E&P on the way to fuel a gas economy : AAPG Annual Convention Houston, 10-13 April 2011. Selected highlights

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E&P on the way to fuel a gas economy – AAPG Annual Convention Houston, 10 – 13 April 2011 – Selected highlights

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1. General impressions and highlights

Taking place in the heart of the US E&P Industry, the convention was one of the best attended with some 8,500 participants. Attendance from Asian countries was clearly visible while Europe remains under-represented. Americans are pleased with the oil price but deeply concerned with the gas price, which is almost three times lower than in Europe and Asia.
As in previous years, small and medium sized companies presented the best papers. Papers from Majors and large NOCs were often disappointing. Talks by senior executives from large companies appear increasingly dictated by their lawyers, probably the reason why these presenters have to religiously read off their approved manuscript, often resulting in very uninspiring presentations.

***US E&P Industry**: There is a move «back home» to the US onshore amongst the US independents (e.g. Encana, Devon, Newfield). With increasing business in the North American onshore, mainly in unconventional gas and oil, these companies leave the more risky international stage and the deep-water operations that have become unaffordable to smaller companies after BP Macondo.*

***Unconventional hydrocarbons** have become a very predominant part of the convention topics with some 25% of all presentations. There is a shift in players: large and very large companies are increasingly taking over the game. The emotional and mostly exaggerated environmental concerns that have been shaking the incipient shale gas exploration in Europe are not perceived as a major threat in N-America; it was striking how few of the speakers on unconventional gas actually addressed the issue. Nevertheless, there is a call for clear and agreed industry standards on shale gas drilling (nearly all environmental problems can so far be related to poor casing and cementing jobs). There is a consensus that this is a technology that takes time to mature. One speaker reminded the audience that in 1876 the US company Western Union declared: «The technology of the telephone has too many shortcomings to be seriously considered as a means of communication!».*

***The future of gas**: In the US, natural gas is 20% cheaper than coal and almost 4 times cheaper than oil (at 3.5 - 4 $/MCF). Large new gas volumes are pushing into the market, making it likely that gas will increasingly substitute other fuels in power generation and eventually in transportation. The present factor 2.5 - 3 difference in gas price between Europe and N-America shows that in spite of LNG, gas markets are not yet global; however, there are major changes in the making, which in due course will lead to a true gas to gas competition and probably to an end to oil indexation.*

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Over the past 25 years global natural gas demand has increased at almost 4% per year. This growth will most likely continue. In power generation natural gas will compete well with coal and nuclear. The much larger potential for natural gas use lies in transportation, although displacing oil is a challenge, given its efficiency, energy density and versatility. Penetration of natural gas in the transport market will probably hinge less on the already existing technology of conventional gas engines but on the timing and development of an efficient hydrogen fuel cell. Methane is today the main raw material for hydrogen (the principal method of producing hydrogen is through steam reforming of methane). If hydrogen fuel cells can be produced at a competitive price and at a large scale they can become the main energy source for transport and possibly also for decentralized power generation (a fuel cell in every house?). We may therefore well move towards a methane-driven economy in the near future.

***Climate change**: Contrary to the three previous conventions the themes Climate change and CO_2 sequestration received much less attention. In times of financial turmoil and severe economic threats climate concerns appear to become of secondary priority, both for the authorities and for the Industry.*

***BP Macondo impact**: A special half-day session was dedicated to the BP blowout. Unfortunately most of the speakers did not submit abstracts (due to legal concerns?). Three issues were prominent:*

1. The impact of tighter regulations and especially much higher insurance premiums will make it increasingly difficult for smaller companies to participate in deep water ventures or even to operate such ventures. Part of the «back to North America» move of several US independents was triggered by the awareness that they can no longer afford to compete in deep water.

2. The partly chaotic response of the Industry and the authorities to the accident in the Gulf showed that both were ill-prepared and, surprisingly, had no clear concepts on how to handle a blow out in such water depths. Many of the measures taken to combat the spill (e.g. chemical dispersants, massive mopping up with oil collection equipment) are now perceived as politically motivated activism that did more harm than good to the environment. It is essential for the industry to develop a better understanding of the physical and biological processes that follow a spill and devise adequate responses and tools for accidents in deep water.

3. The resistance and self-cleaning potential of the ecosystem is considerably greater than often assumed, hydrocarbons being organic substances, originating from biogenic matter and as such not alien products.

***Renewables**: Renewable energies have a strong growth also in the US where several US E&P companies, primarily Chevron, are investing in renewable projects, mainly geothermal. Geothermal use of hot waters from oil and gas fields is a literally hot topic. Enhanced geothermal systems (EGS) are still less developed than in Europe mainly because the US have so far largely concentrated on volcanic areas with naturally high temperature systems at shallow depths. The role of unconventional resources is still extremely modest, e. g. all the installed wind power in the US produces less energy per year than one large oil or gas platform in the Gulf of Mexico. Several speakers predicted that the share of renewables worldwide would be about 30% by the year 2050 (at best).*

***Reserves and reach of fossil fuels**: Unconventional resources have transformed the world outlook for fossil fuels. There is consensus that fossil fuels will still be the main energy source of this century and that gas will carry us well into the next century and possibly beyond. Interestingly US domestic oil production is now 10% higher than in 2006 and US oil reserves have increased by some 3% in the past 10 years (plus 75% in Canada). US gas reserves* *have grown by 54% since 2000 (+ 12% in production) and are now larger than any time in the past 40 years. For the country that has been used as THE textbook example of the peak oil and peak gas theory such reversals are spectacular. No country in the world has added as much gas reserves in the last decade than the US. Interestingly also the conventional gas resources of the world have increased by 20% in the last 10 years. The E&P industry has completely turned around from the sunset image of the 90's. This is best illustrated by the summary of M. Mellow (CEO of Brazilian company HRT, who increased its stock value from 80 million to 7 billion $ in three years): «The Samba has only just started».*

In the following section only very few papers of special interest have been picked out with emphasis on the presently hot topics of gas, unconventional hydrocarbons and reach of fossil energy resources.

2. Technical presentations

2.1 Unconventional oil

The technological progress achieved in shale gas which has led to a better understanding and mastering hydrocarbon production from source rocks, triggers also a higher activity in shale oil production. Oil production in the US has risen by 10% since 2006, partly due to this technical progress in unconventional oil production and high oil prices.
The shale gas focus is increasingly shifting to plays with wet gas as the valuable liquids help to compensate the weak gas price. In the US, the surplus in gas and the ensuing very low gas prices have led companies to place more attention on unconventional oil.

2.2 Unconventional gas

There were a number of papers on coalbed methane (CBM) and tight gas sands; the main interest was clearly on the phenomenal rise of shale gas. As the first «gold rush approach» by small companies is making place for exploration by larger, well-established companies, there is now a more scientific approach and increasing research in shale gas occurrence and production. This is desperately needed after a «wild west» trial and error phase that has started to harm the reputation of the industry. The geological laws that determine the shale gas sweet spots and many of the physical processes, controlling stimulation and production are still poorly understood.
Environmental concerns: all documented problems with groundwater pollution appear to stem from either casing fail or poor cement jobs. In some cases Methane has a natural occurrence in ground water (base line measurements are needed to prove methane contamination through shale gas wells).

«My source rock is my reservoir – Reservoir characterization of organic-rich rocks», Q. Passey (Exxon-Mobil)

Nature of shale gas reservoir

- The source rocks of the conventional plays are the reservoir of the shale-gas plays. Many producing shale gas reservoirs are over mature oil-prone source rocks containing Type I and mainly Type II kerogen.
- Maturity for gas producing source rocks reaches from VR > 1 to > 3.
- Porosity for shale gas production is strictly linked to amount of organic matter. Interclay porosity is filled with water; organic porosity is filled with gas. This micro porosity of the organic matter can be very high, reaching 50% of organic matter.
- The porosity of source rocks has generally been underestimated. Kerogen occupies a much larger volume percent of the rock than is indicated by the TOC weight percentage because of the low grain density of organic matter. E.g. the Woodford Shale, an important shale gas reservoir, has 20 weight% TOC but some 40 volume% organic matter of which half is pore space.

Shale gas: advances in technology, P. Bennet (Bentek Consulting):

- Impact of technological progress on gas production: The 1971 US Peak Gas Production of 62 BCF/d was surpassed in 2011 with 64 BCF/d.
- Technology advances allow higher efficiency:
  - Average drilling time for shale gas wells (nationwide): until 2008 was 20 days per well, now it is 11 days per well.
  - Average price for a shale gas well in 2008: 7 MM $, now 4.5 MM $.
  - Average ultimate recovery per well has doubled in past 5 years.
  - Nearly all ventures are economic at 5 $/MCF gas. (*But the price is below $ 4 at present!*).

Wilhelm Chandler (Shell Exploration VP onshore US)

- Shell entered US unconventional gas only in 2007 and invested since then 23 B $. 1900 staff are employed in unconventionals.
- Unconventional gas is now 10% of Shell's worldwide gas production.
- Unconventional gas requires a different business approach: very large number of continuous acreage and investment decisions, taken at lower levels, rather than few decisions on large projects at high levels (a new mentality compared to the old Shell way of business).
- Emphasis is on reducing the operational footprint. 16 to 32 wells are now being drilled from one pad.

3. Global E&P

3.1 «Key factors shaping the future»

Bill Drennen (Senior VP Hess)

- Differences between deep-water conventional vs. unconventional gas:
  - Wildcat success: 30% (conventional) vs. 95 % (unconventional);
  - BCF/well recoverable: 100 vs. 4–5;
  - Decline rate in 5 years: 40% vs. 85%;
  - Well capex as % of total CAPEX: 50% vs. 90%.
- Key success factor for unconventional E&P is drilling and completion in a low cost manufacturing approach.
- 750 basins worldwide need still to be looked at and have remaining potential.
- Cycle time: Hess does not look at any venture that is likely to have initial production later than 5 years after discovery.
- Above ground risks are getting ever more important, especially in apparent low risk countries (e. g. Hess Paris Basin horizontal drilling and stimulation was halted after public protests). In the eyes of Hess, Europe becomes increasingly an area with high country risk, as existing contracts are not necessarily honoured.

The next era of exploration, D. Lawrence (VP Exploration Shell Americas)

Renewables

- New technologies need long lead times to grow. The first LNG plant went on stream in 1964 but even today LNG covers only slightly more than 2% of the world market. Reaching a percentage of 30% for renewables by 2050 – as requested by the US administration – is thus an enormous challenge.
- The total installed wind power of the US produces less energy than one large oil or gas platform in the Gulf of Mexico.

Energy investments

- Production capacity of 40 Billion BBL/y of

new oil will be required by 2050 and a similar BOE amount of gas.
- Shell invests at present 1 Billion USD/y in R&D and 3 Billion USD/y in Exploration. Reserve replacement in 2010 was 133%.

The exploration frontiers of Shell
- Unconventional oil and gas.
- Shallow water deposits in deep-water settings (e.g. pre-salt play in south Atlantic).
- Arctic: this area will supply 20-25% of future new production (90% offshore).

3.2 Transforming Global E&P

There is a clear move of American independents away from International and deep water to the North American onshore with a strong emphasis on gas. Since many have followed the same strategy and since the large international companies have joined the gas rush, this has resulted in the present oversupply of gas and a drop of gas prices locally below 4 $/MCF. The situation will only change once major substitution of oil by gas is taking place, a likely change, since gas is presently almost four times cheaper than oil (by energy equivalent). Many of the smaller companies that rely only on the gas business may, however, not live to see the upturn.

D. Hager (Executive VP Devon Energy)

- Devon repositioned itself from an international company to an onshore N-America company (sold all international ventures except Brazil), the reasons being:
  - US onshore gives the highest return with the lowest risk, International and Deep-water does not give enough volume for the invested dollar. After BP Macondo insurance premiums and conditions for deep-water operations have become prohibitive, even for larger independents.
  - Domestic gas will be the main fuel for electricity generation in the near future. Present gas price in US is about 3.5 - 4 $/1000CF, $ 4 corresponds to a $ 24/BBL oil price. Substitution of oil will be substantial.
- Drilling: Devon drilled the first horizontal well in Barnett Shale in 2001 but has now 1,100 producing horizontal wells. Drilled 460 horizontal wells in 2010 alone.
- Devon shale oil ventures in US and Canada: Production now 25,000 BOPD, forecast 2020: 175,000 BOPD.

Mark Popisil (Senior VP G&G, XTO Energy, since two years an EXXON subsidiary)

- XTO was founded in 1986 focusing on unconventional gas. Present market value is over 40 Billion USD (200× larger than 20 years ago!). Exxon bought XTO in 2009 for 41 Billion USD. XTO also manages the global unconventional portfolio of Exxon.
- First shale gas venture in 2004. XTO is now the largest unconventional gas producer in N-America.
- Production of shale gas from Barnett shale: 2000: 0.2 BCF/d; 2005: 1.5 BCF/d; 2010: 5.2 BCF/d.
- Technology: Shale gas wells are being refracced after some production life. This can multiply the ultimate recovery.

3.3 Reserves and reach of gas and oil

Mark Popisil (XTO/Exxon)

Global demand forecast (according to Exxon, in Quad BTU, 10^{15}):
- oil (2005 / 2030): 165 / 200
- gas: 100 / 170
- coal: 110 / 130
- nuclear: 25 / 50
- water, wind, solar: 1 / 40

(Note that the biggest absolute volume increase is in gas).

Bill Drennen (Senior VP Hess)

Remaining world resources (conservative estimate)

- Gas: Some 6,000 BBOE of which $^1/_3$ conventional, $^2/_3$ unconventional (tight gas, shale gas, fractured reservoirs).
- Oil: Some 4,000 - 4,500 BBO of which $^2/_3$ conventional, $^1/_3$ unconventional.

D. Lawrence (VP Exploration Shell Americas)

- Global energy demand will double by 2050, main driver being China with a growth in energy demand of 10% per year. Fossil fuels will still cover far over 50% of this demand.
- Gas consumption of China will triple from 109 BCM/y in 2010 to some 330 BCM/y in 2020.
- The reach of the gas resources worldwide is estimated at some 250 years (source IEA, but shared by Shell). *Note: Peter Voser, Chairman Shell at a presentation given in Bern on July 1st 2011, also gave this number as Shell's estimate.*
- Shale gas in the US is 20% of total gas production today and will be 50% in 2020.
- The US will not need any new gas imports for a very long time to come.

CGG-Veritas

- Peak Oil production is expected by 2025 - 2030, a gas peak cannot be seen at present.

L. Fisher, S. Tinker (Fisher-Jackson School of Geosciences, Texas University)

- World Gas reserves:
  - Remaining conventional gas reserves: 6,700 TCF
  - Shale gas resources (according to EIA 2011): 6,600 TCF
  - Other unconventional gas resources and yet to find: 9,400 TCF
  - Estimated total recoverable gas resources: 22,700 TCF
- World gas demand:
  - Now 110 TCF/y; Reach, including resources, is 206 years of 2010 production.
  - Forecasted demand for 2035: IEA 154 TCF, EIA 156 TCF, Rice University 160 TCF, Exxon 170 TCF.
- US Gas reserves:
  - Now as high as early 1970 (the previous peak).
  - US Gas resource estimates: EIA 1,781 TCF, «Potential Gas Agency» Colorado School of Mines 2,170 TCF, NCI 2,281 TCF.

US natural gas resources, J. Curtis (Colorado School of Mines)

- Cumulative past US production: 400 TCF, Proven Reserves 2010: 272 TCF (mainly conventional).
- Reserves and technically recoverable resources stayed at same level of 1,000 - 1,100 TCF from 1990 - 2005 but jumped to 1,850 TCF in 2009.

Natural gas reserve maturation, P. Weijermars (TU Delft)

Not only unconventional gas reserves are growing. World conventional gas reserves have increased some 20% in the past 10 years and 400% since 1970.

4. Natural Gas general

Unconventional gas has totally transformed the US E&P industry and is changing the US energy mix. The Obama administration called Shale Gas «the US response to Fukushima». The administration has a target of cutting oil demand by $^1/_3$ until 2025; replacement will be predominantly gas.

4.1 Forum: The future of natural gas

L. Fisher, S. Tinker (Fisher-Jackson School of Geosciences, Texas University)

One of the best talks of the convention. Scott Tinker was the 2010 president of AAPG (and one who excelled!).

Future role of gas

- Fisher and Tinker see the world moving towards a methane economy over the next decades.
- If trends in carbon reduction and hydrogen increase continue, methane should constitute the dominant fuel in the global energy mix, representing a long-term bridge to a non-fossil, probably hydrogen economy. How much of the non-conventional resources prove to be recoverable and at what price are major uncertainties.
- If history teaches us anything, it supports resource elasticity as geologic understanding increases and as technology advances. Cost and geological availability of natural gas will not constrain a global methane economy.
- Over the past 25 years global natural gas demand has increased at an average annual rate approaching 4%. Several projections show this growth continuing over the next 30 years and beyond.
- With or without emission limits natural gas will continue to fare well in power generation where it competes with coal and nuclear.
- The much larger potential for natural gas use is in transportation, although displacing oil is a challenge, given its tremendous efficiency, density and versatility. The real penetration of natural gas in the transport market likely will hinge on the timing and development of an efficient hydrogen fuel cell. The principal method of producing hydrogen now is through steam reforming of methane and as such methane could be the principal raw material for hydrogen. By 2035 up to 25% of US gas may be used for hydrogen production.

Energy periods (world primary energy)

- Wood economy to 1850
- Coal economy to 1940
- Oil economy to 2030
- Gas economy to 2100+
- Hydrogen economy? after 2100

Energy Efficiency

- Worldwide there is about a 1% energy efficiency increase per year, 2% per year would be technically possible and would have a major impact on the energy balance.

D. Lawrence (VP Exploration Shell Americas)

- Accelerated unconventional gas production is the quickest and cheapest way to reduce CO_2 emissions (replacing coal in power generation). Reduction of 50% in CO_2 emissions are possible vs. older power plants.
- A gas power plant produces energy 50% cheaper than a coal plant and 20% cheaper than a nuclear plant.

4.2 Energy and Mineral Division (EMD) Shale Gas Forum

Global unconventional gas: challenges and scenarios for the road ahead, R. Clarke (Wood Mackenzie)

- Majors put over 90 Billion $ into acquisition of unconventional gas in the last 5 years, most of it in the last two years (Shell, Exxon, Chevron, Statoil). This large capital outlay for unconventional gas will be missing elsewhere in the worldwide E&P investments.
- The regional gas price is the key to economics. Gas developments are long-term, 20 - 30 years; such projects cannot react on short term disruptions like Fukushima (Japan) and Libya in 2011. This is also the reason why – despite the factor 2-3 difference in gas price between N-America and Europe or Japan, there is no plan to export LNG from the US.

- In N-America some 1,100 TCF of unconventional gas are economically recoverable at a gas price of 3-6 USD/MBCF (about 40 years of present N-American consumption).
- Global supply of unconventional gas was 380 BCM/y in 2010, will be 900 BCM in 2025 (equivalent to 28% of 2010 world production).

Shale Gas, view from the bottom of the pyramid, A. Berman (Labyrinth consulting Houston)

Berman gave – as the only speaker – a very negative outlook on shale gas, claiming that it would at best add an additional 20 years supply for the US. In discussion his statements were violently opposed by many of the gas companies.

- Shale gas is at the bottom of the profitability pyramid: high costs, low recovery.
- Claims of profitability at 5 $/MCF cannot be supported. Economics are comparable to CBM. True cost level is 6-8 $/MCF. Gas sells presently at < 4 $/MCF
- Profitability: 16 US gas companies wrote down 35 Billion $ in 2009 and 30 Billion $ in 2010.
- Not all shale gas areas are attractive; there is only a limited area of sweet spots in a shale gas play. After 14,500 wells drilled in the Barnett shale only about 15% of the basin can be considered core sweet spot area (*which is still a huge area, considering the size of the play*).
- Drilling costs are too high since there is still a high demand on rigs. While drilling slows in classical areas like the Barnett, it increases steeply in new plays, driving up prices.
- The gas bubble will burst.

A practical review of the Shale Play, S. Dixon (Chesapeake)

Dixon strongly disagreed with the findings of A. Berman (above), claiming that Berman did not properly interpret some fundamental information and aspects, like the fact, that contrary to conventional gas, exploration finding-rates are very high (> 90%) and thus wasted exploration costs very low.

- US shale gas production shows a dramatic increase. It is only now that the companies are starting to reap the benefits:
  - 2001: 0 MMCF
  - 2005: 1,000 MMCF/d
  - 2010: 8,000 MMCF/d
  - 2011: 14,500 MMCF/d
- For profitability it is essential to produce liquid hydrocarbons as well.
- Shale gas wells have high initial decline but a low to very low late decline rate (the early Barnett wells show after 10-12 years a long-term decline of 3-10% per year).
- Well initials are steadily improving as operators learn to target sweet spots and improve fracs.
- Recovery Factor for shale gas: average 30%.
- Operations are steadily getting cheaper, faster, and more efficient. The present forecast of production and reserves is most likely very pessimistic.

Panel discussion on unconventional gas

- Land prices are beginning to be prohibitive: Few years ago land cost few 100 $/acre, now 10-20 times more. Early entrants can survive, latecomers not, this is prohibitive for small independents unless they already own a large land base.
- Why is there no shale gas in Tertiary rocks? There was no clear answer on this. It might have something to do with the brittleness of the rock (no effective fraccing, unless the rock is very brittle) and/or with the maturity (good shale gas source rocks should be highly mature to over mature).
- Sweet spots might be related to structure (higher natural fracturing on structural high?).

- Environmental concerns about hydraulic fracturing and water pollution are less virulent in US than in Europe. In the US the environmental questions are seen as teething problems of a new technology, in Europe it may threaten the entire unconventional gas business. There is a wide consensus that the observed contaminations of water are rare events (estimated at < 1% of the wells) and always linked to drilling problems with poor casing- or cement jobs. There is no documented case where a deep well (> 1000 m) has been fracked to surface (a claim made by environmental activists). Damaging of cement might occur where extremely high fracturing pressures are applied in combination with a suboptimal well integrity.
  The industry needs to establish and agree standards with the authorities to counter the fears. Europe needs a good success to sway the mood.
- Europe: Costs for unconventional gas production are still prohibitive. The Poland venture breaks even at a gas price of 9 $/MCF, costs may be higher in W-European countries (European gas prices are around 10-11 $/MCF). European shale gas is nevertheless expected to grow to 35% of demand by 2040. But the loss of oil indexation will remove price stability.

4.3 Liquid Natural Gas

Economic determinants of the global NG Balance, K. B. Medlock (Rice University)

- As recently as ten years ago, natural gas markets were isolated from each other. Limited availability of regasification, shipping, and liquefaction capacity, as well as prohibitive costs, inhibited the free flow of LNG from one region of the globe to another.
- Outside the US the increasing gas-to-gas competition marks a dramatic shift from the traditional oil-indexed terms that have historically dominated gas transactions.
- When shale gas made its strong entry after 2005, some 47 LNG terminals were in the permitting stage for the US alone. Most of these plans are scrapped. LNG import of the US will decline from a few BCF/d at present to about 0.5 BCF/d and no additional imports are needed for the next 30 years.

Gulen, Gurcan (Center for Energy Economics, Bureau of Economic Geology, Houston)

- World LNG liquefaction capacity is still modest at slightly over 10 TCF/y. Interestingly total import capacity is only 8.5 TCF/y.
- LNG is displacing pipeline gas to Europe; this has led to a 25-50% decrease in price since 2008 and continued pressure on oil indexation.
- LNG is competitive when distances are > 2,500 - 3,000 km.
- LNG will in future be traded globally like crude, aided also by a diversification in exporters (8 LNG export countries in 1995, 14 in 2010). In 2009 16% of all the LNG traded were spot cargoes.
- Future LNG contracts will be 5 - 10 years vs. 25 - 30 years previously, with no oil indexation. But long-term contracts will still be needed since building a total LNG chain costs 4 - 10 Billion USD.
- Typical costs in USD/MM BTU (or USD/MCF):
  - E&P: 0.6 - 1.3
  - Liquefaction: 1.04 - 1.56
  - Shipping: 0.5 - 1.3
  - Regasification: 0.4 - 0.6
  - Total: 2.6 - 4.8

Acronyms

B: Billion (10^9); BOE: Barrel Oil Equivalent; BBL: Barrel; BOPD: Barrels Oil per Day; BCF: Billion Cubic Feet (10^9); BCM: Billion Cubic Metres; BTU: British Thermal Units; EIA: US Energy Information Agency; E&P: Exploration and Production (of oil and gas); IEA: International Energy Agency; Industry: here the oil and gas industry; LNG: Liquid Natural Gas; M: Thousand; MM: Million; TCF: Trillion Cubic Feet (10^{12}); TCM: Trillion Cubic Metres; TOC: Total Organic Carbon; USD: US Dollar.