Petroleum: History & Economics

Musaed N. AlAwad

مساعد ناصر العواد
Presentation Outline

1. History of Worldwide Oil Discovery
2. Oil in The Middle East
3. Oil in Saudi Arabia
4. Worldwide Oil Types and Reserves
5. Oil Pricing Criterion
6. Oil Price Fluctuation
7. Alternative Energy Resources
8. Conclusions
History of Worldwide Oil Discovery

Various Types of Petroleum Traps (Reservoirs)
History of Worldwide Oil Discovery

Oil Seepage through Fractured Rocks
History of Worldwide Oil Discovery

Oil Seepages in Several Parts of the World
Worldwide ancient people used petroleum seepage for:

1. Lighting.
2. Water proofing.
3. Building.
History of Worldwide Oil Discovery

On August 28, 1859, Edwin L. Drake and Partners made the first successful use of a cable tool drilling rig on a well drilled especially to produce oil in Pennsylvania.

The drill reached its maximum depth of 69.5 feet (21.2 m) on August 27, 1859. Cable tool drilling techniques was used in drilling this well.

It took one and a half year to reach the above depth. In 1900, rotary drilling technique was developed.

The Drake well is often referred to as the "first" commercial oil well, although that title is also claimed for wells in Ontario, West Virginia, Azerbaijan, and Poland, among others.
History of Worldwide Oil Discovery

Wood-made Drilling Cable Tool Rig
History of Worldwide Oil Discovery

Drilling Rigs Everywhere
History of Worldwide Oil Discovery

Drilling Rigs Everywhere
History of Worldwide Oil Discovery

Drilling Rigs Everywhere
History of Worldwide Oil Discovery

Drilling Rigs Everywhere
History of Worldwide Oil Discovery

Drilling Rigs Everywhere
History of Worldwide Oil Discovery

Drake Oil Well Museum
History of Worldwide Oil Discovery

Barrel: bl? or brl? or bbl?

Transportation of Crude Oil Barrels
History of Worldwide Oil Discovery

Cable Toll Drilling Rig
History of Worldwide Oil Discovery

1. Rotation
2. Sharp Bit
3. Force
4. Hole Cleaning

Modern Rotary Drilling Rig - Onshore
History of Worldwide Oil Discovery

Modern Oil Well Configuration
History of Worldwide Oil Discovery

Modern Oil Well Configuration (Low Reservoir Pressure)
History of Worldwide Oil Discovery

Modern Oil Well Configuration (High Reservoir Pressure)
History of Worldwide Oil Discovery

Modern Oil Well Configuration (Wellhead Installation)
History of Worldwide Oil Discovery

Modern Rotary Drilling Rig – Shallow Offshore
History of Worldwide Oil Discovery

- **Drillship**: Operates at water depths up to 12,000ft.
- **Semi-submersible**: Operates at water depths up to 10,000ft.
- **Jack-Up Rig**: Operates at water depths up to 500ft.
- **Drilling Barge**: Operates in shallow waters.

Modern Rotary Drilling Rig – Deep Offshore
History of Worldwide Oil Discovery

In 1859, 69.5 ft Drake vertical open hole well was drilled in one and a half year using cable tool drilling method.

Nowadays, 14000 ft well can be drilled in one month or less using rotary drilling method.

Petroleum wells could be Vertical, Directional, or Horizontal.
History of Worldwide Oil Discovery

Geo-steered maximum reservoir contact well

Advancement in Drilling Technology
History of Worldwide Oil Discovery

Advancement in Drilling Technology
History of Worldwide Oil Discovery

Advancement in Drilling Technology
Arabian Plate ≈ 66% or the World’s oil and gas reserves
### Middle East Oil and Gas

<table>
<thead>
<tr>
<th>KSA - 12</th>
<th>UAE - 6</th>
<th>Kuwait - 5</th>
<th>Iraq - 6</th>
<th>Qatar - 1</th>
<th>Iran - 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Ghawar</td>
<td>7 - Zakum</td>
<td>2 - Burgan</td>
<td>8 - Kirkuk</td>
<td>38 - Dukhan</td>
<td>14 - Gachsaran</td>
</tr>
<tr>
<td>3 - Safaniya</td>
<td>18 - Murban – Bab</td>
<td>23 - Raudhatain</td>
<td>12 - Rumaila</td>
<td>15 - Ahwaz</td>
<td>15 - Ahwaz</td>
</tr>
<tr>
<td>4 - Zuluf</td>
<td>20 - Murban Bu Hasa</td>
<td>29 - Sabriya</td>
<td>16 - Majnoon</td>
<td>17 - Marun</td>
<td>17 - Marun</td>
</tr>
<tr>
<td>6 - Khurais</td>
<td>30 - Asab</td>
<td>35 - Um Gudair</td>
<td>24 - Zubair</td>
<td>32 - Rag e Safid</td>
<td>32 - Rag e Safid</td>
</tr>
<tr>
<td>9 - Abqaiq</td>
<td>31 - Um Shaif</td>
<td>84.6 Billion</td>
<td>27 - West Qurna</td>
<td>34 - Bibi Hakimeh</td>
<td>34 - Bibi Hakimeh</td>
</tr>
<tr>
<td>10 - Berri</td>
<td></td>
<td></td>
<td>36 - Azadegan</td>
<td>36 - Azadegan</td>
<td>36 - Azadegan</td>
</tr>
<tr>
<td>11 - Shaybah</td>
<td></td>
<td></td>
<td>37 - Parsi</td>
<td>37 - Parsi</td>
<td>37 - Parsi</td>
</tr>
<tr>
<td>13 - Marjan</td>
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<tr>
<td>19 - Qatif</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>22 - Abu Safa</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>28 -</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>336 Billion</td>
<td>45.7 Billion</td>
<td>90.2 Billion</td>
<td>49.5 Billion</td>
<td>3.2 Billion</td>
<td>84.6 Billion</td>
</tr>
</tbody>
</table>

Out of the 20 largest oil and gas reserves in the world:

- 15 are in the Middle East (6 in Saudi Arabia, 4 in Iran, 3 in Iraq, 1 in Kuwait, 1 in Abu Dhabi),
- 2 in Russia,
- 1 in South America (Venezuela) and
- 2 in North America (1 in USA-Alaska, 1 in Mexico).
# Middle East Oil and Gas

<table>
<thead>
<tr>
<th>Field, Country</th>
<th>Reserve, $10^9$ bbl</th>
<th>Field, Country</th>
<th>Reserve, $10^9$ bbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Ghawar, Saudi Arabia</td>
<td>79</td>
<td>2 Burgan, Kuwait</td>
<td>69</td>
</tr>
<tr>
<td>3 Cantarell, Mexico</td>
<td>35</td>
<td>4 Bolivar Coastal, Venezuela</td>
<td>31</td>
</tr>
<tr>
<td>5 Safaniya-Khafji, Saudi Arabia</td>
<td>30</td>
<td>6 Rumailia, Iraq</td>
<td>20</td>
</tr>
<tr>
<td>7 Tengiz, Kazakhstan</td>
<td>20</td>
<td>8 Ahwaz, Iran</td>
<td>17</td>
</tr>
<tr>
<td>9 Kirkuk, Iraq</td>
<td>16</td>
<td>10 Marun, Iran</td>
<td>16</td>
</tr>
<tr>
<td>11 Daqing, China</td>
<td>16</td>
<td>12 Gachsaran, Iran</td>
<td>15</td>
</tr>
<tr>
<td>13 Aghajari, Iran</td>
<td>14</td>
<td>14 Samotlor, Russia</td>
<td>15</td>
</tr>
<tr>
<td>15 Prudhoe Bay, Alaska, USA</td>
<td>13</td>
<td>16 Kashagan, Kazakhstan</td>
<td>13</td>
</tr>
<tr>
<td>17 Abqaiq, Saudi Arabia</td>
<td>12</td>
<td>18 Romashkino, Russia</td>
<td>12</td>
</tr>
<tr>
<td>19 Chicontepec, Mexico</td>
<td>12</td>
<td>20 Berri, Saudi Arabia</td>
<td>12</td>
</tr>
<tr>
<td>21 Zakum, Abu Dhabi, UAE</td>
<td>12</td>
<td>22 Manifa, Saudi Arabia</td>
<td>11</td>
</tr>
<tr>
<td>23 Marjan, Saudi Arabia/Iran</td>
<td>10</td>
<td>24 Marlim, Campos, Brazil</td>
<td>10</td>
</tr>
</tbody>
</table>
Middle East Oil and Gas

World’s Normal, Super, and Giant Oil Fields

<table>
<thead>
<tr>
<th>Size</th>
<th>Average Production bpd</th>
<th>Oil Fields Population and Average Productivity</th>
<th>% of the World Total Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small 53%</td>
<td>9,000</td>
<td>4000+ Small Oil Fields &lt; 100,000 bpd</td>
<td>53%</td>
</tr>
<tr>
<td>Medium 12%</td>
<td>130,000</td>
<td>61 Oil Fields 100,000 – 200,000 bpd</td>
<td>12%</td>
</tr>
<tr>
<td>Giant 15%</td>
<td>221,000</td>
<td>29 Oil Fields 200,000 – 300,000 bpd</td>
<td>9%</td>
</tr>
<tr>
<td>Super giant 20%</td>
<td>342,000</td>
<td>12 Oil Fields 300,000 – 500,000 bpd</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>993,000</td>
<td>14 Oil Fields &gt; 500,000 bpd</td>
<td>20%</td>
</tr>
</tbody>
</table>
Middle East Oil and Gas

[Bar chart showing oil reserves for different Middle Eastern countries, with Carbonates reservoirs and Sandstone reservoirs highlighted.

Comparisons:
- Carbonate Reservoirs vs. Sandstone Reservoirs
- Fractured Carbonate Reservoirs vs. Sandstone Reservoirs]
## Worldwide Average Well Productivity

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Well Productivity, bbl/day</th>
<th>Country</th>
<th>Average Well Productivity, bbl/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Saudi Arabia</td>
<td>5623</td>
<td>9 Iraq</td>
<td>1252</td>
</tr>
<tr>
<td>2 Norway (North Sea)</td>
<td>5140</td>
<td>10 Libya</td>
<td>947</td>
</tr>
<tr>
<td>3 Iran</td>
<td>3221</td>
<td>11 Nigeria</td>
<td>940</td>
</tr>
<tr>
<td>4 Kuwait</td>
<td>2278</td>
<td>12 Mexico</td>
<td>875</td>
</tr>
<tr>
<td>5 U.K. (North Sea)</td>
<td>1728</td>
<td>13 Algeria</td>
<td>642</td>
</tr>
<tr>
<td>6 UAE (Abu Dhabi)</td>
<td>1595</td>
<td>14 Venezuela</td>
<td>200</td>
</tr>
<tr>
<td>7 Indonesia</td>
<td>1592</td>
<td>15 China</td>
<td>44</td>
</tr>
<tr>
<td>8 UAE (Dubai)</td>
<td>1578</td>
<td>16 USA</td>
<td>11</td>
</tr>
</tbody>
</table>
Middle East Oil and Gas

Graph showing reserves and production for different regions in 2013:
- **Reserves**
  - U.S.: 2%
  - OPEC: 41%
  - Rest of World: 46%
- **Production**
  - U.S.: 13%
  - OPEC: 10%
  - Rest of World: 25%
- **Consumption**
  - U.S.: 21%
  - OPEC: 69%
Middle East Oil and Gas

Top ten annual net oil importers, 2014

- China: 6.1 million barrels per day
- United States: 5.1 million barrels per day
- Japan: 4.2 million barrels per day
- India: 2.7 million barrels per day
- South Korea: 2.3 million barrels per day
- Germany: 2.2 million barrels per day
- France: 1.6 million barrels per day
- Spain: 1.2 million barrels per day
- Italy: 1.1 million barrels per day
- Taiwan: 1.0 million barrels per day


Saudi Arabia???
Middle East Oil and Gas

The diagram illustrates the projected demand for world oil and the potential production capacity from OPEC countries. The following observations can be made:

- **World Oil Demand**: The demand for world oil has been steadily increasing over the years, with projections indicating a significant rise by 2022.
- **World Oil Production**: The production capacity has been growing, but it is still below the demand curve.
- **OPEC Spare Production**: OPEC has a spare production capacity that can be mobilized to meet additional demand.

By 2014, the demand will surpass the current production capacity, and OPEC will need to increase its spare production to meet the increased demand, as indicated by the vertical dotted line on the graph.
Middle East Oil and Gas

Comparative Oil Reserves (billions of barrels)
Source: Oil & Gas Journal, 2012
Middle East Oil and Gas

Canada Oil Shale

Venezuela Heavy Oil
Middle East Oil and Gas

Oil Shale

Conventional Oil

Heavy Oil

Extraction & Treatment Cost?
Middle East Oil and Gas

Largest Proved Natural Gas Reserves, Jan. 2014

- Russia: 1,688 trillion cubic feet
- Iran: 1,193 trillion cubic feet
- Qatar: 885 trillion cubic feet
- United States: 372 trillion cubic feet
- Saudi Arabia: 291 trillion cubic feet
- Turkmenistan: 265 trillion cubic feet
- United Arab Emirates: 215 trillion cubic feet
- Venezuela: 196 trillion cubic feet
- Nigeria: 181 trillion cubic feet
- Algeria: 159 trillion cubic feet
Oil and Gas in Saudi Arabia

The first oil well in Iran hit oil in Parsumash (MASJED SOLEIMAN) 26 - May - 1908
Oil and Gas in Saudi Arabia

The First Well in Kirkuk Oil Field in Iraq, 1927
Oil and Gas in Saudi Arabia

The First Exploration Concession
In 1910, Othman’s empire started searching for oil in Farasan Islands without any success.

The Second Exploration Concession
In 1926 the British Red Sea Petroleum Company started exploration for oil in the Farasan Islands without success.
Oil and Gas in Saudi Arabia

**The Third Exploration Concession**

In 1923, Holms started searching for oil in AlHassa area in the eastern province of Saudi Arabia. This concession was end with no discovery in 1928.
Oil was discovered in Bahrain island in 1932 in Jebel Dukhan area.
Oil and Gas in Saudi Arabia

Stimulated by the discovery of oil in Bahrain island (Jebel Dukhan) in 1932, attention naturally was directed to the prospects in Saudi Arabia.
Oil and Gas in Saudi Arabia

The Fourth Exploration Concession

In 1933, SOCAL started search for oil in Saudi Arabia. After drilling several oil wells to the same discovery depth in Bahrain no signs of oil appeared. In 1938 the company decided to drill deeper in well no.7 where oil was discovered in commercial quantities at 4717 ft below sea level.

Khamis ibn Rimthan AlAjmi  Well no. 7  Max Steineke
Oil and Gas in Saudi Arabia

Starting Oil Production from Well no. 7
Oil and Gas in Saudi Arabia

With Determination and Insistence, Exploration Continues
With Determination and Insistence, Exploration Continues
Oil and Gas in Saudi Arabia

1. Ain Dar oil field, 1948
2. Haradh oil field, 1949
3. Uthmaniyah oil field, 1951
4. Shedgum oil field, 1952
5. Hawiyah oil field, 1953
6. Fazran oil field, 1957
Middle East Oil and Gas

Ghawwar, the World’s Exceptional Super Giant Oil Fields
Oil and Gas in Saudi Arabia

Saudi Oil Fields Map
Oil and Gas in Saudi Arabia

Saudi Arabia Proven Oil Reserves
Billions bbl

- Technology Advancement
- New Discoveries

265 Bbbls

Year

Oil and Gas in Saudi Arabia

According to Mees: Middle East Oil & Gas News/Analysis

**Recovery Factor = (142/256)\times 100 = 55.5\%**

If EOR add 1.5\% to the proven reserve, then

1.5\% addition = 3.84 Bbbls = One Year Production @ 10 MMbbls
Classification of Crude Oil Based on API Value
## Classification of Crude Oil Based on API Value

<table>
<thead>
<tr>
<th>Type</th>
<th>API Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Heavy</td>
<td></td>
</tr>
<tr>
<td>Extra Heavy</td>
<td></td>
</tr>
<tr>
<td>Asphaltene</td>
<td></td>
</tr>
</tbody>
</table>
Oil and Gas in Saudi Arabia

Quality of Proven Oil Reserves Worldwide
Oil and Gas in Saudi Arabia

Crude Oil Refining Products
## Oil Pricing Criteria

The formula for pricing crude oil is given by:

\[ P_X = P_m \pm A_f \]

Where:
- \( P_X \) = Price of crude oil type X, $/bbl.
- \( P_m \) = Price of Marker (benchmark) crude oil, $/bbl.
- \( A_f \) = Adjustment factor, $/bbl.

<table>
<thead>
<tr>
<th>Geographic Location</th>
<th>Marker Crude Oil</th>
<th>Price Exchange Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe and Africa</td>
<td>Brent Blend</td>
<td>1) London Petroleum Exchange (LPE).</td>
</tr>
<tr>
<td></td>
<td>API = 38.3°.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sulfur content = 0.37 wt%.</td>
<td></td>
</tr>
<tr>
<td>Middle East and Asia</td>
<td>Dubai-Oman-Arab light</td>
<td>2) Singapore International Monetary Exchange (SIMEX).</td>
</tr>
<tr>
<td></td>
<td>API = 32°.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sulfur content = 2.13 wt%.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>API = 39.6°.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sulfur content = 0.24 wt%.</td>
<td></td>
</tr>
</tbody>
</table>

Sometimes, total acid number (TAN) is considered as an important factor.
Middle East Oil and Gas

A barrel of oil cheaper than a bucket of chicken

$28.75

$27.51
Price of Liquids in US$ per barrel

- Chanel no5 perfume: $194,264.31
- Chanel Allure homme aftershave: $93,084.98
- Optrex eye drops: $76,693.93
- Molton Brown hand wash: $12,141.52
- Tabasco Sauce: $6,718.31
- The Ned NZ sauvignon blanc wine: $2,964.55
- Tropicana Orange Juice: $501.85
- Average UK lead free gasoline: $230.69
- Diet Coke: $192.24
- Semi Skimmed milk: $133.56
- Evian Mineral Water: $101.18
- Brent Crude: $54.36

Prices from UK online shops

Price of liquids December 2016 – Brent oil = $54.36 / bbl, £1 = $1.2728, 1 barrel = 158.987 litres
Oil Price Fluctuations

- OPEC (The Organization of Petroleum Exporting Countries)
- Supply and Demand
- Restrictive Legislation
- Political Unrest
- Production Decline
- Financial Markets
- Weather
- World Oil Strategic Reserves
Oil Price Fluctuations

- 1973 OPEC embargo
- 1979 2nd oil crisis
- 1980s Oil glut
- 1990 Iraq invades Kuwait
- 2000s Mid-East turbulence
- Shale Oil glut?
- Financial Crisis
# Middle East Oil and Gas

## Middle East oil field breakeven costs

<table>
<thead>
<tr>
<th>BREAKEVEN OIL PRICE</th>
<th>Brent crude: $48.24*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oman</td>
<td>$28.20 per barrel</td>
</tr>
<tr>
<td>Qatar</td>
<td>$21.66</td>
</tr>
<tr>
<td>Iran</td>
<td>$15.50</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>$12.50</td>
</tr>
<tr>
<td>Iraq</td>
<td>$11.38</td>
</tr>
<tr>
<td>Kuwait</td>
<td>$10.15</td>
</tr>
</tbody>
</table>

* As of closing Nov. 28, 2016
Sources: Rystad Energy UCube; Thomson Reuters Datastream

S. Culp, 29/11/2016

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## Budget Breakeven Estimate

<table>
<thead>
<tr>
<th>Country</th>
<th>Brent crude oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Libya</td>
<td>$184</td>
</tr>
<tr>
<td>Iran</td>
<td>$131</td>
</tr>
<tr>
<td>Algeria</td>
<td>$113</td>
</tr>
<tr>
<td>Iraq</td>
<td>$109</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>$97</td>
</tr>
<tr>
<td>UAE</td>
<td>$74</td>
</tr>
</tbody>
</table>

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Brent crude oil $71.25

Qatar $71
Kuwait $52

Information: IMF, Deutsche Bank
Looking Ahead at Oil Prices

Where investment banks in December’s survey see the price of U.S. crude-oil futures in the next few quarters

Sources: WSJ Market Data Group (oil price); the companies (forecasts); Reuters (photo)

THE WALL STREET JOURNAL
Alternative Energy Recourses

- Petroleum: 37%
- Natural Gas: 25%
- Coal: 21%
- Renewable Energy: 8%
- Nuclear Electric Power: 9%
- Hydropower: 31%
- Wood: 25%
- Biofuels: 23%
- Biomass waste: 6%
- Wind: 11%
- Solar: 1%
- Geothermal: 3%

Total: 100%
Alternative Energy Recourses
Alternative Energy Recourses

Conventional Gas Reservoir (Sandstone)

Unconventional Gas Shale Reservoir

GAS/SOURCE ROCK (SHEAL, COALBIRD METHANE)

Seal
Alternative Energy Recourses

Shale gas as share of total dry natural gas production in 2012
billion cubic feet per day

- **U.S.**
  - 39%

- **Canada**
  - 15%

- **China**
  - <1%

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**ACTUAL AVERAGE MONTHLY WELL OUTPUT**
12/2005-12/2011

First 5 years of well production, average monthly well production

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Month of well production
Alternative Energy Resources

Shale gas as share of total dry natural gas production in 2012
billion cubic feet per day

- U.S.: 40
- Canada: 10
- China: <1%
The Stone Age didn't end for lack of stone, and the oil age will end long before the world runs out of oil.

*Sheik Ahmed Zaki Yamani*

**Economic Depletion**

A reduction in value, i.e. a better and cheaper alternative is found.
Alternative Energy Resources

New Discoveries and Technologies (R=55%)

Figure 5: EIA Peak Oil Projections
Source: Energy Information Administration
ماذا استفادت المملكة من البترول؟
[14:7] And when your Lord made it known: If you are grateful, I would certainly give to you more, and if you are ungrateful, My chastisement is truly severe.