Introduction to Deepwater Development

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UH Petroleum Industry Expert Lecture Series
Petroleum Technology Program
October 29, 2014
Presentation Overview

• A Historical Perspective
• Why Deepwater?
• Deepwater Solutions
• Field Development Planning
• Floating System Selection
• Technology, Trends and Challenges
• Wrap-up
• Q&A
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A Historical Perspective

- First well drilled out of sight of land 67 years ago in 21 ft water depth
  ✓ Today, we are drilling in depths exceeding 10,000 ft
- First offshore platform installed in 1947 in 21 ft of water
  ✓ Today, platforms are being installed in depths exceeding 8,000 ft
- World’s tallest structure was installed offshore in 1979 in 360 ft of water
  ✓ Today, a fixed platform stands in excess of 1,800 ft of water
- First subsea tree installed in early 1960’s in less than 320 ft of water
  ✓ Today, subsea trees are being installed in depths exceeding 9,500 ft of water

Kerr-McGee’s drilling platform, Kermac Rig No. 16, was the first offshore rig in the Gulf of Mexico that was out of sight of land. It was installed in 1947 in 20 ft of water, 10 miles at sea.

The Perdido spar is the deepest floating oil platform in the world at a water depth of about 8,000 ft. It was installed 200 miles from shore and is operated by Shell in the Gulf of Mexico.
1. The drillers were drilling in deepwater long before we had the production capability.
2. The time and depth gap between drilling and production is closing fast.
3. 10,000’ has been the water depth threshold for almost 10 years.
The Deepwater Vision – Then and Now

June 1947 - Oil & Gas Journal

Feb 1959 - Offshore Magazine

Semi
FPSO
Compliant Tower
TLP
Spar
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Why Deepwater?

- Future oil demand will remain strong
- Deepwater is where the remaining big reserves are located
- Deepwater will account for 25% of global offshore production by 2015, compared to just 9% now
- Innovative technologies will allow economic developments in deep and ultra-deepwater

Relative Deepwater Well Activity in 2013
Deepwater Drilling is Rapidly Expanding

• New deepwater basins are being identified at a rapid pace
  – Expansion will be further enabled by the significant additions to the floating rig fleet over the next several years

Source: Wood Mackenzie
Deepwater Has High Potential

Larger average field sizes and more cumulative volumes discovered in deepwater than onshore or shelf

Source: Wood Mackenzie. Deepwater defined as >400m and ultra deep as >1,500m
Long-term Investment Outlook is Good

Global E&P oil and gas capital expenditures (including expex)
Billion USD

Source: Rystad
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Deepwater System Types Currently in Use

Three Deepwater System Groups:

1. **Dry Tree Systems** – Fixed Platform, Compliant Tower, TLP, Spar

2. **Wet Tree Systems** – New Gen. TLPs, Conventional TLPS, FPSOs, Cell Spar, Control Buoy, SS Tiebacks, Semi-FPS

3. **Mixed Dry / Wet Tree Systems** – Fixed Platforms, New Gen. TLP, Conventional TLP, Spar

Deepwater Systems Global Distribution

- **Canada**: 2 FPSOs
- **North Sea**: 21 FPSOs, 14 Semi FPS/FPUs, 2 TLPs
- **North Africa**: 4 FPSOs
- **Gulf of Mexico**: 4 FPSOs (1 US, 3 Mexico), 9 Semi FPS/FPUs, 16 TLPs, 17 Spar/DCVs, 3 Compliant Towers
- **Brazil**: 31 FPSOs, 20 Semi FPS/FPUs
- **West Africa**: 39 FPSOs, 1 Semi FPS/FPU, 6 TLPs, 2 Compliant Towers
- **India**: 1 FPSO, 1 Semi FPS/FPU
- **Southeast Asia**: 22 FPSOs, 1 Semi FPS/FPU, 1 TLP, 1 Spar
- **Australasia**: 15 FPSOs

Total Number of Operating Vessels: 251
Predominant Floater Types

There are four primary industry recognized floating production solutions, accepted because:

- **Proven** - Many years of Operating history
- **Functional** - Used for a large variety of functions, wet or dry tree
- **Scalable** – Wide range of topsides payloads
- **Adaptable** – Applications worldwide
Fundamental Concept Differentiators

- Functionality
- Scalability
- Integration
- Installation
- Flexibility

![Spar (Dry or Wet trees)](image_url)

Semisub (Wet trees)

![TLP (Dry or Wet trees)](image_url)

FPSO (Wet trees)

![FPSO (Wet trees)](image_url)
Semisubmersible Platform – Variants and Differentiators

• **Functionality**
  - Wet trees
  - Subsea BOP drilling, completion, intervention

• **Scalability Constraints**
  - Limited envelope of SCR applicability

• **Installation, Integration**
  - Quayside integration
  - Relatively simple installation

• **Flexibility**
  - Ease of decommissioning, relocation and future expansion
Tension Leg Platform – Variants and Differentiators

• Functionality
  • Dry or Wet trees
  • Subsea BOP drilling, completion, intervention

• Scalability Constraints
  • Tendons limit w.d. to about 5,000 ft

• Installation, Integration
  • Quayside or offshore integration
  • Installation relatively complex

• Flexibility
  • Limited flexibility for decommissioning, relocation
Spar Platform – Variants and Differentiators

- **Functionality**
  - Dry or Wet trees
  - Subsea BOP drilling, completion

- **Scalability Constraints**
  - Dual barrier production riser with increasing depth and pressure
  - Very large payloads (>25,000 tons)

- **Installation, Integration**
  - Offshore deck installation

- **Flexibility**
  - Limited flexibility for decommissioning, relocation, expansion
Floating Production, Storage & Offloading – Variants and Differentiators

- **Functionality**
  - Wet trees
  - Subsea BOP drilling, completion, intervention

- **Scalability Constraints**
  - No water depth constraints
  - Riser constraints in deeper waters
  - Very large payloads (>25,000 tons)

- **Installation, Integration**
  - Shipyard integration
  - Suitable for harsh and remote locations

- **Flexibility**
  - Good flexibility for decommissioning, relocation, expansion
Emerging Deepwater Floating Platforms

- MinDOC 3™ (dry tree, worldwide)
- Sevan, MonoBR Circular FPSO (wet tree, worldwide)
- FPSO with drilling (mild, directional seas)
- Floating LNG (wet tree, worldwide)
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Field Development Planning Process

- To define an **optimum reservoir depletion** and compatible **facilities development plan** that has a high probability of meeting an Operator’s major business drivers

- **It occurs in early project phases** when reservoir information is limited and uncertainty of key decision variables is high
Early Planning Creates the Greatest Value

- The **greatest value to a project** is created in the **Appraise and Select phases** which involve:
  - Developing a robust **reservoir model** and depletion plan
  - Optimizing the **drilling program** (greatest recovery with fewest wells)
  - Minimizing **well performance** uncertainty
  - Selecting the right **surface facility** plan

- The **spend in these phases** is generally a small percentage of the **total development spend** but provides substantial added value to the project
Project Phases Have Distinct Objectives

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
<th>Phase 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appraise</td>
<td>Select</td>
<td>Define</td>
<td>Execute</td>
<td>Operate</td>
</tr>
</tbody>
</table>

- **Determine potential value of the opportunity and alignment with business strategy**
- **Generate and select the preferred development plans**
- **Finalize scope, cost, schedule, execution plan & get project funded**
- **Design, fabricate, install, commission project**
- **Start-up, operate, maintain asset to maximize return**

**Field Development Planning** → **Front End Loading** → **Execution** → **Optimize Performance**

Typical Timeline = 5-7 Years

**DO THE RIGHT PROJECT**

1-2 Years

**Pre-FEED** 8-12 Months

**FEED** 12-15 Months

2-4 Years

**Ability to Impact Results**

Stage Gate – Decision to Proceed

26 - Wood Group Mustang
Planning is a Collaborative Process

- Objective is to **select a development plan that satisfies an Operator’s commercial, strategic and risk objectives**

- It involves a **continuous interaction** between key elements:
  - Subsurface
  - Surface
  - Business

- The process **requires continuous and effective collaboration and alignment between reservoir, well construction, surface facilities and commercial teams**
Typical Project Cost Distribution

Relative Level of Influence on Cost

Solid execution strategy needed early in order to “get it right”
Proper Planning is Critical to Success

**Feasibility Studies**
- Identify alternatives
- Determine technical feasibility
- Determine Commercial Viability

**Concept Studies**
- Screen alternatives
- Select development concept

**FEED**
- Define development concept
- Design basis
- Cost
- Schedule
- Execution Plan

**Execute EPCI**
- Detail design
- Construction
- Installation
- HUC
Planning for Success – Feasibility Phase

- Does the technology exist?
- Is it technically feasible?
- Can it be built to the required size?
- Can it be installed?
- Do the risks appear manageable?
Planning for Success – Concept Selection

• Which concept will have the highest NPV?
• Constructability and install ability issues
• First-of-a-kind issues
• Site conditions
• Potential contracting constraints
• Risk analysis
Planning for Success – FEED Phase

• Strive for a fabrication friendly design
• Strive for an installation friendly design
• Identify risks and develop mitigation plans
• Develop a manageable contracting strategy
• Develop a realistic cost estimate and schedule
Planning for Success – EPCI Phase

• Reflects pre-sanction planning
• Focus becomes ‘work the plan’
• Inadequate planning leads to serious problems
• Recovery is expensive
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Floating System Selection Factors

- **Functional**
  - Dry/Wet trees; drilling, workover
- **Technical**
  - Water depth; Metocean; Shut-in pressure; risers
- **Execution**
  - Topsides integration, installation and commissioning
- **Operations**
  - Safety; reliability; availability
- **Flexibility**
  - Contracting; future expansion; relocation
- **Commercial**
  - Capex, Opex and schedule
Key Drivers for Floating System Selection

• **Reservoir** characteristics drive everything

• **Field architecture** and layout / future expandability

• **Riser** options / platform motions

• **Metocean** criteria

• **Topsides** requirements

• **Local content** requirements

• **Drilling & completion** strategy

• **Risk** issues & mitigating measures

• **Execution** plan and delivery model
## Completion Strategy Drives Floater Selection

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Total Subsea (wet-tree)</th>
<th>Surface (dry-tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPEX Cost</td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td>DRILEX Cost</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>OPEX Cost</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Production Reliability</td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td>Reservoir Mgmt and Productivity</td>
<td>Lower</td>
<td>Higher</td>
</tr>
</tbody>
</table>
### Deepwater Concept Qualification Matrix

#### Deepwater Field Development Concept Selection Matrix

**Legend:**
- Field Proven
- Qualified

* "Unconventional" FPSOs include Sevan SSP, Petrobras Mero, BR, Global SSP SSP320 & SSP PLUS.

#### MAJOR CAPABILITY
- FIELD APPLICATION EXPERIENCE
- PRODUCTION
- DRILLING
- STORAGE
- WATER DEPTH RATING
- PAYLOAD SENSITIVE
- DECK/HULL MATING OFFSHORE
- DECK/HULL MATING @ FABRICATION YARD
- SMALL AREA
- LARGE AREA
- WET TREE
- DRY TREE
- WELLS COUNT
- NEARBY INFRASTRUCTURE
- REMOTE
- SMALL FOOTPRINT (Mooring System)
- CALM
- AREA WITH HURRICANES/PHOENIX
- HARSH
- STEEL CATHETER RISER (SCR) CAPABLE
- FLEXIBLE PIPE CAPABLE
- TOP TENSIONED RISER
- OIL PIPELINE EXPORT APPLICATION
- SHUTTLE PIPELINE
- GAS PIPELINE

#### INSTALL
- RESERVOIR INFO.
- ARIAL EXTENT

#### TREE TYPE
- CONVENTIONAL FIXED PLATFORM (>1,000')
- COMPLIANT TOWERS
- FDPSOs
- FPSOs
  - Spread Moored
  - Turret Moored
  - Unconventional
- CONVENTIONAL TLPs
- PROPRIETARY TLPs
- SPARS
  - Dry Tree
  - Wet Tree
- SEMI-FPSUs
  - CONVENTIONAL
  - DEEP DRAFT WET TREE
  - DEEP DRAFT DRY TREE
  - SUBSEA TIEBACKS

#### EXPORT
- GAS REINJECTION

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38 - Wood Group Mustang
Technology Enables Longer Gas Tiebacks

World Record Subsea Tiebacks • Sanctioned, Installed, Operating or Future Tiebacks (Water Depth vs. Tieback Distance) • As of March 2014

Notes: 1. Assistance from Quest Offshore Resources, Inc. (www.questoff.com)
Typical Decision Tree for Screening Floating Platforms – Large Multiple Reservoirs

Reservoir Size
> 150 mmboe recoverable

Production Well Count > 10

Production Throughput > 100 mboepd

Compact Reservoir

> 5000 Ft WD
- Dry Tree TLP with Drilling
  - Big Foot
- Wet Tree Semi with Drilling
  - Thunder Horse

< 5000 Ft WD
- Dry Tree Spar with Drilling
  - Hoover
  - Holstein
  - Mad Dog
  - Genesis
- Dry Tree TLP with Drilling
  - Auger
  - Mars (A)
  - Ram Powell
  - Ursa
  - Brutus
  - Olympus

> 5000 Ft WD
- Wet Tree Spar
  - Lucius
  - Heidelberg

< 5000 Ft WD

Areally Extensive Reservoir

Wet Tree FPU
- Tahiti

Wet Tree Spar
- Wet Tree TLP
- Wet Tree Semi

Wet Tree Semi
- Na Kika
- Atlantis
- Ind. Hub
- Jack St. Malo
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Deepwater Technology Needs

Integrity Management, Flow Assurance, Big Data Management

- Subsea Power Distribution
- Subsea Boosting
- Flow Assurance
- Water Processing
- Metocean Design Criteria
- Low Motion Spar, Semi
- Ultradeep Moorings
- Ultradeep Risers
- Ultradeep and HV Umbilicals
- Gas Conditioning
- Fixed Moored FPSO
- HP Flexibles
- MPD
- BOP Reliability
- Liner Drilling
- Zonal Isolation
- Fiber Optic Downhole
- HP/HT Completion Design
- Lower Tertiary Completions
- Rigless Intervention
- Zonal Isolation
- Deepwater Technology Needs
Deepwater Development Trends

- Capex inflation outpacing oil & gas price inflation
- Most deepwater projects are now “Mega-Projects”
- Industry struggling to achieve acceptable commercial results
- Geographic, geologic and geopolitical trends are root causes

Source: HIS CERA, Wood MacKenzie
Recent Macro Trends in Deepwater Projects

- **Trends**
  - Increasing project complexity – geology, geography, geopolitics
  - Project Capex escalation outstripping oil/gas price escalation

- **Consequence**
  - Many greenfield projects deferred, cancelled, recycled
  - More redevelopment/expansion projects
  - Greater project execution uncertainty

- **Mitigation**
  - Increased emphasis on FEL
  - Faster qualification/adoption of enabling and EOR technologies
  - Bridge skills gap
Putting Field Development Costs in Perspective

GoM – Exxon Hoover - $1.2bn  
Installed 2000

GoM – BP Horn Mountain $650M  
Installed 2002

GoM – BP – Thunderhorse - $5bn  
Installed 2005

GoM – Anadarko I-Hub - $2bn  
Installed 2007

GoM – Chevron Tahiti - $2.7bn  
Installed 2009

GoM – Chevron JSM - $7.5bn  
Installed 2014
# Quantifying Impact on a Surface Facility

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Mars A TLP</th>
<th>Olympus TLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanctioned</td>
<td>-</td>
<td>Sep-93</td>
<td>Sep-10</td>
</tr>
<tr>
<td>Water Depth at Floater</td>
<td>ft</td>
<td>~ 2,940</td>
<td>3,028</td>
</tr>
<tr>
<td>Functions</td>
<td>-</td>
<td>Full Drilling &amp; Production</td>
<td>Full Drilling &amp; Production</td>
</tr>
<tr>
<td>Trees</td>
<td>-</td>
<td>Dry</td>
<td>Dry</td>
</tr>
<tr>
<td>Production TTRs</td>
<td>-</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

## Topside Design Basis

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Mars A TLP</th>
<th>Olympus TLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Oil Rate</td>
<td>mbopd</td>
<td>100 (220 after debottlenecking)</td>
<td>100</td>
</tr>
<tr>
<td>Peak Gas Rate</td>
<td>mmscfd</td>
<td>110 (220 after debottlenecking)</td>
<td>180</td>
</tr>
<tr>
<td>Water Injection</td>
<td>mbwpd</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Quarters</td>
<td>-</td>
<td>160</td>
<td>190</td>
</tr>
<tr>
<td>Drilling Rig Hook Load</td>
<td>pounds</td>
<td>1 million</td>
<td>2 million</td>
</tr>
</tbody>
</table>

Development Cost: ~ $1 bn

Unknown
Quantifying Impact on a Surface Facility

**Olympus TL P is more than twice as ‘big’ as Mars TL P**
- Olympus weighs over 120,000 tons; heavier than 300 Boeing 747 Jumbo Jets
- Base of Hull to Top of Derrick is 406 ft tall (approximately 1.5 x Height Superdome)
- Olympus combined deck area = 342,000 ft² (greater than total floor Superdome @ 269,000 ft²).
- Olympus column spacing = 250 feet (c to c) – similar footprint to One Shell Square

<table>
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<th>Olympus TLP</th>
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</thead>
<tbody>
<tr>
<td>Hull</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeboard</td>
<td>ft</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Draft</td>
<td>ft</td>
<td>87</td>
<td>105</td>
</tr>
<tr>
<td>Column Diameter</td>
<td>ft</td>
<td>66.5</td>
<td>90</td>
</tr>
<tr>
<td>Column Length</td>
<td>ft</td>
<td>162</td>
<td>205</td>
</tr>
<tr>
<td>Column c/c Spacing</td>
<td>ft</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>Pontoon (width x height)</td>
<td>ft x ft</td>
<td>27.5 x 24.7</td>
<td>50 x 31.5</td>
</tr>
<tr>
<td>Tendons</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number (corner x #)</td>
<td>-</td>
<td>4 x 3</td>
<td>4 x 4</td>
</tr>
<tr>
<td>Outer Diameter x Wall Thickness</td>
<td>in x in</td>
<td>28 x 1.2</td>
<td>38 x 1.44</td>
</tr>
<tr>
<td>Tendon Weight</td>
<td>st</td>
<td>6,200</td>
<td>13,000</td>
</tr>
</tbody>
</table>
Quantifying Impact on a Surface Facility

Impact on Olympus TLP

Topsides – 50% greater operating load
- Heavier process equipment for HP reservoir
- Larger drilling rig for deeper reservoir
- Greater Water Injection capacity to increase well recovery

Riser Tension – 2.8 times greater
- Heavier production risers for HP reservoirs
- Greater tension factor for higher metocean loads

Tendon Pretension – 3.5 times greater
- Design and survival case loads for 2INT-MET metocean basis

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Mars A TLP</th>
<th>Olympus TLP</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topsides – Operating (no Risers)</td>
<td>st</td>
<td>18,500</td>
<td>27,500</td>
<td>1.49</td>
</tr>
<tr>
<td>Riser Payload</td>
<td>st</td>
<td>4,000</td>
<td>11,000</td>
<td>2.75</td>
</tr>
<tr>
<td>Topsides – with Riser Payload</td>
<td>st</td>
<td>22,500</td>
<td>38,500</td>
<td>1.71</td>
</tr>
<tr>
<td>Hull Steel &amp; Outfitting</td>
<td>st</td>
<td>15,600</td>
<td>35,800</td>
<td>2.29</td>
</tr>
<tr>
<td>Ballast</td>
<td>st</td>
<td>3,600</td>
<td>10,700</td>
<td>2.97</td>
</tr>
<tr>
<td>Hull – Including Ballast</td>
<td>st</td>
<td>19,200</td>
<td>46,500</td>
<td>2.42</td>
</tr>
<tr>
<td>Pre-Tension</td>
<td>st</td>
<td>9,800</td>
<td>34,000</td>
<td>3.47</td>
</tr>
<tr>
<td>Displacement</td>
<td>st</td>
<td>51,500</td>
<td>119,000</td>
<td>2.31</td>
</tr>
</tbody>
</table>
Challenges: Stretched Supply Chain

- Massive surge in demand on supply chain started in the year 2000
- Supply chain overwhelmed by this surge
- Created industry-wide skills shortage and dilution of Contractor capabilities
Some Deep Offshore R&D Challenges

- Ultra Deep
- Long tie-backs
- Asset Integrity
- Cost reduction
- Dispersed resources

- New materials
- All Electric technology
- Electrical Down Hole Safety Valve
- Innovative subsea tools for IMR AUVs
- Environment and underwater geohazards Monitoring
- MPPs - Subsea boosting

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The Deepwater Game is Changing

• Development opportunities are more **challenging**...deeper water, more complex reservoirs; sub-economic accumulations; ultra-deepwater and remote locations; viscous oil, low energy drive

• **Capex/risk exposures are large**...cost exposure in the billions; high cost drilling & infrastructure

• **Pressure to shorten schedule and reduce cost continues**...longer cycle times; standardization; technology development vs rapid deployment

• **Lack of local logistics/service industry**...affects project delivery

• **Competent/skilled staffing shortages**...demand still exceeds supply; building local capability can be difficult
Instability and Change Also Impact the Industry

Selected Incidents Impacting O&G Industry

- Alaska: 2012 - Shell exploration rig slips moorings
- US: Ongoing developments in shale gas and oil redefine industry supply
- Gulf of Mexico: 2010 - off shore drilling moratorium following Macondo incident
- Scotland: Speculation on O&G industry based on work in independent
- UK: 2011 - Further changes to fiscal regime hit mature field economics
- Algeria: 2013 - In Amenas gas plant attacked
- Nigeria: 2014 - Large scale theft by thieves
- Argentina: 2012 - Nationalisation of Repsol stake in YPF
- Venezuela: 2014 - Series of protests, political demonstrations, and civil unrest
- France: 2012 - Ban on hydraulic fracturing
- Libya/Egypt: 2010-11 - Arab spring uprisings impact oil and gas infrastructure and activity
- Kazakhstan 2014 - Fines by government due to production halt/gas leaks
- Ukraine 2014 - Conflict and renewed cold war
- ME and Azerbaijan: Ongoing contract renewals
- Syria: 2012 - Civil war leads to exit of IOCs
- Nigeria 2013 - Law on fines on operators responsible for oil spills
- Australia: 2012 - Inflation hits NWS LNG economics

Source: Bain analysis, Literature search
Offshore Magazine Posters

For additional information about Deepwater go to Offshore Magazine’s Website:
www.offshore-magazine.com/maps-posters.html
Useful Industry Websites

• www.offshore-mag.com
• www.Oilpro.com
• www.offshore-technology.com
• www.upstreamonline.com
• www.ogjonline.com
• www.rigzone.com
• www.oilonline.com
Advice to Early Career Engineers

• Information is what you need to make money in the short term

• Knowledge is a deeper understanding of how things work and is attained by:
  • Long and arduous study
  • Setting aside profit motive
  • Having intrinsic desire just to know

• Choose KNOWLEDGE over INFORMATION!
Summary

• Current trend of increasing CAPEX and recycling projects is unsustainable
• Unconventionalists competing for Capital allocation
• Geologic, geographic & geopolitical trends & increased demand on supply chain fundamental drivers
• Solutions include managing reservoir uncertainty, improving capital efficiency, investment in technology, rationalizing local content and bridging skills gap
Questions?

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