Saudi Arabia and Iranian Operations

Edward O. Price, Jr.
OIL IN CHINA
Million Barrels Per Day

Deliveries

Crude Oil Production
WORLD PETROLEUM DELIVERIES
Transportation vs Other Use
(Excluding Eastern Europe)

Million Barrels Per Day

1979: 53.5
   - Transportation: 21.1 (39%)
   - Other Use: 32.4 (61%)

1983: 46.6
   - Transportation: 21.1 (45%)
   - Other Use: 25.5 (55%)

2003: 70.3
   - Transportation: 35.7 (51%)
   - Other Use: 34.6 (49%)

Other Use

Transportation Fuel
OIL AND GAS FIELDS AND RETAINED AREAS
AS OF YEAR-END 1988
Saudi Aramco Proved Oil Reserves
Development Status
(1/1/2004)

260 Billion Barrels

Developed
131, 50%

Undeveloped
129, 50%
2002 Average Finding and Development Costs

Note: Using 3-Year Running Averages

Example of Initial Field Development Cost

$ per Daily Barrel

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<tr>
<th>Field</th>
<th>Capacity</th>
<th>Year</th>
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<td>300 MBCD</td>
<td>2003</td>
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<td>Qatif</td>
<td>500 MBCD</td>
<td>2004</td>
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- Shaybah: 5,000
- Haradh: 2,000
- Qatif: 4,000
Peak Depletion Rates
(% of Initial Proved Reserves)

Source: Saudi Aramco

Note: Based on highest monthly rate & total field orig. reserves
Year-end 2003 Reserves & Oil Production Share

100%
90%
80%
75%
60%
50%
40%
30%
20%
10%
0%

Reserves

Production

Rest of the World
Saudi Arabia
Ghawar Field The Super Giant

- Largest Oil Field in the World
- Discovery (1948)
- Onstream (1951)
- Peripheral Water Injection (1965)

Area Size: 174 Miles x 16 Miles
Ghawar Field - The Super Giant

The Ghawar field is the world’s largest oil producing field. It is approximately 174 miles (280 kilometers) long and has an average width of 16 miles (25 kilometers). This elongated field, located 620 miles (100 kilometers) southwest of Dhahran, is formed by a structural entrapment of oil along a major anticline, the “En Nala Axis”. Its greatest width is in the ‘Ain Dar/ Shedgum areas.

The field was first discovered in 1948 by drilling ‘Ain Dar-1 to a depth of 6,296 feet (1,919 meters) subsea, reaching the Arab Formation in the Upper Jurassic, and the Dhruma Formation in the Middle Jurassic. Further exploration of the field resulted in additional discoveries of five more oil producing areas: Haradh in 1949, ‘Uthmaniyyah in 1951, Shedgum in 1952, Hawiyah in 1953, and Fazran in 1957, confirming that the areas constitute a single oil field.
SAFANIYA FIELD
SAFANIYA RESERVOIR
3-D STRUCTURE
The Other Key Fields Are All "Mature"

- Abqaiq’s key producing areas are now “pockets” of by-passed oil.
- Berri appears headed for a “gas blow down”.
- Safaniya/Zuluf/Marjan are losing their great water aquifer and are all old, too.
- Shaybah is a very complex to produce reservoir.
- Hawtah Trend was contaminated by injected water.
Saudi Aramco’s “New Projects” Are Extremely Complex

- Qatif will be a key test: Can it produce 500,000 barrels per day for any time (let alone 30 years)?
  - Discovered in 1945.
  - Field was converted into naphtha storage cavern in 1977.
  - High percent of H₂S.

- Abu Sa’fah will use massive numbers of ESP.
Future Field Development Becomes More Challenging

- Khurais has been a problem field for 40 years.
- Over 90 wells had tried to get oil to flow properly.
- Perhaps advanced technology will finally solve this riddle.
- Between Khurais and Manifa lie 41 billion barrels of Saudi Arabia’s proved reserves.
Vertical Wells In Saudi Arabia Are Now Obsolete

- By late 1990s, vertical production wells watered up too fast.
- 2nd generation wells: Extended reach horizontal wells.
- 3rd generation wells: Maximum reservoir contact ("MRC") wells.

- 4th generation wells: Intelligent well completions (automatic water shutoff valves).
- This is how rising water cut was "solved".
Rewards And Risks Of Water Injection During Primary Depletion

- Saudi Arabia’s aggressive use of water management has kept its prime reservoir pressures high.
- This led to extremely high flow rates.
- Well productivity has been steadily declining.
- Extended reach, multilateral wells/intelligent wells are finishing the primary/secondary sweep.
- Once it is over, tertiary recovery is “the next step”.
## Yearly Average MSC Schedule (MBCD)

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