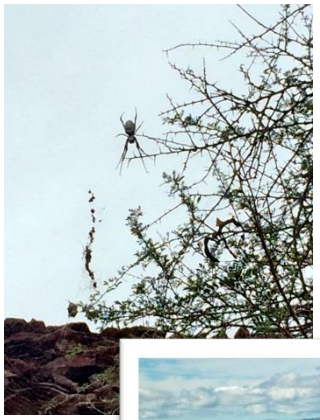
GOT PROGRAM OF WORK AND STUDIES UNDERWAY

Morten Wiencke, GE Oil & Gas
Operating Agent

Karratha LNG Tour



For comparison: Snøhvit LNG, Hammerfest, Norway
Subsea to Beach (160 km)

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Costs gone up by 3-4x over last 10 years

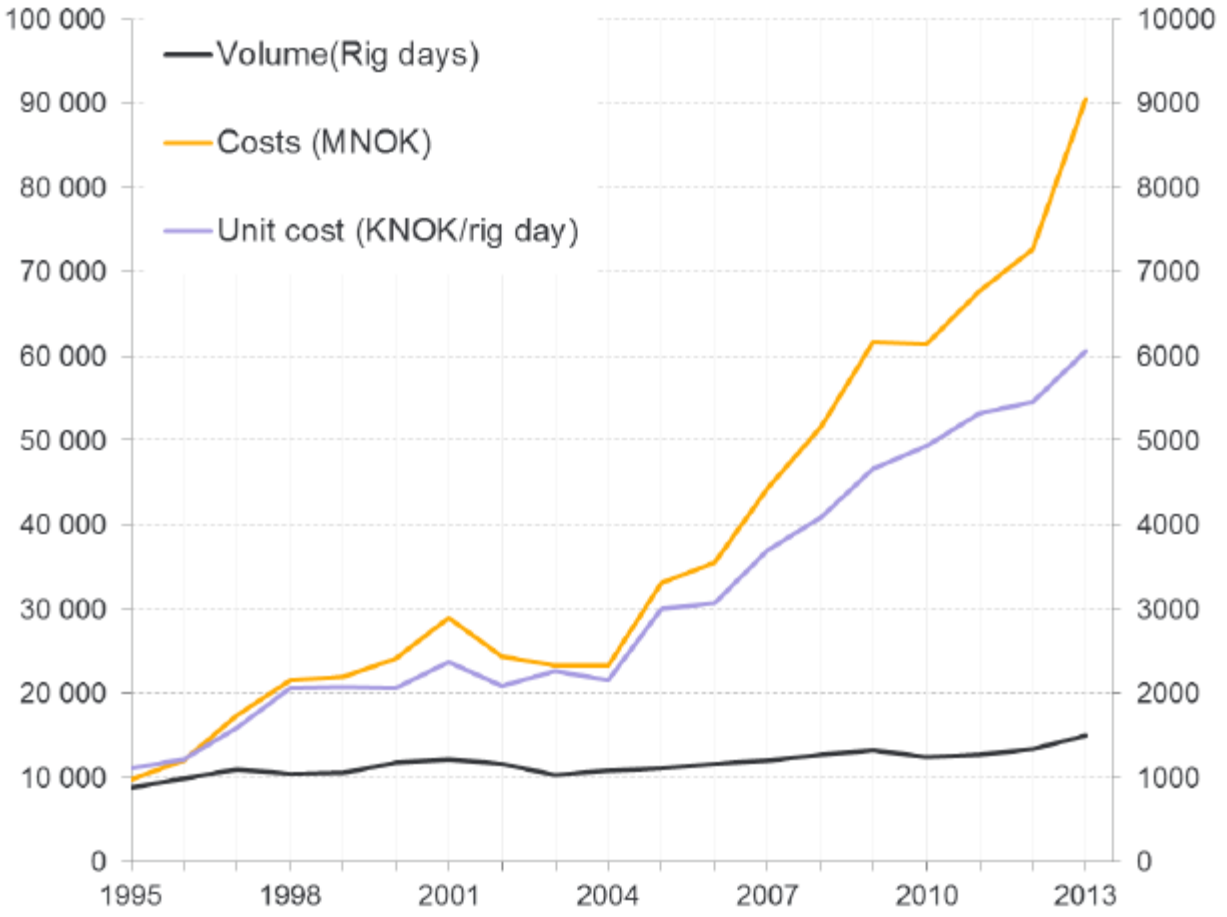
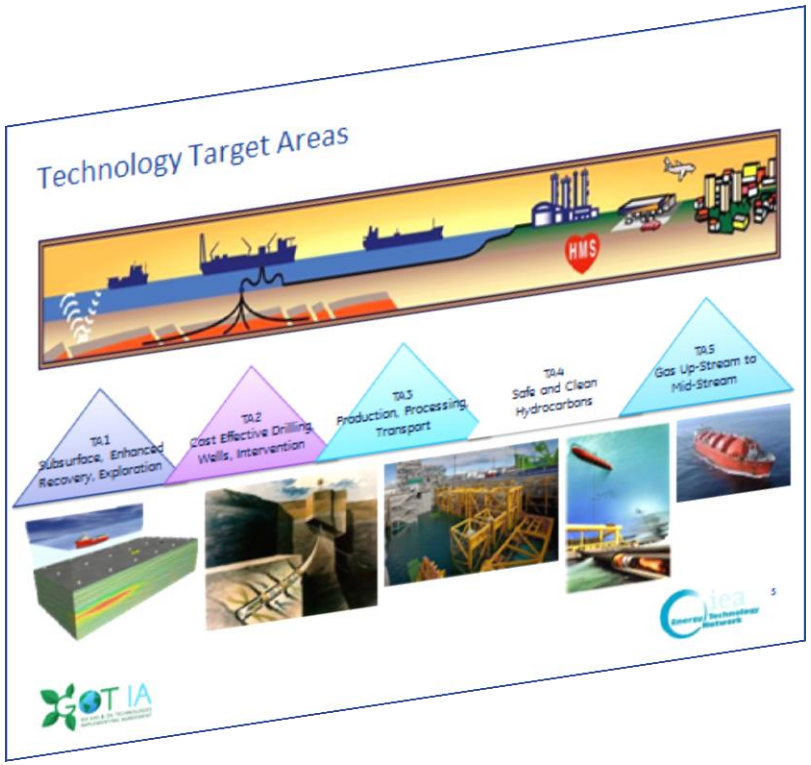


Figure 2: Historical comparison of cost, unit cost and volume on the NCS

GOT Workshops –
Florence (Apr'14) > Rio (Sep'14) > WDC (Oct'14) > Colorado (Oct'14) > Perth (Apr'15)



Conventional Greenfield Development

Conventional Brownfield Development

Unconventionals

Crosscutting:
Risk management
Regulations and standards; documentation, processes, technology, interfaces, regulations
Innovation; Technology, collaboration, regulations, big data
Cost efficiency; cost benefit, life cycle cost

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GOT Studies Work Group 1, 2, 3

General structure

Length: approx. 100 pages*

The paper should include the following segments

- Executive Summary
- Introduction / Background
- Current Landscape / State of the Art
- Challenges and Technology Gaps
- Outlook
- Enabling Technologies and Catalysts
- Innovation
- Social License to Operate
- Conclusions and Way Forward
- Notes, appendix, bios, acknowledgements

Work program

The work program will consist of compilation of data to establish a cost index and the main cost-drivers, the market potential and the main regulatory framework which can influence technology development and innovation. These data will be used to identify the most important technologies, technology gaps and innovation potential and make recommendations for prioritization and other measures.

Cost level (where applicable)

- Compile data to establish a cost index the last 10 years.
- Analyze the compiled data to describe how much of the cost increase is caused by changes in activity and how much is due to inflation.
- Identify the most important drivers for cost increase in the time period, (and make forecasts?)

Market:

- Compile relevant market data (e.g. estimates of remaining reserves and resources, estimated date of closure and main production challenges of relevance to drilling and wells).
- Analyze time horizon for implementation of new technology
- Analyze size of market (resource base, time, economy) and the share that can be realized by new technology

Regulatory framework:

- Compile information on main regulatory frameworks
- Analyze effects of regulations on the balance between fostering innovation and conservation of existing, "out-dated" technology

Technology assessments:

- Identify the most important new or coming technologies for improving cost-efficiency and functionality for safety, environment and subsurface needs.
- Identify technology gaps and outline new technology research and development processes, including time horizons.
- Analyze match of time horizons between market and technology research and development processes.
- Analyze innovation potential of the outlined technology research and development processes.

Recommendations

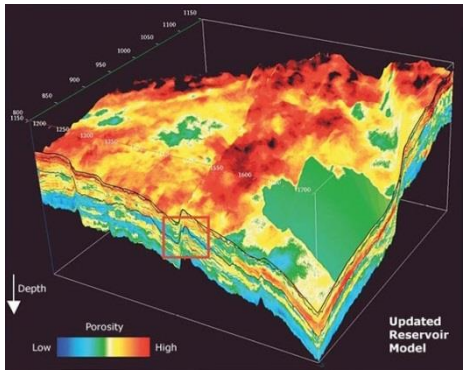
*) Including graphs, charts, tables, illustrations, appendix, etc. Can be more if deemed necessary

Conventional Greenfield

Maturing HC Resources through Improved Development Technology

Topics

- Enhanced reservoir characterization and modeling
- Harsher E&P – technologies, operations, safety and environment
- Development of efficient/low cost small fields
- More efficient resource & environmentally friendly utilization of associated / stranded gas

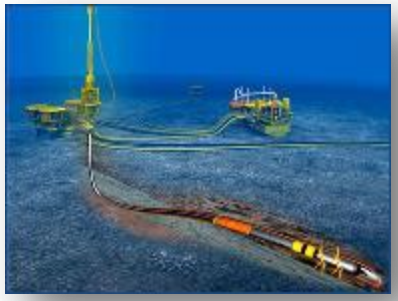


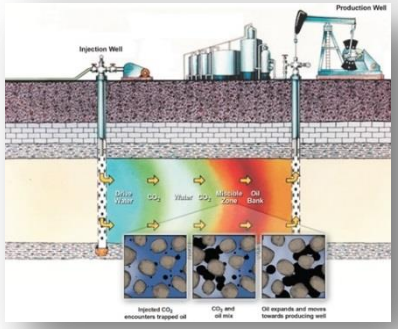
Conventional Brownfield

Technology Focus – Drilling & Intervention

Topics

- Maximum exploitation of petroleum resources in producing oil fields
- Enabling production of stranded oil in mature oil regions, e.g. immobile oil
- Enhancing gas recovery/economic field life of gas fields
- Extending economic lifetime of onshore and offshore producing fields





- *Effect of individual brown field policies of individual countries;*
- *Support of international monitoring programs on e.g lifetime extension or well abandonment;*
- *Alignment of individual programs at country level, + task sharing and distribution internationally*

Unconventionals

Enhancing Recovery and Environmental Sustainability

Topics

- Hydraulic fracking & stimulation methods and techniques to increase and enhance recovery
- Water use, drinking water and disposal of wastewater
- Air emissions related to unconventional HC production
- Technologies for best drilling practices and inspection
- Reducing footprint: Air, water, waste, community impact

GOT – Technology challenges, value proposition

Big swings

The industry is facing fundamental challenges.

- **Cost level**. CAPEX has not resulted in overall increase in production capacity. Customized one-off solutions are the rule instead of standardization and normal industry mass production.
- **Safety**. No substantial break-throughs in increased safety since Macondo. Recently a fire on an FPSO in Brazil killed 6 people. The cap project for oil spill containment failed when Shell's deployment vessel stranded in Alaska.
- **Sustainability.** The fossil industry is seen as a transient sunset industry on the way to renewables.

Technologies

New subsurface imaging and modelling – Eliminate the risk for dry holes, reduce exploration drilling cost by 50 %

Monobore wells / pinhole drilling – drill out the diameter needed for the production tubing, reduce cost by 50 % or more

Laser assisted drill bits – increase rate of penetration (ROP) by 50 %

Smarter and lighter BOPs – reduce/eliminate downtime

Subsea to beach – enable long tiebacks to shore or existing infrastructure, using standardized seabed modular architecture, reduce cost by 50 %

Seabed drilling and production systems, unmanned facilities, enabling the Arctic

Also, improve safety and reduce risk by not exposing people to hazards on topside facilities

Enhanced recovery – improve flooding, sweep etc using CO2, reduced salinity water etc, increase recovery by 50 % (from 40 to 60 %)

Remove and manage carbon (CO2) by CCS(+EOR), making gas more competitive to coal and renewables in key markets (Europe)

Thank you

Increased recovery

- Oil and gas industry average recovery factors in conventional reservoirs are 30-40 % and even best in class stop at 50%, leaving the other 50 % behind
- For the unconventional shale gas/oil resources, the unrecovered volumes may be as high as 90 %.
- To challenge these limitations - combine resources to accelerate research in advanced microfluidics (including nanofluids and “designer water”), and related new enhanced oil recovery technologies.
- Fundamental gamechanger – taking the hydraulic fracking experience from UC to Conv?

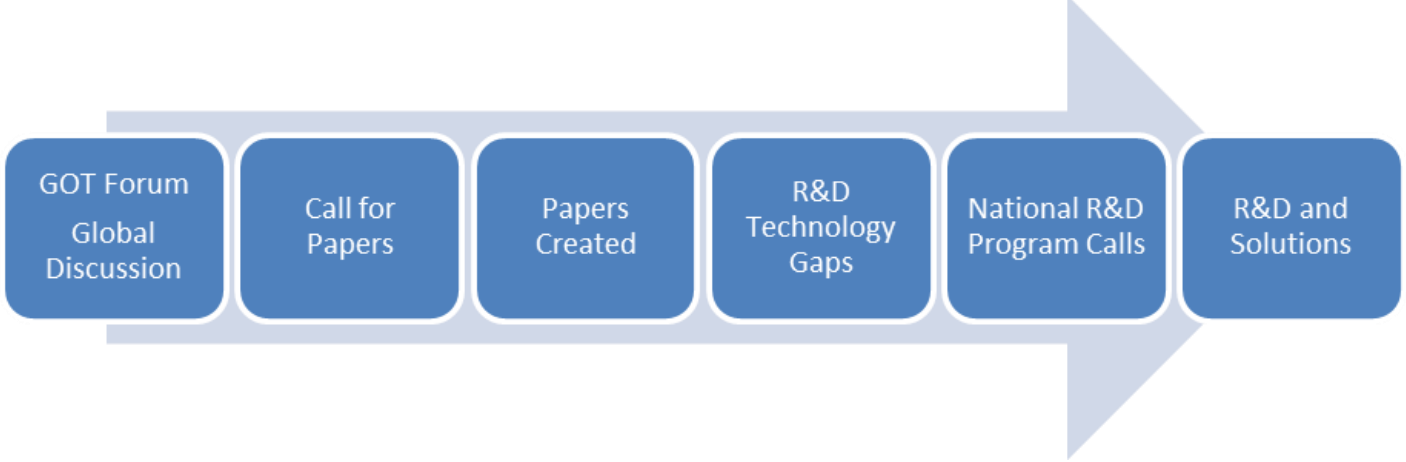
Cost of developing resources to reserves

- 50% of the development cost offshore is associated with drilling of wells requiring the removal of up to 50 times more rock out of the ground than what is physically needed for the actual production tubing.
- Potentially transformational solutions to this big challenge lie in new drilling solutions like Managed Pressure Drilling (MPD) and Dual Gradient Drilling where the number of casings can be reduced while maintaining or even exceeding current safety factors for pore pressure and rock integrity. Riserless monobore drilling and ‘pinhole’ exploration wells are on the horizon as are laser assisted drill bits.

Cost of developing resources to reserves

- The other 50 % of development cost is offshore facilities, requiring huge CAPEX and OPEX to build and sustain completely integrated and self-sustained production facilities.
- Fundamentally novel mindsets are required to eliminate the surface facilities, utlizing the seabed as free estate and allowing for a new subsea architecture designed to bring the oil and gas safely and less expensively to the offtake point.

Process



Overall purpose

Create white papers within relevant challenge areas based on topics identified from the Global GOT Forum

Timeline

- Q1: Finalize scope, bidders list, ExCo approval, call issued
- Q2: Nominate review panel, concept papers (offfers) received, evaluation & award
- Q3: Draft reviews
- Q4: Paper delivered, implementation in GOT

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