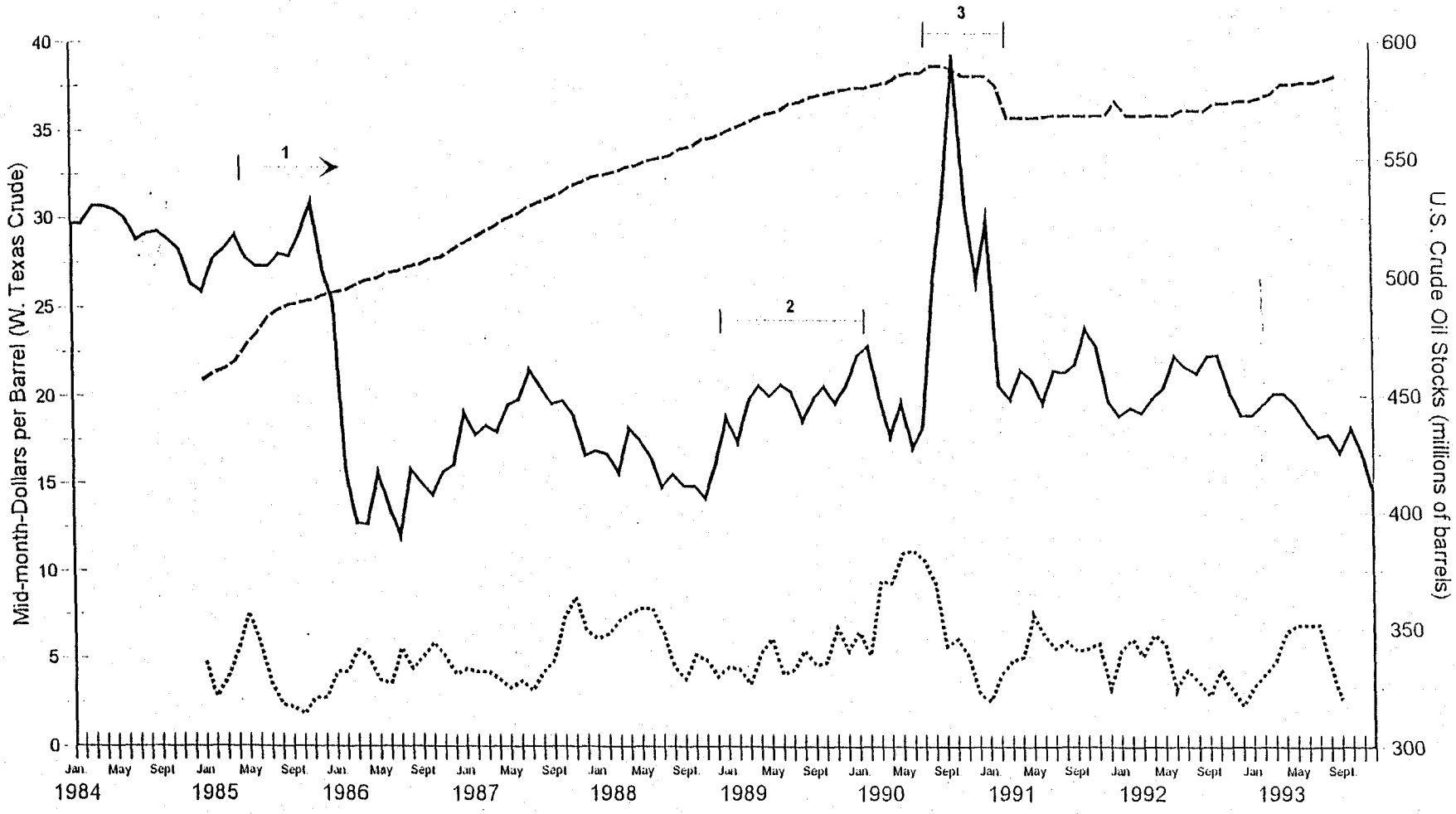
Primary Energy Consumption Per Capita - Non-OECD (Selected Years)



Sources: Handbook of International Economic Statistics, 1993, pg 32 (table 16) pg 87 (table 41);

Figure 8

Monthly Spot Price and U.S. Crude Oil Stocks (1984-1993)



Source: American Petroleum Institute

1 Saudi Arabia no longer acts as a swing producer (summer, 1985) and increased production results in a price collapse

2 Exxon Valdez Oil Spill (1989), Home Heating Oil Crisis (1989-1990)

3 Persian Gulf Crisis (Aug. 1990 - Feb 1991)

Monthly Spot Price (WTI)

U.S. Stocks (privately-owned)

SPR (government-owned)

Table 1

A. Average Annual Growth Rates of Energy Consumption By Sector and By Source

	Residential & Commercial			Industrial			Transportation			Total		
	1960-70	1970-80	1980-90	1960-70	1970-80	1980-90	1960-70	1970-80	1980-90	1960-70	1970-80	1980-90
Coal	-8.8%	-8.2%	0.6%	0.2%	-3.5%	-1.2%	--	--	--	2.0%	2.1%	1.9%
Natural Gas	5.0%	0.2%	-0.2%	4.3%	-1.2%	0.1%	--	--	--	5.1%	-0.6%	-0.5%
Petroleum	1.9%	-3.2%	-3.1%	2.8%	1.8%	-1.2%	3.8%	2.0%	1.2%	3.6%	1.3%	-0.2%
Electricity	7.5%	4.0%	3.0%	5.1%	3.2%	1.4%	--	--	--	7.2%	3.0%	2.4%
Total	4.6%	1.5%	1.0%	3.2%	0.6%	-0.2%	3.8%	1.8%	1.2%	3.8%	1.2%	0.6%

B. Annual Volume of Energy Consumption By Sector and By Source (quadrillion Btu)

	Residential & Commercial			Industrial			Transportation			Total		
	1970	1980	1990	1970	1980	1990	1970	1980	1990	1970	1980	1990
Coal	0.37	0.15	0.16	4.66	3.16	2.76	--	--	--	12.27	15.46	19.00
Natural Gas	7.41	7.54	7.22	9.60	8.39	8.50	--	--	--	21.69	20.38	19.28
Petroleum	4.31	3.04	2.17	7.79	9.53	8.32	15.31	19.01	21.81	29.52	34.20	33.55
Electricity	2.79	4.35	6.02	1.95	2.78	3.23	--	--	--	5.15	7.14	9.31
Total	21.65	25.65	28.79	28.59	30.61	29.93	16.07	19.69	22.54	66.33	75.96	81.26

APPENDIX B: ILLUSTRATIVE ENERGY CRISIS SCENARIOS

POLITICAL SCENARIOS

Regime Changes

- *Saudi Arabia/Persian Gulf* - Potential threats to the stability of the Saudi royal family traditionally have been said to emanate from a number of sources, including regional foes Iran and Iraq, and from indigenous sources such as the Saudi technocratic class, armed forces, or Islamic militants. While the likelihood of these concerns presently are considered to be low, the most probable internal threat to the regime is posed by Muslim extremists. The overthrow of the Saudi regime by an Islamic revolutionary movement with anti-Western sentiment could result in a curtailment or temporary cessation of oil exports to the West (although the ability to do so might be constrained by the new regime's need to generate continued income through oil sales). Such a cessation would cause disruptions in oil markets and cause prices worldwide to jump. These effects would be magnified if alternative, large-scale sources of petroleum, such as those located in the FSU, were not available to help offset the loss. Conflict also could develop between a revolutionary Islamic Saudi government and neighboring Iran, as the two regimes might compete more fiercely for leadership of the Muslim world (Doran and Buck 1991). Such heightened political tensions would destablize other Gulf oil-producing states such as Kuwait, further exacerbating the crisis.

  Another variation of the above scenario might involve the rise of a radical Saudi Islamic government that threatens to use its oil resources as a political tool to force the creation of a Palestinian state or other territorial concessions from Israel concerning the occupation of disputed Arab territory. Yet another scenario might involve civil unrest or strikes in the Saudi oilfields resulting in the damage to production or transportation facilities, but not leading to the overthrow of the government. The Saudi Shiite Muslim minority, geographically concentrated in the oil-producing eastern province, is frequently mentioned in this context, having previously engaged in civil unrest and subversive activities.

  Externally, Iran and Iraq are formidable potential adversaries with greatly superior military strength than Saudi Arabia and the smaller Gulf states. Iran has previously fomented unrest in Saudi Arabia, Bahrain, and Kuwait in an effort to destabilize those governments. Iraq also harbors extreme animosity toward the Saudi royal family and seeks to dominate other weaker Arab Gulf regimes. It provided safehaven and support to dissident Saudi leftist elements in the 1960s and 1970s. Saudi opposition to Iraq's 1990 invasion of Kuwait and its role in the allied 1991 Desert Storm operation ousting Saddam Hussein's forces from that country have only served to deepen Baghdad's distaste for the Saudi royal family. Baghdad will pose a direct

military threat to Saudi Arabia and other Gulf states so long as the Iraqi Baath Party remains in power. This threat will grow with time, as Iraq rebuilds its armed forces from the losses it suffered during the recent Gulf conflict.

An outright invasion of Saudi territory by Iran or Iraq would prompt extreme concern over the availability of Saudi oil exports and result in crisis conditions. Such a development also would put Baghdad or Tehran in a commanding position to influence world oil prices, as a result of their control over a significant portion of the world's proven petroleum reserves. More likely might be missile or air attacks that seriously damage Saudi and/or Kuwaiti oil installations, resulting from regional hostilities such as renewed warfare between Iran and Iraq.

- *Russia/FSU* - Russia and other former Soviet states with substantial energy reserves like Kazakhstan or Azerbaijan have been identified as potential alternative sources for petroleum and natural gas outside the Middle East. Outside of OPEC, the FSU maintains the largest known oil reserves in the world (DOE 1992b). The FSU also has a strong economic incentive to earn foreign hard currency. Diversification of world oil supplies resulting in a decreased reliance upon the Middle East would greatly enhance U.S. energy security during the next twenty-five years. However, as noted by former National Security Adviser Zbigniew Brzezinski in the March-April 1994 edition of *Foreign Affairs*, "...considerable evidence suggests that the long-term prospects for stable Russian democracy are not very promising." Thus, the future availability of energy resources in the former Soviet Union as an alternative to the Middle East appears precarious.

  A variety of scenario conditions are plausible in the near-term resulting in the ouster of Russian President Boris Yeltsin's administration or a successor reform-oriented government. One such scenario would involve a military coup by hardline supporters of the former authoritarian communist regime. Another scenario envisions the rise to power of an ultra-nationalist Russian regime headed by an charismatic personality such as extremist Russian politician Vladimir Zhirinovsky, either through the electoral process or extra-parliamentary means. Declining living conditions brought on by ongoing free market economic reforms, coupled with rising lawlessness and ethnic strife, could stimulate these or other extreme regime changes. Either regime type might be unwilling to allow Western energy firms to help revitalize the Russian oil sector, or could impose such unacceptable operating parameters on these firms so as to effectively drive them out. Either regime type also might be inclined to seek portions of the former territory of the Soviet Union through force of arms. Developments such as these would call into question the short- and long-term availability of energy resources in Russia and the FSU.

- *Venezuela* - Venezuela represents the second largest source for U.S. oil imports after Saudi Arabia. Venezuela also experienced two failed military coup attempts in 1992. Concerns persist that another such episode could occur. Were a military coup to oust

Venezuela's freely elected government, U.S. economic sanctions could be emplaced, especially if the ruling junta were to be accused of widespread human rights abuses. The loss of Venezuela as a source for petroleum imports would likely not produce an energy crisis in and of itself. However, if coupled with one or several other international developments that resulted in a real or perceived reduction in world oil supply, then responses to those developments could evolve into a crisis condition.

- *Quebec Succession* - Were the Canadian province of Quebec to separate from the rest of Canada and cut electricity exports to the northeast United States, New York and the New England states might be forced to search for alternative electricity sources. While the likelihood of the dissolution of Canada is considered low in the short- and long-term, the advent of such a scenario could impact the petroleum market by forcing U.S. utilities to revert to oil-fueled power plants to meet the shortfall. In conjunction with other energy market disruptions, this scenario could help bring about a crisis situation.

- *Algeria/Egypt* - Both nations currently face indigenous Islamic extremist movements dedicated to the violent overthrow of their respective governments. Conditions in Algeria at the present time pose a greater immediate-term threat to regime stability. Nevertheless, conditions also could rapidly deteriorate in Egypt in the coming years. Persistent insurgent and terrorist activities by the Armed Islamic Group, factions of the Islamic Salvation Front and other militant Islamic movements in Algeria could result in civil war during the next five years. Coupled with widespread public dissatisfaction with the current military-dominated Algerian regime, the end result could be the establishment of a revolutionary Islamic government. This, in turn, could lead to a disruption in Algerian oil and gas exports. According to the Energy Information Agency, the impacts of a disruption of Algerian exports would result in Italy's loss of 20 percent of its natural gas imports, the loss of liquified natural gas exports to France, Belgium, and Spain, and, as Algeria is a major supplier of low-sulphur fuel oil (LSFO), "a rise in residual fuel oil prices in response to a LSFO scarcity and its premium over higher sulfur grades of residual fuel oil" (IEA 1992a).

  Should radicals affiliated with the Islamic Group seize power in Egypt, significant political reverberations would be felt throughout the Arab World. Egypt, along with Saudi Arabia, serves as the most important Arab supporter of U.S. interests in the Middle East. Its demise could undermine progress on the Israeli-Arab peace front, make Saudi Arabia more vulnerable to its regional adversaries, and remove a counterweight to the neighboring radical African states of Libya and Sudan. An extremist regime in Egypt might also threaten to disrupt oil tanker traffic transiting the Suez Canal from the Red Sea to the Mediterranean. Were an Egyptian fundamentalist government to align itself with the militant Islamic government in Sudan to support other like-minded movements in North Africa, moderate Arab governments in Tunisia and Morocco would also be threatened.

Regional Conflict/Civil Unrest

- *Arab-Israeli* - The Arab-Israeli dispute has long been an underlying force for regional instability in the Middle East and an impediment to energy security. Recent progress has been made between Israel, the Palestine Liberation Organization (PLO), Jordan, and other Arab countries toward negotiating a settlement of the many associated complex problems and issues. However, many serious impediments to lasting peace remain. This dispute will remain a focal point for regional instability in the immediate term.

  Significant opposition to the peace process emanates from Palestinian rejectionists, Islamic extremist factions supported by Iran, other Arab states, and from right-wing and extreme nationalist Israeli settler groups. Opposition elements have vowed to use whatever means necessary to undermine the peace process. Concerted terrorist activities by extremists, failure to provide basic services in the Occupied Territories and/or develop a viable economic base there, coupled with the failure of Palestinian, other Arab (particularly Syrian), and Israeli negotiators to reach agreement on outstanding land and resource issues, could doom this progress and ultimately result in another highly destabilizing Arab-Israeli war.

  Conversely, the achievement of lasting peace agreements between Israel, the PLO, Jordan, and Syria would remove a primary cause of past tensions in the Middle East. The accompanying reduction in political tensions and removal of trade barriers that would result would add stability to the entire region and benefit all its economic sectors.

- *Russia/Intra-FSU* - Ethnic and political tensions in Russia and between Russia and the former Soviet republics could manifest itself in any number of destabilzing scenarios with implications for U.S. and global energy security. Inside the Russian Federation, separatist movements in the oil-producing republics of Tatarstan or Chechenia could result in armed revolt. If suppressed, Tatar or Chechen insurgents could resort to widespread urban terrorist actions in other areas of the Russian Federation, perhaps targeting energy concerns. Tensions between the Ukraine and Russia over ownership of the Black Sea Fleet, status of the Crimea, or the plight of the 11 million ethnic Russians in the Ukraine could lead to a major conventional war. As both states are nuclear powers, a worst-case scenario envisions a nuclear exchange. The large ethnic Russian population in the oil-wealthy nation of Kazakhstan also could lead to a major conflict between that state and Russia. Numerous other potential trouble spots exist, such as the ongoing war between Armenia and Azerbaijan over the disputed territory of Nagorno-Karabakh, or disputes between the Central Asian states of Uzbekistan, Kyrgyzstan, or Tajikistan. These and other potential developments could inflict serious damage on oil production and transport facilities, deter badly needed Western capital and technology flows to the FSU, and otherwise prevent significant exploitation of the area's energy reserves.

- *Nigeria* - As Africa's largest petroleum producer, OPEC-member Nigeria is a significant oil supplier for the United States and Europe (EIA 1992a). However, Nigeria has experienced political instability as a result of the military government's refusal to facilitate a transition to civilian rule. This has resulted in labor unrest among the nation's energy sector workforce. Widespread disturbances could lead to a paralysis of Nigeria's oil production and distribution system. On its own, such a development would be unlikely to promote an international energy crisis. However, in conjunction with other supply disturbances elsewhere, such developments could contribute to the development of crisis conditions.

- *Korean Peninsula* - Hostilities could break out on the Korean Peninsula as a result of international efforts to halt North Korea's illicit nuclear weapons development activities. A major Korean conflict could disrupt regional oil supplies, increase international demand, and prompt snowballing concerns throughout energy markets. Belligerent statements by Pyongyang indicate the North's willingness to attack South Korea and Japan in the event of United Nations economic sanctions. Use of a nuclear device, should one in fact now exist in the North's arsenal, would be a serious concern under such circumstances. A non-nuclear conflict also would carry serious implications, as bomber or missile attacks by the North could target any of nine South Korean nuclear power reactors, potentially resulting in significant radioactive releases. An air strike against North Korea's two small weapons-capable reactors also might result in serious radioactive releases. Military conflict on the Korean Peninsula or elsewhere resulting in a nuclear radiation incident also could serve to generate massive international opposition to nuclear energy, undermining its place as an alternative form of electrical power generation, and placing a strain on other world energy sources.

- *Persian Gulf* - Military conflict in the Persian Gulf could result in a significant disruption of petroleum to the United States and other major world consumers. Worst-case scenarios envision significant damage as the result of hostilities being inflicted on oil production, refining or transportation targets. The willingness of Gulf combatants to attack oil installations has been demonstrated repeatedly during recent military conflicts (Iran-Iraq 1980-88, the 1990-91 Gulf crisis, and the 1994 Yemeni conflict). A related worst-case conflict scenario could involve the use of weapons of mass destruction by Iran or Iraq against each other's or other Gulf oil producers' oil facilities, resulting in lasting damage to the region's oil production facilities. The most destabilizing conflicts would probably involve either Iran or Iraq as instigators. Both have demonstrated designs on the territory of smaller Gulf states, as well as extreme hostility toward each other.

  Despite its defeat in the 1991 Gulf War, Iraq does not recognize Kuwait's internationally demarcated borders and remains a threat to Kuwaiti territorial integrity. A retired U.S. State Department official with extensive experience in the Middle East noted in a private discussion with one of the authors that he expects Iraq

to re-invade Kuwait in the future, regardless of whether or not Saddam Hussein remains in power. Iran also harbors expansionist desires, as demonstrated by its April 1992 occupation of the island of Abu Musa near the strategic Strait of Hormuz. Abu Musa and two other disputed islands, Lesser Tunb and Greater Tunb, are also claimed by the United Arab Emirates. Iran has actively supported Islamic extremist activities in Saudi Arabia, Kuwait, Bahrain, and other Gulf countries.

A large Gulf conventional conflict resulting in significant damage to oil production facilities, as the result of sabotage, ballistic missile attack, or other hostile acts, would likely lead to the onset of crisis conditions. Blockage of a major transportation route, such as the sinking of a tanker at the Strait of Hormuz, also could have a crisis-inducing effect. Lesser regional conflicts such as the May 1994 Yemeni civil war or the 1992 Saudi-Qatar border clash also could prove destabilizing to the region.

- *Turkey* - Indigenous unrest emanating from the clash between Islamic and secular movements, worsening economic conditions, or other factors could lead to political instability. Likewise, tensions with Russia could escalate dangerously over control of the Bosporous. As a result of its strategic geographic location, Turkey is positioned to play an important role in the development and export of petroleum from Central Asia. Should future destabilizing events involving Turkey result in the closure of sea lanes from the Black Sea to the Mediterranean or of oil pipelines, a major bottleneck to the export Central Asian oil could develop.

Terrorism

- A concerted terrorist campaign against select energy-related targets such as nuclear power plants or oil tankers could help precipitate an energy crisis. Terrorists might target nuclear power facilities in the United States, Japan, South Korea, France, India, the FSU, the Middle East, or elsewhere resulting in the release of large amounts of radioactivity. Terrorist groups that might contemplate such activities could include environmental extremists, ethnic separatists, extreme nationalists, fanatical religious elements, or hostile state intelligence operatives or their surrogates. Public reaction to the simultaneous destruction of several nuclear power facilities could force the abandonment of many nuclear energy programs worldwide. This would significantly increase the demand for other energy sources such as petroleum. The simultaneous destruction of several supertankers at sea could cause a temporary shortage and subsequent price spike. The sabotage of a supertanker at a transportation choke point could impede the delivery energy products. Depending upon international economic/market conditions at the time, the resulting impact could stimulate crisis conditions, especially when magnified by widespread public fear.

ENVIRONMENTAL/TECHNICAL

- *Environmental Regulation* - Stringent environmental regulation could result from the advent of major atmospheric deterioration from fossil fuel usage. Other possible stimulants to the imposition of extreme environmental regulation, such as the effective abandonment of nuclear power generation, could occur as the result of one or more disastrous Chernobyl-like accidents. Current nuclear energy use in the United States is only about 9 percent of U.S. total energy consumption. Worldwide nuclear energy use constitutes only 7 percent of total world energy consumption. However, a perceived need to move rapidly away from nuclear power would put a concomitant demand on other, easily available fossil fuels, with a subsequent impact on those markets. More stringent clean gasoline regulations also could contribute to crisis conditions should the availability of reformulated gasoline not meet levels of demand.

- *Failure of a "Clean" Fuel* - Natural gas has a public image of being a clean burning fuel, but as a fossil fuel, it produces large quantities of carbon dioxide, a greenhouse gas. The Washington State Energy Office estimated that in Washington State alone there would be a 40 percent increase in greenhouse gas emissions by 2010 under the scenario of planned energy production projects, and that 11 percent of those would come from the 2000 megawatts worth of natural gas-fired electricity generation. Natural gas is thus a "clean" fuel only in comparison to coal or oil, and its role in meeting the nation's energy needs in an environmentally acceptable manner appears to be somewhat oversold. The United States has committed to reduce greenhouse gas emissions to 1990 levels by the year 2000. It is questionable whether this is possible under a rapid and simple substitution of natural gas for other fossil fuels. There is also fear that natural gas will not remain cheap, and that the life-cycle costs of its power plants are being ignored. If the current estimate is correct that greenhouse gases need to be reduced by 60 percent in order to stabilize atmospheric concentrations, natural gas may not be an adequate replacement for oil and coal, particularly in the face of carbon taxes. If there were a recognized need to drastically reduce greenhouse gas emissions as quickly as possible, an overreliance on natural gas could be as crisis-provoking as an overreliance on oil.

- *Tanker Accidents*. An EIA study notes that growing oil and product tanker traffic is increasing the likelihood of supply disruptions resulting from bad weather, tanker collisions, or acts of piracy, terrorism, or war. Human error, the increasing age of the world tanker fleet, and questions surrounding the dependability of navigational equipment all increase the chances of accidents. While worst-case scenarios would involve disruptions at the Straits of Hormuz or Malacca, where the largest amount of oil transits, EIA rates the Bosporus as having the greatest possibility of creating an accidental oil supply disruption (*Oil & Gas Journal* 1994c). Oil flows through the Bosporus could increase significantly in the future should the former Soviet republics of Azerbaijan and Kazakhstan become major oil exporters.

ECONOMIC

- *Rapid Economic Growth* - The World Energy Council predicts that by the year 2020, energy use among developing countries could account for as much as 60 percent of the world total (The Economist 1994). Rapid economic growth accompanied by significant energy demand among developing countries during the next twenty years could result in crisis conditions if available world energy supplies are insufficient to satisfy demand. An IEA report indicates that world oil demand could hit 94 million barrels a day by 2010 (The Economist 1994). If capital investment among major energy producers is inadequate, demand for oil could outstrip world production capacity, despite the existence of adequate proven reserves. Intense global competition for energy products could ensue, leading to dramatic price increases.

  The developing countries of the world have electrical demand growing at three times the annual 2 percent rate of the United States. Asia will account for half of the world increase in energy consumption between now and 2015 (*Oil & Gas Journal* 1994a). China, no longer a net oil exporter by the year 2000, will account for much of that growth, as will Thailand, Malaysia, India, and Indonesia (*New York Times* 1994). Japan will remain the region's largest oil importer. Current regional oil exporters, Indonesia and Malaysia, will also become net oil importers within the next five years, widening the gap between regional production and consumption (*Oil & Gas Journal* 1994a). The Middle East currently exports about four times as much oil to Asia (including Japan) as it does to the United States (British Petroleum 1993). Political developments in the Persian Gulf, FSU or elsewhere impeding the flow of natural gas or oil to Asia could result in crisis if excess world production capacity was unavailable.

- *Russia/FSU* - The failure of the Russian/former Soviet energy sector to attract sufficient Western technology and capital to modernize its inefficient and outdated infrastructure likely would remove it from consideration as an alternative to current reliance on Middle East oil. Production in the FSU has declined from 12 million barrels a day to less than 8 million in recent years and could soon drop below 5 million. Collapse may be inevitable without an infusion of Western technology (DOE 1992b). A total collapse would lead to greater world reliance upon Middle East oil and increase the vulnerability associated with Middle East-based or other energy crisis scenarios. Impediments to Western assistance include uncertainty as to legal ownership of mineral and property rights; taxation and pricing issues; strict and fluctuating export controls; and structural difficulties of making a deal with local and national leaders suspicious of the West (International Trade Commission 1993 and DOE 1992b).

- *Dollar Devaluation* - Any situation causing massive devaluation of the dollar, such as a runaway national debt, could result in an energy crisis as foreign energy sources became prohibitively expensive. Furthermore, if the dollar were to weaken

substantially, oil-producing countries could choose to benchmark the price of their crude against another foreign currency rather than the dollar, driving up the cost of foreign oil to the American consumer. The effect would be magnified with respect to the cost of foreign refined product, which is an increasing percentage of imported oil sales.