The Challenges of Arctic Oil Exploration and Production

HAVE A SAFE DAY!!!

S/R Puget Sound
Oct 10, 2001
North Bound to
Valdez, Alaska.
Wind 88 Knots,
Prop 65 RPM's,
Hard Left Rudder
For 7 Hours.
Ship Still Moving
"Backwards".

Picture taken seconds before
smashing into port side,
shattering 2” thick
glass porthole
in officer's lounge.

A Part of Braemar Technical Services Incorporating:

BRAEMAR ADJUSTING
BRAEMAR ENGINEERING
BRAEMAR OFFSHORE
BRAEMAR
CASBARIAN

BRAEMAR
ADJUSTING
Content

1. The Arctic
2. Milestones
3. Key Players
4. Environmental Concerns
5. Operational Challenges
6. Facility Design and Operation
7. A look at BP’s Liberty Project
8. Emergency Response Planning
The Arctic Circle is the region above the parallel of latitude that runs 66° 33' 44" (or 66.5622°) north of the Equator.
Estimated US$100 billion of new investment heading for the far north over the next decade.
Arctic Oil & Gas Resources
USGS 2008

ARCTIC BOUNDARIES

- A coastal nation can claim exclusive economic rights to natural resources on or beneath the sea floor up to 200 nautical miles beyond their land territory (exclusive economic zone or EEZ).
- If the continental shelf extends beyond that distance, the country must provide evidence to a UN commission.

CONTINENTAL SHELF CLAIMS

1. Claims cannot extend beyond 350 nm from territorial sea baseline.
2. Claims further limited to 100 nm past a water depth of 2,500 m.
3. Claims cannot extend beyond 60 nm from foot of continental slope.
4. Minimum thickness of sediment.

Potential claim beyond 200 nautical miles

- U.S.A.
- Russia
- Iceland
- Norway
- Denmark
- Canada

Territorial sea/EEZ
- Unclaimable
- Median line
- Agreed boundary
- 350 nm from baseline

Overlapping U.S.-Canada EEZ

Lomonosov Ridge

North Pole

Greenland (Denmark)

Norway-Russia boundary

Newly agreed Norway-Russia special area

ICELAND

GREENLAND

RUSSIA

Norway

U.S.A.
Discovered Reserves

**Discovered Natural Gas Reserves (Bcf) by Country**

<table>
<thead>
<tr>
<th>Country</th>
<th>Reserves (Bcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>0</td>
</tr>
<tr>
<td>Canada (Arctic Ocean)</td>
<td>0</td>
</tr>
<tr>
<td>Norway</td>
<td>0</td>
</tr>
<tr>
<td>Russia</td>
<td>580,000</td>
</tr>
<tr>
<td>Russia (Sakhalin)</td>
<td>10,000</td>
</tr>
<tr>
<td>USA (Alaska)</td>
<td>0</td>
</tr>
</tbody>
</table>

**Discovered Offshore Arctic Fields by Country**

<table>
<thead>
<tr>
<th>Country</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>33</td>
</tr>
<tr>
<td>Canada (Arctic Ocean)</td>
<td>41</td>
</tr>
<tr>
<td>Norway</td>
<td>31</td>
</tr>
<tr>
<td>Russia</td>
<td>23</td>
</tr>
<tr>
<td>Russia (Sakhalin)</td>
<td>19</td>
</tr>
<tr>
<td>USA (Alaska)</td>
<td>27</td>
</tr>
</tbody>
</table>

**Discovered Oil Reserves (Mbbl) by Country**

<table>
<thead>
<tr>
<th>Country</th>
<th>Reserves (Mbbl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>3,000</td>
</tr>
<tr>
<td>Canada (Arctic Ocean)</td>
<td>1,000</td>
</tr>
<tr>
<td>Norway</td>
<td>100</td>
</tr>
<tr>
<td>Russia</td>
<td>4,000</td>
</tr>
<tr>
<td>Russia (Sakhalin)</td>
<td>1,000</td>
</tr>
<tr>
<td>USA (Alaska)</td>
<td>3,000</td>
</tr>
</tbody>
</table>

**Production Cost Curve**

Available Quantity (Mbbl)

- Already Produced
- Conventional
- Conventional
- CO2 EOR
- Other EOR
- Deep Water
- Arctic
- Heavy Oil
- Bitumen

Cost Range (Mbbl)

- Low Oil Price
- Medium Oil Price
- High Oil Price
Arctic Milestones

1920: Oil is discovered at Norman Wells, in the Canadian Northwest Territories.


1968: Oil is discovered at Prudhoe Bay, in the United States.

1975: Five offshore wells are drilled in Greenland.

1977: Oil starts flowing through the Alaska Pipeline.

1979: First offshore lease sales in the Beaufort Sea, United States.

1984: The Snøhvit field is discovered in the Barents Sea, Norway.

1989: The Exxon Valdez oil spill occurs in Alaska.

1994: Pipeline ruptures in Komi Republic, Russia, sparking a massive oil spill.

2000: Goliat oil field is discovered in Norway, east of Snøhvit.
Arctic Milestones

2001 : Three exploration wells are drilled in the Faroe Islands.


2007 : Snøhvit starts producing gas.

2007 : Russia plants a flag at the bottom of North Pole, sparking international outcry.

2007 : The Northwest Passage becomes navigable for the first time in recorded history.

2007 : Gazprom, Total and Statoil team up to develop Shtokman, in Russia.

2008 : Shell bids $2.1 billion for drilling rights in the Chukchi Sea.

2008 : The U.S. Geological Survey appraises Arctic reserves at 22% of the undiscovered, technically recoverable resources in the world.

2010, April : Russia and Norway strike a maritime border agreement, ending a 40-year row over an area in the Barents Sea.
2010, June: UK-based Cairn starts drilling offshore Greenland.

2010, September: The first-ever Russian tanker of hydrocarbons to navigate the Northern Sea Route reaches China in 22 days, roughly half the time it would take going through the Suez Canal.

2011: Exxonmobil and Russian National company Rosneft form an Arctic exploration partnership.

2012, April: Rosneft and Italian company Eni sign an Arctic exploration partnership.

2012, May: Rosneft and Statoil, majority owned by the Norwegian State, sign an Arctic partnership.

2012, August: USA chartered Ocean Energy Safety Advisory Committee concluded there is a need to modernise US regulations to include Arctic Specific Standards, to prevent Oil Spills, Contain them and Respond to them quickly.

2013, September: Imperial, Exxon Mobil Corp. and BP filed a project description with regulators as a first step in the proposed drilling on two jointly held licences about 175 kilometres northwest of Tuktoyaktuk, NWT.
Major “Players”
Licensing & Activity
### Arctic Construction Projects

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Location</th>
<th>Developers</th>
<th>Project Phase</th>
<th>Project Value</th>
<th>Startup</th>
<th>Reserves</th>
<th>Water Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpine Satellites</td>
<td>Alaska, Western North Slope</td>
<td>Conoco Phillips, Anadarko Petroleum</td>
<td>Design</td>
<td>$1,000</td>
<td>2016</td>
<td>330 million bbl</td>
<td></td>
</tr>
<tr>
<td>Cape Farewell Exploration</td>
<td>Offshore Greenland</td>
<td>Capricorn Oil, Petronas, Nunaoil</td>
<td>Design</td>
<td>$150 Million</td>
<td>2018</td>
<td>Exploration</td>
<td>50 - 2,000 metres</td>
</tr>
<tr>
<td>Uummannarsuaq Block Exploration</td>
<td>Offshore Greenland</td>
<td>Capricorn Oil, Petronas, Nunaoil</td>
<td>Planning</td>
<td>$50 Million</td>
<td>2018</td>
<td>Exploration</td>
<td>300 - 1,400 metres</td>
</tr>
<tr>
<td>Kingittoq and Saqqamuit Block Exploration</td>
<td>Offshore Greenland</td>
<td>Capricorn Oil, Petronas, Nunaoil</td>
<td>Planning</td>
<td>$50 Million</td>
<td>2015</td>
<td>Exploration</td>
<td></td>
</tr>
<tr>
<td>Liberty Offshore Oil Field</td>
<td>Beaufort Sea</td>
<td>BP</td>
<td>Planning</td>
<td>1,500 Million</td>
<td>2020</td>
<td>150 million bbl</td>
<td></td>
</tr>
<tr>
<td>Yamal Peninsula Oil &amp; Gas Developments</td>
<td>Yamal Peninsula (Kara Sea) - Russia</td>
<td>Gazprom, Wintershall, E.ON AG, Total, Shell</td>
<td>Drilling</td>
<td>$10,000 Million</td>
<td>2012</td>
<td>4.9 trillion m³</td>
<td></td>
</tr>
<tr>
<td>Goliat Oil &amp; Gas Field</td>
<td>Barents Sea</td>
<td>ENI, Statoil</td>
<td>Contract Awarded</td>
<td>$6,500 Million</td>
<td>2014</td>
<td>192 million bbl oil 257 billion ft³ gas</td>
<td>420 metres</td>
</tr>
<tr>
<td>Sallii Block Exploration</td>
<td>Offshore Greenland</td>
<td>Capricorn Oil, Petronas, Nunaoil</td>
<td>Planning</td>
<td>$50 Million</td>
<td>2018</td>
<td>Exploration</td>
<td></td>
</tr>
<tr>
<td>West Disko Exploration Block - Sigguk and Eqqua Blocks</td>
<td>Offshore Greenland</td>
<td>Capricorn Oil, Petronas, Nunaoil</td>
<td>Planning</td>
<td>$200 Million</td>
<td>2015</td>
<td>Exploration</td>
<td>300 - 1,400 metres</td>
</tr>
<tr>
<td>West Disko Exploration Block 4-7</td>
<td>Offshore Greenland</td>
<td>Esso, Dong, Husky Oil, Nunaoil</td>
<td>Planning</td>
<td>$200 Million</td>
<td>2022</td>
<td>Exploration</td>
<td>500 metres</td>
</tr>
<tr>
<td>West Disko Block 8 Exploration</td>
<td>Offshore Greenland</td>
<td>PA Resources, Nunaoil</td>
<td>Drilling</td>
<td>$250 Million</td>
<td>2014</td>
<td>1,520 metres</td>
<td></td>
</tr>
<tr>
<td>Teriberka Refinery (Murmansk)</td>
<td>Teriberka, Russia</td>
<td>Sevmorneftegaz</td>
<td>Planning</td>
<td>$1,000 Million</td>
<td>2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shtokman LNG Plant (Murmansk) - Phase 1</td>
<td>Teriberka, Russia</td>
<td>Gazprom, Total</td>
<td>Project on Hold</td>
<td>$7,500 Million</td>
<td>2019</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shtokman Gas Field - Phase 1</td>
<td>Barents Sea</td>
<td>Shtokman, Gazprom, Total</td>
<td>On Hold</td>
<td>$15,000 Million</td>
<td>2017</td>
<td>134,195 billion ft³</td>
<td>340 metres</td>
</tr>
</tbody>
</table>

*Information collected from EIC DataStream (www.the-eic.com)*
Why the Arctic? “Players”

2014: Shell said it would suspend its operations in the Arctic — and possibly withdraw for good.
• Shell is the main company to have purchased leases for oilfields off Alaska's Arctic shores
• Has hit technical and legal hurdles obtaining actual drilling permits.
Environmental Concerns...

The Arctic: “A cold Serengeti”

Illustrative map of areas in the Arctic where selected birds, mammals, and fish form major aggregations to breed, stage, migrate, or overwinter. When oil and gas activities including transportation occur in such areas, such aggregations are vulnerable to disturbances and oil spills.
Environmental Concerns...

The coastal plain is the biological heart of a huge arctic/subarctic ecosystem. Any disruption could affect the entire ecosystem.

Environmentalists feel that the entire coastal tundra would be disrupted, affecting polar bears in their dens, calving grounds for caribou, and migratory birds in the area.
Environmental Concerns...
An Operational Challenge
Ice Road Truckers
Extreme temperatures
Sea Ice
Ice bergs
Strudel scour

Strudel is the German word for “whirlpool.” Strudel scour describes an event in which, during spring melt, a large volume of freshwater flows onto pack ice and drains through a hole or crack in the ice creating a severe whirlpool down to the seabed, where the water pressure can wash layers of the seabed away, creating a hole more than 12 feet deep.
Permafrost Thaw

Depending on the pipeline’s proximity to the permafrost layer, thawing of the permafrost could cause the seafloor to settle, creating a depression and putting strain on the pipeline.

**Installation**

**Operation**

Ground settles as ice-rich permafrost soil thaws around pipe

- Pipeline deflection
Offshore E&P

Ice-breakers often required in winter.

Frequent severe weather (although, as my Houston colleagues pointed out, “they never had to evacuate for a Hurricane!”).
# Operational limits

Environmental Factors That Determine Operational Limitations in the U.S. Arctic Ocean

Percentages of time when operating limits for response are reached because of the environment

<table>
<thead>
<tr>
<th></th>
<th>Winter (Jan.-March)</th>
<th>Spring (April-June)</th>
<th>Summer (July-Sept.)</th>
<th>Fall (Oct.-Dec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ice Condition</strong></td>
<td>Solid (100%)</td>
<td>Solid (80%) Broken Ice (20%)</td>
<td>Broken Ice (60%) Open Water (40%)</td>
<td>Open Water (20%), Broken Ice (60%), Solid (20%)</td>
</tr>
<tr>
<td><strong>Darkness</strong></td>
<td>81%</td>
<td>21%</td>
<td>13%</td>
<td>77%</td>
</tr>
<tr>
<td><strong>Wind</strong></td>
<td>22%</td>
<td>13%</td>
<td>21%</td>
<td>33%</td>
</tr>
<tr>
<td><strong>Fog</strong></td>
<td>57%</td>
<td>58%</td>
<td>48%</td>
<td>55%</td>
</tr>
<tr>
<td><strong>Temperature &lt;=-35 F</strong></td>
<td>37%</td>
<td></td>
<td></td>
<td>4%</td>
</tr>
</tbody>
</table>
Operational limits

Arctic Seasonal Drilling Limits

Icy conditions reduce the efficacy of oil spill response most of the year.

<table>
<thead>
<tr>
<th>Inaccessible</th>
<th>Accessible</th>
<th>Inaccessible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter ice cover</td>
<td>Spring breakup</td>
<td>Open water</td>
</tr>
</tbody>
</table>

Infrastructure Needed

Challenge not only due to harsh environment but also due to remote nature of the locations.
Operational Response
High Tech Drilling
North Slope, Alaska

North Slope operations use drilling technology to minimize environmental impacts.

- Pipeline to the Trans-Alaska Pipeline
- Mud and cuttings are ground up and injected downhole.
- Directional drilling is used to drill horizontally and/or reach different accumulations.
- High tech bottom hole assemblies have sophisticated instrumentation which allows directional drilling with precise location information.
- Multiple wells can be drilled with multilateral drilling technology.
- Modern drilling technology minimizes the footprint.

Technology...
Subsea production system: The future of Arctic production?
Example of Statoil Orman Lange (Not quite Arctic at 62 degree N latitude...)
Cost: NOK12 billion (US$ 2 billion)
Logistical Challenge... Offshore Production

Actual size...
First ever installed in 2007 in the South-Eastern Barents Sea for Lukoil.
Ice Class Vessels

1945 vessel, Dalstroy (Classification 1C)
Bunkering Tanker Vs. Modern Icebreaker
Challenges - The Environment

But it’s getting warmer...
Challenges – Ice Movement

Existing Shipping Routes - Ice-breakers often required to “open” path for tankers.

Changing Ice-Cap and Iceberg migration.
Logistical Challenge... Offshore Production

Supply and Demand of all ICE Class OSVs

*Supply and demand for individual ICE classes may vary according to season and/or prevailing ice conditions

Supply and Demand of all ICE Class Pipelay Vessels

*Supply and demand for individual ICE classes may vary according to season and/or prevailing ice conditions

But with FOIROTs or offloading Arctic specific FPSOs, you need Tankers...

Icebreaking Tanker project:
- 70,000 tdwt capacity
- 1.7m ice breaking ability (continuous)
- 2 x 10MW Tractor Pod propulsion
Working Conditions...

Winter work only onshore
Productivity decreases by 30 to 40%
Rig Winterization

• Elimination of pockets of liquid.
• Maintaining constant flow in exposed piping.
• Insulation
• Heat tracing
• Instrumentation seals.
• Wind walls to reduce heat loss rate.
• Use of methanol
• Steam service outlets for de-icing.
Ice-Resistant Platforms
BP’s Liberty Project

- Artificial island 31 acres of gravel in size.
- Located in the shallow water inside the Beaufort Sea’s barrier island.
- Targeting reservoir containing an estimated 1.5 million bbl of oil
- Estimated cost of US$1.5 billion dollars
- Minimize environmental footprint.
BP’s Liberty Project – Drilling

- Production piping is protected by additional series of casings.
- Target is approximately 2 miles deep and 6-8 miles across.
- Longest extended reach wells ever attempted.
- Controversy?
  - Offshore drilling
  - Registration as ‘onshore’ rig.
BP’s Liberty Project – Drilling Rig

• One of the most powerful rigs in the world.
• Built in Vancouver, BC
• Fitted with eight 2,640 hp engines.
• Low temperature tolerant steel.
• Total cost of US$215 Million.
• Original plan was to start production by 2011.
• Setbacks following Deepwater Horizon disaster and issues with rig have delayed project.
• New plan is for production by 2020.
Greenland is requiring companies that drill in its waters to pay for a $2 billion bond upfront – before drilling even begins – in order to cover the cost of cleaning up any oil spills that might occur.
Emergency Response Challenge...

Large area with few harbors and even fewer airports. Severe weather exacerbates the problem.

Potential high mitigation costs.
Ice affects clean-up operations
### Ice affects clean-up operations

#### Seasonal Constraints to Cleaning Up an Arctic Oil Spill

The symbols show the approximate operating limits for mechanical oil removal and burning of spilled oil under various concentrations of ice and weather conditions.

<table>
<thead>
<tr>
<th>Limiting Factor</th>
<th>Ice Coverage</th>
<th>Wind</th>
<th>Wave Height</th>
<th>Visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oil spilled on top of ice or among ice</td>
<td>Oil spilled under solid ice</td>
<td>0-20 mph</td>
<td>21-35 mph</td>
</tr>
<tr>
<td>Conditions</td>
<td>&lt;10%</td>
<td>11%-30%</td>
<td>31%-70%</td>
<td>&gt;70%</td>
</tr>
<tr>
<td>Mechanical recovery with no ice management</td>
<td>✓</td>
<td>○</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Mechanical recovery with ice management</td>
<td>✓</td>
<td>○</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>In-situ burning</td>
<td>✓</td>
<td>○</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>
Conclusion...

- Arctic offshore drilling operations into hydrocarbon-bearing zones should be limited to period when the drilling rig and its associated spill-response systems are capable of working and cleaning up a spill in Arctic conditions.

- Vessels, drilling rigs, and facilities should be built to withstand maximum ice forces and sea states that may be encountered.

- Equipment needed to control a spill, such as relief rigs and well control containment systems, should be designed for and located in Alaska’s Arctic so they can be readily deployed.

- Spill response equipment should be sufficiently robust to remove oil caught in ice-infested waters and trapped under ice.

- Redundant systems – including blowout preventers, double-walled pipelines, double bottom tanks, and remotely operated controls – should be installed because equipment and logistical access is unavailable for long parts of the year due to the harsh weather or ice cover.