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R E P O R T

Promoting International Energy Security

Volume 1, Understanding Potential Air Force Roles

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Prepared for the United States Air Force

RAND PROJECT AIR FORCE

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Preface

The dramatic rise in oil prices in 2008 increased attention on the sources of imported oil, the workings of the world oil market, and the potential problems of meeting future demand for liquid fuels. This technical report is the first in a four-volume series examining U.S. Air Force roles in promoting international energy security. In this first volume, we examine the world oil market, energy security issues associated with petroleum, and how energy market and security considerations relate to Air Force operational planning. The other three volumes present exploratory studies that examine potential opportunities where the Air Force can promote energy security through bilateral and multilateral partnerships.

The other three volumes in this series are:

- Andrew S. Weiss, F. Stephen Larrabee, James T. Bartis, and Camille A. Sawak, *Promoting International Energy Security*, Vol. 2: *Turkey and the Caspian*, Santa Monica, Calif.: RAND Corporation, TR-1144/2-AF, 2012.
- Ryan Henry, Christine Osowski, Peter Chalk, and James T. Bartis, *Promoting International Energy Security*, Vol. 3: *Sea-Lanes to Asia*, Santa Monica, Calif.: RAND Corporation, TR-1144/3-AF, 2012.
- Stuart E. Johnson, Caroline Baxter, James T. Bartis, and Duncan Long, *Promoting International Energy Security,* Vol. 4: *The Gulf of Guinea*, Santa Monica, Calif.: RAND Corporation, TR-1144/4-AF, forthcoming.

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Readers interested in the topic of energy security may also find the following RAND reports to be of interest.

- *Alternative Fuels for Military Applications* (Bartis and Van Bibber, 2011)
- *Imported Oil and National Security* (Crane et al., 2009).

RAND Project AIR FORCE

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Summary

This volume briefly examines the world oil market, how developments in that market might affect "wholesale" supplies of jet fuel, and what measures the Air Force might take to protect itself against high fuel prices and supply disruptions. To better examine the potential Air Force role in promoting international energy security, we conducted three exploratory studies. The first of these focused on measures the U.S. Air Force could take to improve energy security in Turkey and the Caspian Basin (Weiss et al., 2012), the second on the energy sea-lanes from Hormuz to Asia (Henry et al., 2012), and the third on the Gulf of Guinea (Johnson et al., forthcoming). For these exploratory studies, we purposely selected topic areas outside of the Middle East because there is already an active U.S. military presence in the Persian Gulf and the Strait of Hormuz.

The World Oil Market

Global demand for liquid fuels is about 87 million barrels per day (bpd). At present, over 98 percent of this demand is met by petroleum products derived from crude oil and, to a much smaller degree, liquid hydrocarbons coproduced with natural gas. Over one-half of global crude oil production enters the international oil trade.

As with many other commodities, oil prices are subject to large variations. For petroleum, price volatility is especially pronounced for three reasons:

1. It takes a fairly long time to bring new production on line in response to price signals—generally at least six years and often much longer.
2. Once new production is brought on line, the marginal cost of continuing production is fairly low.
3. Over the short term, petroleum demand is fairly unresponsive to prices.

These three factors account for the persistent high petroleum prices during most of the 1970s and early 1980s and the 17 years of low prices beginning in 1985. The low petroleum prices during the late 1980s and 1990s resulted in what, in retrospect, turned out to be an underinvestment in new petroleum production, leading to historically high crude oil prices in 2007 and 2008.

Complicating this structural picture of the world petroleum market are two major institutional problems. First, an international oil cartel, the Organization of the Petroleum Exporting Countries (OPEC), has a strong interest in keeping world crude oil prices high and in reducing price volatility. The history of oil prices since 1973, however, shows that OPEC has had mixed success meeting both objectives. In fact, the net result of OPEC's existence may

be increased crude oil price volatility: The organization's attempts to maintain high oil prices when prices are already high tend to promote overinvestment in new oil production in nations, including some members of OPEC, that do not conform to OPEC's production quotas.

The second institutional problem stems from the location of the world's petroleum resources. While most of the world's conventional petroleum resources are located in nations astride the Persian Gulf, many other locations also have appreciable resources. But nearly all the major oil exporting nations outside the Persian Gulf, as well as a few inside, suffer from governance problems that seriously impede investment in additional productive capacity. The notable exceptions are Canada and Norway. By presenting a barrier to investment in petroleum (and natural gas) production, governance shortfalls make world oil prices more volatile and higher than they would otherwise be. For example, in just two countries, Iraq and Nigeria, continuing conflict is causing daily production to be millions of barrels below what the two nations' resource base is able to support. In most of the other important oil exporting countries, governance shortfalls center on corruption, the lack of the rule of law, and persistent violations of human rights.

Responding to the Oil Market

While the Department of Defense (DoD) is one of the world's largest fuel users, its consumption of about 340,000 bpd is a small fraction (less than one-half of 1 percent) of global petroleum demand. Considering that the United States produces over 8 million barrels of oil per day domestically and imports an additional 3 million bpd from secure supplies in Canada and Mexico, we can find no credible scenario in which the military would be unable to access the 340,000 bpd of fuel it needs to defend the nation.

While DoD and the services will have access to the wholesale fuel supplies they require, the purchase price may be uncomfortably high. As fuel consumers, DoD and the services have only one effective option to deal with high petroleum prices: to reduce use of petroleum fuels overall. This can be accomplished by purchasing equipment that is more energy efficient; by adopting maneuvers schemes that are more energy efficient; and, in the short term, by implementing energy conservation measures to reduce petroleum use. Alternative liquid fuels do not offer DoD a way to appreciably reduce fuel costs.

Promoting Energy Security

As fuel purchasers, neither the U.S. Air Force nor DoD has enough power to influence the world oil market. But as part of the armed forces of the United States, the Air Force plays an important and productive role in the world oil market. The armed services are the backbone of the U.S. national security policy that ensures access to the energy supplies of the Persian Gulf and the stability and security of key friendly states in the region. Moreover, the U.S. Navy's global presence ensures freedom of passage in the sea-lanes that are crucial to international trade in petroleum and natural gas.

Can more be done? Is there a productive role for the Air Force and, more broadly, DoD in further promoting energy security? These two questions motivated our three exploratory studies.

Major Findings from the Case Studies

Turkey and the Caspian

In the Caspian Region, the major security threat to energy infrastructure stems from the ongoing tensions between Russia and Georgia. The Russian invasion of Georgian territory in 2008 caused a precautionary multiweek shutdown of the pipelines carrying oil and natural gas from Azerbaijan to Turkey. We found that energy infrastructures in the remaining nations in the Caspian region are being addressed fairly well, especially considering the current low threat level.

Turkey appears as a special case because of its geostrategic location, status as a NATO member, and long relationship with the U.S. Air Force. Kurdish terrorists have been able to execute numerous successful attacks on oil pipelines traversing eastern Turkey. While these attacks do not significantly threaten the national security of Turkey, they do lead investors to weigh pipeline security risks when considering the investments that will be required for Turkey to realize its goal of becoming an energy hub between Europe and both the Caspian and the Middle East. Another important Turkish energy transit issue is the oil tanker traffic through the Bosporus Strait. From the Turkish perspective, concerns center on the potential damage from a major oil spill. From the oil industry's perspective, concerns center on the possibility of a terrorist attack that could block tanker passage for many months. Considering its state of development and military capabilities, Turkey certainly has the wherewithal to address pipeline attacks and the concerns regarding the Bosporus. However, the U.S. Air Force could play a productive, albeit limited, role in promoting technology transfer and best practices on infrastructure protection, with the main motivation being to strengthen the U.S. and USAF relationship with Turkey.

Sea-Lanes to Asia

Another potential role for the Air Force is in assisting the U.S. Navy in sea-lane protection. Asia's sea-lanes are a growing security concern because of the increasing dependence of rapidly expanding Asian economies on imported energy sources. Unfortunately, regional security mechanisms have not kept pace and are no longer commensurate with the region's growing significance.

On this topic, our first major finding is that a joint approach, in which the Air Force provides meaningful assistance to the Navy, offers a more efficient and effective application of U.S. defense assets than the current approach, which relies almost solely on Navy assets. By capitalizing on interdependencies between the Air Force and Navy, a joint approach would lay a foundation for addressing more strategic concerns, including the overall role of the U.S. Air Force in ensuring access to global commons, and the collaborative development of an interdependent force posture. Our second, and more significant, finding is that overall U.S. interests are best served by a multinational approach to the protection of the energy sea-lanes to Asia. This approach provides a much better mechanism for addressing potentially serious threats that might arise if one or more of the countries along the sea-lane fails or goes rogue. Additionally, multinational cooperation in sea-lane protection provides a means of dampening the simmering tensions and lingering disputes that prevail within Asia. From the U.S. Air Force perspective, a multinational approach provides new opportunities for interaction, building partnerships, and ensuring access.

The Gulf of Guinea

Nigeria is an important oil exporter, and recent developments indicate that appreciable exports may soon be flowing from Ghana. Security shortfalls are a significant impediment to hydrocarbon production and transport in Nigeria. Our examination of the security situation in Nigeria and other nations bordering the Gulf of Guinea indicates that current and future U.S. Air Force capabilities in building partnership capacity offer security improvements that could promote greater production of petroleum and natural gas. However, any efforts to build military partnerships in this region must consider broader U.S. goals, especially the risks that U.S.–provided military capabilities might be applied to local civilian populations. While there are signs of improved governance in Nigeria, these considerations suggest that Ghana, an emerging petroleum producer with considerably better governance, may be a more attractive partner.

Key Findings

Three key findings emerged from the results of our examination of the world oil market and from our three exploratory studies. First, as fuel purchasers, neither the U.S. Air Force nor DoD has appreciable power to affect the world oil market. Their only effective option for reducing fuel expenditures is to use less fuel.

Second, where security shortfalls impede hydrocarbon production or transport, current and future U.S. Air Force partnership-building capabilities offer security improvements that could promote greater production of petroleum and natural gas resources. Notable examples of nations where security shortfalls are significantly impeding investment and production are Nigeria; Iraq; Sudan; and, most recently, Libya. Unless addressed, pipeline security issues will impede investment in Turkey.

Although current and future Air Force partnership-building capabilities offer security improvements, partnerships associated with energy infrastructure protection are impeded by concerns that U.S. assistance will threaten the sovereignty of the host country. Additionally, U.S. government concerns about human rights violations and corruption may impede partnership building in such countries as Nigeria.

Our third key finding is that the vulnerability of the petroleum supply chain can be leveraged to achieve broader U.S. objectives, such as diffusing tensions along the Asian sea-lanes, where our primary concern is the potential for conflict between the two regional pillars, India and China. Energy security concerns also may help strengthen existing partnerships (e.g., Turkey) or building new partnerships (e.g., India) with current and prospective allies.

Acknowledgments

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This report benefited greatly from formal reviews by Frank Camm; Prof. Richard K. Betts of Columbia University; and William D. Dries, AF/A5XS.

Abbreviations

bpd	barrels per day
Btu	British thermal unit (roughly, the amount of energy required to raise the temperature of one pound of water one degree Fahrenheit)
DoD	Department of Defense
EIA	U.S. Energy Information Administration
IEA	International Energy Agency
OPEC	Organization of the Petroleum Exporting Countries
OSD	Office of the Secretary of Defense
PAF	Project AIR FORCE
WTI	West Texas Intermediate

CHAPTER ONE

Introduction to Energy Security

Energy security considerations are a growing component of military planning and operations. Multiple forces are driving this trend, including developments in the world oil market, the growing concerns about global climate change, the challenges of delivering fuel to forward-based units, and the vulnerability of military installations to disruptions in electric power. In response to these concerns, the Army, Navy, and Air Force headquarters now include energy policy offices. In the Office of the Secretary of Defense (OSD), operational energy issues are addressed by the new Office of the Assistant Secretary of Defense for Operational Energy Plans and Programs, and facilities-related energy issues are under the purview of the Office of the Deputy Under Secretary of Defense for Installations and Environment. Overall, the Air Force is focusing increasingly on the need to reduce energy costs and address vulnerabilities in the energy supply chain. In this report, we look beyond these measures, which are directed at the better use and management of energy and examine the broader geostrategic implications of energy security on Air Force planning.

What Is Energy Security?

Ensuring a steady supply of affordable, environmentally sound energy has been the high-level energy policy goal of the United States since the founding of the U.S. Department of Energy in 1977, if not before.[1] This simple statement directly links to the three areas where energy insecurity adversely affects the nation: economics (affordability), national security (steady supplies), and the environment (see Figure 1.1).

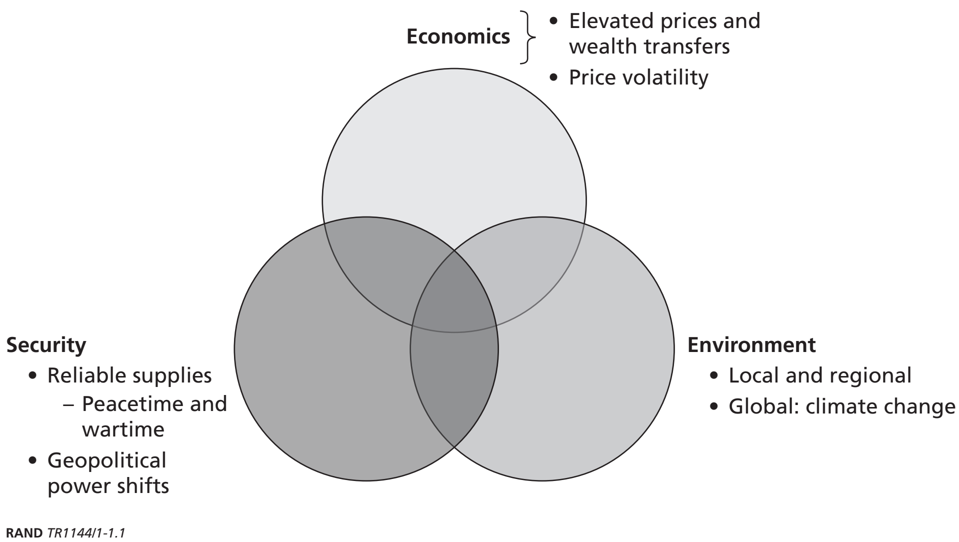
Economics

High world oil prices translate into massive transfers of wealth from oil-importing countries to oil-producing countries. In 2008, spot prices for crude oil peaked at over $140 per barrel, and the value of crude oil imports the United States received amounted to $334 billion (U.S. Energy Information Administration [EIA], 2011h, Table 5.20). In that year, nationwide expenditures for petroleum products reached $871 billion dollars (EIA, 2011e, Table ET1), which averages more than $8,000 per U.S. household.[2]

1 Although the high-level goal has remained stable, succeeding presidential administrations have differed in the policy approaches they have taken and the degree of emphasis they placed on promoting energy production, energy efficiency and conservation, environmental protection, and energy research and development (Bartis, 2004).

2 This estimate represents the total selling price, including most taxes, to final users in the United States and covers both domestic and imported sources. The per-household cost includes direct and indirect expenditures and is based on the U.S.

Figure 1.1
The Three Components of Energy Security



Oil prices tend to be highly volatile for fundamental, as well as institutional reasons, as discussed in Chapter Two. This volatility impedes business planning and heightens the risks of investments that are sensitive to energy prices. The September 2008 financial crises caused U.S. and world oil demand to drop and oil prices to plummet from the record highs. For example, in July of 2008, U.S. refiners paid an average of $128 per barrel for imported crude oil. By December of that year, average acquisition costs dropped to under $36 per barrel. By December 2009, acquisition costs climbed to $73 per barrel. Overall, the landed value of crude oil imports to the United States dropped by about 40 percent between 2008 and 2009.

Security

Energy security focuses on the reliability of the energy supply chain. For petroleum, this is a special concern because so much of global production comes from countries located in politically unstable regions. Global crude oil distribution depends heavily on open access to sealanes, but certain of them, such as those from Hormuz to Asia, may not be secure during hostilities. Natural disasters can also affect the reliability of petroleum supplies. For example, a large proportion of U.S. oil refining capacity is located in states bordering the Gulf of Mexico and therefore susceptible to hurricane damage.

A second security issue is associated with the large wealth transfers that occur when oil prices are high. Because some oil-exporting countries are hostile to the United States, their receiving high revenues raises several national security concerns. For example, Iraq under Saddam Hussein and Iran under its current leadership have used oil revenues to purchase weapons or to build industrial bases of their own to manufacture weapons. Moreover, perceptions that oil prices will greatly increase or that oil is becoming more scarce have caused oil-importing countries to pursue special relationships with oil-exporting countries. In some cases,

Census estimate of 117 million households in 2008 (U.S. Census Bureau, 2009).

these relationships have impeded U.S. multilateral diplomatic efforts, notable examples being China's relations with Iran and Sudan.

Environment

The third component of energy security centers on our national environmental priorities. All energy decisions involve environmental trade-offs, and no form of energy—oil, natural gas, coal, nuclear, or renewables—is exempt. While the developed nations have made remarkable progress in addressing local and regional environmental problems, important pollution reduction objectives remain that are tightly associated with the use of hydrocarbon fuels, especially petroleum in vehicles and coal in power plants. Meanwhile, energy production and use in many developing nations are causing air and water quality problems that are severely detrimental to the health of their citizens.

Across the globe, progress has been limited on reaching agreements to address the problem of global climate change. Progress will require major global reductions of the greenhouse gas emissions that result from consumption of fossil fuels. This implies a long-term trend toward greater efficiency in the use of energy, less dependence on coal and petroleum, and greater use of nuclear and renewable energy.

Energy Security and the Air Force

The three components of energy security at the national level translate into challenges for the Air Force (see Table 1.1) and, more broadly, for the Department of Defense (DoD).

Certain of the effects on the Air Force, such as high fuel costs and disruptions to planning, are no different from those many businesses encounter. As are many private firms, the Air Force is implementing measures to reduce energy costs by reducing energy usage. Concerning climate change, the petroleum fuel used in combat vehicles, aircraft, ships, and other weapon systems causes less than one-half of one percent of total national greenhouse gas emissions.[3] While measures that reduce energy usage will decrease greenhouse gas emissions, there is no additional compelling case for forcing the military to reduce the greenhouse gas emissions associated with the training applications and deployment of tactical weapon systems. Nonetheless, it is certainly possible that a political decision might be forthcoming over the next few decades that would mandate such a reduction.

Not surprisingly, the security component of energy security affects the military very differently from how it does the civilian sector. Because of the domestic and international importance of reliable energy supplies, the United States has given assured access to petroleum supplies a high priority among its defense policy imperatives (Crane et al., 2009). The armed services are responsible for maintaining the integrity of the global commons, including the sea-lanes that support the international oil trade; of deterring aggression; and in some cases, such as in response to Iraq's invasion of Kuwait, of intervening to protect an oil-producing

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3 This estimate is based on 2009 DoD consumption of jet fuel, 501 trillion Btu, and fuel oil, 149 trillion Btu (EIA, 2011h, Table 1.13). CO2 emission factors are 67.8 metric tons per billion Btu of jet fuel and 70.3 metric tons per billion Btu of diesel fuel oil (IPCC, 2006). Total CO2 emissions for DoD use of both fuels is 34 million metric tons. This might be a slight overestimate of the contribution from tactical weapon systems since small amounts of jet fuel and fuel oil are used for heating buildings and in administrative vehicles. Measured as CO2 equivalents, the total for anthropogenic emissions of greenhouse gases in the United States is about 6.6 billion metric tons (EIA, 2011c).

Table 1.1
How Energy Security Problems Affect the Nation and the Air Force

	The Nation	The Air Force
Economics	Elevated prices and wealth transfers	High fuel costs for the Air Force and for the rest of DoD
		Funds for unfriendly governments to purchase or develop weapons
	Price volatility	Disruption of planning, programming, and budgeting
Security	Reliable supplies	Potential need for armed intervention
		Protection of the peacetime supply chain
		Threats to energy supplies to warfighters
	Geopolitical power shifts	Impediments to coalition-building
Environment	Climate change	Mandated reductions in fossil fuel use

nation. Moreover, the anxiety over oil supplies that promotes special relationships between oil-exporting and -importing nations may impede coalition building in support of U.S. military operations.

At present, DoD is developing policies and plans to ensure the integrity of the in-theater energy supply chain. The wars in Iraq and Afghanistan have clearly demonstrated the high costs of delivering petroleum to in-theater installations and frontline warfighters engaged in counterinsurgency operations. The advent of precision, long-range weapons has raised new challenges for protection of the fuel supply chain in any major conflict. While this report looks more broadly at global energy security issues, we do not question the importance of current DoD efforts that are addressing the costs of and vulnerabilities in the energy supply chain to forward-based units.

Organization of This Volume

In Chapter Two, we begin with a broad-brush review of the world oil market. This review is intended to cover essential points for officers and military planners. Our focus is on a few key issues: Why are oil prices so volatile? Are world petroleum supplies running out? What makes oil so different from other commodities that are traded internationally, such as cotton or steel? In Chapter Three, we conclude by laying out the policy framework for dealing with the three components of energy security and then examine the Air Force role in that policy framework.

CHAPTER TWO

World Oil Market Review

High world oil prices mean allocating a larger share of the defense budget to fuel purchases. Some commentators argue that the 2008 price spike is a warning that world oil supplies are running out, that much higher fuel prices are inevitable, and that the military should take decisive measures to ensure that it has the fuel supplies it needs to protect the nation. Our analysis suggests that the anxiety over the continued availability of petroleum-based military fuels is excessive.[1] Further, much of the dramatic increase in oil prices seen in 2004 through 2008 can be explained by structural and institutional features of the world oil market, as explained in this chapter.

The International Oil Trade

In 2010, world demand for liquid fuels climbed to about 87 million barrels per day (bpd).[2] The United States is the world's largest user of liquid fuels, accounting for 22 percent of global consumption. While oil demand in the developed world stayed fairly constant, demand in the developing world, especially in Asia, rose considerably between 2000 and 2010. For example, the total demand of countries that are not members of the Organization for Economic Cooperation and Development increased by 11 million bpd, reaching about 40 million bpd in 2010.

About one-half of the global demand for liquid fuels is met by crude oil exported from an oil-producing country to an oil-consuming country. To facilitate these transfers, crude oil and refined petroleum products are traded on numerous commodity exchanges, the most notable of which are the New York Mercantile Exchange, which trades a crude oil known as West Texas Intermediate (WTI), and the Intercontinental Exchange Futures Europe, which trades a crude blend known as Brent Crude, WTI, and other types of crude and refined petroleum products. Although actual production of both Brent Crude and WTI is very small compared to global oil demand, the trading in these crude oils serves to establish price benchmarks for the global oil trade.[3] Moreover, commodity exchange prices strongly influence contractual terms in direct agreements affecting the production and purchase of crude oil.

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1 The major military fuel is the jet fuel known as JP-8, which Air Force, Army, and ground-based Navy aviation and Army tactical battlefield equipment all use. Other important military fuels are JP-5 and F-76. JP-5 has a lower flashpoint and is used for aircraft and ground vehicles deployed on ships. F-76 is marine distillate fuel the Navy uses on all non-nuclear combatant ships.

2 An oil barrel holds 42 gallons.

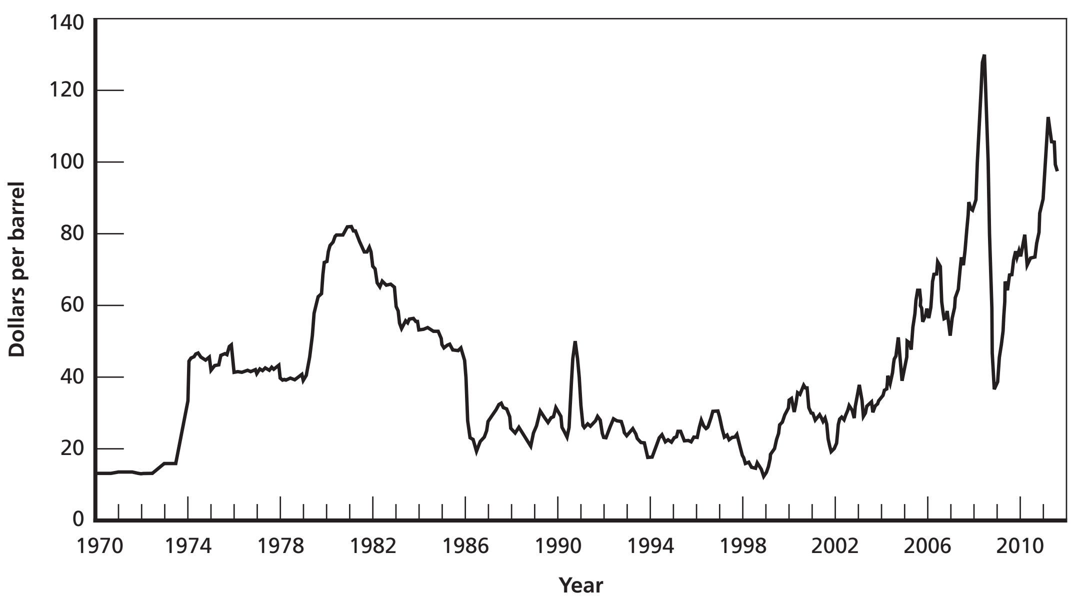
3 Because both WTI and Brent Crude are high-quality crudes (i.e., sweet and light), they tend to be priced well above the average crude delivered to refineries. Prices of Persian Gulf crude track these prices but follow indices more relevant to that

Oil Prices

Figure 2.1 presents a 40-year history of the prices that U.S. refineries have paid for imported crude oil.[4] The three prominent features in this history are two dramatic price increases and the intervening period of fairly low prices. The first price increase began in the winter of 1973–1974, when Arab oil producers attempted a selective embargo on the United States and the Netherlands in response to their support of Israel during the Yom Kippur War. Although the embargo was unsuccessful, real crude oil prices nearly tripled within a few months. Oil prices were further boosted a few years later because Iranian production decreased during the Iranian revolution.

The resulting high oil prices prompted energy conservation measures and the more efficient energy use, resulting in a 14-percent decrease in global demand from 1979 to 1985. High prices also motivated investments in oil exploration and oil field development in nations that were not members of the Organization of the Petroleum Exporting Countries (OPEC). OPEC's share of global oil production dropped dramatically, and OPEC was unable to function as a cohesive price-controlling cartel. These two trends led to a glut in the market and culminated in a major price drop in 1986 that led to 18 years of fairly low oil prices, with real (2010 $) per-barrel prices generally between $20 and $30 dollars.[5]

Figure 2.1
Costs of Imported Oil to U.S. Refiners (2010 dollars)



SOURCE: EIA (2011g) and Bureau of Economic Analysis (2011).
RAND *TR1144/1-2.1*

region, including Oman Crude (traded on the Dubai Mercantile Exchange) and Platt's Dubai price assessment (DiPaola, 2010).

4 From EIA, 2011g, adjusted to 2010 real dollars using the implicit price deflaters for gross domestic product (Bureau of Economic Analysis, 2011).

5 The notable exception is the brief price spike in response to Iraq's 1990 invasion and occupation of Kuwait.

During this period of low oil prices, many oil companies faced critical financial problems. For the oil industry, this was a time of restructuring and rationalization, including cost-cutting, downsizing, and mergers (Maugeri, 2006; Yergin, 2009). Investments in finding and developing new oil resources decreased. Meanwhile, low prices reduced the motivation to conserve energy, and global demand for oil steadily grew.

The second major price increase began in 2004 and peaked in mid-2008. Spot prices for WTI climbed to over $145 per barrel (nominal dollars). These high prices did not last. Five months after peaking, spot prices had tumbled to about $30 per barrel. The cause of the price collapse is clear: The financial crisis in the latter half of 2008 and the accompanying recession accelerated the decrease in petroleum demand that was already occurring as a result of the high oil prices of 2007 and 2008. When market participants, including speculators in oil futures, perceived this trend as inevitable, they attempted to unload their holdings, which resulted in a precipitous price decline (Figure 2.1). By mid-2009, crude oil prices had substantially recovered as a result of production cutbacks by Persian Gulf producers and stronger-than-expected demand from emerging market economies, such as China, which successfully weathered global economic turmoil. For the 12 months ending November 1, 2010, spot prices for WTI ranged between $70 and $85 per barrel for the most part (EIA, 2011f).

Starting in November 2010, oil prices entered a higher range, with spot prices generally fluctuating between $85 and $92 per barrel through mid-February 2011. Thus price increase appears to have been motivated by continued strong growth in petroleum consumption by emerging economies, particularly China.

A far larger price increase occurred in mid-February 2011 as market participants feared that political unrest in North Africa and the Middle East might impair global crude oil production. Conflict in Libya resulted in a loss of Libyan exports, which had been running at about 1.5 million bpd. Early in the conflict Saudi Arabia did pledge to make more crude oil available by drawing on its spare production capacity, which in April 2011 was about 3.2 million bpd (International Energy Agency [IEA], 2011). Fear of an eventual large disruption and uncertainty about Japan's near-term demand for petroleum kept the market on edge. For a few days in April, spot prices for WTI exceeded $110 per barrel. Even higher crude oil prices were recorded in other commodity markets. These high prices did not hold, but since then, the oil market has remained highly volatile, with the WTI spot price dropping briefly (in October 2011) to $75 per barrel before heading up to the $90 range.

Where Are Prices Heading?

Rational analysis cannot predict where petroleum prices are heading. There are simply too many variables and unknowns. That oil prices will steadily rise over the long term is a widely held assumption. After all, global petroleum resources are limited, and as depletion continues, the costs of recovery will rise. But when that rise will occur and how steep it will be are not predictable. Meanwhile, where oil prices will be in 10 or 15 years is anyone's guess. This is an important fact for decisionmakers, which we will return to later in Chapter Three.

Why Are the Price Swings So Large?

The main reasons are structural. Driving steep price increases are the long lead times required to bring new oil production on line combined with the limits on the ability of most oil consumers to reduce their oil use in response to higher prices. Once a change to higher prices is perceived as a stable event (as opposed to a short-term transient), it takes a few years to expand production from existing oil fields significantly and much longer—in some cases, over a decade—to secure access to, engineer, and achieve appreciable production from previously untapped oil reservoirs.

Meanwhile, demand for petroleum products will stay fairly high because that demand is based on investments and purchases (for example, in vehicles) made when oil prices were lower. If there were readily available substitutes for petroleum, oil consumers could switch to these substitutes and thereby put downward pressure on prices. But for the most part, especially in the case of transportation—air, ground, or sea—there are no readily available alternatives.

Once oil supplies become plentiful and prices decrease, oil prices tend to stay depressed for a long time, for example, the 18-year span of low prices starting in 1986. This is because the major costs associated with opening an oil field are the up-front expenditures required for field characterization, engineering, and development. Once an oil field is producing, the marginal costs of continuing production are fairly small. For alternative sources of petroleum, such as heavy oils, oil sands, oil shale, and coal- and natural gas-derived liquids, the marginal costs of continuing production may be somewhat higher, but up-front investment costs may also be higher.

Exacerbating these structural factors are two major institutional factors: OPEC and the severe governance problems in many oil exporting countries.

OPEC

OPEC is a cartel that attempts to adjust production for the purposes of stabilizing oil prices and increasing the oil export revenues of its member nations. The 40-year history of petroleum prices in Figure 2.1 clearly shows that OPEC has had mixed success with both objectives. Currently, OPEC comprises 12 member nations.

Our analysis found no empirical support favoring any single theory of the behavior of OPEC since it was created. What we can say is that its behavior has been very complicated, which is to be expected considering the diverse interests of its members. Recent behavior suggests that the best description of OPEC is that it has a small core of nations that can act cohesively on occasion, while the remaining members behave as price takers, selling as much as they can at the prevailing price (Bartis, Camm, and Ortiz, 2008). For example, when oil prices were at their record highs in 2008, all oil-producing countries, including all OPEC members, were producing at their maximum rates to capture extraordinarily high profits. When demand fell and prices decreased in 2009, only three OPEC member countries, the OPEC core, significantly reduced production: Saudi Arabia, Kuwait, and the United Arab Emirates.

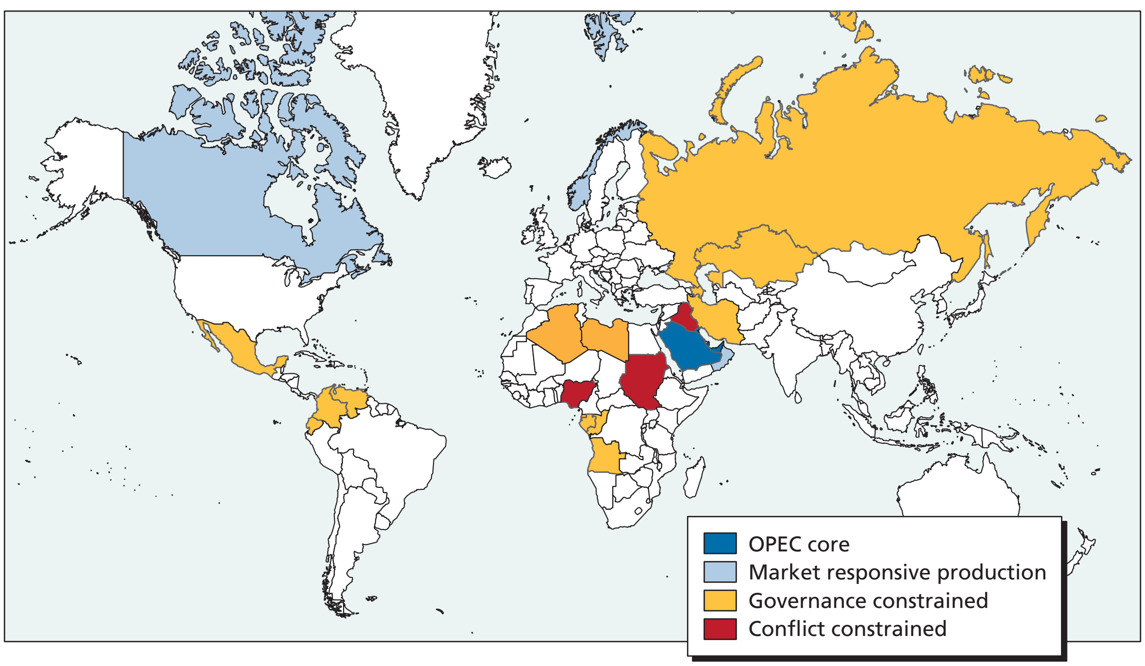
Since oil exports are an important source of the operating revenues of all OPEC member governments, OPEC is biased toward keeping oil prices high. For example, the OPEC core was slow to expand production after the 1980 oil price shock and during the run-up to the record prices of 2008. This behavior caused prices to be higher than they would have been in the absence of a cartel. When oil prices are depressed, OPEC has difficulty achieving consensus that its members should cut production, and thereby government revenues, for the purpose of raising prices. This behavior further depresses prices, prolongs the depression period, and eventually leads to a shortage of investment.

Governance Problems

One of the major trends in the petroleum industry over the past few decades has been a shift of resource control from private companies to governments. Over 80 percent of world oil reserves are now controlled by national oil companies (Yergin, 2008, p. 770). Consequently, political and social welfare considerations often figure prominently in decisions affecting investments in oil production.

The map in Figure 2.2 color-codes the 24 nations that exported over 200,000 bpd in 2009 (EIA, 2011b). Of these nations, the four shown in dark blue—Saudi Arabia, Kuwait, the United Arab Emirates, and Qatar—are listed as members of the OPEC core.[6] Of the remaining 20, only the three shown in light blue—Canada, Norway, and Oman—do not suffer from internal conflict or severe governance problems that limit investment and production of petroleum. In Iraq, Nigeria, and Sudan, shown in red, continuing internal conflict severely impedes oil production. Known Iraqi petroleum resources are likely able to support production levels well beyond the 2.5 million bpd level of 2010 (BP, 2011); recent estimates of the country's potential range from 7 million to well over 10 million bpd.[7] Nigeria also has substantial upside potential, as we discuss in Volume 4 (Johnson et al., forthcoming). And for the remaining countries, highlighted in gold on the map, impediments to investment in oil production derive from governance shortfalls covering one or more of the following: control of corruption, political stability, the rule of law, regulatory quality, and government effectiveness (Kaufmann, Kraay, and Mastruzzi, 2010).

Figure 2.2
Nations with Net Petroleum (crude oil and products) Exports of over 200,000 Barrels per Day in 2009



RAND *TR1144/1-2.2*

[6] Qatar's inclusion in the OPEC core is somewhat arbitrary. Its net petroleum exports are about 1 million bpd.

[7] For example, the International Energy Agency projects total Iraqi production of 7 million bpd in 2035 in its "new policies" scenario (IEA, 2010b). Iraq's oil minister, Hussain al-Shahristani, has stated that he expects the country's oil production capacity to exceed 12 million bpd by 2017 (Ng, 2010).

Oil Supplies

Oil Anxiety

Anxiety over the future availability of oil has a long history. As early as the 1880s, geologists realized that production levels in western Pennsylvania could not be sustained. Oil specialists predicted that a decline in American production was imminent and that the chances of finding another large field "are at least one hundred to one against it" (Yergin, 2008, p. 36). In 1919, the president of the Colorado School of Mines raised the question "Will new oil fields be discovered to meet the increased demand in the future?" and responded "The answer is extremely doubtful" (Alderson, 1919). The possibility of global petroleum shortages was raised both prior to and during World War II. Following the war, petroleum anxiety in the United States took on a second dimension: fear of import dependence. For example, in 1947, the U.S. Department of the Interior called for a crash program that would produce 2 million bpd of synthetic fuels from coal and oil shale. But as more was learned about manufacturing synthetic fuels, cost estimates steadily increased until they were much higher than conventional fuels. Within a few years, low-cost domestic and imported oil brought the national synthetic fuels program to an end (Yergin, 2008, p. 410). The oil price increases associated with the 1973 Arab oil embargo and the 1979 Iranian revolution fueled a new round of speculation that world oil resources were running low. Part of that response was a new national program directed at synthetic fuels. For the most part, the oil price collapse in 1985 (see Figure 2.1) put shortage fears, as well as plans for synthetic fuels, to rest.

Peak Oil

With this history in mind, it is not surprising to find that the large crude oil price increases since 2003 have fostered new speculation that global oil production has or will soon peak, to be followed by a fairly rapid decline. For example, Colin Campbell, a leading proponent of peak oil, predicted that total global liquid fuel production would peak in 2010 or slightly thereafter, followed by a rapid decline, so that 2030 production would be nearly 40 percent below current levels (Campbell, 2002).[8] Such a rapid decline would be devastating for the economies of both developed and developing countries. But the oil Armageddon Campbell and other "peak oilers" have predicted has drawn criticism, in some cases derision, from a broad spectrum of resource economists and petroleum experts (Adelman, 2004; Wolf, 2005; Maugeri, 2006; Gorelick, 2010).

Is the World Running Out of Oil?

Global oil supplies are finite. Consequently, oil production must peak. The question is not whether but when and how that peak comes about. Considering all sources of petroleum, including conventional crude, natural gas liquids, tar sands, and heavy oils, our best estimate is that global production will peak between 2030 and 2050. This estimate is consistent with recent projections from EIA and IEA and the findings of analysts with access to extensive data on global petroleum resources (EIA, 2011a; IEA, 2010b; Jackson, 2009; Nehring, 2007; Kerr, 2007).[9]

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8 Campbell is the founder of the Association for the Study of Peak Oil and Gas. His prediction covers conventional crude oil, including arctic and deep-water production, as well as heavy oils, tar sands, and natural gas liquids.

9 In fact, many of the recent petroleum supply projections from EIA and others, such as ExxonMobil (ExxonMobil, 2010), show steadily increasing global production through 2030.

More important than "when" global oil production might reach its maximum is the form that that maximum takes on. A consensus is developing that global oil production is less likely to come to a sharp peak and more likely to hit a plateau that might continue for some decades and then slowly decline. While a production plateau is far less catastrophic than a sharp peak and rapid decline, it is likely that oil prices could be both high and very volatile during the plateau period (Greene, 2010; Jackson, 2009). In response to these high prices, demand will moderate as petroleum consumers look for transportation options that are more energy efficient. Also, during this period of high prices, vast amounts of alternative fuels, derived from oil shale, coal, biomass, and possibly algae, would become economically competitive, which would moderate further price increases and extend the duration of the plateau.

Could oil production peak before 2030? Yes, but the reasons for an earlier peak have less to do with geology and more with above-ground actions that might occur in producing and consuming nations. For example, enduring political instability or conflict in a major oil-producing nation or region could reduce production levels and cause global production to peak earlier than it would otherwise. In this case, we would expect petroleum prices to rise considerably. Alternatively, an early supply peak could occur in response to a global agreement to reduce greenhouse gas emissions. Globally, oil use is responsible for a large portion (about 37 percent) of the greenhouse gas emissions associated with energy use (IEA, 2010a). World leaders are calling for a 50-percent reduction in global greenhouse gas emissions by 2050 (Stolberg, 2008). If such a large reduction is to be achieved or even approached, it is inconceivable that global oil production will continue to grow much beyond its current level of about 85 million bpd.[10] In this case, we would expect consumer prices for petroleum products to increase (for example, as a result of a tax or other mechanism that would decrease demand) but prices paid to crude oil producers to drop in response to decreased demand.

Could oil production peak after 2050? That is also a possibility; in fact, continued growth in production would be consistent with the 120-year historical experience of growing oil production despite periodic episodes of oil anxiety. This would occur if advances in technology allowed economic expansion and greater recovery of global oil resources, including access to unconventional resources, such as oil shale; improved recovery of tight oils, such as those being produced from North Dakota's Bakken formation; and greater development of oil sands.[11]

Why Is Oil Different?

There are many different commodities on the world marketplace, yet none of these, including precious and industrial metals, rivals the public attention petroleum garners in the United States.

One obvious reason is that Americans spend a lot of their income on petroleum, either directly, when they purchase fuel for their vehicles, or indirectly, when they purchase products

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[10] For example, in the 2010 World Energy Outlook, the International Energy Agency examined a future scenario in which world anthropogenic greenhouse gas emissions in 2035 would be slightly less than half of 2010 emissions. In this scenario, world liquid fuel production (excluding biofuels) in 2035 drops to 78.5 million bpd. Moreover, prices paid to crude oil producers would be only slightly higher than current prices (IEA, 2010b).

[11] For example, the largest known oil shale deposits in the world are located in the Green River Formation (Western Colorado, Utah, and Wyoming). Recoverable estimates for just the western U.S. oil shale resources range from 500 billion to 1.1 trillion barrels (Bartis et al., 2005). Total U.S. petroleum consumption is about 7 billion barrels per year.

made with petroleum derivatives or with energy supplied by petroleum. And just about everything in the United States is delivered using trucks, trains, aircraft, and ships that consume petroleum. For the United States, these direct and indirect expenditures were, on average, over $8,000 per household annually (see Introduction), a sizable fraction of household income.[12]

A second reason is the lack of readily available substitutes for petroleum. When the price of beef jumps, consumers can switch to chicken or other alternatives. When the price of petroleum jumps, many consumers have no choice but to pay higher prices. For many Americans, private vehicles are the only practical option for getting to and from work, school, and shopping; public transportation is often unavailable or inappropriate.

The third reason was discussed earlier in this chapter: the long lead time required to bring new petroleum production on line. This problem and the lack of readily available substitutes are the main causes of the high levels of volatility that we see in oil prices.

Perhaps the most important difference between oil and many other commodities is the concentration of oil resources in nations that have serious shortfalls in governance and/or that are intent on limiting production for the purpose of keeping prices higher than they would be otherwise in a competitive market.

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[12] For household expenditures, see the introduction to this section. Median household income in 2008 was about $52,000 (Semega, 2009).

CHAPTER THREE

An Air Force Guide to Energy Security

Coping with the Oil Market

In this chapter, we examine options available to the Air Force in its role as a purchaser (albeit via the Defense Logistics Agency) and user of fuel. On average, DoD uses about 340,000 bpd of liquid fuels annually.[1] Of this amount, about 250,000 bpd is jet fuel. Most of the rest is either naval distillate or diesel fuel. Roughly one-half of this fuel is purchased in the United States. Foreign fuel purchases primarily serve the needs of military units based outside the United States. Total Air Force liquid fuel consumption is about 160,000 bpd annually, nearly all of which is jet fuel.

Since fuel and, in particular, jet fuel is so important to DoD's ability to train, deploy, and fight, questions have been raised about the prospects for the continued availability of petroleum-based military fuel supplies (e.g., Parthemore and Nagl, 2010). Our analyses show that there is no threat on the horizon to the availability of bulk supplies of military fuels. DoD is among the world's largest purchasers of petroleum but even so, accounts for only 0.4 percent of worldwide petroleum production. Petroleum production in just the United States is currently about 8 million bpd.[2] Adding to these domestic supplies are the net 3 million bpd of secure supplies imported annually from Canada and Mexico. With over 11 million bpd of secure petroleum supplies, we find it inconceivable that the U.S. military would not be able to access the fuels it requires to maintain readiness and perform its missions. In the unlikely event that the market is not responsive to military needs, the Defense Production Act (P.L. 81-774) contains provisions that would give the priority to the production and delivery of petroleum products to DoD and it contractors.

Dealing with High Oil Prices

While DoD will have access to all the fuels it requires, it may have to pay a hefty price. Unfortunately, no one can predict where petroleum prices are heading over the next few decades. It is certainly possible that the long-term trend could lead to much higher prices than are currently in effect. The world oil market might also experience a severe, albeit temporary, price shock in response to the disruption of large amounts of petroleum production. This could happen, for

1 This figure is for fiscal year 2009 and includes the use of liquefied petroleum gases and alternative fuels, such as biodiesel, compressed natural gas, and ethanol-gasoline blends (EIA, 2010(a) AER, Table 1.13).

2 This estimate (from EIA, 2011d, Table 3.1) includes refinery processing gains associated with domestic fuels production but excludes renewable fuels, such as ethanol and biodiesel, neither of which is suitable for use in military weapon systems (Bartis and Van Bibber, 2011).

example, if there were a prolonged closure of the Strait of Hormuz, through which pass about 16 to 17 million bpd of petroleum, which is about 20 percent of global petroleum demand.

Facing the current high and potentially even higher petroleum prices, DoD and the military services have basically the same options available to businesses and households. Businesses can invest in equipment that is more energy efficient. They can often find ways to conduct operations using less energy. Households have a number of options to reduce their fuel bills; for example, they can buy automobiles with high gas mileage, add more home insulation, buy more-efficient appliances, and lower thermostats. Air Force counterparts to these actions include

- investing in new aircraft and upgrading existing aircraft and engines to increase fuel efficiency
- investing in deployable assets that require less energy (e.g., insulated tents, more-efficient power generators)
- adopting less fuel-intensive schemes of maneuver
- reducing the flight hours for pilot and crew training.

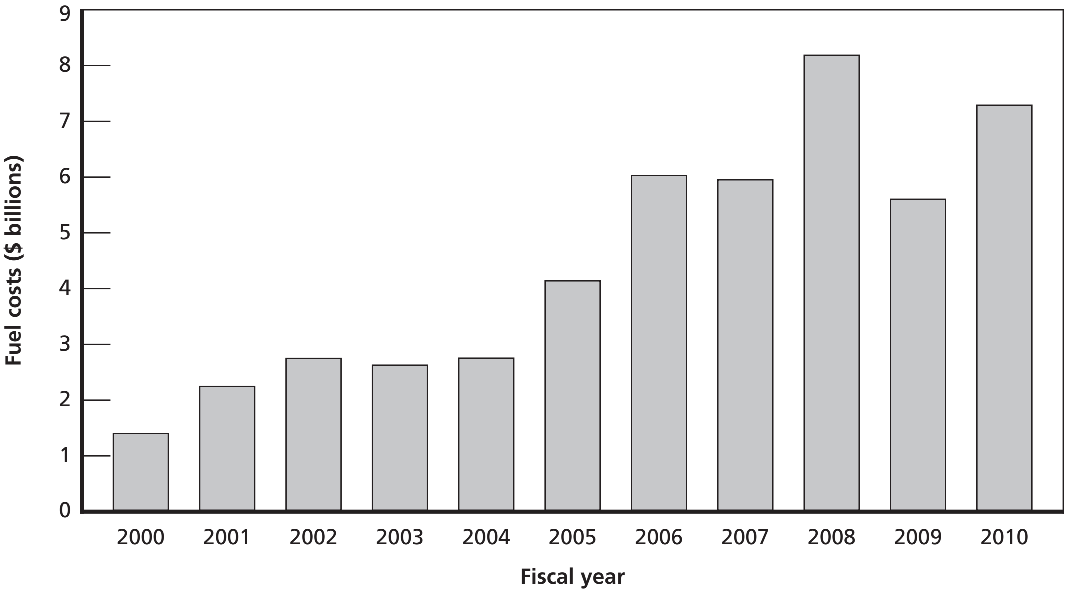
This list is not inclusive; its purpose is to demonstrate the two energy cost-cutting options available to the Air Force—energy efficiency (the first two examples) and energy conservation (the second two examples). These are the only options that offer appreciable savings in DoD (and Air Force) expenditures for liquid fuels. With continued advances in performance of renewable energy technologies (e.g., wind and solar), some small reductions in petroleum use may come from the use of renewable systems for the production of power at domestic and forward-based installations.

In a recent study, RAND examined military applications for alternative fuels (Bartis and Van Bibber, 2011). That and other RAND work on alternative fuels have found that significant national benefits would accrue from establishing a large (i.e., millions of barrels per day), commercially competitive alternative-fuels industry in the United States. These national benefits include depressing the world petroleum price, thereby reducing wealth transfers, and possibly lower greenhouse gas emissions. But alternative fuels do not appear to offer direct military benefits. While certain alternative fuels are no less able than conventional fuels to meet DoD's needs, they offer no particular military benefit over their petroleum-derived counterparts. For example, even if alternative fuels can be produced at lower costs than those prevailing for conventional fuels, they will be priced at market rates. Moreover, alternative liquid fuels do not offer to reduce the logistical burden of getting liquid fuels to forward-based units (Bartis and Van Bibber, 2011).

Dealing with Oil Price Volatility

Of the military services, the Air Force has the highest petroleum fuel costs. As shown in Figure 3.1, annual fuel costs increased threefold between 2004 and 2008, rising to about \$8.2 billion. This chart clearly illustrates that budgets that assume current petroleum costs can diverge from actual incurred costs by more than a factor of two. The record 2008 fuel expenditure was between 5 and 6 percent of total Air Force expenditures in that year. To put this into perspective, the average U.S. household probably spends a larger percentage of its income on energy than does the U.S. Air Force. In comparison, fuel costs for commercial airlines in 2008

Figure 3.1
Air Force Fuel Expenditures from 2000 to 2010



SOURCE: USAF, 2011.
RAND *TR1144/1-3.1*

ranged from 30 to 40 percent of annual expenditures (United Airlines, 2009; AMR Corporation, 2009; Continental Airlines, 2009).

Although our research did not address approaches for mitigating fuel price volatility, we can say that a number of approaches are available. One approach would mimic what private enterprises, such as commercial airlines, do to mitigate the adverse impacts of fuel price increases: develop and implement a fuel hedging strategy. Such hedging strategies involve transaction costs, however, which may be politically disadvantageous. Although commercial airlines are willing to accept these transaction costs, they have potentially much more to lose than the Air Force does from fuel price volatility (Defense Business Board, 2004).

A similar alternative would be for the Air Force (via Defense Logistics Agency Energy) to execute fuel contracts for future delivery during the programming phase of the multiyear Planning, Programming, Budgeting, and Execution System process. This would lock in the prices that the service would pay in the execution year. This approach would change Defense Logistics Agency's standard fuel contracting approach, which includes provisions for adjusting sale prices to accommodate variations in world prices. Large petroleum corporations, however, may be unwilling to sign multiyear, fixed-price fuel contracts. Were fuel prices to drop, these corporations would be in the politically embarrassing position of "overcharging" the federal government.

Nonhedging options are also available to the Air Force and may be politically more acceptable. These include requesting additional appropriations from Congress to cover fuel price increases or establishing a working capital fund that would smooth out fuel price variations (Defense Business Board, 2004; Bartis, Camm, and Ortiz, 2008).

Promoting Energy Security

As fuel purchasers, neither the Air Force nor DoD has enough power to influence the world oil market. Their fuel purchases are simply too small. But as part of the armed forces of the United States, the Air Force plays an important and productive role in the world oil market. The armed services are the backbone of the U.S. national security policy that assures access to the energy supplies of the Persian Gulf and the stability and security of key friendly states in the region. Moreover, the U.S. Navy's global presence assures freedom of passage in the sea-lanes that are crucial to the international trade in petroleum and natural gas.

Can more be done? Can the Air Force productively take further steps to promote energy security? To answer these questions, we conducted three exploratory studies, described in the other volumes in this series, focusing on

1. the Caspian oil and gas exporting nations and Turkey (Weiss et al., 2012)
2. the sea-lanes from Hormuz to Asia (Henry et al., 2012)
3. Nigeria and other potential oil exporting countries in the Gulf of Guinea (Johnson et al., forthcoming).

Because the U.S. military already has an active presence in the Persian Gulf and in the Strait of Hormuz, we purposely selected topic areas outside the Middle East.

The analysis reported in this four-volume series led us to conclude that there are roles for the Air Force but that important caveats apply. For nations in which security shortfalls impede hydrocarbon production or transport, current and future U.S. Air Force partnership-building capabilities offer security improvements that could promote greater production of petroleum and natural gas resources. Notable examples of nations in which security shortfalls significantly impede investment and production are Nigeria, Iraq, and Sudan. While we did not examine the situation in Iraq or Sudan, our review of partnership-building capabilities in Nigeria and other nations bordering the Gulf of Guinea suggests that any efforts to build military partnerships in this region must consider the risk that U.S.-provided military capabilities might be applied to local civilian populations. While there are signs of improved governance in Nigeria, these considerations suggest that Ghana may be a more attractive partner.

In the Caspian Region, the major security threat to energy infrastructure stems from the ongoing tensions between Russia and Georgia. The Russian invasion of Georgian territory in 2008 caused the pipelines carrying oil and natural gas from Azerbaijan to Turkey to shut down for several weeks as a precautionary measure. We found that the security of the energy infrastructure is being fairly well addressed in the remaining nations in the Caspian region, especially considering the current low threat level.

Turkey appears as a special case because of its geostrategic location, status as a NATO member, and long-time relationship with the U.S. Air Force. Kurdish terrorists have been able to execute numerous successful attacks on oil pipelines traversing eastern Turkey. While these attacks do not significantly threaten the national security of Turkey, they do cause investors to weigh pipeline security risks when considering the investments that will be required for Turkey to realize its goal of becoming an energy hub between Europe and both the Caspian and the Middle East. Another important Turkish energy transit issue is the oil tanker traffic through the Bosporus Strait. From the Turkish perspective, concerns center on the potential damage from a major oil spill. From the oil-industry perspective, concerns center on the possibility of a terrorist attack that might block tanker passage for many months. Considering its state of development and military capabilities, Turkey certainly has the wherewithal to address pipeline attacks and the concerns about the Bosporus. However, the U.S. Air Force could play a productive, albeit limited, role in promoting technology transfer and best practices on infrastructure protection, with the main motivation being the strengthening of the U.S., and U.S. Air Force, relationship with Turkey.

Another potential role for the Air Force is in assisting the U.S. Navy in sea-lane protection. Three quarters of the petroleum passing through the Strait of Hormuz is heading to Asian ports. This and other sea-lanes to Asia are a growing security concern because Asia's expanding economies increasingly depend on imported energy sources, specifically oil, natural gas, and coal gas. Unfortunately, regional security mechanisms have not kept pace and are no longer commensurate with the rise in the region's significance.

On this topic, our first major finding is that a joint approach, in which the Air Force provides meaningful assistance to the Navy, offers a more efficient and effective application of U.S. defense assets. By capitalizing on interdependencies between the U.S. Air Force and the U.S. Navy, a joint approach would lay the foundation for addressing more strategic concerns and the collaborative development of an interdependent force posture. Our second, and more significant, finding is that overall U.S. interests are best served by taking a multinational approach toward the protection of the energy sea-lanes to Asia. This approach provides a much better mechanism for addressing the potentially serious threats that might arise if one or more of the countries along the sea-lane fails or goes rogue. Additionally, multinational cooperation in sea-lane protection provides a means of dampening the simmering tensions and lingering disputes that prevail in Asia. From the U.S. Air Force perspective, a multinational approach provides new opportunities for interaction, building partnerships, and assuring access.

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