

CSIS

Center for Strategic and International Studies
1800 K Street N.W.
Washington, DC 20006
(202) 775-3270
Access: Web: CSIS.ORG
Contact the Author: Acordesman@aol.com & NawafObaid@aol.com

Saudi Petroleum Security: Challenges & Responses

Anthony H. Cordesman and Nawaf Obaid
Center for Strategic and International Studies

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Please note that this document is a working draft and will be revised regularly as part of the CSIS Saudi Arabia Enters the 21st Century Project. It is also being used by the authors to develop a forthcoming book on Saudi security. To comment, or to provide suggestions and corrections to the authors, please e-mail them at acordesman@aol.com, nawafobaid@aol.com and PBaetjer@csis.org.

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The Saudi Energy Security Problem

Saudi Arabia not only faces internal energy security challenges, it is in the center of a region that now dominates the world's petroleum exports and whose importance will grow steadily over the coming decades.

The Role of the Gulf and Middle East in Energy Exports

The Middle East and North Africa have some 63% of all of the world's proven oil resources, and some 37% of its gas. In 2001, the Gulf alone had over 28% of all of the world's oil production capacity, and the entire MENA region had 34%.¹ These reserves, and low incremental production costs, ensure the region will dominate increases in oil production through at least 2015. The EIA estimates that Saudi Arabia alone will account for 4.2 MMBD of the total increase, Iraq for 1.6 MMBD. Kuwait for 1.3 MMBD, and the UAE for 1.2 MMBD. These four countries account for 8.3 MMBD out of a worldwide

¹ Estimates differ according to source. The last comprehensive USGS analysis was performed in 2000, and was seriously limited by the fact many countries were affected by war or internal turmoil and declared reserves without explaining them or provided data by field. Standard estimates of reserves by non-USG sources like those in the *Oil and Gas Journal* and *World Oil* do not adjust reported data according to a standardized methodology or adjust for the large number of countries that never alter their estimates of reserves for actual production.

For example, six of the ten nations with the largest proven reserves are in the MENA region. An IEA analysis shows a range of 259-263 billion barrels for Saudi Arabia, 105-133 billion for Iran, 66-98 billion for the UAE, and 31-29 billion for Libya. The figure of 115 billion for Iraq is consistent only because it is a figure announced in the past by the Iraqi government and there are no accurate, verified estimates. To put these figures in perspective, the range for Russia is 60-69 billion, 25-35 billion for Nigeria, 23-21 billion for the US, and 52-78 billion for Venezuela. (International Energy Agency, "Oil Market Outlook," World Energy Outlook, 2004, OECD/IEA, Paris, October 2004, Table 3.2.)

Estimates alter radically if an unconventional oil reserve like Canadian tar sands are included. The Middle East has only about 1% of the world's known reserves of oil shales, extra heavy oil, tar sands, and bitumen. Canada has 36%, the US has 32%, and Venezuela has 19%. The rest of the world has only 12%. The cost-effectiveness of producing most of these reserves, and the environmental impact, is highly uncertain, however, even at high oil prices. (International Energy Agency, "Oil Market Outlook," World Energy Outlook, 2004, OECD/IEA, Paris, October 2004, Figure 3.13.)

Reserve estimates also change radically if ultimately recoverable reserves are included, and not simply proven reserves. Some estimates put the total for such reserves at around 2.5 times the figure for proven reserves. For example, the IEA estimate for the Middle East drops from around 60% to 23%. Such estimates are speculative however, in terms of both their existence and recovery price, and do not have significant impact on estimates of production capacity through 2025-2030. They also ignore gas and gas liquids. The Middle Eastern share of undiscovered oil and gas resources rises to 27% based on existing data.

Such estimates are also heavily biased by the fact that so little experimental drilling searching for new fields occurred in the Middle East between 1992 and 2002. The IEA estimates that only 3% of some 28,000 wildcat explorations for new fields worldwide took place in the Middle East. Recent exploration in key countries like Iran, Iraq, and Libya has been minimal. Some 50 Saudi fields, with 70% of the reserves that are proven, still await development. (International Energy Agency, "Oil Market Outlook," World Energy Outlook, 2004, OECD/IEA, Paris, October 2004, Figure 3.15.)

total of 17.9 (46%). To put these figures in perspective, Russia will account for an increase of only 1.3 MMBD.²

The International Energy Agency estimates cover a longer period than the EIA estimates. They predict that that total conventional and non-conventional oil production will increase from 77 MMBD in 2002 to 121.3 MMBD in 2030. This is a total increase of 44.3 MMBD worldwide. The Middle East will account for 30.7 MMBD, or 69% of this total. The IEA also estimates that the rate of dependence on the Middle East will increase steadily after 2010 as other fields are depleted in areas where new resources cannot be brought on line. It estimates that 29 MMBD, or 94% of the total 31 MMBD increase in OPEC production between 2010 and 2030 will come from Middle Eastern members of OPEC.³

Changing Patterns in Import Dependence that Affect the Global Economy

This dependence will be easier to secure with a friendly and stable Iraq, but the US has no choice. The US Energy Information Agency (EIA) summarizes the trends in Gulf oil exports as follows in its International Energy Outlook for 2004, and it should be noted that its estimates are based on favorable assumptions about increases in other fuels like gas, coal, nuclear and renewable energy, and favorable assumptions about increases in conversion efficiency, and other aspects of energy efficiency:⁴

In 2001, industrialized countries imported 16.1 million barrels of oil per day from OPEC producers... Of that total, 9.7 million barrels per day came from the Persian Gulf region. Oil movements to industrialized countries represented almost 65 percent of the total petroleum exported by OPEC member nations and almost 58 percent of all Persian Gulf exports.⁵ By the end of the

² Guy Caruso, "US Oil Markets and the Middle East, DOE/EIA," October 20, 2004.

³ IEA estimate in the *World Energy Outlook for 2004*, Table 3.5, and analyzed in Chapter 3.

⁴ The DOE/EIA, *International Energy Outlook for 2004*, can be found at <http://www.eia.doe.gov/oiaf/ieo/download.html>.

⁵ See <http://www.eia.doe.gov/emeu/cabs/pgulf.html>. In 2003, Persian Gulf countries had estimated net oil exports of 17.2 MMBD of oil (see pie chart). Saudi Arabia exported the most oil of any Persian Gulf country in 2003, with an estimated 8.40 MMBD (49% of the total). Also, Iran had estimated net exports of about 2.6 MMBD (15%), followed by the United Arab Emirates (2.4 MMBD -- 14%), Kuwait (2.0 MMBD -- 12%), Iraq (0.9 MMBD -- 9%), Qatar (0.9 MMBD -- 5%), and Bahrain (0.01 MMBD -- 0.1%).

U.S. gross oil imports from the Persian Gulf rose during 2003 to 2.5 MMBD (almost all of which was crude), from 2.3 MMBD in 2002. The vast majority of Persian Gulf oil imported by the United States came from Saudi Arabia (71%), with significant amounts also coming from Iraq (19%), Kuwait (9%), and small amounts (less than 1% total) from Qatar and the United Arab Emirates. Iraqi oil exports to the United States rose slightly in 2003, to 481,000 bbl/d, compared to 442,000 bbl/d in 2002. Saudi exports rose from 1.55 MMBD in 2002 to 1.77 MMBD in 2003. Overall, the Persian Gulf accounted for about 22% of U.S. net oil imports, and 12% of U.S. oil demand, in 2003.

Western Europe (defined as European countries belonging to the Organization for Economic Cooperation and Development -- OECD) averaged 2.6 MMBD of oil imports from the Persian Gulf during 2003, an increase of about 0.2 MMBD from the same period in 2002. The largest share of Persian Gulf oil exports to Western Europe came from Saudi Arabia (52%), with significant amounts also coming from Iran (33%), Iraq (7%), and Kuwait (6%).

Japan averaged 4.2 MMBD of net oil imports from the Persian Gulf during 2003. Japan's dependence on the Persian Gulf for its oil supplies increased sharply since the low point of 57% in 1988 to a high of 78% in 2003. About 30% of Japan's Persian Gulf imports in 2003 came from Saudi Arabia, 29% from the United Arab Emirates, 17% from Iran, 12% from Kuwait, 11% from Qatar, and around 1% from Bahrain and Iraq

forecast period (2025), OPEC exports to industrialized countries are estimated to be about 11.5 million barrels per day higher than their 2001 level, and more than half the increase is expected to come from the Persian Gulf region.⁶

Despite such a substantial increase, the share of total petroleum exports that goes to the industrialized nations in 2025 is projected to be almost 9 percent below their 2001 share, and the share of Persian Gulf exports going to the industrialized nations is projected to fall by about 13 percent. The significant shift expected in the balance of OPEC export shares between the industrialized and developing nations is a direct result of the economic growth anticipated for the developing nations of the world, especially those of Asia.

OPEC petroleum exports to developing countries are expected to increase by more than 18.0 million barrels per day over the forecast period, with three-fourths of the increase going to the developing countries of Asia. China, alone, is likely to import about 6.6 million barrels per day from OPEC by 2025, virtually all of which is expected to come from Persian Gulf producers.

North America's petroleum imports from the Persian Gulf are expected to double over the forecast period. At the same time, more than one-half of total North American imports in 2025 are expected

combined. Japan's oil imports from the Persian Gulf as a percentage of demand continued to rise to new highs, reaching 78% in 2003.

⁶ Estimates by country are necessarily uncertain. The International Energy Outlook for 2004 estimate of production capacity in MMBD for MENA countries is as follows:

Country	2001	2010		2020		2025	
		Reference	High Price	Reference	High Price	Reference	High Price
Iran	3.7	4.0	3.5	4.7	3.8	4.9	4.3
Iraq	2.8	3.7	2.9	5.3	3.7	6.6	4.6
Kuwait	2.3	3.7	2.3	4.4	2.9	5.0	3.4
Qatar	0.6	0.6	0.6	0.8	0.7	0.8	0.7
Saudi Arabia	10.2	13.2	9.4	18.2	12.9	22.5	16.0
UAE	2.7	3.3	2.7	4.6	3.3	5.2	3.9
Total Gulf	22.4	27.9	21.4	38.0	27.3	45.0	32.9
Algeria	1.6	2.0	1.6	2.4	2.0	2.7	2.2
Libya	1.7	2.0	1.7	2.6	2.1	2.9	2.4
Other Middle East	2.0	2.2	2.4	2.6	2.9	2.8	3.1
Total Other	4.3	6.2	5.7	7.6	7.0	8.4	7.7
Total MENA	26.7	34.1	26.1	45.6	34.3	53.4	40.6
Total World	79.3	95.1	90.0	114.9	107.2	126.1	117.3
(US)	9.0	9.5	9.9	8.9	9.6	8.6	9.0

OPEC data are labeled confidential but are very similar. The IEA does not provide country-by-country estimates, but uses very similar models with similar results. It estimates total world production was 77 MMBD in 2002, and will increase to 121 MMBD in 2030. If one looks at the data for the Middle East, the latest IEA estimates are as follows:

The IEA estimate in the World Energy Outlook for 2004, Table 3.5, is:

	2002	2010	2020	2030	Ave. Annual Growth
OPEC Middle East	19.0	22.5	37.4	51.8	3.6%
Other Middle East	2.1	1.8	1.4	1.0	-2.7%
Total	21.1	24.3	38.8	52.8	
Non-Conventional Oil (Worldwide)	1.6	3.8	6.1	10.1	6.7%
World	77.0	90.4	106.7	121.3	1.6%

to be from Atlantic Basin producers and refiners, with significant increases expected in crude oil imports anticipated from Latin American producers, including Venezuela, Brazil, Colombia, and Mexico. West African producers, including Nigeria and Angola, are also expected to increase their export volumes to North America. Caribbean Basin refiners are expected to account for most of the increase in North American imports of refined products. With a moderate decline in North Sea production, Western Europe is expected to import increasing amounts from Persian Gulf producers and from OPEC member nations in both northern and western Africa. Substantial imports from the Caspian Basin are also expected.

Industrialized Asian nations are expected to increase their already heavy dependence on Persian Gulf oil. The developing countries of the Pacific Rim are expected to almost double their total petroleum imports between 2001 and 2025.

While quantified estimates of export dependence are uncertain, it is clear that it would take a massive breakthrough(s) in technology or discoveries of reserves outside the Middle East and North Africa (MENA) to change these trends.

Dependence on MENA Export Security and High Rates of Energy Investment in the Region

Moreover, both the military security of the MENA region, and its ability to achieve the necessary investment in new energy production are critical US strategic interests. For example, some 40% of all world oil exports now pass daily through the Strait of Hormuz and both EIA and IEA projections indicate this total will increase to around 60% by 2025-2030.⁷

The IEA projections, for example, indicate that Middle Eastern Exports will total some 46 MMBD by 2030, and represent more than two-thirds of the world total. This means that the daily traffic in oil tankers will increase from 15 MMBD and 44% of global interregional trade in 2002, to 43 MMBD and 66% of global interregional trade in 2030. This means that the daily traffic in LNG carriers will increase from 28 BCM and 18% of global interregional trade in 2002, to 230 carriers and 34% of global interregional trade in 2030.⁸ The IEA does, however, estimate that these increases would be some 11% lower if oil prices remained consistently high in constant dollars.

The International Energy Agency also estimates that imports will rise from 63% of total OECD demand for oil in 2002 to 85% in 2030 some \$3 trillion dollars must be invested in the oil sector from 2003 to 2030 to meet world demand for oil, and something approaching half of this total must be invested in the Middle East. Some \$234 billion will

⁷ See <http://www.eia.doe.gov/emeu/security/choke.html#HORMUZ>. The Strait is the narrow passage between Iran and Oman that connects the Persian Gulf with the Gulf of Oman and the Arabian Sea. It consists of 2-mile wide channels for inbound and outbound tanker traffic, as well as a 2-mile wide buffer zone. The EIA estimates that some 13 MMBD flowed through the Strait in 2002. The IEA puts the figure at 15 MMBD in 2003. Both agencies indicate that the amount of oil moving by tanker will increase steadily as Asian demand consumes a larger and larger share of total exports.

Closure of the Strait of Hormuz would require use of longer alternate routes (if available) at increased transportation costs. Such routes include the 5 million-bbl/d capacity Petrolina (East-West Pipeline) and the 290,000-bbl/d Abqaiq-Yanbu natural gas liquids line across Saudi Arabia to the Red Sea. Theoretically, the 1.65-MMBD Iraqi Pipeline across Saudi Arabia (IPSA) also could be utilized, more oil could be pumped north to Ceyhan (Turkey), and the 0.5 million-bbl/d Tapline to Lebanon could be reactivated.

⁸ International Energy Agency, "Oil Market Outlook," *World Energy Outlook, 2004*, OECD/IEA, Paris, October 2004, Table 3.7 and 3.8.

be required for tankers and oil pipelines, and again, a substantial amount must go to the MENA area.⁹

The US Buys Oil in a Global Market, Not From Countries Per Say

Under most conditions, the normal day-to-day destination of MENA oil exports is strategically irrelevant. Oil is a global commodity, which is distributed to meet the needs of a global market based on process bid by importers acting in global competition. With the exception of differences in price because of crude type and transportation costs, all buyers compete equally for the global supply of available exports, and the direction and flow of exports changes according to marginal price relative to demand. As a result, the percentage of oil that flows from the MENA region to the United States under normal market conditions has little strategic or economic importance. If a crisis occurs, or drastic changes take place in prices, and every importing nation will have to pay the same globally determined price as any other nation, and its source of US imports will change accordingly. Moreover, the OECD nations is required to share all imports with other OECD countries in a crisis under the monitoring of the International Energy Agency.

The size of direct imports of petroleum is also only a partial measure of strategic dependence. The economy of every industrialized state is dependent on energy-intensive imports from Asia and other regions, and what comes around must literally go around. While the EIA and IEA do not make estimates of indirect imports of Middle Eastern oil in terms of the energy required to produce the finished goods, the US, Europe, and Japan all import them from countries that are dependent on Middle Eastern exports.

To put this dependence in perspective, direct US oil imports increased from an annual average of 7.9 MMBD in 1992 to 11.3 MMBD in 2002, and 2.6 MMBD worth of US petroleum imports came directly from the Middle East in 2002.¹⁰ If indirect US imports, in the form of manufactured goods dependent on imports of Middle Eastern oil were include, the resulting figure might well be 30-40% higher than the figure for direct imports.

Saudi Arabia's Importance to Energy Security

There have been many studies over energy security over the years, including studies by the CIA, EIA, and IRA. All have found that Saudi Arabia is a key petroleum exporter and central to a steadily more interdependent global economy. Saudi Arabia is also the only oil producer that has consistently sought to maintain surplus oil production capacity, with a nominal goal of 2 MMBD. This situation will not change in the foreseeable future.

Saudi holds one-quarter of the world's proven oil reserves, with 259.4 billion barrels (another 2.5 billion barrels are in the Saudi-Kuwait Neutral Zone). According to the Energy Information Agency (EIA) of the US Department of Energy, it has another 2.5 billion barrels in the Saudi-Kuwaiti Neutral Zone), and may contain up to 1 trillion barrels of ultimately recoverable oil.ⁱ

Saudi Arabia now has the capacity to produce a maximum of 11.2 million barrels of crude per day (with a sustained capacity of 10.6 – 10.8 million bbl/d). The Kingdom has

⁹ International Energy Agency, "Oil Market Outlook," World Energy Outlook, 2004, OECD/IEA, Paris, October 2004, Chapter 3.

¹⁰ BP/Amoco, BP Statistical Review of World Energy, London, BP, 2003, p. 17.

roughly 80 oil and gas fields and more than 1,000 oil wells. The Supreme Petroleum Council oversees the nationalized oil industry, the Saudi Arabian Oil Company (Saudi Aramco). The massive petrochemicals firm, Saudi Basic Industries Corporation (SABIC), is only partially government owned.

Saudi Arabia claims that it is "easily capable" of producing up to 15 million bbl/d in the future and maintaining that production level for 50 years. Aramco claims that the average depletion rate for Saudi oil fields is 28%, with the giant Ghawar field having produced 48% of its proved reserves. Aramco also claims that, if anything, Saudi oil reserves are underestimated, not overestimated.ⁱⁱ

The EIA reports that outside analysts, notably Matthew Simmons of Houston-based Simmons and Company International, have disputed Saudi Aramco's optimistic assessments of Saudi oil reserves and future production, pointing to -- among other things -- more rapid depletion rates and a higher "water cut" than the Saudis claim. However, the EIA forecasts that Saudi oil production capacity could reach 18.2 million bbl/d by 2020, and 22.5 million bbl/d by 2025.ⁱⁱⁱ

Critical Saudi Energy Facilities

Saudi Arabia has some 80 oil and gas fields, and over 1,000 wells.^{iv} More than half of the Kingdom's oil reserves, however, are contained in eight fields, including the world's largest onshore and offshore fields, Ghawar and Safaniyah, respectively. Ghawar is the world's largest oil field, with estimated remaining reserves of 70 billion barrels). Safaniya is the world's largest offshore oilfield, with estimated reserves of 35 billion barrels). According to the EIA, Ghawar's main producing structures are, from north to south: Ain Dar, Shedgum, Uthmaniyah, Farzan, Ghawar, Al Udayliyah, Hawiyah, and Haradh. Ghawar alone accounts for about half of Saudi Arabia's total oil production capacity, and could be a key target if any attack was made on Saudi fields. Safaniya, however, would be more attractive in terms of asymmetric attacks because offshore fields are easier targets.

Saudi Arabia produces a wide variety of crude oils, from heavy to super light. 65-70% of the country's aggregate oil production capacity is considered light gravity. The remainder is either medium or heavy, although the country is moving towards reducing these two grades. Ghawar is the major producer of Arabian light crude. Arab Extra Light crude comes from Abqaiq, an enormous field, containing 17 billion barrels of proven reserves. Shaybah -- with estimated reserves of 15 billion barrels -- produces a mix of Arabian light and Arabian Extra Light. Its current export capabilities are shown in Figure 1.

Figure 1:
Saudi Maximum Production Capacity
by Grade

<i>Type of Crude</i>	<i>Million bbl/d</i>
Arabian Super Light	0.250
Arabian Extra Light	1.400
Arabian Light	6.700
Arabian Medium	1.450
Arabian Heavy	1.200
<i>Total</i>	11.200

Source: Saudi National Security Assessment Project.

The current production capabilities of Saudi Arabia's oilfields are shown in Figure 2. The EIA also reports that major efforts are underway to increase production capacity,^v

In March 2002, Aramco awarded major turnkey contracts to Italy's Snamprogetti (\$630 million) and Technip-Coflexip (\$360 million) aimed at increasing total Saudi oil production capacity by 800,000 bbl/d (500,000 bbl/d of Arabian light and 300,000 bbl/d of Arabian medium), by October 2004. The \$1.2 billion project, known as the Qatif producing facilities development program (QPFDP), is located in the eastern part of the country near Dhahran, and will serve crude oil production from fields in the area. QPFDP involves construction of two gas-oil separation plants (GOSPs), as well as gas treatment and oil stabilization facilities. Qatif production is slated to replace production elsewhere in Saudi Arabia, not to boost overall capacity. In June 2004, Reuters reported that Saudi Arabia planned to bring on the first production from Qatif (and also from another field, Abu Safa), by July 2004.

...Another potential project, at the Khurais field, could increase Saudi production capacity by 800,000 bbl/d at a cost of \$3 billion. This would involve installation of four GOSPs, with a capacity of 200,000 bbl/d each, at Khurais, which first came online in the 1960s but was mothballed by Aramco (along with several other fields -- Abu Hadriya, Abu Jifan, Harmaliyah, and Khursaniyah) in the 1990s.

The \$280 million Haradh-2 project aims to increase production capacity at the Haradh oil field to 900,000 bbl/d -- triple current production -- by 2006. This will involve adding a second, 300,000-bbl/d GOSP to Haradh (in addition to one 300,000-bbl/d GOSP inaugurated in January 2004), while shutting in some heavy oil production in the Ghawar area. Haradh also will produce significant volumes of non-associated natural gas, natural gas condensates (perhaps 170,000 bbl/d), and sulfur.

...Saudi Arabia's long-term goal is to develop its lighter crude reserves, including the Shaybah field located in the remote Empty Quarter area bordering the United Arab Emirates. Shaybah contains an estimated 15.7 billion barrels (or higher) of premium grade 41.6o API sweet (nearly sulfur-free) crude oil, with production potential believed to be 1 million bbl/d (output as of early April 2004 was around 560,000 bbl/d). Overall, the Shaybah project cost around \$2.5 billion, with production starting in July 1998. According to Oil Minister Naimi (October 1999), the development of Shaybah showed that "the cost of adding...capacity - that is, all the infrastructure, producing and transportation facilities - necessary to produce one additional barrel of oil per day in Saudi Arabia is,

at most, \$5,000 compared to between \$10,000 and \$20,000 in most areas of the world. So both our current production costs, and the costs for developing more production capacity for the future, are probably the world's lowest." The Shaybah complex includes three gas/oil separation plants (GOSPs) and a 395-mile pipeline to connect the field to Abqaiq, Saudi Arabia's closest gathering center, for blending with Arab Light crude (Berri and Abqaiq streams). In addition to oil, Shaybah has a large natural gas "cap" (associated gas), with estimated reserves of 25 trillion cubic feet (Tcf). Gas production of 880 million cubic feet per day (Mmcfd) is reinjected, along with natural gas liquids (NGLs). A possible gas recovery project could be implemented within 5 or 6 years, potentially for use in petrochemical production.

Oil fields are large area targets, with many redundant facilities. While fires can be set in many areas of a working field, including at oil wells, fires do not produce critical or lasting damage. Unless wells are attacked with explosives deep enough in the wellhead to result in permanent damage to the well, most facilities can be rapidly repaired.

There also, however, are larger items of equipment and central facilities that would do far more to interrupt production and many of which require months of manufacturing time to replace. Such facilities include central pumping facilities, gas-oil separators (GOPs), and related power plants, water injection facilities, and desalination plants. Vulnerability also increases sharply if key targets in a field are attacked as a system, rather than as individual elements, and if expert assistance is available to saboteurs or attackers.

<u>Figure 2</u>	
<u>Saudi Field Production</u>	
<i>Facility</i>	<i>Million bbl/d</i>
Abqaiq	0.450
Abu Safah	0.300
Safaniyah	1.500
Shaybah	0.500
Ghawar	5.500
Qatif	0.500
Marjan	0.450
Berri	0.400
Zuluf	0.800
Koreis (mothballed)	0.150
Neutral Zone	0.350
Khurushaniya (mothballed)	0.100
Munifa	0.000
Hawtah	0.200
Total	11.200
<i>Source: Saudi National Security Assessment Project.</i>	

The Saudi Pipeline and Export System

The Saudi pipeline and export system is another key potential vulnerability, although most pipeline facilities can be repaired relatively easily and quickly, with the expectation of some pumping and control facilities. According to the EIA, the Saudi oil system is divided into a northern producing area and a southern producing area. Northern oil is refined at multiple refining locations and then sent to Ras Tanura (and to a lesser extent Ras al-Juaymah).^{vi}

All the petroleum from the southern areas is pumped to Abqaiq and from there to Ras Tanura and Ras al-Juaymah. The 5 million bbl/d East-West Crude Oil Pipeline (Petroline), operated by Saudi Aramco since 1984 (when it took over from Mobil), is used mainly to transport Arabian Light and Super Light to refineries in the Western Province and to Red Sea terminals for export to European markets.

The Saudi government expanded the Petroline in part to maintain Yanbu as a strategic option to Gulf port facilities in the event that exports were blocked at that end. Furthermore, it is clear that Petroline's capacity could be expanded significantly, and that this would enhance the line's strategic value. Yanbu, however, remains a far less economic option for Saudi oil exports than Ras Tanura. Among other factors, shipments from Yanbu add about five days roundtrip travel time for tankers through the Bab al-Mandab strait to major customers in Asia compared to Ras Tanura (via the Strait of Hormuz). In addition, according to Oil Minister Ali al-Naimi, the Petroline is only utilized at half capacity. Given this fact, as well as the desire to boost natural gas usage, Saudi Aramco has begun converting the line to natural gas pumping capability. The natural gas will supply Yanbu's petrochemical and power facilities.

The 290,000 bbl/d Abqaiq-Yanbu natural gas liquids pipeline runs parallel to the Petroline is, which serves Yanbu's petrochemical plants. The Trans-Arabian Pipeline (Tapline) to Lebanon is mothballed, and the 1.65-million-bbl/d, 48-inch Iraqi Pipeline across Saudi Arabia (IPSA), which runs parallel to the Petroline from pump station #3 (there are 11 pumping stations along the Petroline, all utilizing on-site gas turbine electric generators) to the port of Mu'ajjiz, just south of Yanbu, was closed indefinitely following the August 1990 Iraqi invasion of Kuwait.

Most of Saudi Arabia's crude oil is exported from the Gulf via the huge Abqaiq processing facility, which handles around two-thirds of the country's oil output. This makes it another key potential target. Saudi Arabia also has several major oil terminals for loading its oil exports, which are shown in Figure 3. Its primary oil export terminals are located at Ras Tanura (5.5 - 6 million bbl/d capacity; the world's largest offshore oil loading facility) and Ras al-Juaymah (3 - 3.5 million bbl/d) on the Gulf, plus Yanbu (4.5 - 5 million bbl/d) on the Red Sea. Combined, these terminals can handle from between 13 - 14 million bbl/d. Each of these terminal is a major potential target for terrorist or asymmetric attacks.

Figure 3:**Saudi Oil Terminals**

Ras Tanura: World's largest offshore oil loading facility, on the Gulf; 5.5 - 6 million bbl/d capacity).

Yanbu: On the Red Sea, fed by Petrolina; 4.5 - 5 million bbl/d capacity.

Jubail, Ras al-Juaymah: On the Gulf northwest of Ras Tanura; 3 - 3.5 million bbl/d capacity.

Jeddah: On the Red Sea south of Yanbu.

Jizan: On the Red Sea, refined products.

Ras al-Khafji: On the Gulf in the Saudi-Kuwaiti Neutral Zone, crude oil.

Rabigh: On the Red Sea, north of Jeddah, crude oil and refined products.

Zuluf: Offshore in the Gulf, linked to Zuluf oil field.

Saudi Refineries and Product Facilities

The Kingdom has eight refineries, with a combined crude throughput capacity of roughly 1.75 million bbl/d, in addition to about 1.6 million bbl/d of overseas refining capacity. A new 200,000 bbl/d fractionation component was completed at the Ras Tanura refinery in August 2003. There are plans to increase the Rabigh refinery's capacity to as much as 400,000 bbl/d and upgrade its product slate from "low-value" heavy products to gasoline and kerosene. Another innovation will be the addition of an ethane cracker fed by natural gas from the Eastern Province through a converted oil line.

Figure 4:**Major Refineries****(Capacity 1/1/04E)****bbl/d**

Saudi Aramco-Rabigh	400,000
Ras Tanura	300,000
Yanbu	190,000
Riyadh	120,000
Jeddah	60,000
Saudi Aramco/Mobil-Yanbu	340,000
Petromin/Shell-al-Jubail	305,000
Arabian Oil Company-Ras al-Khafji	30,000

Saudi Natural Gas

While most outside studies focus on Saudi export capabilities, Saudi Arabia is becoming steadily more dependent on using its natural gas to free up oil for export, and

to provide the feedstock for petrochemical exports. This makes Saudi gas facilities another major potential energy target. The EIA describes current and planned scale of Saudi Gas facilities as follows:^{vii}

...Using natural gas instead of oil domestically will help free up additional crude oil for export (OPEC quotas are on production, not exports). Overall, Saudi Arabia aims to triple natural gas output (to 15 Bcf/d) by 2009. To date, Saudi Arabia has not expressed great interest in exporting liquefied natural gas mainly due to doubts regarding economic viability and concerns that gas exports could compete with more lucrative oil exports.

...Domestic demand is driving a \$4.5 billion expansion of the MGS, which was completed in 1984. The MGS feeds gas to the industrial cities of Yanbu on the Red Sea and Jubail, which combined account for 10% of the world's petrochemical production. Prior to the MGS, all of Saudi Arabia's natural gas output was flared.

... Saudi Arabia's proven natural gas reserves are estimated at 224.7 trillion cubic feet (Tcf), ranking fourth in the world (after Russia, Iran, and Qatar), and up about 5 Tcf from 2002. Most (around 60%) of Saudi Arabia's currently proven natural gas reserves consist of associated gas, mainly from the onshore Ghawar field and the offshore Safaniya and Zuluf fields. The Ghawar oil field alone accounts for one-third of the country's proven natural gas reserves.

... only 15% of Saudi Arabia has been "adequately explored for gas," according to Aramco's vice president for new business development, Khalid al-Falih. Most new associated natural gas reserves discovered in the 1990s have been in fields which contain light crude oil, especially in the Najd region south of Riyadh. Most of Saudi Arabia's non-associated gas reserves (Mazalij, Al-Manjoura, Shaden, Niban, Tinat, Al-Waar, etc.) are located in the deep Khuff reservoir, which underlies the Ghawar oil field. Natural gas also is located in the country's extreme northwest, at Midyan, and in the Empty Quarter (Rub al Khali) in the country's southeastern desert. The Rub al Khali alone is believed to contain natural gas reserves as high as 300 Tcf.

Another large natural gas field, called Dorra, is located offshore near the Khafji oil field in the Saudi-Kuwaiti Neutral Zone and may be developed by Japan's AOC. Dorra development is controversial, however, because part of it is also claimed by Iran (which calls the field Arash). The maritime border between Kuwait and Iran remain undemarcated, but Saudi Arabia reached an agreement with Kuwait in July 2000 to share Dorra equally. Currently, Iran is resisting any moves by Kuwait and Saudi Arabia to develop the field on their own. Iran and Kuwait have been discussing their offshore boundary since 2000.

... Gas development is slated to consume a large share of Saudi Aramco's budget (in late 1999, Aramco decided to invest \$45 billion over 25 years on upstream gas development and processing facilities), and Aramco is aiming to add 3-5 Tcf of new non-associated natural gas reserves per year to meet rapid (5%-7% annual) gas demand growth. Non-associated gas development is desirable in particular because it guarantees a steady flow of gas regardless of oil output, which tends to fluctuate. Currently, non-associated gas accounts for 40% of Saudi Arabia's total gas reserves.

...Following cancellation of the SGI, Saudi Arabia repackaged the (gas) project as a series of smaller, more focused contracts, with better rates of return than previously offered. At the same time, the Saudis moved away from the integrated upstream/downstream gas, water, power, and petrochemical nature of the SGI, and instead specifically targeted upstream natural gas development in the area that had comprised Core Venture 3. Downstream and "midstream" elements of the SGI will now be handled separately, in large part by SABIC and Aramco. In July 2003, Saudi Arabia reached a tentative deal (officially signed on November 15) with Royal Dutch/Shell and Total on Blocks 5-9 and 82-85 in the Shaybah and Kidan areas of the "Empty Quarter" region. Besides the major European companies, Saudi Aramco -- replacing

ConocoPhillips -- will have a 30% share in the \$2 billion project. Shell will maintain a 40% share and Total the remaining 30%. The deal covers an area of 81,000 square miles.

In January 2004, Russia's Lukoil won a tender to explore for and produce non-associated natural gas in the Saudi Empty Quarter. Lukoil will operate in Block A, near Ghawar, as part of an 80/20 joint venture with Saudi Aramco. Also in January 2004, China's Sinopec won a tender for gas exploration and production in Block B, while an Eni-Repsol consortium was granted a license to operate in Block C. Under terms of the agreements, Aramco will take "sales quality gas" on a take-or-pay basis for \$0.75 per million Btu, while condensates and natural gas liquids will be sold at international market rates (note: Saudi accession to the WTO will most likely require it to give up the dual pricing system for natural gas, and also to set up a comprehensive, transparent regulatory framework for the natural gas sector). In addition, the Saudi government will fund a pipeline connection from the country's Master Gas System (MGS) to contract delivery points.

Additional natural gas production is being encouraged as a feedstock for the country's growing petrochemical industry (at Yanbu and Jubail, for instance), as well as for electricity generation, desalination plants and other industrial establishments, and as a replacement for direct oil burning. In July 2003, Saudi Arabia invited more than 40 companies to bid on three onshore natural gas blocks in the South Ghawar area. As of December 2003, approximately 20-30 companies reportedly had expressed interest.

...In October 2002, construction was completed on a \$4 billion, 1.4-billion-cubic-foot (Bcf)-per-day, non-associated gas processing plant at Hawiyah, located south of Dhahran and east of Riyadh near the giant Ghawar oil field. Hawiyah represents the largest Saudi natural gas project in more than 10 years, and the first to process only non-associated gas (from the deep Khuff and Jauf reservoirs). Hawiyah was officially inaugurated in October 2002, and reportedly is producing enough natural gas to free up around 260,000 bbl/d of Arabian Light crude oil for export.

Besides Hawiyah, Foster Wheeler has been managing a \$2 billion project to build a new natural gas processing plant at Haradh, 120 miles southwest of Dhahran. The Haradh plant is similar in scope to one at Hawiyah. When completely online -- reportedly all four trains were completed as of June 2003 -- total Saudi natural gas processing capability will increase by around 1.5 Bcf/day, to around 9.5 Bcf/day. Eventually, a \$900-\$1,100 million, 3,800-Mmcf/d "straddle plant" -- a natural gas reprocessing plant located adjacent to a gas transmission line for the purpose of extracting light hydrocarbon liquids newly formed due to recurring compression and decompression of gas during transmission -- may be built as well. If so, the straddle plant will likely service both Haradh and Hawiyah and increase Saudi NGL production..

In other natural gas-related developments, a key pipeline project was completed in June 2000 to extend the MGS from the Eastern Province (which contains large potential gas and condensate reserves) to the capital, Riyadh, in the Central Province. This is part of a broader expansion of the existing gas transmission system in Saudi Arabia, reportedly to include the construction of around 1,200 miles of additional natural gas pipeline capacity (on top of 10,500 miles of oil, gas, condensate, products, and natural gas liquid pipelines currently in operation) by 2006.

Saudi Petrochemicals

Petrochemicals are an other source of vulnerability. SABIC, the largest non-oil industrial company in the Middle East, now accounts for about 10% of the world's petrochemical production.

Saudi Arabia also has wide-ranging plans for the expansion of its petrochemical production using natural gas. In 2001, SABIC completed an ambitious expansion of the Yanbu petrochemical facility at a cost of \$1 billion, making it the largest polyethylene plant in the world. In 2003, Saudi Aramco awarded a contract to Snamprogetti to

construct new units at the facility. SABIC has also approved a loan for \$1.15 billion to build a new petrochemical plant in the eastern industrial city of Jubail. The facility is slated to come online in the second half of 2004, is expected to produce 1 million tons of ethylene per year, in addition to olefins, polyethylene and glycol ethylene.

Saudi Strategic Reserves

Saudi Arabia has a Strategic Storage Program, the Kingdom has increased its strategic storage capacity for oil products by several billion barrels. In August 2004, the Kingdom opened an underground storage facility in Jeddah with a reported storage capacity of 945,000 barrels of crude oil and refined products. The purpose of the Saudi Strategic Storage Program is to ensure oil supplies during a crisis. So far, Saudi Arabia has invested more than \$2.9 billion to build underground storage facilities in five sites: Riyadh, Jiddah, Abha, Madinah and Qassim. The facilities are connected via pipeline to the bulk plants and refineries.

Petroleum Infrastructure Security

While details of the Saudi security budget are classified, it is estimated to total more than \$5.5 billion in 2003. And the 2004 security budget is expected to be 50% higher than the previous year, making it by far the highest in the Middle East. Between 2002-2004, the Saudi government allocated approximately \$1.2 billion to increase security at all of its energy facilities. At any one time, it is estimated that there are between 25,000 to 30,000 troops protecting the Kingdom's oil infrastructure. "For years, Saudi Arabia has recognized the importance of protecting its vital facilities, long before the recent terrorist actions. So we've always maintained a high level of security," says Abdullatif Othman, Executive Director of Saudi Aramco affairs.

Recent Patterns of Vulnerability

These concerns are not misplaced. On May 1st, 2004, four attackers broke into the offices of ABB Lummus in Yanbu, a Saudi petrochemical compound, and killed six senior multi-national workers and one Saudi. Al-Qaeda claimed responsibility. The Yanbu attack was followed by a similar incident at the end of May at a residential complex in Khobar that killed 22 people, mainly foreigners. In the first few weeks of June 2004, several more foreign workers were killed, including one who was kidnapped and beheaded. Other terrorist plots have been foiled. In 2002, counter-intelligence investigations uncovered a sabotage plot against the Ras Tanura terminal. Importantly, while many Saudi Aramco workers with suspected extremist sympathies were interrogated, Saudi authorities determined that none of the company's employees were involved.

Al-Qaeda sympathizers are not the only threat to the Saudi oil supply. There is also concern over the large Shiite Muslim population in the Eastern Province (Al Ahsa, where much of the petroleum infrastructure is located). In late 1979 and early 1980, riots among this group were alleged to have been inspired by taped messages of the late Ayatollah Khomeini. In 1996, Saudi Shiite terrorists, trained and financed by Iran's Revolutionary Guard, planted a truck bomb that killed 19 American Air Force personnel at the Khobar Towers near Dhahran, headquarters of Saudi Aramco. Shiites – which make up just under 50 percent of the labor force of Saudi Aramco and around 7.5 percent of Saudi Arabia's

population – have suffered from economic, political, and religious discrimination. The Saudi government has recognized that this represents a potential security threat and has taken steps to address Shiite grievances.

The attacks in Yanbu and Khobar in the spring and summer of 2004 fanned fears about the vulnerability of Saudi Arabia's oil infrastructure, especially in the West, where the media was filled with almost daily reports about instability in the Kingdom and its repercussions on world energy markets. Following the attacks, a senior U.S. State Department official warned that Saudi economic facilities and infrastructure are likely targets of terrorists. And with oil prices at an all time high, such fears gained new urgency in mid 2004. In fact, a "security premium" of at least several dollars was likely factored into the price of oil during that time.

It is important to note, however, that during the attack on Yanbu, Saudi security agents were able to quickly cordon the industrial portions of the facility and force the terrorists away from the compounds and into the city proper, where they were quickly killed; the industrial complex was never in danger. Still, analysts point to several scenarios, which at the very least, could destabilize Saudi oil production.

Saudi Arabia's Improving Security Capabilities

Securing the Kingdom's energy infrastructure, which covers hundreds of square miles, is a complex and daunting task. The Kingdom's five enormous oil fields are connected by thousands of miles of pipeline. Ghawar, the world's largest field, is 150 miles long and 25 miles wide. The Kingdom has fortified its oil infrastructure security through the use of high tech surveillance systems and the creation of special security units, as well as deployment of members of various military and security forces.

Under the auspices of the Ministry of Interior, a special unit has been created to oversee security at the major oil facilities. This unit is made up of representatives from the Special Security Forces, Special Emergency Forces, the General Security Service (the domestic intelligence service), regular forces of the Public Security Administration (including police officers), the Petroleum Installation Security Force (PISF), specialized brigades of the National Guard, the Navy, and the Coast Guard (See Chart 1 and 2 for overview of Saudi security & intelligence).

In most cases, the Petroleum Installation Security Force (supplemented by specialized brigades of the National Guard) guards the wells and other important installations within a given facility. Members of the Special Emergency Forces and elements of the National Guard and regular police forces generally protect the perimeters of these installations. The Navy and Coast guard work to protect terminal docks and off shore fields, and the Air Force provides surveillance and protection from the air. Finally, threat assessment and intelligence gathering is conducted by the General Security Service and members of the Special Security Forces act as an elite anti-terrorism squad.

An example of the intensive security at these facilities can be found at Abqaiq, the Kingdom's largest oil processing facility, and the largest crude stabilization plant in the world. Recently Abdallah Jumah, the CEO of Saudi Aramco, revealed that Abqaiq and other major installations are protected by approximately 5,000 security guards in the employ of Saudi Aramco. These guards work at key checkpoints and act as a police force

within the compounds; the outer perimeter is defended by a specialized brigade of the National Guard and the Special Emergency Forces. At the heart of Abqaiq are ten cylindrical towers within which hydro-desulphurization occurs (the process of making crude oil “sweeter”). Specialized units that work in cooperation with the perimeter forces cordon each tower.

At Ghawar, the world’s largest oil field, security is massive. The Petroleum Installation Security Force protects all major wells in the enormous complex. Outside each of the facilities stand National Guard personnel, as well as elements of the Special Emergency Forces. There is continuous air surveillance from helicopters and round the clock F15 patrols. On the perimeter, heavily equipped National Guard battalions stand guard.

Saudi Arabia’s terminals are similarly well defended. On an average day, anywhere between 2.5 - 3 million barrels of oil flow through the Ras al-Juaymah terminal. From the main platform, the oil flows to five mooring buoys located offshore, each capable of transferring an estimated 1.5 - 2 million bbl/d to awaiting tankers. At Ras Tanura, the average capacity is 4.5 – 5 million bbl/d, with one platform alone handling 47% of the terminal’s exports. Clearly, a successful attack on one of these terminals or on the off-loading platforms could be devastating. For this reason, security at these complexes is colossal and comprehensive. Each terminal and platform has its own specialized security units, comprised of Saudi Aramco security forces and specialized units of the National Guard and the Ministry of Interior. The Coast Guard and components of the Navy protect the installations from the sea. The thousands of tankers entering and leaving these areas each year are escorted by naval ships and covered from the air. Pilots at the Dhahran airbase (only 10-15 minutes flying time from Ras Tanura) are trained to defend against any hijacked aircraft.

Perhaps the weakest link in the system is the estimated 17,850 kilometers of pipeline in the Kingdom. While it is impossible to protect the entire length from sabotage, Saudi security forces have ensured that any damage can be quickly contained and repaired. The pipeline is monitored and controlled from a central command center at Saudi Aramco, so that any suspicious activity can be immediately investigated. Strategically located along the length of the line are specialized backup teams, which can be quickly dispatched by helicopter to repair any damage. Internal estimates reveal that in a worst-case scenario – where an entire section of pipeline is destroyed – repair teams could bring the pipeline back to normal operation within 36 hours (Saudi Arabia maintains the world’s largest stockpile of repair pipeline, stored throughout the length of the pipeline).

Overall Vulnerability

It is impossible to completely eliminate the threat of terrorism against the Kingdom’s energy infrastructure, and Saudi Arabia faces the threat of conventional military attack, asymmetric warfare, and proliferation as well. Given the recent security efforts by the Saudi government (much of which remains classified), the overlapping and redundant layers of defense around key installations, and the extensive disaster planning

and drills that has taken place has significantly lessens the probability of any major attacks being carried out successfully.

Short of a spectacular strike on the scale of 9/11, or some form of systematic sabotage from inside Saudi Aramco or other key energy industries, most foreseeable assaults are likely to be quickly confined and any resulting damage is likely to be repaired relatively quickly. Energy security will, however, be a continuing problem for Saudi Arabia and the world. Moreover, global energy use expected to rise by more than 50% by 2025, and the security of Saudi energy exports will play a steadily more vital role in the world's economy.

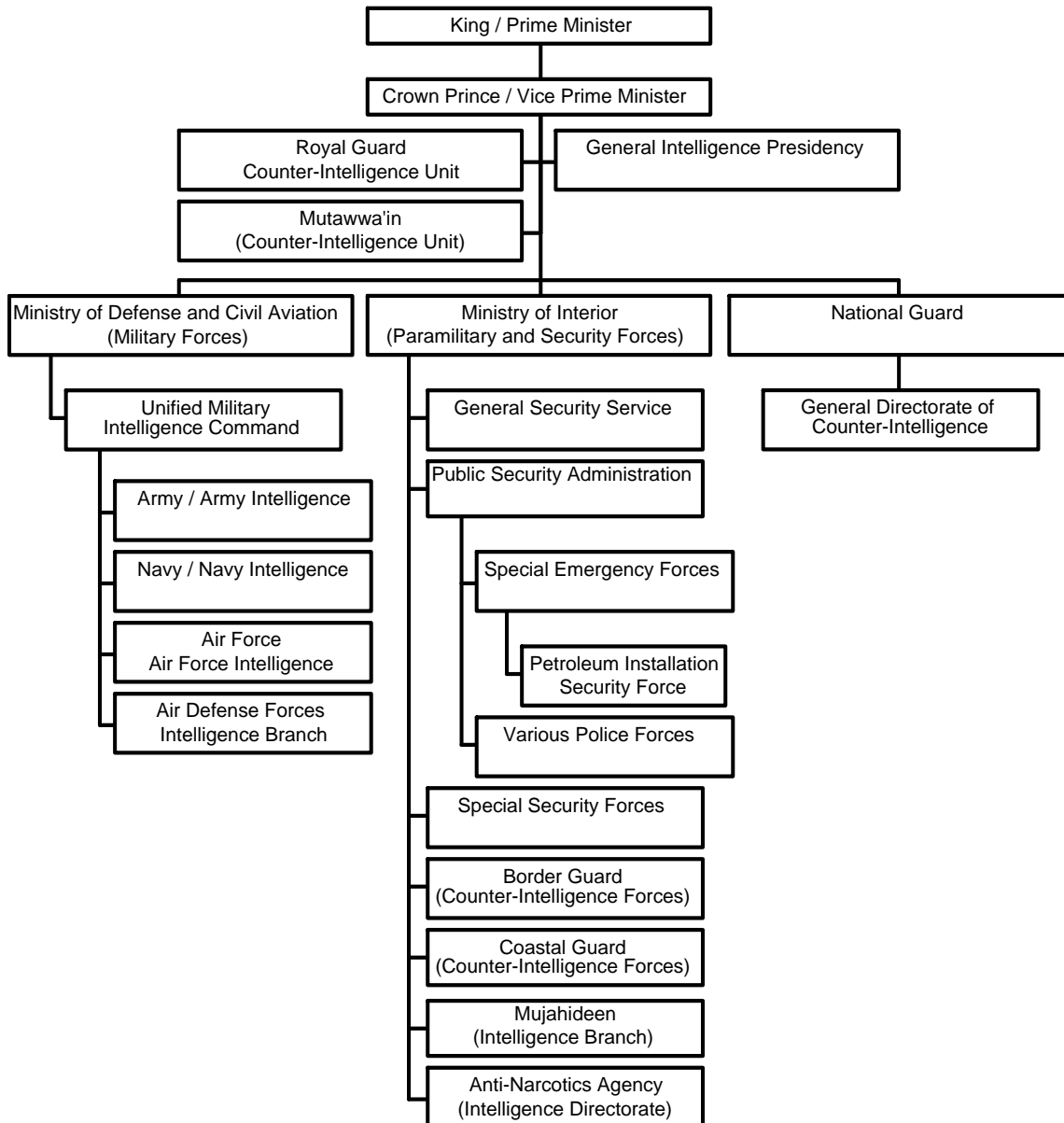
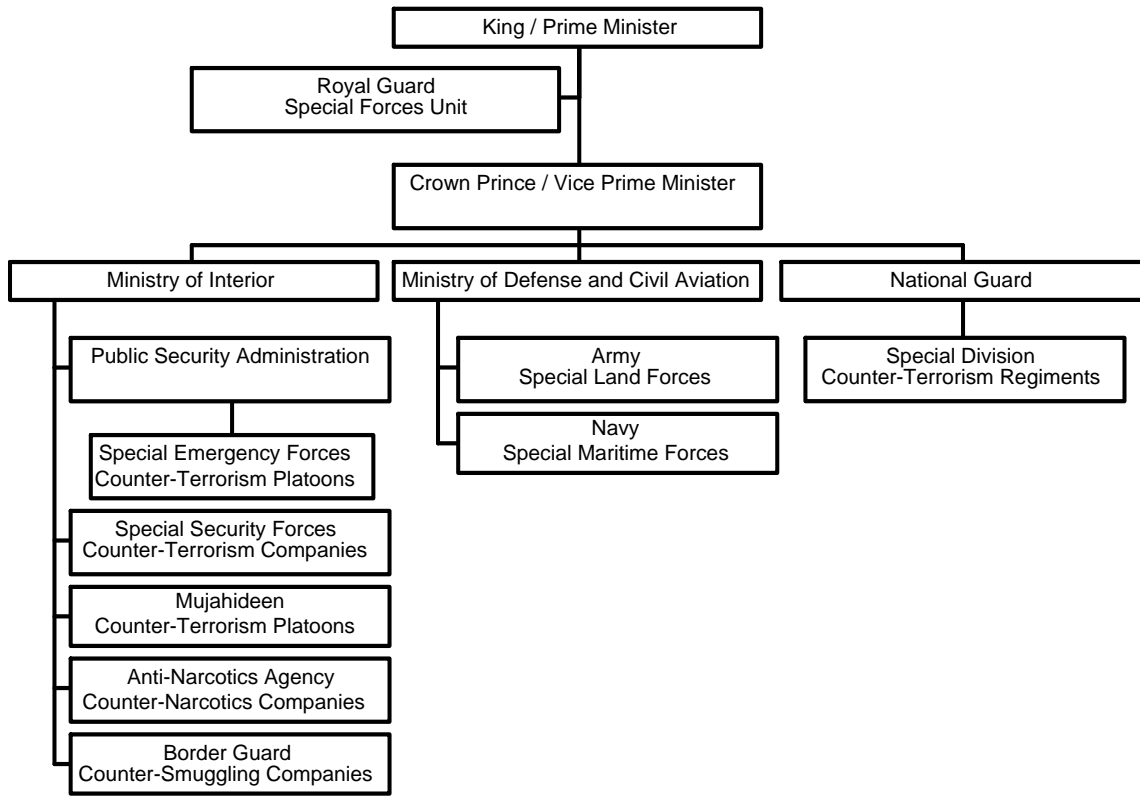
Chart 1: The Saudi Intelligence and Security Community

Chart 2: Saudi Counter-Terrorism Forces

ⁱ See EIA/DOE, Saudi Arabia, Country Study, June 2004, <http://www.eia.doe.gov/emeu/cabs/saudi.html>

ⁱⁱ EIA/DOE, Saudi Arabia, Country Study, June 2004, <http://www.eia.doe.gov/emeu/cabs/saudi.html>

ⁱⁱⁱ EIA/DOE, Saudi Arabia, Country Study, June 2004, <http://www.eia.doe.gov/emeu/cabs/saudi.html>

^{iv} EIA/DOE, Saudi Arabia, Country Study, June 2004, <http://www.eia.doe.gov/emeu/cabs/saudi.html>

^v EIA/DOE, Saudi Arabia, Country Study, June 2004, <http://www.eia.doe.gov/emeu/cabs/saudi.html>

^{vi} This analysis is adapted from the text in EIA/DOE, Saudi Arabia, Country Study, June 2004, <http://www.eia.doe.gov/emeu/cabs/saudi.html/>

^{vii} EIA/DOE, Saudi Arabia, Country Study, June 2004, <http://www.eia.doe.gov/emeu/cabs/saudi.html/>.