MARSH

Marsh Risk Management Research

INDUSTRY PERSPECTIVE

MANAGING RISK ON THE NEW FRONTIERS OF ENERGY EXPLORATION

MAY 2013

MARSH GUY CARPENTER MERCER OLIVER WYMAN

MARSH & McLENNAN COMPANIES

CONTENTS

INTRODUCTION

Global demand for energy is expected to increase by 1.6% per annum over the next 20 years, representing a 39% increase on total 2011 consumption. With population and income growth driving this surge, developing markets such as China and India are expected to account for the bulk of the energy demand growth. Although the fuel mix is expected to shift away from oil and coal towards renewables (mimicking the growth of nuclear power in the 1970s), renewables and other alternative sources are expected to account for less than a fifth of world energy use by 2030.

While natural resources are finite, a common misconception is that short-term reserves are dwindling and available supplies will deplete in the near future. In reality, technological innovation is currently keeping pace: Deepwater drilling, shale gas exploration, and the oil under the Arctic are the "new frontiers" of energy exploration that may help fuel the world's demand for hydrocarbons, along with a Middle East region looking to remain the world's energy superpower for years to come. The dynamics of global supply and demand are changing as a result of these new sources, as shown by the United States, which has recently become a net oil-product exporter.

This report examines the new frontiers of energy exploration, evaluating the changing risk landscape for companies involved in the exploration and production (E&P) of hydrocarbons from reserves previously untapped for a variety of reasons, ranging from intensive capital requirements to environmental objections. It also outlines strategies to mitigate the risk associated with each new frontier and help organizations and other energy-exploration stakeholders reduce their vulnerability in a space where one misstep could sink an entire industry.

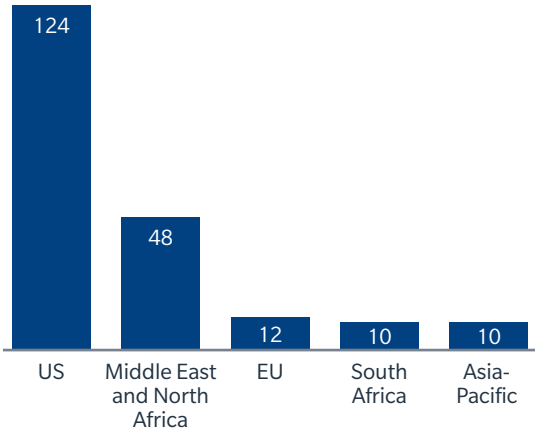
DEEPWATER DRILLING

Within a decade, 40% of the world's oil is expected to come from deep water, which is typically defined as water depths greater than 1,500 metres. Since 1995, the number of wells drilled in water deeper than 200 metres has increased exponentially.

IMPACT ON RISK LANDSCAPE

Deepwater exploration is changing the oil and gas risk landscape in a number of ways. First, reserves are only available to nation states with offshore sovereignty. Trends are currently skewed toward the US, with 60% of deepwater drilling occurring in the Gulf of Mexico, which accounts for 80% of US oil production and holds 80% of its oil reserves. Opportunities favor E&P companies with an established presence with host nation states, which places overwhelming control in the hands of the US (see Figure 1).

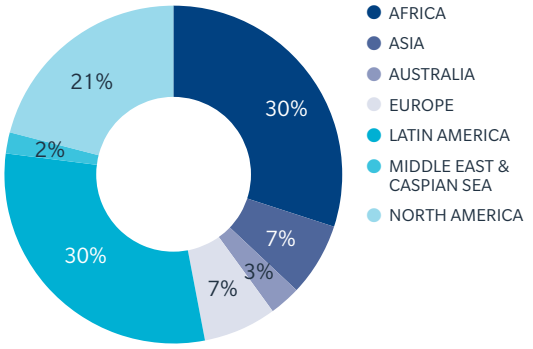
FIGURE 1: DEEPWATER WELLS PER REGION



Source: SubsealQ

Despite advances in drilling technology, the costs associated with deepwater drilling are prohibitive to all but the largest companies. Only the most financially strong can invest in these waters — just 13 companies are expected to produce 84% of worldwide deepwater capital expenditure in the next four years[1] in three dominant regions (see Figure 2). If current trends continue, the basic cost of drilling is set to rise year-on-year. Aside from standard investment, daily rig rates have significantly increased over the last decade, as the availability of the most advanced equipment decreases and local jurisdictions limit the age of rigs allowed to drill in their territories. The risk of new competitors entering the market is considered to be low, while the focus on ensuring a return on investment for established companies will continue to sharpen as requirements for capital expenditure increase.

FIGURE 2: DEEPWATER CAPITAL EXPENDITURE 2012-2016 BY REGION



Source: Infield Systems Limited. *Deep and Ultra-deepwater Market Report to 2016.*

Finally, the risk exposures to companies from deepwater E&P have not fundamentally changed over the past decade. They include:

- Well blowout.
- Environmental liability.
- First-of-a-kind (FOAK) technology.
- Availability of sub-sea expertise and equipment.
- Supply chain disruption.

- Regulatory compliance.
- Environmental tax.
- Oil/gas price volatility.

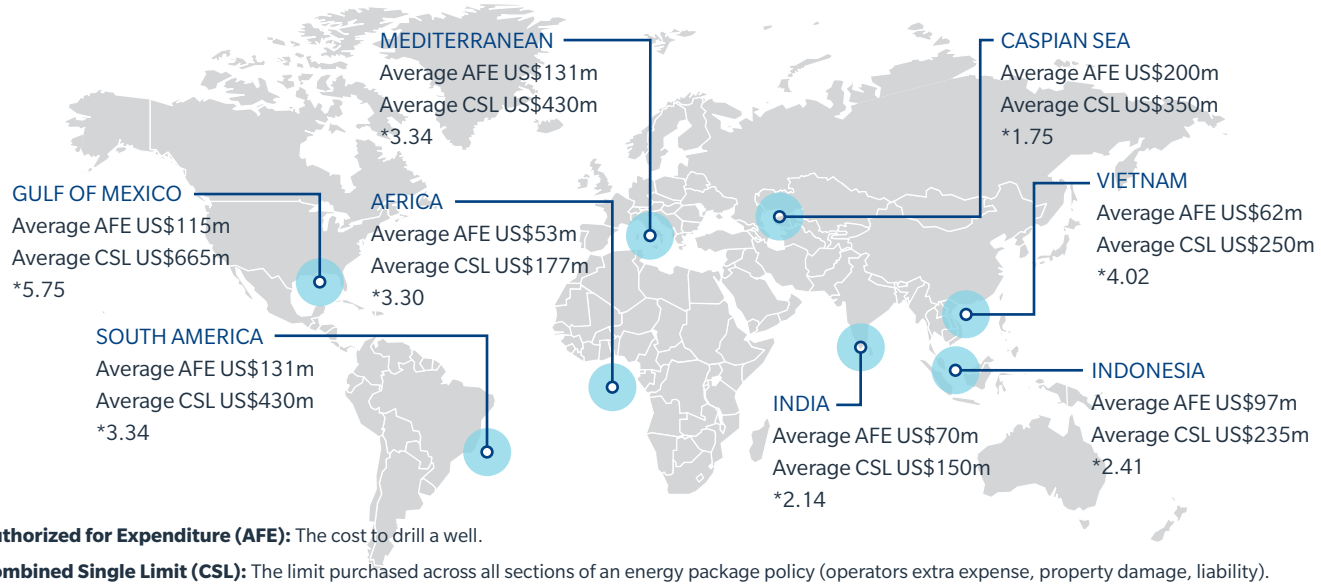
Following the Deepwater Horizon oil spill in 2010, however, the perception of risk exposures has heightened and the contractual landscape of the industry has changed. US regulations have become more stringent and companies are now increasingly alert to the far-reaching reputational and financial damage that can be suffered in the event of a leak or spill.

For these reasons, operational controls to minimize environmental, health, and safety risk should strengthen and further standardize the industry. Furthermore, drilling contractors have organizational preservation as a main driver to ensure high standards of operational and process safety. Another incident on the scale of Deepwater Horizon would likely change the contractual regime forever, pushing some liability back onto the contractor, thereby prohibiting all but the largest contractors from operating. Improvements in technology should also lead to higher standards of reliability and insurers' desire to see sound enterprise risk management should increase the focus on risk in its widest context.

The Deepwater Horizon incident has not aligned all deepwater wells into the same bracket in terms of insurance limits purchased. While upstream premiums may have increased dramatically since 2010, limits remain dependent upon the region in which the exploration is taking place, as does the limit to which one is able to spend on drilling and subsequently producing a well. This is best shown using benchmarking data produced by Marsh's Energy team in the months following the Deepwater Horizon incident in the Gulf of Mexico (see Figure 3).

The risk profile of deepwater drilling is increasingly characterized by catastrophic events: low-likelihood risks with very high ramifications — in terms of cost, reputation, and environmental impact, for example —

FIGURE 3: BENCHMARKING DATA FOR DEEPWATER INSURANCE PURCHASES



Authorized for Expenditure (AFE): The cost to drill a well.

Combined Single Limit (CSL): The limit purchased across all sections of an energy package policy (operators extra expense, property damage, liability).

* Average multiple of AFE to limit Source: Marsh

should they occur. In order to maintain profitable operations in deepwater drilling environments, risk exposures should become increasingly well managed, pushing risk exposures to the left of the traditional probability scale. However, the impact of a "black-swan" risk materializing will also continue to increase with greater depths of drilling and the use of new technology.

The rising risk of black-swan events means that resilience measures, crisis management, and response plans for companies involved in deepwater E&P need to be well developed, especially as there are typically multiple operators and organizations with various interdependencies involved in getting oil and gas to market. For example, it is not atypical to have different companies providing each of the following drilling roles: owner and contractor, operator, blowout-preventer provider, cementing well walls, mud-engineering services, well logging services, well casings provider, wellhead equipment provider, and remote-operated vehicles.

MANAGING THE RISK

Organizations should consider the following steps to address exposures associated with deepwater drilling amid a changing oil and gas risk landscape:

1. Develop an approach to identify and evaluate risk exposures from a top-down perspective (such as scenario analysis) that aims to assess risk and interdependencies across the whole organization. This approach should complement the bottom-up approach to risk management.

2. Evaluate risks derived from working with third parties and explicitly seek reassurance as to the efficacy of partners' approaches to risk management.

3. Establish the risk exposures derived from the supply chain by mapping supply chain dependencies.

4. Build crisis management and recovery plans in conjunction with third parties to improve response planning and resilience to an incident.

ARCTIC EXTRACTION

Energy exploration in the Arctic is beginning to capture the attention of influential people across the globe, from the CEOs of major oil companies to the heads of environmental organizations. With the quantity of ice in the Arctic declining annually, both in terms of volume and surface coverage, oil companies could potentially access vast quantities of untapped hydrocarbons. Estimates suggest that the region currently has 136.6 billion barrels of oil equivalent (BBOE)[2], and a United States Geological Survey report from 2008 estimates that a further 346 BBOE remain undiscovered.

SURVEYING COSTS AND CHALLENGES

Despite the potentially vast untapped resources, the risk exposures from this frontier have hitherto been a natural barrier to entry. The conspicuous risks to companies stem from the climate and isolated geography of the Arctic — ice blocks, storms, engineering and electrical communication complications, and the limited availability of expertise in remote areas all pose challenges. Like deepwater drilling, exploration in this area requires significant investment.

Production income cannot be accounted for when factoring in debt repayments. Only 22 of the 174 fields discovered have produced hydrocarbons, with an average lag time of 13 years. Just 38 new fields are expected to come into production between 2012 and 2018.[3] This highlights the return on investment (ROI) question: Is it economically viable? Deepwater drilling has suffered at the hands of low oil prices, but Arctic exploration has the problem that 85% of the estimated reserves are natural gas (the majority of which is expected to be in the Russian segment). In looking at natural gas prices versus oil over the past 30 years, the commodity of oil has been significantly

more valuable; coupled with the vast supply of gas emanating from shale, the Arctic begins to look like a less attractive frontier.

Other complications center on the extreme risk-mitigation requirements for drilling in this region. For example, one must have a standby rig to drill relief wells in the instance of a blowout, significantly adding further costs to any exploration. Also, reputational damage from a blowout in the Arctic would likely be irreparable, and inevitably followed by a moratorium on drilling in certain Arctic regions.

Despite the risks, it is expected that US$20 trillion will be spent in the region between 2011 and 2035.[4] Companies from Norway, Russia, Canada, and the US are expected to dominate this outlay.

If Arctic ice continues to retreat and engineering competence is advanced through technological improvements, exploration of Arctic reserves will become more likely and less expensive. However, companies buying insurance to protect themselves in the event of blowout — operators' extra expense (OEE) and against third party liability claims — face the task of careful market analysis. Typical offshore limits purchased in both these instances vary greatly from policies incepting in 2012 (see Figure 4), and companies in the Arctic may consider purchasing limits at the higher end of these scales.

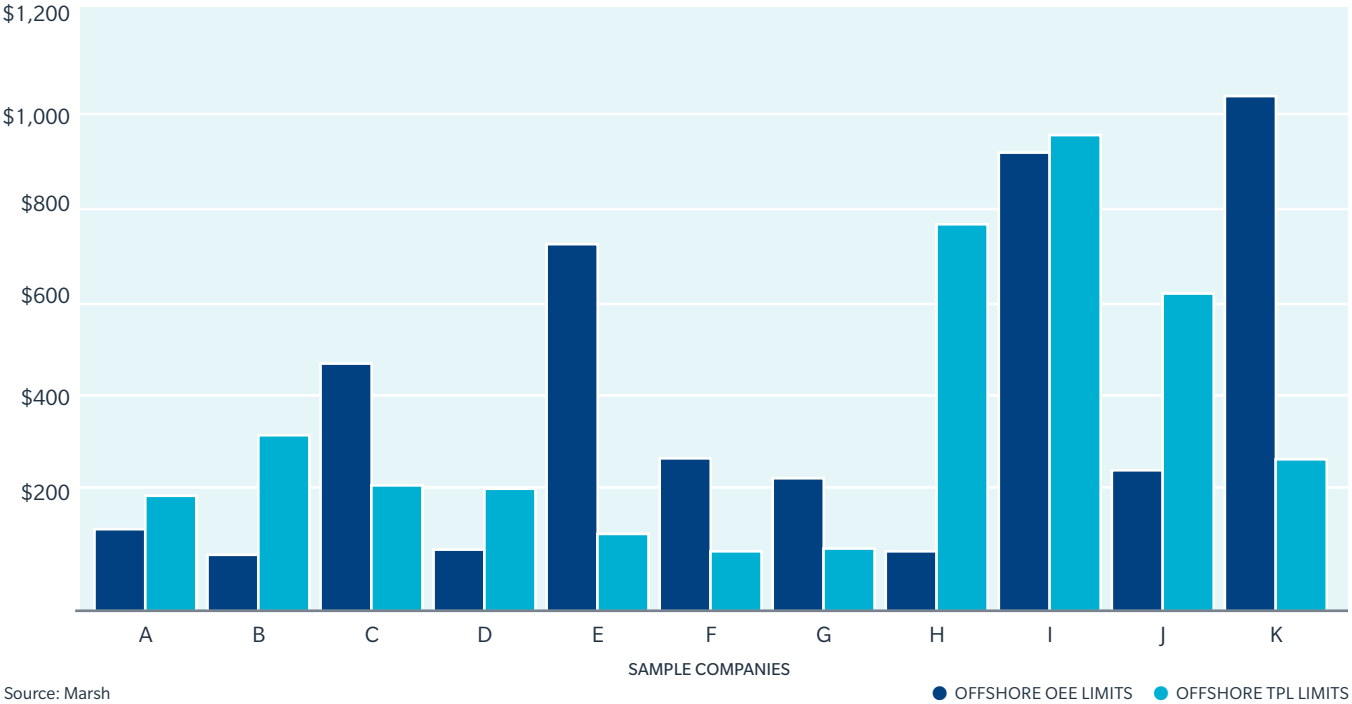
MANAGING THE RISK

Organizations should consider the following steps to address exposures associated with extracting energy in the Arctic amid a challenging environment:

1. Introduce an enterprise-wide approach to risk management to view and evaluate the risks of a field development. This approach allows an integrated and holistic view of likely risk exposures and opportunities, and helps to avoid assessing exposures in narrow silos.

FIGURE 4: INSURANCE LIABILITY LIMITS PURCHASED

US$ MILLIONS



Source: Marsh

2. Apply quantitative risk analysis (QRA) techniques to identified risk exposures to add a degree of rigor and robustness to otherwise subjective assessments of impact and likelihood. QRA can determine likely risk impacts at varying degrees of confidence and help evaluate the effectiveness of mitigation measures in controlling those exposures.

SHALE GAS

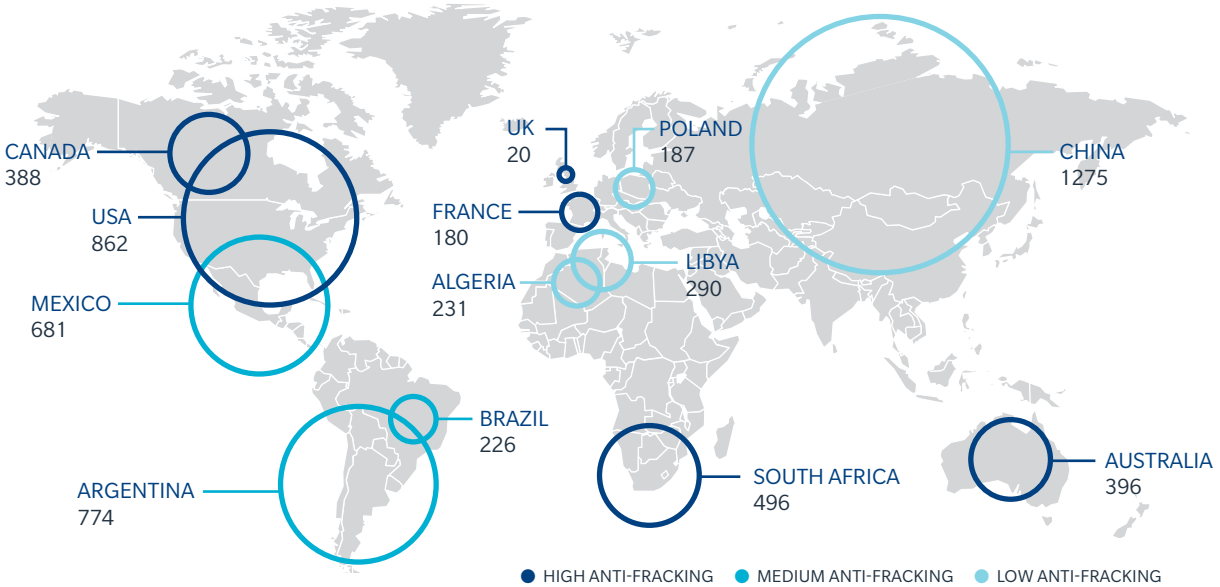
The recent development of shale gas extraction has revolutionized global energy markets. Coupled with deepwater drilling, it has helped convert the US into a net oil-product exporter for the first time in decades. Gas reserves in the US have increased from 4.7 trillion m^3 in 1991 to 8.5 trillion m^3 at the end of 2011; by 2035, the US is expected to only have to import 1% of its natural gas requirements.[5] Total worldwide shale reserves are estimated to be more than 6,600 trillion cubic feet[6], and unlike other hard-to-reach natural resources, shale is more evenly distributed across the globe.

SIGNIFICANT EXPOSURES

The associated risk exposures derived from shale gas production are significant. There has been widespread condemnation, ranging from allegations of contaminating water tables to claims that it induces earthquakes. As such, activist groups have begun operating worldwide, especially in developed countries such as France, Canada, and Australia (see Figure 5). Although shale exploration uses similar techniques to those used in conventional platforms, the difference comes in the process of fracking itself. It is perhaps for this reason that the insurance markets, as a proxy for the inherent risk profile, are not clear on the coverage currently in place for

FIGURE 5: SHALE GAS RESERVES OF SELECTED COUNTRIES AND THE ANTI-FRACKING MOVEMENT

SHALE RESERVE (TRILLION CUBIC FEET), ANTI-FRACKING MOVEMENT ACTIVITY



Source: The Global Anti-Fracking Movement, Control Risks (2012)

shale activities. Current policies are not always updated to specifically include fracking activities, which could result in disputes when OEE and liability claims are presented. Underwriters are becoming more educated in the process via client presentations, engineering studies, and general investigations into the activity. This development has helped minimize shale exclusions being imposed into policy wordings and the number of disputes arising from shale gas claims.

Shale gas exploration remains contentious because it can be intrusive for local communities. Although South Africa and the UK have recently lifted a moratorium on fracking, bans still exist in some parts of the world. India has suspended fracking activities (although a licensing round is expected this year), and a handful of American states, mainly in the east, prohibit this activity. In New York, more than 100 communities have introduced a ban, while other local governments in Australia, Ireland, and Bulgaria have also banned fracking.

Shale gas exploration remains contentious because it can be intrusive for local communities.

MANAGING THE RISK

Organizations should consider the following steps to mitigate the distinct risks associated with shale gas exploration, including reputational risk:

1. Where shale gas exploration is under consideration, companies should pay due attention to their strategy for managing stakeholder relations. Consultation and engagement with communities local to reserves will become necessary for proactively managing reputational risk.

2. Emergency response plans and recovery strategies for dealing with an unplanned incident should be well developed and rehearsed. The manner in which local communities and the media are responded to will be critical in the event of an unforeseen incident.

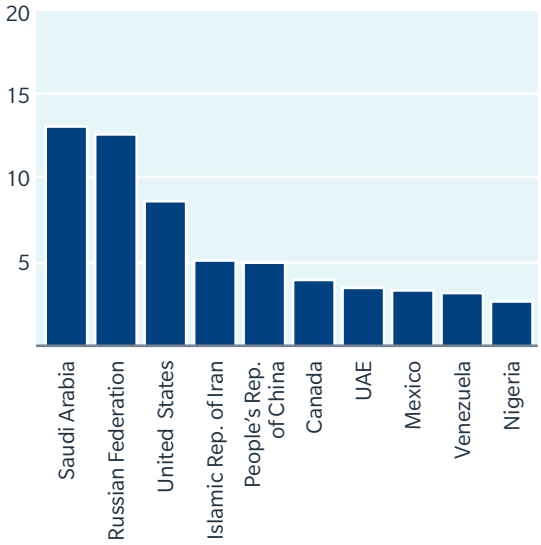
THE MIDDLE EAST

The Middle East has long been considered the world's energy superpower. It might be assumed, however, that the rise of new frontiers of energy exploration could push this region into decline. For example, three decades ago, Organisation for Economic Co-operation and Development member countries exported 16% of total energy produced, but by 2010 this figure had risen to 38%. This increase helps explain why only three of the top 10 oil producers in 2011 were based in the Middle East (see Figure 6). However, crucially, with the exception of Venezuela and Canada, the remainder of the top 10 oil producers are outproducing their reserve base (see Figure 7). Although the US produced 8.8% of the world's oil in 2011, its proven reserve base is just 1.9%. By contrast, Middle Eastern countries, without exception, are underproducing relative to their reserve base.

The vast reserves that remain in the Middle East cannot be overlooked: 70% of the world's reserves are held in Organization of the Petroleum Exporting Countries (OPEC) nations, and five of the top seven countries with proven reserves are in the region (see Figure 8). Given this dynamic, a resurgence of Middle Eastern oil output should be expected. By 2030, OPEC liquid petroleum output is expected to rise by 12 million barrels per day (B/D), supported mainly by Iraq and Saudi Arabia; OPEC's market share is likely to reach levels not seen since the 1970s, producing around 45% of petroleum-based products. In comparison, non-OPEC liquid petroleum output is expected to grow by 5 million B/D.

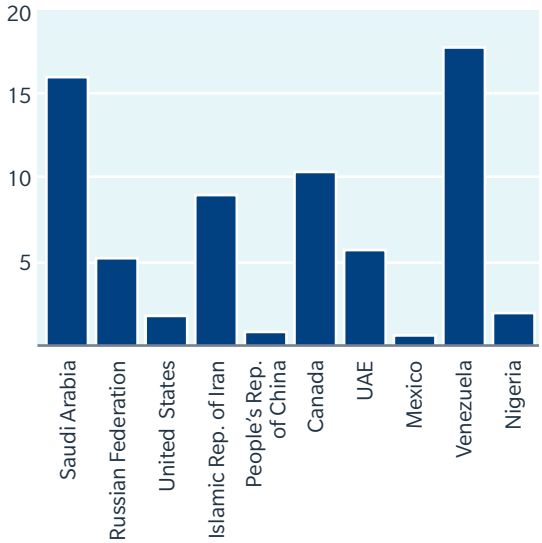
This growth will come at a cost. Infrastructure in the region is underdeveloped and there is an acute need for new investment. If North Africa is included, figures range from between US$19 trillion and US$38 trillion of investment needed to meet future demand. Investment will continue to shape the dynamic between national oil companies (NOCs), international oil companies (IOCs), and hybrids. Traditionally, NOCs, or sovereign

FIGURE 6: PRODUCTION OF TOP 10 PRODUCING COUNTRIES (% OF WORLD TOTAL* FOR 2011)



* 83.576 thousand million barrels (tmb)
Source: International Energy Agency (IEA), Key World Statistics 2012

FIGURE 7: RESERVES OF TOP 10 PRODUCING COUNTRIES (% OF WORLD TOTAL* FOR 2011)



* 1652.6 thousand million barrels (tmb)
Source: BP Statistical World Energy Review 2012

FIGURE 8: TOP 10 COUNTRIES WITH OIL RESERVES

TOP 10 PROVED RESERVES	THOUSAND MILLION BARRELS
Venezuela	297
Saudi Arabia	265
Canada	176
Iran	154
Iraq	141
Kuwait	101
UAE	98
Russia	88
Libya	47
Nigeria	37

Shading indicates country in the Middle East region.

Source: OPEC data

governments, have provided access to hydrocarbon reserves, while relying on IOCs to provide technical skills, project management expertise, and access to markets. This dynamic will continue to change as NOCs develop their own capabilities in these areas.

An indicator of the changing relationship between NOCs and IOCs can be seen in the number of traditional joint venture and production-sharing agreements that are being supplanted by dollar-per-barrel tariffs, often triggered or enhanced by built-in production level targets. These arrangements, as well as the desire for host states to impose levies on IOCs in the form of taxation and royalties, have produced a complex risk/reward environment.

Host nations are increasingly seeking to exercise control over projects through a requirement that IOCs partner with NOCs, and through their demand that NOCs become shareholders in companies that participate in the oil and gas value chain. These requirements can lead to a number of challenges for both parties, including:

- Increasing risk to national/strategic/operational objectives due to additional complexity of operating with non-aligned partners.
- Growing potential for divergence on operating standards may expose one party to a higher hazard/operational loss exposure.
- Increasing difficulty in protecting intellectual property.
- Mounting investment requirements for exploration activities due to more demanding contract terms.

MANAGING THE RISK

Organizations should consider the following steps to evaluate and address exposures associated with energy exploration in the Middle East, a region likely to remain the world's energy superpower for years to come:

1. Undertake political risk assessments before embarking on new investments, perhaps in new geographies, to consider the stability of political and fiscal environments, the robustness of the legal framework, and the potential consequences from plausible change. Depending on the nature of the threat, risk management may range from the lobbying of ministers regarding the legal framework and fiscal policy to contingency planning for staff repatriation from territories that have become hostile. Political risk, in all its guises, should be the subject of robust analysis and pre- and post-loss mitigation — preparedness allows organizations to respond to incidents in a measured and controlled manner.

2. Develop project risk management processes that allow for transparent risk allocation between partners and enable considered provisioning for risk events. This in turn reduces volatility for the balance sheet and allows for pragmatic mitigation should risk events materialize.

3. Apply a supply chain risk assessment that evaluates risks derived from third parties (for example, suppliers, joint venturers, investors, and contractors); this is a valuable technique for understanding dependencies and sources of risk.

4. Strengthening contract negotiation and management through:

   A. Contract risk due diligence and allocation.

   B. Joint venture management guidelines.

   C. Concentrated budget allocation with a tighter due diligence process to steer exploration activities.

SUMMARY OBSERVATIONS

A single event can transform the fortunes of an entire industry. An oil spill on the scale of the Deepwater Horizon disaster, for example, would likely result in the imposition of another moratorium on drilling on the Outer Continental Shelf, or worse, while local objections to fracking present significant risks to shale gas companies. Within this context, reports of the decline of the Middle East as an energy superpower appear greatly exaggerated, but as recent history has shown, companies working in the region have a plethora of political risks to contend with.

As demand pushes energy exploration into increasingly inhospitable geographies, the danger of a low-likelihood-but-catastrophic disaster rises and the requirement for more sophisticated risk management strategies becomes vital. The Key Risks Summary (see page 11) shows that each frontier poses its own set of risks.

One characteristic common to all of the frontiers discussed in this report is the requirement for significant capital investment. Over the past 10 years, worldwide costs of developing production capacity have doubled, largely due to increases in the cost of materials, personnel, equipment, and services. With costs amplified further in the pursuit of challenging reserves, attention will be increasingly focused on ensuring the required return on investment is achieved while managing risk appropriately.

The consequences of the wide breadth of risk exposures in the new frontiers of energy exploration should: improve operational standards across the industry (and create a degree of consistency between operators and contractors); lead to the management of risk exposures from an enterprise-wide perspective; and help develop measures, such as continuity plans and contingency measures, to improve the resilience of a company.

Firmly embedding strategic decision-making in the boardroom is a benefit for all organizations, but for those operating on the new frontiers of energy exploration, it is vital.

---

[1] Infield Systems Limited. *Deep and Ultra-deepwater Market Report to 2016.*

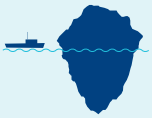
[2,3] Infield Systems Limited. *Offshore Arctic Oil and Gas Market Report to 2018.*

[4] International Energy Agency. *World Energy Outlook 2011.*

[5] KPMG Energy Institute. *Shale Gas — A Global Perspective.*

[6] U.S. Energy Information Administration. "World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States," available at http://www.eia.gov/analysis/studies/worldshalegas/pdf/fullreport.pdf, accessed 18 March 2013.

KEY RISKS SUMMARY



ARCTIC:

- Storms
- Icebergs
- Cold and mechanical failure
- Isolated geographically
- Ecologically sensitive
- Politically sensitive
- Resource difficulties — six months of darkness a year
- Reputational risk
- ROI — expensive investment
- Regulation
- Supply chain
- Delays in delivery of rig/vessel

DEEPWATER:

- Regulatory — moratorium reapplication
- Supply chain
- FOAK risk — new technology
- Well blowout — high pressure/ temperature wells
- Original equipment manufacturer (OEM) capacity constraints
- Lack of sub-sea expertise
- Resource nationalism
- Rig sinking
- Terrorist attack — rig seizure
- Tax changes
- Lack of shipyard/drydock capacity

SHALE GAS:

- Reputational risk; political risk
- Environmental — lack of containment; seismic; contamination
- Activist groups
- Liability exposure
- Intrusive to local communities

MIDDLE EAST:

- Geopolitical volatility
- Conflict of interest between IOCs and NOCs
- Joint ventures between IOCs and NOCs with non-aligned processes and standards
- Asset expropriation
- Tax changes
- Aging assets and infrastructure
- Contractual risk

NOTES

ABOUT MARSH

Marsh is a global leader in insurance broking and risk management. We help clients succeed by defining, designing, and delivering innovative industry-specific solutions that help them effectively manage risk. We have approximately 26,000 colleagues working together to serve clients in more than 100 countries. Marsh is a wholly owned subsidiary of Marsh & McLennan Companies, whose market-leading professional services companies offer clients advice and solutions in the areas of risk, strategy, and human capital.

ABOUT MARSH RISK CONSULTING

Marsh Risk Consulting (MRC) is a global organization comprising more than 800 consulting specialists in more than 35 countries. These specialists are dedicated to providing clients in all industries and geographies with strategic advice and innovative solutions across a comprehensive range of insurable and non-insurable risk issues.

ABOUT MARSH'S ENERGY PRACTICE

Marsh's Energy Practice is at the forefront of advising energy companies on risk and insurance issues impacting operational success. Our network of more than 300 energy specialists is globally coordinated from 12 strategic hubs. We manage more than US$2 billion of insurance premiums in the energy markets on behalf of close to 1,000 clients. Our wealth of expert knowledge is augmented by market-leading risk engineering, project risk management, and claims advisory services.

For further information, please contact your local Marsh office or visit our website at marsh.com

Marsh is one of the Marsh & McLennan Companies, together with Guy Carpenter, Mercer, and Oliver Wyman.