Global Oil Choke Points

How Vulnerable Is the Global Oil Market?

SECTOR VIEW

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Asia Oil & Gas:	1 – POSITIVE
European Oil & Gas:	1 – POSITIVE

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The global oil market is very vulnerable to potential supply disruptions, given that reserves are heavily concentrated among a handful of major producers and consuming centers are often far from producing basins. In this report, we identify 10 vulnerable points along the supply chain or "choke" points where disruption could interrupt a substantial volume of oil flow. About 55 million b/d or 64% of the world's total oil flows through these points, with the top three alone accounting for 46% of the total supply. For each choke point, we provide an assessment of its potential impact on the global oil trade and the possible threat it currently faces.

- Crude oil production and reserve are heavily concentrated among a handful of major producers and regions. In 2006, the Middle East accounted for 62% of the world's identifiable proved liquid reserves and 31% of the output. Eight of the top 10 producers are net oil exporters that collectively supply roughly 29 million b/d of crude oil and petroleum products to the rest of the world, or 34% of the global oil demand.

- Major oil producing basins are often located far away from the consuming centers. Seven of the world's 10 largest consuming countries lack sufficient oil production capacity to meet their internal consumption and report a total deficit of about 30 million b/d, or more than 35% of the world's demand. According to *BP Statistical Review of World Energy,* the petroleum market's average physical trading volume between major regions exceeded 52 million barrels per day in 2006, or approximately $1.7 trillion a year in today's price levels.

- Choke points: Straits of Hormuz, Strait of Malacca, Abqaiq processing facility, Suez Canal, Bab el-Mandab, Bosporus/Turkish Straits, Mina al-Ahmadi terminal (Kuwait), Al Basrah oil terminal (Iraq), LOOP (United States), Druzhba pipeline (Russia).

PLEASE SEE ANALYST(S) CERTIFICATION(S) ON PAGE 41 AND IMPORTANT DISCLOSURES INCLUDING FOREIGN AFFILIATE DISCLOSURES BEGINNING ON PAGE 42

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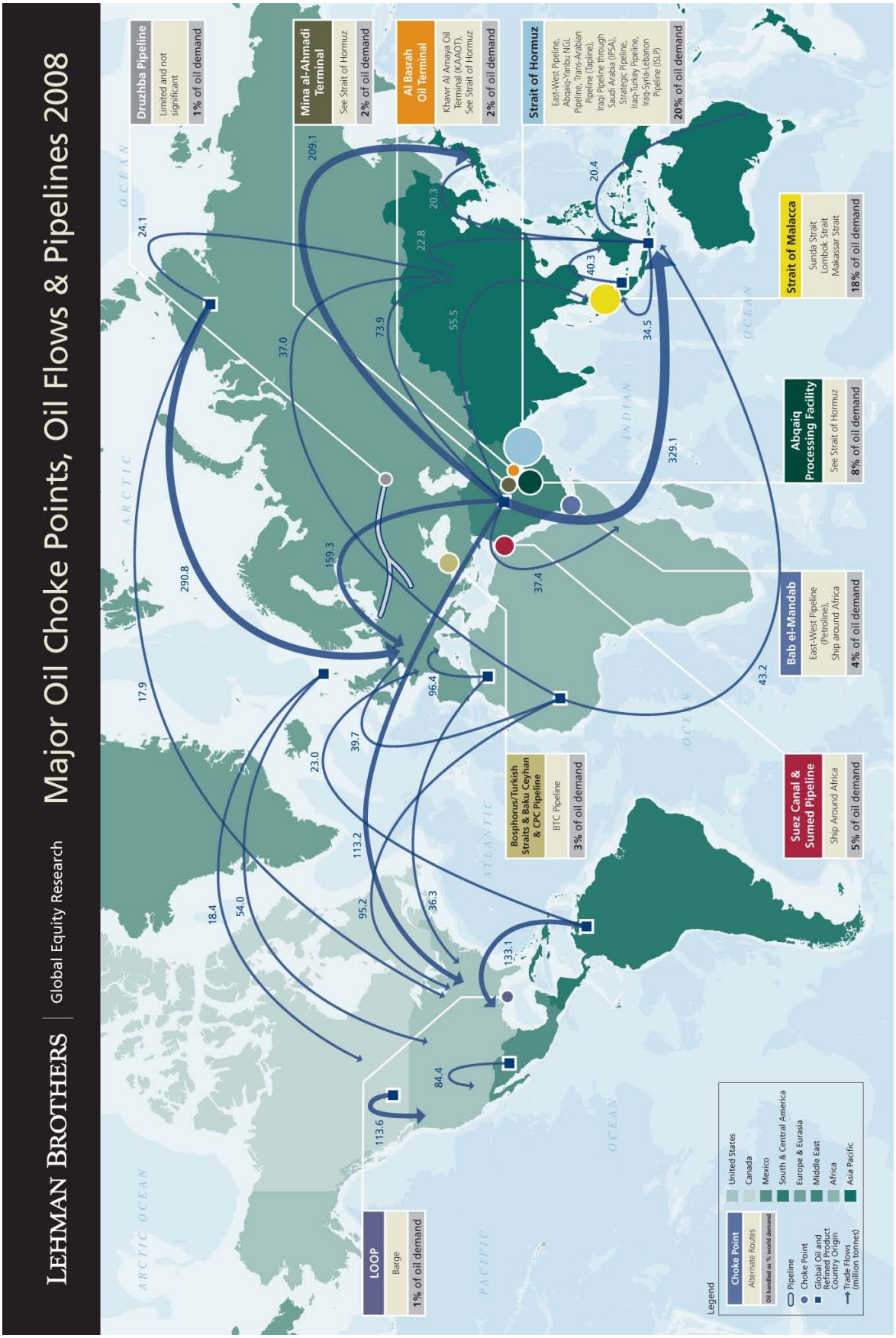


Source: Company Reports and Lehman Brothers research

Investment Conclusion

How vulnerable is the global oil market to supply disruption? This is a question that has been repeatedly raised in recent years by policy makers, industry executives, and the investment community. At first glance, the answer to this question seems trivial: The global oil market is clearly vulnerable to potential supply disruptions. However, it becomes less trivial when we try to quantify the potential risks in term of their impacts on the global petroleum supply/demand balance as well as the probability of such a disruption.

As a starting point, there is more than one potential weak link in the highly complex and interconnected global petroleum market. It is a truly global product and consists of several rather distinct characteristics that differentiate petroleum from any other commodity.

The world's top 10 producers represent approximately 62% of the global output.

1. Crude oil production and reserve are heavily concentrated among a handful of major producers and regions. In 2006, the Middle East accounted for 62% of the world's identifiable proved liquid reserves and 31% of the output. The world's top 10 producers represent approximately 62% of the global output. Eight of the top 10 producers are net oil exporters that collectively supply roughly 29 million b/d of crude oil and petroleum products to the rest of the world, or 34% of the global oil demand.

Seven of the world's 10 largest consuming countries report a total deficit of about 30 million b/d, or more than 35% of the world's demand.

2. The major oil producing basins are often located far away from the consuming centers. Seven of the world's 10 largest consuming countries lack sufficient oil production capacity to meet their internal consumption, and these countries report a total deficit of about 30 million b/d, or more than 35% of the world's demand. According to the *BP Statistical Review of World Energy,* the petroleum market's average physical trading volume between major regions exceeded 52 million barrels per day in 2006, or approximately $1.7 trillion a year at today's price levels. Moreover, as a result of declining production at the historical core-producing basins in the OECD region such as North America and North Sea as well as rising demand in China, India, and other developing Asian countries, the pace of global oil trade and the world's dependence on longer haul supply have been increasing sharply over the last several years. Not surprisingly, the bulk of global petroleum trade relies heavily on marine transportation.

3. Crude oil export revenue contributes the lion's share of the foreign currency earnings and government budget for most of the major oil-exporting countries. Thus, any prolonged downward price pressure could trigger severe consequences and could potentially destabilize the balance of power in several sensitive regions.

4. OPEC is the only legitimate and active price-setting cartel that we know of in the global marketplace. Therefore the cartel's actions may potentially at times distort the underlying fundamental price setting mechanism in the marketplace (at least temporarily). As a result, we think the existence of OPEC contributes both stability as well as uncertainty. If OPEC is the central bank of the global oil market, then Saudi Arabia could be considered its president.

To better understand the supply risks that we face today, we outline our list of the top 10 global oil choke points in this report. While the Energy Information Administration (EIA) has published in the past a list of 10 transit choke points, we have expanded our scope to include ports, processing centers, or any other systems where disruption could potentially interrupt or even eliminate a substantial volume of the worldwide oil flow/supply. Figure 1 shows the 10 chokepoints we selected in the order of their importance. For each choke point, we provide an assessment of its potential impact on the global oil trade and the possible threat it currently faces.

Figure 1: Lehman Brothers Choke Points

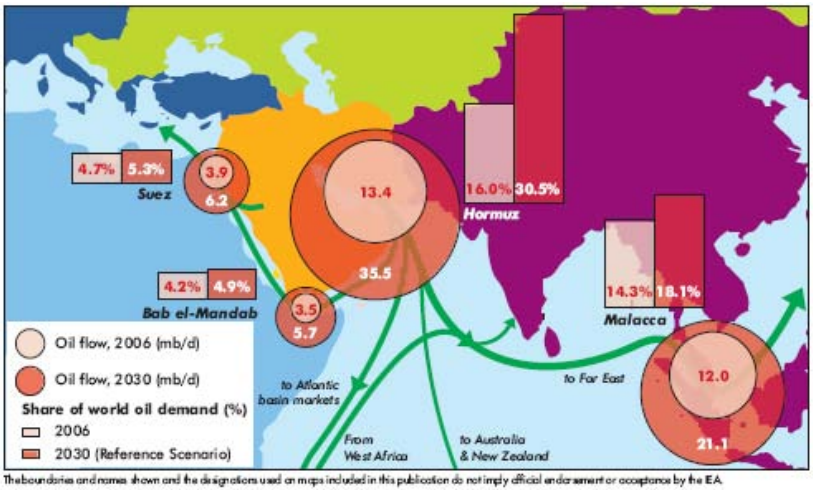
No.	Choke Points	Capacity, mm b/d	% of total world demand	Export destination	Location, comments
1	Strait of Hormuz	16.5-17.0	20%	Europe, U.S., Asia	Narrow waterway between the Gulf of Oman in the southeast and the Persian Gulf in the southwest.
2	Strait of Malacca	15.0	18%	Asia	The Strait of Malacca lies between Malaysia and Singapore and connects the Indian Ocean with the South China Sea and the Pacific Ocean
3	Abqaiq processing facility	6.8	8%	Europe, U.S., Asia	The town, northeast of some of the largest Saudi oilfields (including the large Ghawar field), houses the largest oil processing plant in the world and handles around two-thirds of the entire oil production of Saudi Arabia.
4	Suez Canal and Sumed Pipeline	4.5	5%	Europe, U.S.	The Suez Canal, located in Egypt, connects the Red Sea and Gulf of Suez with the Mediterranean Sea.
5	Bab el-Mandab	3.3	4%	Europe, U.S., Asia	Connects the Red Sea with the Gulf of Aden and the Arabian Sea
6	Bosporus/Turkish Straits + Baku Ceyhan + CPC pipeline	2.4	3%	Western and Southern Europe	Turkey, connects the Black Sea with the Mediterranean Sea
7	Mina al-Ahmadi terminal, Kuwait	2.0	2%	Europe, U.S., Asia	An oil port is north of Ash Shuaiba, and handles most of Kuwait's petroleum exports
8	Al Basrah oil terminal, Iraq	1.5	2%	Europe, U.S., Asia	The Al Basrah Oil Terminal (ABOT) is an offshore crude oil marine loading terminal located off the south-eastern coast of Iraq in the Northern Persian Gulf. According to the U.S. Embassy in Iraq, ABOT is Iraq's primary oil terminal and accounts for 97% of Iraq's oil exports into world markets.
9	LOOP, U.S.	1.2	1%	United States	Deepwater port in the Gulf of Mexico off the coast of Louisiana. Most tankers offloading at LOOP are too large for U.S. inland ports. LOOP handles 13% of the nation's foreign oil, about 1.2 million b/d, and connects by pipeline to 35% of the U.S. refining capability.
10	Druzhuba pipeline, Russia	1.2	1%	Europe	2,500 miles, Russian Druzhba export pipeline connected to Adria pipeline (flows reversed) to terminus at Omisalj (Croatia)
	Total	54.9	64%		

Source: Lehman Brothers research

Interlinkages Between Choke Points and Alternate Routes

Since maritime routes are all interconnected, tankers heading toward or away from Abqiaq, Al Basrah oil terminal, and the Persian Gulf face additional chokepoints. In the nearest vicinity, the Straits of Hormuz proves to be a bottleneck for vessels accessing the Arabian Sea for world markets. For ships heading toward Asia, the Strait of Malacca is a probable chokepoint and for destinations to the Western countries, Bab El-Mandeb en route to the Suez Canal/Sumed Pipeline face additional bottlenecks. Figure 2 below shows interlinkages between some of the chokepoints.

Figure 2: Linkages Between Choke Points



Source: IEA Oil Supply Security 2007

Cushion: OECD Inventory and Drawdown Rates

Since excess inventory is a source of future readily available supply in the event of disruptions, we think it is important to consider inventory as part of the overall supply mix, particularly in light of the existing massive government strategic petroleum inventory reserve in the OECD countries. Total OECD crude inventory at the end of October 2007, stood at 2.2 billion barrels. Including products, this rises to 4.2 billion barrels, or about 139 days of forward import coverage (imports are about 30 million b/d). Figure 4 shows the maximum drawdown rates of their strategic reserve by the OECD countries. The maximum that OECD countries can draw from stocks in the first month of any disruption is estimated to be 12.9 million b/d, which is 43% of their total import requirement.

Figure 3: Crude Inventory

Million barrels	U.S.	North America	Europe	Asia	Total
Government-controlled (SPR)	283	694	177.4	385	1,257
Industry	697	450	317	174	940
Total crude stocks	979	1,144	494	559	2,197
Total stocks (crude + products)		1,985	1,375	832	4,193

U.S. data are as of last week, Other stock data are as of October 2007.

Source: IEA, EIA

Figure 4: Maximum Drawdown Rates

000 b/d Month	U.S. SPR	Japan JNOC	Germany EBV	France CPSSP	Spain CORES	Other	Total
1	4,267	1,870	1,899	480	975	3393	12884
2	4,200	2,139	1,899	397		798	9433
3	4,200	1,765	1,899	397		356	8617
4	4,200	1,244	605	397		246	6692
5	2,900	1,159	605	183		33	4880
6	1,700	693		70			2463
7	950	657		27			1634
8	220	390					610
9		127					127
10		102					102
11		84					84
12		102					102
Stocks, Million bbls	689	316	196	59	31	126	1417

Source: IEA, EI, Lehman Brothers estimates

U.S. Security Measures for Strategic Oil Facilities

As the world's biggest oil importer and consumer, the United States is well aware of its vulnerability to potential terrorist attacks on the strategic oil facilities around the globe. According to the *Oil Daily (published November 16, 2006),* a new initiative—dubbed the Global Critical Energy Infrastructure Protection Strategy—has been established under the State Department's Critical Infrastructure Protection office in the aftermath of the Abqaiq attack in early 2006 (the task force has been officially set up since May 2006).

This new effort aims to encourage information, expertise, and technology transfer to increase security at strategic oil installations. The United States has approached other governments for bilateral security cooperation, including potential data sharing (such as tests conducted by the U.S. Department of Homeland Security on blast walls or breaching of security perimeters), which would provide experienced security personnel for consultation, and so forth.

The program is currently focusing primarily on oil facilities that exceed 1 million b/d of capacity, with the secondary attention on installations of more than 500,000 b/d. So far, it is only targeting the oil operations and does not include the natural gas facilities.

Strait of Hormuz

The Strait of Hormuz is a narrow waterway between the Gulf of Oman in the southeast and the Persian Gulf in the southwest. On the north coast is Iran (Persia) and on the south is the United Arab Emirates and Musandam, an exclave of Oman.

Description: The narrowest section of the strait is only 21 miles wide, having two one-mile-wide channels for marine traffic separated by a two-mile-wide buffer zone. It is the only sea passage to the open ocean for several petroleum-exporting Persian Gulf States.

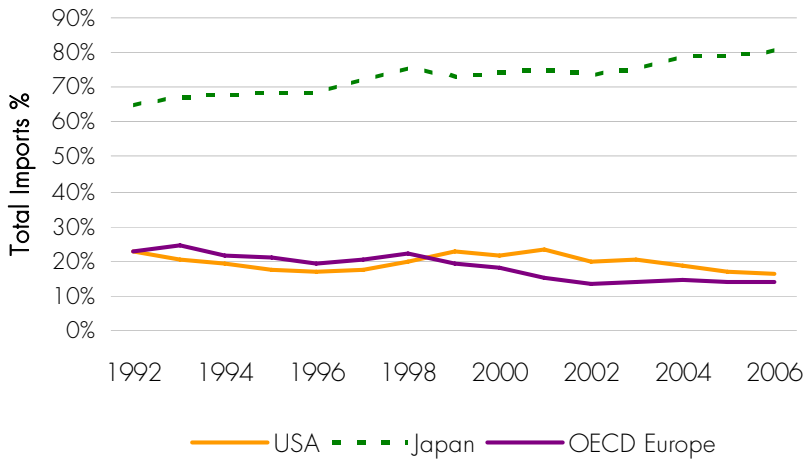
Figure 5: Map of Strait of Hormuz

Source: Lehman Brothers

Oil Flows

Approximately 16.5 million–17.0 million b/d, or 20% of the world oil supply flows through the Strait of Hormuz to Japan, Europe, the United States, and other Asian countries. EIA estimates about 18% of U.S. net oil imports, 20% of Western Europe (OECD), and 80% of Japan's total oil imports sourced from the Persian Gulf last year, while about 93% of oil exported from the Persian Gulf, is transited by tanker through the Strait of Hormuz. As a result, any aggression by Iran or any other nation would disrupt a large portion of the world's oil supply and economy.

Figure 6: Gross Oil Imports from the Persian Gulf as Percent of Total Gross Oil Imports



Source: EIA

Security Remains a Concern

Since Oman, Iran, and the United Arab Emirates share the border around the Straits, all three countries are crucial in fostering a secure environment there. Oman and the UAE are among the key U.S. allies in the region. The United States supplies both countries with most of their arms purchases, including advanced fighter aircraft such as the F-15 and F-16. In addition, the United States has maintained a substantial naval carrier task force in the Persian Gulf area.

Not surprisingly, the Straits of Hormuz top our list of the global oil choke points. During the Iran/Iraq war, there were attacks on third-party tankers that resulted in a 25% reduction in tanker traffic through the Gulf at the worst point. More recently, in March 2007 and January 2008, there were concerns about either an Iranian attack on a U.S. vessel or a U.S. attack on an Iranian vessel. According to Lehman Brothers energy economist Ed Morse, the United States in March 2007 undertook the largest naval exercises in the Persian Gulf since the 2003 attack on Iraq.

Alternate Routes

See pages 32–33.

Straits of Malacca

The Strait of Malacca lies between Indonesia, Malaysia, and Singapore, connecting the Indian Ocean with the South China Sea and the Pacific Ocean. This is the shortest sea route between the Persian Gulf and the Asian markets.

Description: The Strait of Malacca remains one of the most important shipping lanes in the world because of its high-volume traffic of more than 50,000 vessels a year. This is more than double the number that crosses the Suez Canal and about three times the number of ships that use the Panama Canal. However, the narrow channels, shallow reefs, and tiny islands create a natural bottleneck that drastically raises the risk of collision. The narrowest point of this strait is the Phillips Channel in the Singapore Strait, which is only 1.7 miles wide at its narrowest point. Pirate attacks have also been a repeated problem in this part of the world.

Figure 7: Straits of Malacca Map

Source: Lehman Brothers

Oil Flows

Approximately 15 million b/d of oil and petroleum products flow through the Strait of Malacca, the second highest volume behind the Strait of Hormuz. Oil flows from the Persian Gulf, to the Indian Ocean, through the Strait of Malacca, to the South China Sea and Pacific Ocean toward Japan, South Korea, China, and other Pacific Rim countries.

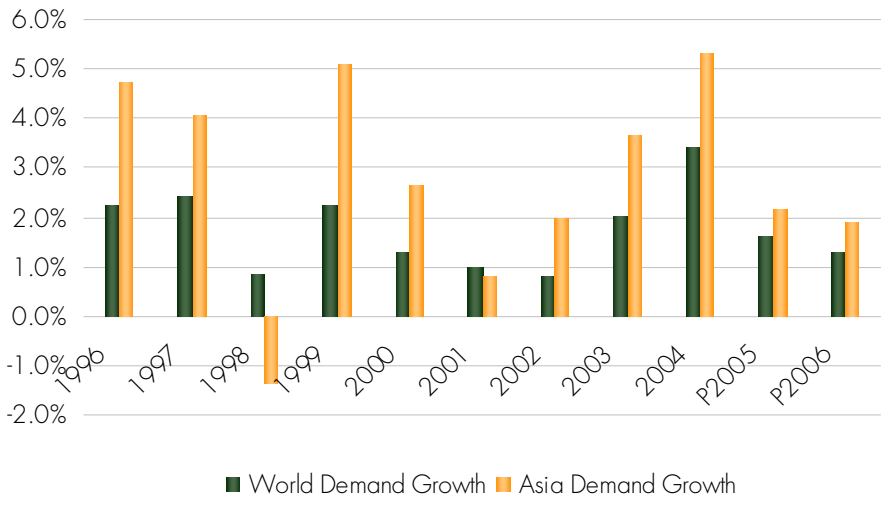
According to the U.S. Department of Homeland Security, approximately 30% of the world's trade and half of its oil transit through the Strait of Malacca and Singapore. Closure of this waterway would raise freight rates worldwide and cause severe shipping delays, as alternate routes around the Lombok and Sunda Straits are substantially longer. With roughly half of the world's fleet required to sail further, any disruption at the Strait of Malacca will likely lead to significant increased vessel capacity requirements.

Rising Asian Oil Demand Will Likely Lead to Substantial Traffic Increase

Even assuming the region's demand growth rate will slow to 2% a year, the region's oil demand could rise by 50% over the next 20 years.

Fueled by robust economic growth, non-OECD Asia oil demand is projected to rise much faster than the rest of the world over the next two decades. Since 1996, Asia Pacific has increased oil consumption by an average of 2.8% a year compared with the global growth rate of 1.7%. As consumption in these countries grow, the Strait of Malacca will likely report significant increase in maritime traffic. Even assuming that the region's demand growth rate will slow to 2% a year, the region's oil demand could rise by 50% over the next 20 years. We expect the bulk of increased demand will require long-haul supplies from the Middle East and Africa. However, it is questionable that the Strait of Malacca waterway could accommodate the expected traffic increase.

Figure 8: Asia Pacific and Global Oil Demand Growth, 1996–2006



Source: EIA, Lehman Brothers

Alternate Routes

Although the Strait of Malacca has undesirable navigational features, it remains the preferred route for international shippers compared with alternative routes such as the Sunda or Lombok-Makassar straits. Figure 7 marks these alternate routes on a map.

The Sunda Strait: lies between the Indonesian islands of Java and Sumatra and connects the Java Sea to the Indian Ocean. It is 50 miles long and 15 miles wide on its northeastern entrance, with a deep depth level at its western end that becomes shallower in

parts of its eastern end (depth of only 20 meters, or 65 feet). Because the strait is narrow and shallow at certain points, it is extremely difficult to navigate through and is not favored by oil tankers. Other hazards include strong tidal flows, man-made obstructions such as oil drilling platforms to the north of western Java, a volcano, and tiny islands.

Although the Lombok and Makssar Straits do not have navigational hazards along the channel, these routes require an additional 3.5 days, which add to transportation cost.

Lombok/Makassar Straits: The Lombok Strait is located between the islands of Bali and Lombok, while the Makassar Strait lies between the islands of Borneo and Sulawesi in Indonesia. Most ships transiting the Lombok Strait also pass through the Makassar Strait. It is the safest route for supertankers because it is wider, deeper, and less congested than the Strait of Malacca. According to the Maritime Institute of Malaysia (MIMA), although the Lombok and Makssar Straits do not have navigational hazards along the channel, these routes require an additional 3.5 days at a speed of 14–16 knots and an extra mileage of 1,600 nautical miles, which add to transportation cost. Results show that only tankers of more than 300,000 dwt (Ultra Large Crude Carriers or ULCCs) have been using this waterway to transport crude from the Persian Gulf to Asia, but the number of these vessels has declined.

Proposals to Relieve the Strait of Malacca

Proposed Isthmus of Kra Pipeline: A 320 km (193 mile) pipeline is proposed to be built across the Ishmus of Kra in northern Malaysia from the Kedah state, across Perak state, to northeastern Kelantan state. The pipeline is expected to become operational in 2014, transporting about 20% of the oil currently transiting the strait, and potentially cut three days off the journey from the Middle East to China, Japan, and South Korea. Several proposals have been submitted for the pipeline construction, one of which involves the construction of a coastal refinery. However, in July 2007, Malaysian Prime Minister Abdullah Ahmad Badawi instead retracted his decision and opted to examine the cost and environmental impact of the proposed pipeline. Considering the difficulty of laying pipeline across the northern mountain range and the high cost involved, the probability of the pipeline project carrying through is debatable.

Compared with the Sunda route, the canal would cut 2,500–3,000 km (four to five days); or 3,000–3,500 km (five to seven days) instead of Lombok.

Thai Government Proposed Canal Via Isthmus of Kra (Thai Canal): Throughout the course of its history dating back to King Narai the Great, the Thai government has proposed to build a canal through the Isthmus of Kra. The canal would shave off 1,200–1,400 km, or one to three days, versus the Strait of Malacca route. Compared with the Sunda route, the canal would cut 2,500–3,000 km (four to five days); or 3,000-3,500 km (five to seven days) instead of Lombok. The Thai Canal is projected to take around five to seven years to build at a cost of Bt650bn ($22 billion). Although the project has received strong support from some Thai politicians, it remains somewhat unlikely to proceed as hoped, given its high price and unfavorable environmental impact.

We note some discrepancies from various sources concerning the aforementioned project details and their likelihood of completion.

Abqaiq – The Well-Protected Fort

Abqaiq is a small Saudi Aramco camp in the interior of the Eastern Province of Saudi Arabia. The town, northeast of some of the largest Saudi oilfields (including the huge Ghawar field) houses the largest oil processing plant in the world and handles around two-thirds of the entire oil production of Saudi Arabia. It covers approximately one square mile.

Figure 9: Map of Abqaiq

Source: Lehman Brothers

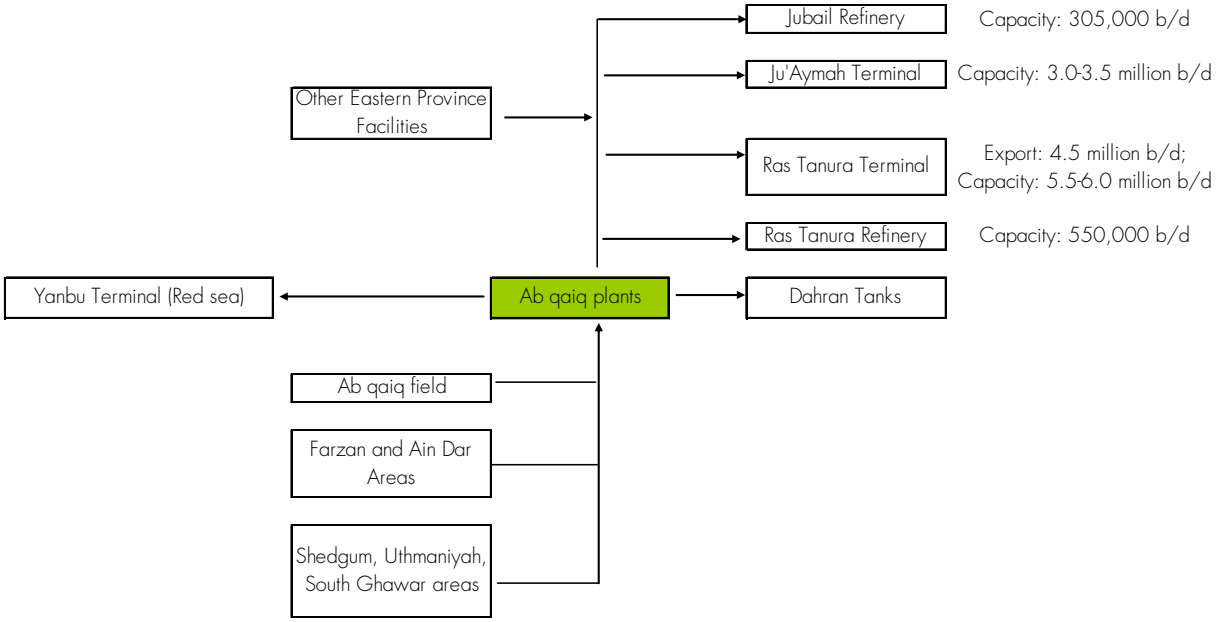
Oil Flows

Abqaiq processes around 6.8 million b/d of crude oil, or more than two-thirds of total Saudi oil production. After the raw crude stream (oil, natural gas, water, sand, etc.) are processed by the GOSPs (Gas Oil Separation Plants), the sour oil (containing H2S, hydrogen sulphide) is sent by pipeline to Abqaiq. Upon completion of the processing, oil is pumped to Ras Tanura (where it is exported), or further refined at a domestic refinery. Abqaiq also has NGL (Natural Gas Liquids) plants that extract natural gas liquids (butane, propane, hexane, etc.), which will then send to other sites for further separation and purification. Figure 8 below shows the oil flows to and from Abqaiq facility.

Ras Tanura is the biggest oil-exporting port in the world. On average, this port exports around 4.5 million b/d of oil (capacity of 5.5 million–6.0 million b/d). The other terminal

north of Ras Tanura on the Gulf is Ras al-Juaymah (3.0 million–3.5 million b/d). Abqaiq also supplies two refineries—Ras Tanura (550,000 b/d) and Jubail (305,000 b/d).

Figure 10: Abqaiq Oil Facility Relationship in the Saudi Oil Network

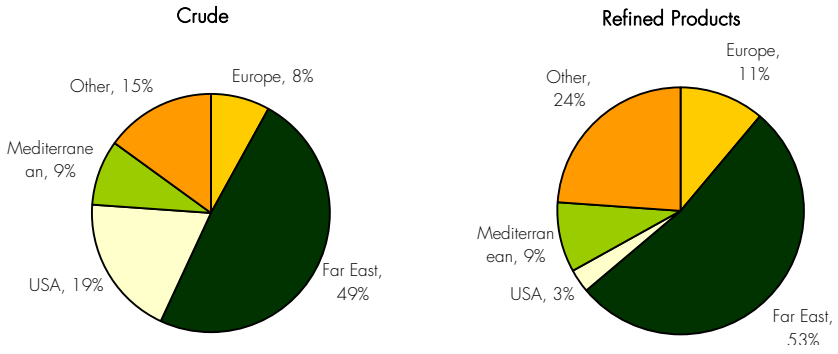


Source: Lehman Brothers, Saudi-US Relations Information Service

Countries Affected

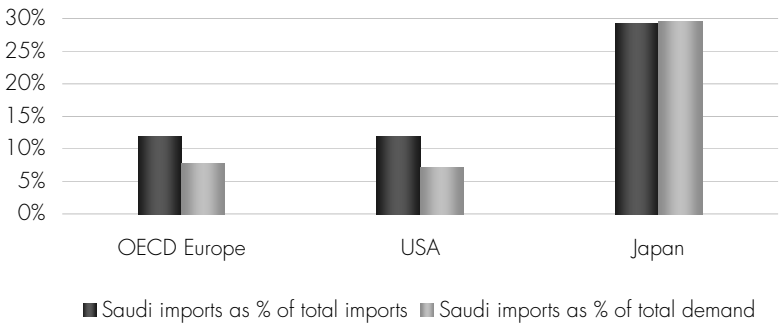
Figure 11 below shows the split of Saudi exports. All of the oil through Ras Tanura and Ras al-Juaymah passes through the Straits of Hormuz, which is another choke point we discussed earlier in this report. Total Saudi exports account for 8% of oil demand in OECD Europe, 7% for the United States, and 29% for Japan.

Figure 11: Saudi Exports by Region (2005 Data)



Source: www.eia.com

Figure 12: Significance of Saudi Imports to Consumers



Source: www.eia.com

Security for Abqaiq

According to Abdallah Jumah, the CEO of Saudi Aramco, Abqaiq and other major installations are protected by approximately 5,000 security guards directly employed by Saudi Aramco. These guards work at key checkpoints and act as a police force. In addition, 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, there are 10 cylindrical towers within in which hydro-desulphurization occurs. Specialized units that work in cooperation with the perimeter forces safeguard each tower. On top of that, Saudi security officials said that Abqaiq is highly redundant. Saudi officials believe that even in the event of a successful strike in one area of the facility, output could be maintained by shifting the processing to other areas.

Security for Saudi Oil facilities

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 forces shown in Figure 13. At any given time, there are an estimated 25,000 to 30,000 troops protecting the Kingdom's infrastructure. Each terminal and platform has its own specialized security unit, comprised of 5,000 Saudi Aramco security forces and an unknown number of specialized units of the National Guard and Ministry of Interior. At Ghawar, the world's largest oil field, security is extensive. The Petroleum Installation Security Force protects all major wells in this vast 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 around the clock F15 patrols. On the perimeter, heavily equipped National Guard battalions stand guard.

The abortive terrorist attack on Saudi Arabia's giant Abqaiq oil processing complex in February 2006 and more recent direct threats by Al-Qaeda against oil infrastructure have highlighted the challenges faced by the Saudi authorities as they seek to maintain their reputation for secure and reliable oil production and exports to global markets. Mindful of the sustained terrorist threat, Saudi Interior Minister Price Naif ibn 'Abd al-'Aziz told the Shura Council on July 1 that the Interior Ministry was establishing a 35,000 strong

Facilities Security Force (FSF) with a remit to protect not just oil and gas infrastructure but also power and water facilities as well as other major industrial assets including petrochemicals, metals, and other industries. The force will be recruited over the next two years.

Figure 13: Forces Guarding Oil Infrastructure in Saudi Arabia

Type of Force	Responsibility
Special Security Forces	An elite antiterrorism squad
Special Emergency Forces	Protect the perimeters of oil & gas installations
General Security Service	Threat assessment and intelligence gathering
Public Security Administration (including police officers)	Protect the perimeters of oil & gas installations
Petroleum Installation Security Force (PISF)	Guards the wells and other important installations within a given facility
Specialized brigades of the National Guard (SANG)	Protect the perimeters of oil & gas installations
Navy	Work to protect terminal docks and off shore fields
Coast Guard	Work to protect terminal docks and off shore fields

Source: Lehman Brothers

Kingdom's Pipeline Network Is the Weakest Link

Saudi's pipeline network is 11,092 miles long. Even though 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 that 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).

Suez Canal and Sumed Pipeline

The Suez Canal, located in Egypt, connects the Red Sea and Gulf of Suez with the Mediterranean Sea. It is located on the west of the Sinai Peninsula and serves as a two-way water transport route between Europe and Asia.

Description: The Suez Canal serves as a two-way water transport route between Europe and Asia. It is 190 km long and 300 meters wide. The canal supports approximately 8% of the world's shipping traffic with almost 50 vessels traveling through the canal daily. Because of its narrow width, it can be easily blocked and led to a major disruption in oil transport.

The Suez Canal is 1,000 feet at its narrowest point and is unable to handle large tankers. According to EIA, the Suez Canal Authority (SCA) is discussing the possibility of widening and deepening the canal to accommodate very large carrier-type vessels (VLCC) and ULCC.

Sumed (also known as *Suez-Mediterranean pipeline*) consists of two parallel 42-inch lines running 200 miles. The pipeline has been in operation since January 1977 and has served as an alternative to the Suez Canal to transport loads from tankers that are too large to pass fully laden through the canal. The pipeline is owned by Arab Petroleum Pipeline Co., a joint venture of EGPC (50%), Saudi Aramco (15%), Abu Dhabi's ADNOC (15%), three Kuwaiti companies (15% total), and Qatar's QGPC (5%).

Figure 14: Map of Suez Canal

Source: Lehman Brothers

Oil Flows

Approximately 4.5 million b/d flows through the Suez Canal (1.4 million b/d) and Sumed pipeline (3.1 million b/d), or about 5% of the global oil supply. It serves as an important

transit avenue for oil traveling from the Persian Gulf to Europe (some oil also goes to the United States). According to EIA, Saudi Arabia exported roughly all of 2.3 million b/d crude oil northbound shipments through the Sumed in 2006.

Concerns

Closure of the Suez Canal and/or Sumed Pipeline would divert tankers around the southern tip of Africa (the Cape of Good Hope), adding greatly to transit time and tying up significant tanker capacity.

The Suez Canal has been closed twice in the past, first in 1956 and again from 1967 to 1975.

Figure 15: Key Dates and Events

July 1956	The United States and the United Kingdom withdrew their pledge to support the construction of the Aswan Dam; Egyptian president Gamal Abdel Nasser seized the canal and declared it to be the property of the Egyptian people.
October 29, 1956	Britain, France, and Israel invaded Egypt.
November 4, 1956	The United Nations ordered them to leave and decreed the Suez Canal to be the property of Egypt.
June 1967	The canal was closed due to the outbreak of the Six-Day War; Israel took over the Sinai Peninsula, which resulted in the Suez Canal becoming a buffer zone between the forces of fighting.
1973	Egypt reclaimed the Suez Canal in the 1973 Arab-Israeli War.
June 5, 1975	The canal was reopened.

Source: Lehman Brothers

Alternate Route

Ship around Africa: While the Sumed Pipeline acts as an alternative route for the Suez Canal, the only alternative in both cases is for the ships to be detoured around the Cape of Good Hope. This route would significantly increase shipping costs as well as transportation time, as oil tankers would have to divert their route several thousands of miles. It would take approximately12–14 additional days to reach the same European destination.

The Sumed pipeline is a 320-km-long oil pipeline that links the Ain Sukhna terminal on the Gulf of Suez with Sidi Kerir on the Mediterranean. It provides an alternative to the Suez Canal for transporting oil from the Persian Gulf region to the Mediterranean.

Bab El-Mandeb

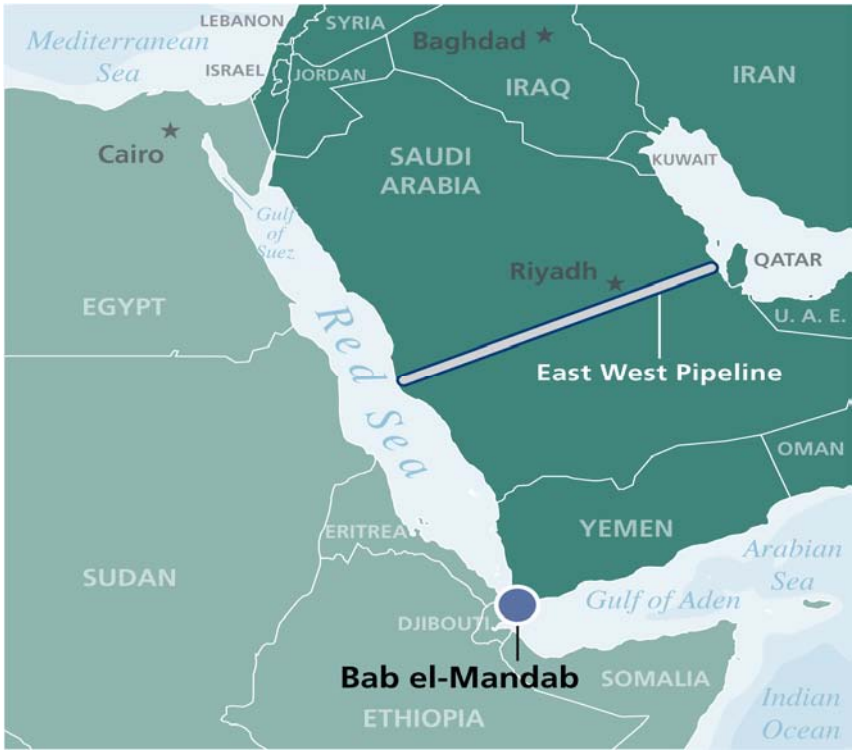
The Bab El Mandeb separates Djibouti and Eritrea from Yemen. It connects the Red Sea to the Indian Ocean via the Gulf of Arden.

Description: The Strait of Bab el-Mandeb is 20 miles wide divided into two channels by the Perim Island: the western channel, Dact-el-Mayun (16 miles wide) and eastern channel, Alexander's Strait (2 miles wide). It is responsible for much of Europe's crude oil imports, as it allows tankers to deliver oil from the Persian Gulf to the Suez Canal and Sumed Pipeline (for onward shipment to Europe and the United States).

Oil Flows

Approximately 3.3 million b/d flows from the Persian Gulf through the Bab el Mandeb. According to EIA, 2.1 million b/d traffic flow via Bab el-Mandeb reaches the Suez Canal and Sumed Pipeline.

Figure 16: Map of Bab El Mandeb



Source: Lehman Brothers

Concerns

The large amount of tanker traffic makes navigation difficult along the narrow channels. Closure of this strait could prevent tankers from the Persian Gulf from reaching the Suez/Sumed. Disruption in the strait would force a detour around the Cape of Good Hope, which would lengthen the shipping time frame and substantially tighten near-term oil supply.

Security Remains a Concern

Security remains a concern for foreign firms in the region, as Bab el Mandeb lies next to Yemen, a relatively insecure area where there have been several attacks on foreign ships, oil tankers, and pipelines. On October 12, 2000, the U.S. Navy missile destroyer USS Cole was attacked by an Al-Qaeda suicide bombing that killed 17 sailors and injured 39. The attack was located in the port of Aden in Yemen, approximately 150 miles away from the Bab el-Mandab.

Unfortunately, despite efforts from the United States, Yemen remains a relatively unstable country where any political upheaval could potentially disrupt the flow of oil shipments through the Strait.

This incident has resulted in the establishment of U.S. military and intelligence centers in Djibouti and Somalia as part of their efforts to prevent Al-Qaeda attacks in the region. In 2001, Djibouti leased Camp Le Monier to the United States. However, in October 2002, the French oil tanker Limburg was attacked off the Yemen coast, leading to an explosion, the death of one crew member, and an oil spillage of 90,000 barrels into the Gulf of Aden. In July 2006, it was announced Camp Le Monier would be expanded from 97 acres to roughly 500 acres. Unfortunately, despite efforts from the United States, Yemen remains a relatively unstable country where any political upheaval could potentially disrupt the flow of oil shipments through the Strait.

Figure 17: Key Dates and Events

October 2000	USS Cole was attacked by Al-Qaeda suicide bombers at the port of Aden in Yemen, approximately 150 miles away from the Bab el-Mandab
2001	Djibouti leased Camp Le Monier to the United States to help maintain security.
October 2002	French oil tanker Limburg was attacked off the Yemen coast.
July 2006	Camp Le Monier was announced to expand from 97 to roughly 500 acres.

Source: Lehman Brothers

Alternate Routes via East-West Pipeline and Around Africa

The Bab el-Mandab could be bypassed for northbound oil traffic through the East-West 4.8 million b/d oil pipeline of Saudi Arabia, or alternatively ship around the entirety of Africa. However, there is no alternate route for oil heading south.

East-West Pipeline (Petroline): See pages 32–33.

Ship around Africa: If maintaining current supply capacity is desired and the Bab el Mandeb is closed, the remaining oil left over from the East-West Pipeline, or about 1 million b/d, would need to be detoured around the Cape of Good Hope. This route will significantly increase shipping costs, as it will add approximately 4,750 nautical miles. Assuming at 14.0–14.5 knots per hour, this will add 12–14 days to reach Rotterdam from the Persian Gulf (Ras Tanura). Meanwhile, this alternate route will add about 2,700 nautical miles or seven to nine days to reach LOOP (Louisiana Offshore Oil Port). To put this into perspective, it currently takes about 21–22 days to reach Rotterdam and 31 days for LOOP, transiting the Bab El Mandeb en route for the Suez.

Straits of Bosporus+ BTC Pipeline + CPC Pipelines

Straits of Bosporus/Turkish Straits is a 17-mile-long waterway, which connects the Black Sea with the Mediterranean Sea and supplies Western and Southern Europe with oil from the Caspian Sea.

Description: The strait is made up of the Bosporus and Dardanelles and divides Asia and Europe. The Bosporus joins the Black Sea with the Sea of Marmara and the Dardanelles connects the Sea of Marmara and the Mediterranean Sea. Straits of Bosporus is the world's narrowest strait used for international navigation.

The Straits are governed under the Montreux Convention, which gives Turkey control over the Bosporus and the Dardanelles. While Turkish maritime authorities have the right to levy tolls on the passing tankers and is also responsible to check ships for sanitary conditions and safety, the Bosporus and Dardanelles Straits are considered international waterways, and Turkey is prohibited from restricting their use during peace time.

Oil Flows

2.4 million b/d (nearly all southbound; mostly crude oil but also includes several hundred thousand barrels per day of products). Oil shipments via Bosporus decreased from 3.1 million b/d to current levels as Russian exports shifted toward the Baltic ports. Traffic volume through the strait is expected to increase as Azerbaijan and Kazakhstan increase future crude production and exports.

Oil currently flows from Central Asia to the Black Sea port of Novorossiysk and then shipped onward to the Mediterranean Sea via the Bosphorus Straits. The flow of oil from the terminal at Novorossysk has more than doubled since the end of the Cold War, which has lead to increased congestion in this critical waterway.

Figure 18: Straits of Bosporus + BTC Pipeline + CPC Pipelines

Source: Lehman Brothers

Heavy Traffic Has Become a Safety Hazard

As traffic has skyrocketed over the last several years, accidents in the Straits have become more common, putting both the local environment and the 11 million residents of Istanbul at risk of major environmental catastrophe.

The Straits are geographically challenging to accommodate large-scale marine transportation. The channel contains no less than four acute bends, two of them in less than 2 kilometers apart, at a point where the width is only 700 meters wide. As traffic has skyrocketed over the last several years, accidents in the Straits have become more common, putting both the local environment and the 11 million residents of Istanbul at risk of a major environmental catastrophe. Concerned by this risk, Turkey passed measures in 1994 aimed to slow and to better regulate the oil traffic through the Straits. It has also backed alternative means to transport oil and gas out of Central Asia. The newly adopted regulations have sometimes resulted in costly delays. Since Russia currently accounts for 25% of the traffic through the waterway, it is not surprising that the Russian government has protested Turkey's unilateral decision on this subject. The Russian government has challenged the new measurements and alleged that they violate Turkish treaty commitments. Russia believes this is an attempt by Turkey to control the oil flow out of the Central Asia, since the Turks have supported the construction of an oil pipeline that would transit through Turkey to reach the Mediterranean Sea.

CPC Pipeline: The 1,510-km pipeline connects the Tengiz oil field in Kazakhstan to a newly constructed Novorossiisk-2 Marine Terminal on Russia's Black Sea coast. The

throughput of the first phase construction is rated at 28.2 million tons (500,000 b/d) of oil per year. The first phase was completed in 2001 and reached its full capacity by mid-2004.

According to the original planning, subsequent expansions should have quickly proceeded after the completion of the first phase construction and should reach a maximum throughout run rate of 67 million tons per annum, or 1.4 million b/d by 2015. However, the pipeline's future expansion plan has recently been thrown into turmoil as a result of objections from the Russian government. On several occasions, most recently on July 26, Transneft, Russia's state-owned oil pipeline monopoly, has said that CPC should not be expanded unless alternative routes out of the Black Sea were developed in parallel.

Transneft's partners have long campaigned to increase the capacity of the pipeline to take advantage of Kazakhstan's rising oil production by increasing shipments through Russia. However, Transneft has long held up any expansion.

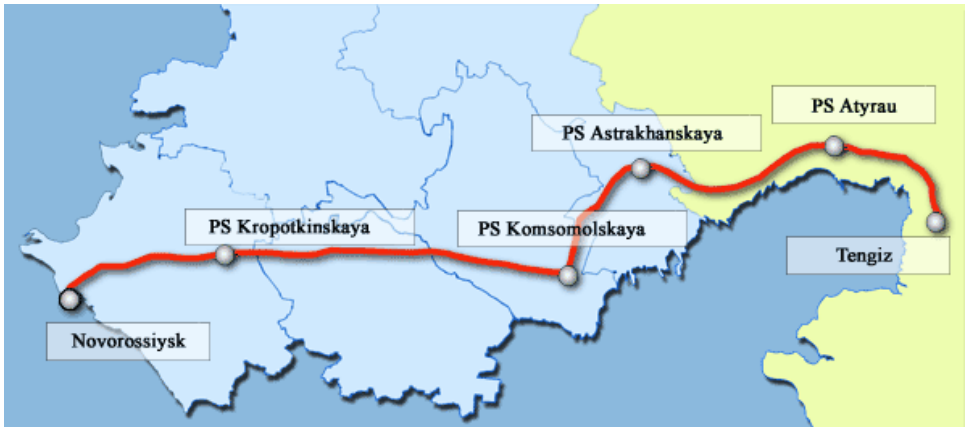
The consortium is made up of seven partners, with Russian state-owned oil transport company Transneft, the government of Kazakhstan, and U.S. energy giant Chevron Corp. owning the largest stakes. Transneft's partners have long campaigned to increase the capacity of the pipeline to take advantage of Kazakhstan's rising oil production by increasing shipments through Russia. However, Transneft has long held up any expansion and is currently demanding that the transit fee through Russian territory be raised from $29 to $38 per ton of oil. Transneft is also trying to increase its power on the CPC board. The price hike would bankrupt the consortium, something that would allow Transneft and the Kremlin to gain complete control of the pipeline.

Prompted by Transneft's lack of cooperation in the CPC expansion, Kazakhstan has been seeking alterative route for its oil export.

Prompted by Transneft's lack of cooperation in the CPC expansion, Kazakhstan has been seeking an alterative route for its oil export, including via the Baku-Tbilisi-Ceyhan pipeline. Kazakhstan has also been increasing its energy links with China, with a 200,000 b/d oil pipeline running from Atasu in Kazakhstan to Alashankou, China. Kazakhstan and China also plan to build a natural gas pipeline in conjunction with Turkmenistan that would divert natural gas supplies from Russia.

CPC's export volumes transit through the Bosporus and the traffic load on the Straits is, of course, subject to considerable discussion.

Figure 19: CPC Pipeline



Source: www.cpc.ru

Alternative Routes

The BTC Pipeline is used primary to carry oil from the Azeri-Chirag-Guneshli oil field in the Caspian Sea to the Mediterranean Sea. The total length is 1,776 km of which 440 km is resided in Azerbaijan, 260 km in Georgia and final 1,076 km in Turkey. It was given that name since it passes through Baku, the capital of Azerbaijan; Tbilisi, the capital of Georgia; and Ceyhan, a port on the southeastern Mediterranean coast of Turkey. It is the second longest oil pipeline in the world (the longest being the Druzhba pipeline from Russia to central Europe).

There are eight pump stations along the pipeline route, two intermediate pigging stations, and 101 block valve stations. It is patrolled by national guards. In addition, since the entire pipeline has been placed underground, it reduces its vulnerable to potential sabotage.

According to the current plan, the pipeline should reach 1 million b/d of capacity in 2009, in tandem with the expansion of the AIOC project.

South Stream Pipeline: Gazprom and Eni recently reached an agreement to start the feasibility work on a new 30 bcm/year gas pipeline from Russia to Europe via the Black Sea. The partners suggest that this could be operational by 2013, and the initial cost estimate is close to $15 billion. The pipeline is expected to carry gas from Russia to the Bulgaria coast and onward into southeast and central Europe via two as yet unspecified routes. Feasibility work is expected to be completed by year-end 2008.

Other pipeline proposals: 1) an extension and product flow reversal (proposed to run from south to north) of the Ukrainian Odessa-Brody pipeline to Poland; 2) a route from Burgos in Bulgaria to Alexandropoulos in northern Greece, now known as the Bapline project; 3) A rival proposal for a trans-Turkish route from Samsun to Ceyhan; 4) the AMBO project that seeks to build a line from Bulgaria through Macedonia to Vlore in Albania; and

5) the project for a line across the northern Balkans from Constanza in Romania to Omisalj in Croatia and Trieste in Italy

Figure 20: Caspian Region Pipeline Network

Source: EIA

Mina Al-Ahmadi Terminal, Kuwait

Located north of Ash Shuaiba, Mina Al-Ahmadi is Kuwait's principal oil port.

Description: Mina-Al-Ahmadi consists of four separate facilities. Excluding the new pier that is current under construction, the port contains three piers with a total of 12 offshore berths that can load at a run rate of 2 million b/d. The south pier contains eight berths varying in depth from 12 to 15 meters. The north pier has four berths with a depth of about 18 meters and could handle tankers in excess of 100,000 tons. The artificial sea-island is designed to handle up to 375,000-ton tankers. It consists of a loading platform with six docking platforms in almost 30 meters of water and a single point mooring, which is controlled and connected by marine pipelines to the artificial sea-island. Finally, there is a new pier currently under construction. Upon completion, the port's export capability could increase to 3 million b/d.

In addition to the port facilities, Mina Al-Ahmandi is the home of three refineries.

Figure 21: Mina al-Ahmadi Terminal Map

Source: Lehman Brothers

Oil Flows

According to EIA, in 2005, Kuwait exported the majority of its oil (1.38 million b/d) to Asia-Pacific countries such as Japan, India, Singapore, South Korea, Taiwan, and Thailand. Other oil exports were split between Western Europe (112,000 b/d) and to the United States (123,000 b/d). About 614,000 b/d of refined product, roughly 65 percent of Kuwait's total production, were also exported, mostly to Asia-Pacific countries (440,500 b/d), and Western Europe (119,900 b/d).

Concerns

The Kuwaiti energy sector has suffered several high-profile accidents in recent years, which have had a significant impact on its operation.

The Mina al-Ahmadi terminal was almost completely destroyed after the Gulf War in 1991, as the Iraqi forces either set ablaze or destroyed most of the oil wells and facilities.

In January 2002, there was an explosion and fire at an oil-gathering center near Kuwait's northern Raudhatain oil field due to a gas leak in a pipeline. Output decreased 250,000 b/d and resulted in a loss of $250 million for the Kuwaiti government. The facility did not return to full capacity until January 2005.

In addition to the facilities' poor workplace safety record, security is a major concern, or for that matter, the lack of a security system in place is a major concern. Contrary to Saudi Arabia's oil installation, Kuwaiti appears to be relatively unprepared to defend itself against serious terrorist threats.

Alternate Routes

See pages 32–33.

Al Basrah Oil Terminal (ABOT)

The Al Basrah Oil Terminal (ABOT) is an offshore crude oil marine loading terminal located off the southeastern coast of Iraq in the Northern Persian Gulf. It is Iraq's primary oil terminal and accounts for 97% of Iraq's oil exports into world markets.

Description: Previously, this terminal was called Mina' al Bakr (MABOT) and was later renamed to ABOT in October 2003. Structurally, the ABOT terminal is capable of handling VLCCs and has an offloading capacity of 300,000–400,000 b/d on each of its four berths. More than 30 years old, ABOT had suffered from a lack of maintenance and significant damage during the Iran-Iraq War (1980–88) and the Gulf War (1990–91). The terminal operated under the Oil for Food program for a few years with minimal maintenance. ABOT was recently refurbished to improve tanker loading efficiency, upgrading its capacity from 1.6 million b/d to 3 million b/d. Renovations include a newly installed piping metering system and added safety features such as fire hoses.

The sale of oil through ABOT currently accounts for approximately 95% of the government revenue. A temporary closure of the terminal would result in an estimated $100 million revenue loss each day.

Not surprisingly, ABOT has been a target for insurgents, given its importance to the Iraq government's finances. To put this into perspective, the sale of oil through ABOT currently accounts for approximately 95% of the government revenue. A temporary closure of the terminal would result in an estimated $100 million revenue loss each day. Obviously, in addition to the ABOT facilities, the surrounding southern oil field operation and the connected pipeline network are both essential to maintain the continuous operation here.

Figure 22: Middle East and Iraqi Oil Terminals Map

Source: Lehman Brothers

Oil Flows

Export oil originates from Rumaila oil fields (capacity 2.4 million b/d) in southern Iraq to the Basrah refinery, which is then sent to Iraq's two oil terminals: ABOT and Khor Al Amaya Oil Terminal (KAAOT). Oil is carried from the Al Faw onshore terminal via two 48-inch pipelines to the tip of Al-Faq Peninsula, then 50 kilometers under sea south to ABOT, to be loaded onto the tankers. The Al Faw Terminal serves as storage as well as pumping stations for the terminals.

Security Remains a Concern

ABOT and KAAOT security is under the U.S. Naval Forces Central Command. The Combined Task Force (CTF) 158 is responsible to maintain security at both oil terminals in support of the UN Security Council Resolution 1723, which mandates the multinational force to keep security and stability in Iraqi waters and supports Iraq's request for security aid. Iraqi marines will eventually assume responsibility of ABOT and KAAOT security as they train under CTF 158.

Following a failed terrorist suicide attack in April 2004, the United States and the local authority have since adopted added security measurements.

Following a failed terrorist suicide attack in April 2004, ABOT was shutdown for two days, which resulted in a cost of $28 million and a spike in world oil prices. Three ordinary fishing boats exploded near the oil terminal that killed two U.S. Navy Seals and one Coast Guardsman when the third boat was intercepted by a coalition ship. As a result of this accident, the United States and the local authority have since adopted added security measurements.

ABOT and KAAOT terminals have two separate zones extending from the outer edge of the terminals—an outer 3,000 meter warning zone and an inner 2,000 meter exclusion zone.

Prior to the 2004 attack, Al Basrah and KAAOT terminals were surrounded by a 2-nautical-mile (approximately 3,700 miles) security zone. Now, both terminals have two separate zones extending from the outer edge of the terminals—an outer 3,000-meter warning zone and an inner 2,000-meter exclusion zone.

Vessels that enter the outer meter warning zone are able to navigate out en route to another destination or proceed to the terminal; the inner meter exclusion zone is for vessels heading for the terminals only. All vessels in the area are required to identify themselves, state their intentions, and request permission to enter the zone, if applicable. Although coalition maritime forces will actively contact unidentified vessels, vessels that have entered the warning zone without making contact will face consequences that include disabling or even destroying the suspect vessel. For authorized tankers, security sweeps are conducted before they pull up to the oil terminals. Only tankers and support vessels authorized by terminal operators or Coalition Maritime Security Forces are allowed to enter the exclusion zones. In the event that the vessel does manage to get past maritime security forces, Iraqi and U.S. Navy Seals provide the last layer of defense to secure ABOT and KAAOT.

Rehabilitation of ABOT

One of the most important improvements at ABOT has been the installation of 24 custody transfer meters and associated flow provers that measure how much crude oil is exported from the terminal.

The renovation of ABOT is part of Iraq's long-term strategy of restoring to the country's prewar oil production capacity. The Gulf Region Division (GRD) gave the task to the U.S. Army Corps of Engineers, which invested $67.5 million to rehabilitate the export facility. One of the most important improvements at ABOT has been the installation of 24 custody transfer meters and associated flow provers that measure how much crude oil is exported from the terminal. Previously, the Southern Oil Company was using accounting procedures on tankers that had a tendency to be less accurate than turbo meters. As a result of the faulty metering system, smugglers were suspected to be diverting billions of dollars worth of crude onto tankers. Accurate metering is imperative if Iraq seeks International Monetary Fund loans for its remaining oil infrastructure improvements. The new turbo metering system is accurate within 1/100 of 1%.

Other improvements include functional upgrades, major safety deficiency corrections, and power generation installment. The reconstruction project is divided into two phases with design, engineering, procurement, and training ongoing throughout the course of the project. Figure 20 details the project phases.

Figure 23: Rehabilitation of ABOT

Phase 1
Repair and refurbish Berths 1, 2, 3, 4 loading arms
Repair hydraulic systems for loading arms, 24-inch and 48-inch valves
Repair hydraulic bridging systems
Complete development of emergency evacuation program
Complete development of health, safety, and environmental program
Operation, refurbishment, and maintenance training
Phase 2
Installation of a complete emergency shutdown system, installation of separate flow metering computer system, and separate ESD/F&G system for each platform
Refurbishment and installation of two generators on MD 6 and single auxiliary building for platform A
Completion of fire protection system, including foam skids
Installation of two new turbine meter streams and the connection of three existing meter streams on platform A (instrumentation, flow control valves, and motorized valves)
Replacement of positive displacement meter streams on platforms A and B
Replacement of positive displacement meter streams on platform B with the same turbine meter streams of platform A
Life raft installation
Precommissioning and commissioning all operating systems

Source: The Office of the Special Inspector General for Iraq Reconstruction, Lehman Brothers

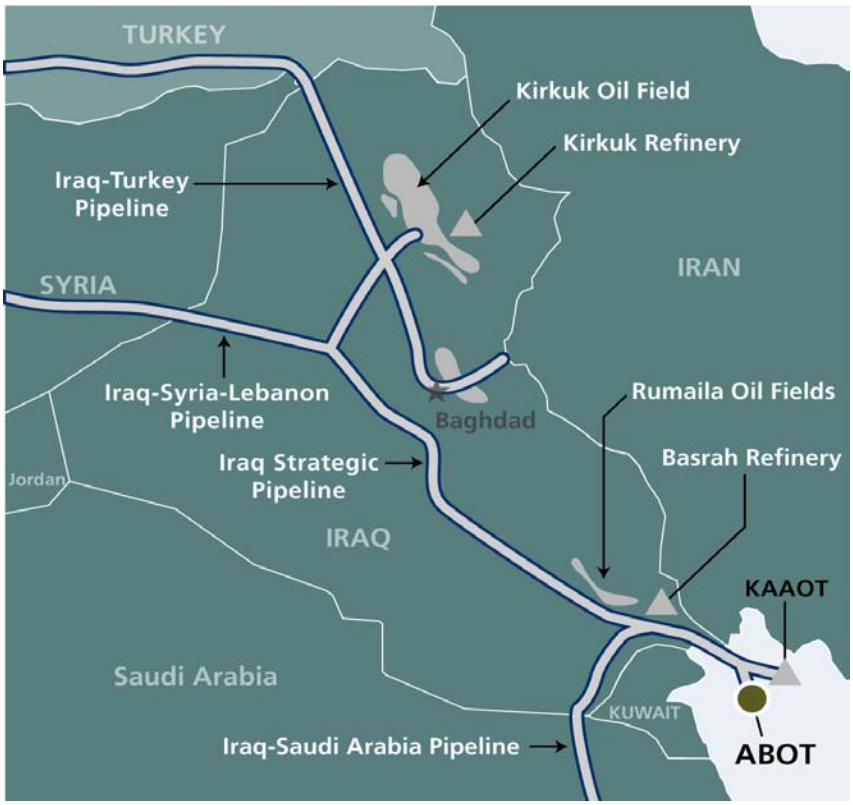
Alternate Routes

Khawr Al Amaya Oil Terminal (KAAOT): Located approximately 35 kilometers off Iraq's southern shores and 6 kilometers north of ABOT, Iraq's other active terminal Khawr Al Amaya (KAAOT) provides about 5% of Iraq's oil distribution capacity. A 42-inch subsea export line running from the pump station on the Al Faw peninsula feeds KAAOT. Structurally, this terminal contains two rectangular main platforms and a berth on the north and south ends of the west platform fitted with four loading arms, two of which are usable

and can only be used one at a time due to pumping problems. Unlike ABOT, the berths on KAAOT contains a shallower draft and typically caters to smaller vessels that can carry up to 1 million barrels of crude going to shorter destinations such as India.

Other potential export methods are victim to poor maintenance, sabotage, and lack of diplomatic agreements. They include Iraq-Syria-Lebanon Pipeline (ISLP), Iraq-Turkey Pipeline (ITP), Iraq Pipeline through Saudi Arabia (IPSA), and Strategic Pipeline. For more details, please refer to pages 32–33 of this report.

Figure 24: Iraq Pipeline Map



Source: Lehman Brothers

Iran and Iraq to Sign Pipe Deal

In a rather interesting development, in August 2007, Iran and Iraq signed and finalized an oil deal to build two pipelines. According to plan, the new pipeline will carry Iraqi crude to Iran with oil products from Iranian refineries exported back to Iraq. The agreement includes the purchase of 100,000 b/d of crude oil from southern Iraq Al Basrah via a 350,000 b/d 32-inch pipeline to be refined at the Bandar Abbas refinery and the sale of 2 million liters/d of refined products back to Iraq via a 16-inch pipeline. The initial agreement was signed in mid-2005 and the MoU in August 2006.

Alternate Routes to Persian Gulf Choke Points

There are four choke points in the Gulf region that are covered in this report—the Strait of Hormuz, Abqaiq processing facility, Min al-Ahmadi terminal, Kuwait and Al Basrah oil terminal, Iraq. Below we list some routes that could serve as alternate routes in case any of the four above shut down. It is important to note that these routes in all likelihood will not be able to fully compensate the loss of oil supply from any one of the choke points above. We have broadly categorized these alternate routes into two categories: 1) routes via Saudi Arabia which take oil to the Red Sea, 2) via Iraq that take oil to the Mediterranean Sea, and 3) via UAE to the Persian Gulf.

Via Saudi Arabia to the Red Sea

East-West Pipeline (Petroline): The 745-mile East-West Pipeline is the most viable alternate route to ship Saudi oil circumventing the Straits of Hormuz. It has a capacity of approximately 5 million bl/d. The pipeline connects Abqaiq to the port of Yanbu on the Red Sea. Upon reaching Yanbu, oil can be transported by tanker via the Suez Canal or Sumed pipeline for delivery. The Saudis have expanded the East-West Pipeline in part to maintain Yanbu as a strategic option to Gulf port facilities in the event that exports were blocked from passing through the Straits of Hormuz in the Persian Gulf. Only 2.5 million b/d is currently being transported through the East-West pipeline, as shipments from Yanbu add up to five days roundtrip travel time for tankers through the Bab-al-Mandab strait to major customers in Asia.

Although the amount of oil carried is only a fraction of its capacity, the East-West pipeline is sufficient to supply refineries and petrochemical plants in Yanbu and still have small amounts for export.

Abqaiq-Yanbu Natural Gas Liquids (NGL) Pipeline: Running parallel to the East-West Pipeline is the 290,000 b/d Abqaiq-Yanbu NGL Pipeline, serving Yanbu's petrochemical plants. After upgrades in 2008, the pipeline capacity will increase to 555,000 b/d.

Trans-Arabian Pipeline (Tapline): The Tapline from Qaisumah to Sidon, Lebanon, was mothballed in 1984 because of turmoil in Lebanon and economic reasons. Saudi Arabia terminated the portion to Jordan in 1990 as a result of the Jordanian support for Iraq during the Gulf crisis. In 1983, the Tapline's Lebanese section was closed altogether. Since then, the Tapline had been used exclusively to supply oil to Jordan, although Saudi Arabia terminated this arrangement to display displeasure with perceived Jordanian support for Iraq in the 1990–91 Gulf crisis. The pipeline's operational capacity is approximately 50,000 b/d, or a fraction of the design capacity of 500,000 b/d.

Via Iraq to the Mediterranean Sea

Iraqi Pipeline through Saudi Arabia (IPSA) Pipeline: The IPSA pipeline, which runs from southern Iraq south through Saudi Arabia and then parallel to the East-West Pipeline westbound to the Red sea north of Yanbu, was closed in August 1990 after the Iraqi invasion of Kuwait. In June 2001, Saudi Arabia expropriated the IPSA line and converted

the line to carry natural gas to Yanbu, though it could be another outlet for about 1.65 million b/d of oil.

Strategic Pipeline: The "Strategic Pipeline" built by Iraq in 1975 is a north-south system. According to the original design, it would consist of two parallel lines of 700,000 b/d each. However, after the completion of the first line, work on the second parallel line was ceased during the Gulf War of 1990–91. Although the system is designed to enable northern Kirkuk crude to be exported from the Persian Gulf and for southern Rumaila crudes to be shipped through Turkey, it needs rehabilitation and is currently nonoperational.

Iraq-Turkey Pipeline: The 600-mile Iraq-Turkey Pipeline from Iraq's Kirkuk oil region to the Turkish port of Ceyhan has been operating only sporadically during the past few years due to security issues. The system contains two pipelines—a 40-inch pipeline with a 900,000 b/d capacity and a 46-inch pipeline with a 500,000 b/d capacity. Usable capacity on the line is believed to be roughly 500,000–600,000 b/d with significant repairs and upgrades still required.

Iraq planned to resume oil exports through Turkey via the new 500,000 b/d pipeline that stretches 100 km (62 miles) from the oil center of Kirkuk to the refining center of Baiji. Operations started in September 2007, initially at a rate of 300,000 b/d, boosting Iraqi exports from an average of 1.7 million–1.8 million b/d in July 2007 to 2.2 million b/d. However, security surrounding Iraq remains extremely difficult. On September 18, 2007, an insurgent attack damaged an isolated section of the pipeline. Iraqi officials say that crude exports from Kirkuk to Ceyhan will not be delayed and the system is anticipated to operate as planned. The Iraq Pipeline Watch, which tracks attacks against oil installations and personnel, lists more than 400 attacks since the end of the war.

Iraq-Syria-Lebanon Pipeline (ISLP): The ISLP connects the Kirkuk oil region to Syria's port of Banias. Iraq used this pipeline between 2001 and 2003 to transport 200,000 b/d of oil from southern Iraq to Syrian refineries. However, pipeline flows have stopped since the U.S. war began in 2003. The system consisted of two pipelines with a combined capacity of 700,000 b/d and used to carry 450,000–600,000 b/d.

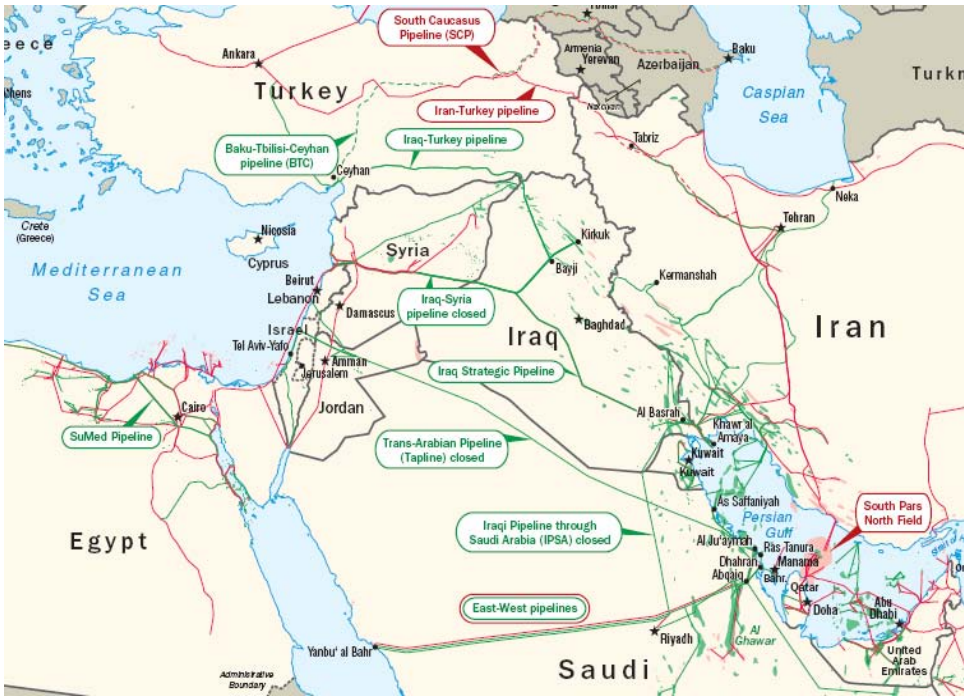
In August 2007, Iraq and Syria agreed to reopen this pipeline and establish a new gas pipeline from western Iraq to the Syrian gas center of Deir Ezzor. Iraq intended to replace the existing pipeline with a new 1.4 million b/d pipeline to Syria, but no progress of the plan has been released. The two countries are also in discussions to trade refined oil products by establishing oil storage facilities on both sides of the common border.

Via UAE to the Persian Gulf.

Habshan-Fujairah Pipeline: A 1.5 million b/d, 360 kilometer pipeline running from Habshan oilfields to the Fujairah port, seaside of the Strait of Hormuz. The pipeline is being constructed by Abu Dhabi's International Petroleum Investment Company (IPIC) at an estimated cost of Dh35 billion ($9.9 billion) for 2009 completion.

The Habshan Fujairah Pipeline will enhance Abu Dhabi's security, bypassing the Strait of Hormuz. We think it may generate increased interest in future bypasss projects from UAE's neighbors. For example, Oman has suggested a long distance pipeline through Saudi Arabia's Empty Quarter desert to the Duqm port in Oman.

Figure 25: Alternative Routes to Persian Gulf Choke Points



Source: www.eia.com

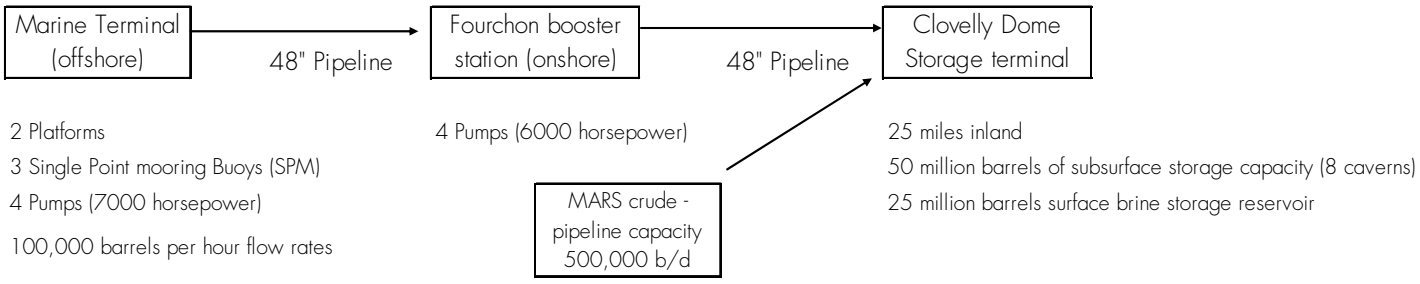
The Louisiana Offshore Oil Port (LOOP)

The Louisiana Offshore Oil Port (LOOP) is a deepwater port in the Gulf of Mexico off the coast of Louisiana near the town of Port Fourchon. LOOP provides tanker offloading and temporary storage services for crude oil transported on some of the largest tankers in the world. Most tankers offloading at LOOP are too large for U.S. inland ports. Marathon Pipe Line LLC, Murphy Oil Corporation, and Shell Oil Company are LOOP's owners.

Description: Tankers offload at LOOP by pumping crude oil through hoses connected to a Single Point Mooring (SPM) base that is sitting in water depth of 115 feet, enough to accommodate the world's biggest oil tankers, which require water depths of up to 85 feet. Three SPMs are located 8,000 feet from the Marine Terminal. The SPMs are designed to handle ships up to 700,000 deadweight tons. The crude oil then moves to the Marine Terminal (Fourchon Booster Station) via a 56-inch diameter submarine pipeline. The Marine Terminal consists of a control platform and a pumping platform. The control platform is equipped with a helicopter pad, living quarters, control room, vessel traffic control station, offices and life support equipment. The pumping platform contains four 7,000-hp (5.22 MW) pumps, power generators, metering and laboratory facilities. Crude oil is handled only on the pumping platform where it is measured, sampled, and boosted to shore (Clovelly Dome Storage Terminal) via a 48-inch diameter pipeline.

Fourchon Booster Station is located just on-shore in Fourchon and Clovelly Dome Storage Terminal located 25 miles inland near Galliano, Louisiana. The Fourchon Booster Station has four 6,000-hp (4.47 MW) pumps that increase the pressure and the flow rate to the Clovelly Dome Storage Terminal. A submarine pipeline moves crude oil to Clovelly, Louisiana, where LOOP maintains eight underground salt caverns capable of storing up to 50 million barrels of crude oil as temporary storage before the oil is shipped to the various refineries.

Figure 26: Oil Flows from the Terminal to the Storage Terminal



Source: Lehman Brothers

Oil Flows

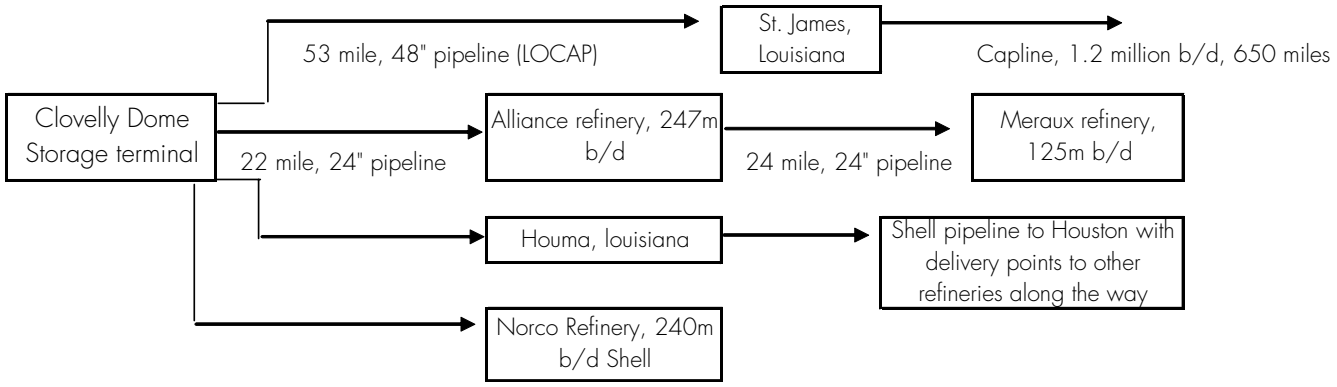
LOOP handles 13% of the nation's foreign oil import, about 1.2 million b/d. It is connected via pipeline to 35% of the U.S. refining capacity.

In 1996, one cavern was dedicated to the MARS stream coming in from the deepwater Gulf of Mexico. The MARS crude oil system uses the same distribution system used by the foreign barrels. In addition, LOOP has an above-ground tank farm consisting of six 600,000 barrel tanks.

Four pipelines connect the onshore storage facility to refineries in Louisiana and along the Gulf Coast. LOOP also operates the 53-mile, 48-inch LOCAP pipeline that connects LOOP to CAPLINE at St. James, Louisiana. CAPLINE is a 40-inch pipeline that transports crude oil to several Midwest refineries (which is the largest pipeline system delivering crude oil from the Gulf Coast to the Midwest). Including Capline, LOOP is connected to more than 50% of the U.S. refinery capacity and has offloaded over 7 billion barrels of foreign crude oil since its inception.

Crude oil production and imports that are not sent to other states are processed at Louisiana's 16 operating refineries, clustered mostly along the Lower Mississippi River and in the Lake Charles area. With a refining capacity of more than 2.5 million barrels per day, Louisiana produces more petroleum products than any state but Texas.

Figure 27: Oil Flow from Clovelly Storage to Refineries



Source: Lehman Brothers research

Figure 28: Pipeline Links from LOOP

Source: Lehman Brothers, EIA

Druzhba Pipeline, Russia

The Druzhba pipeline is the world's longest oil pipeline. Constructed in the USSR in 1974, it has been transporting oil from central Russia to points west over a distance of some 4,000 km (2,500 miles) since its inception.

Description: The pipeline begins in Samara in southeastern Russia, where it collects oil from western Siberia, the Urals, and the Caspian Sea. It runs to Mozyr in southern Belarus, where it splits into a northern and southern branch. The latter branch runs south into Ukraine, Slovakia, the Czech Republic, and Hungary. The northern branch crosses the remainder of Belarus to reach Poland and Germany. There have been recent proposals to extend this branch to the German North Sea port of Wilhelmshaven, which would reduce oil tanker traffic in the Baltic Sea and make it easier to transport Russian oil to the United States. The Mažeiki refinery in Lithuania and Ventspils oil terminal in Latvia are connected to the main pipeline by the branch pipeline from Bryansk Oblast.

Today, it is the largest principal artery for the transportation of Russian (and Kazakh) oil across Europe. The Russian oil company Transneft is the pipeline's operator.

Figure 29: Map of Druzhba Pipeline

Source: Lehman Brothers

Oil Flows

The flow through the Pipeline is about 1.2 million to 1.4 million b/d and it mainly serves Eastern Europe, Netherlands, Italy, Germany, and France.

Of the total flow, only about 350,000 b/d flows through the southern branch to Hungary, the Czech Republic, and Slovakia. Figure 26 shows the 2006 Russian Oil Exports through the Druzhba Pipeline.

Figure 30: 2006 Russian Oil Exports Through Druzhba Pipeline (thousand b/d)

Country	Oil Exports (Thousand b/d)	% of refining capacity
Germany	437	18%
Poland	466	100%
Hungary	136	84%
Czech Republic	104	53%
Slovakia	118	103%
Total	1261	

Source: EIA

The pipeline's operators and transit states had considered reversing the pipeline's flow, giving Russia a new export outlet on the Adriatic Sea. The proposal included expanding the pipeline's capacity from 100,000 b/d to 300,000 b/d at a cost of around $320 million. However, in 2005, the proposal was cancelled after Croatia's objections based on the environmental impact study.

Concerns

Russia is a major supplier of crude oil and natural gas to Europe. According to EIA, OECD Europe's reliance on Russian crude exports has grown from around 9% of total crude imports in 1995 to around 29% in 2006. Accordingly, the share of Europe's oil consumption that comes from Russia has grown from around 7.5% to about 25% during the same period.

Russia's proposal for a new Urals pricing scheme and restriction of some exports from the Druzhba pipeline to Lithuania seems to highlight the country's intention to seize more control over its crude exports.

The relationship between Russia and Belarus has recently been of concern, with Russia stopping the oil flow through the Druzhba pipeline from January 8–10, 2007 over a price dispute. There has also been an increase in activism from the Russian government. Russia's Economic Minister German Gref has proposed to develop a new pricing scheme for the Urals in an attempt to narrow the Brent-Urals spread. This development together with the restriction of some exports from the Druzhba pipeline to Lithuania seems to highlight Russia's intention to take more control over its crude exports.

Finally, all of the ports and pipelines are operating at or near capacity, leaving limited alternatives if problems arose at Russian export terminals. With a windfall in oil export tariffs over the past several years, Transneft, the state oil transport monopoly, has taken steps to upgrade the country's pipeline system, with an emphasis on building new export pipelines to increase and diversify export routes for oil exporters.

Figure 31: Russian Oil Exports by Export Outlet, 2006 (000 b/d)

Country	Oil Exports (000 b/d)	% of total oil export
Novorossiysk	768	19%
Other Black Sea	217	5%
Primorsk	1,255	30%
Druzhba Pipeline	1,261	30%
Lithuania	158	4%
Non-Transneft Sea	170	4%
China (Rail)	178	4%
Murmansk (Rail)	47	1%
Other non-Transneft Rail	47	1%
CPC	53	1%
Total	4,155	100%

Source: EIA

Alternate Route

The alternative routes are very limited and not significant. However, there are plans of capacity expansion in most major pipelines in Russia:

Baltic Pipeline System (BPS) Expansion: The BPS carries crude from Russia's West Siberian and Timan-Pechora oil provinces westward to Primorsk, providing an alternative route to Northern Europe. Capacity at Primorsk has been steadily increasing and stood at 1.5 million b/d in March 2007. After the transit dispute with Belarus in January 2007, Transneft plans to build a pipeline from the Belarus border to Primorsk with a capacity of 1 million b/d initially and expandable to 1.5 million b/d.

Adria Reversal Project: There has been a plan for the reversal of the Adria pipeline, spanning between the port of Omisalj, Croatia and Hungary since the 1990s. This expansion would give Russia a new export outlet on the Adriatic Sea. The proposal also included expanding the pipeline's capacity from 100,000 b/d to 300,000 b/d. However, in 2005, the proposal was shelved after Croatia raised objections based on the environmental impact study.

BTC and proposed Bourgas Alexandropoulis pipeline: See page 24.

Rail: About 5% of Russian crude oil exports are currently transported through rail, primarily to the Chinese market, given the lack of pipeline route. Although this option could be extended to Europe as a last resort, it would be much more expensive than the pipeline.

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