Economically difficult times as a driver for technical innovation: Comments and key information – AAPG Annual Convention Denver 2015

Peter Burri[1]

Key words: AAPG Convention, oil, gas, unconventional oil, unconventional gas, Peak Oil, Peak Gas, global energy, global gas market, LNG, CO_2 sequestration, hydraulic fracturing

1 General

The convention was held in Denver in May–June 2015 and drew only some 5,000 attendees, considerably less than at previous events, reflecting the more difficult economic environment. Delegates from Europe were drastically down since several European companies had issued travel restrictions in the face of low oil prices. Surprisingly, also attendance from Asia, especially China was much reduced – both as presenters as well as visitors, indicating that also the Chinese State Oil Companies feel the economic squeeze.

The present economic pressure, caused by the low oil price, is likely to lead to a lot of innovative new technology and higher efficiency in operative processes. The Industry has always been most innovative when it was under pressure. When oil prices collapsed in the early 80's, the further development of the N-Sea had been declared dead; it turned out to be one of the most innovative times for offshore technology and the high time of the N-Sea was still ahead.

2 US E&P Industry

A statement by one of the presenters illustrates the mood: «In these times our job is not to find oil and gas, our job is to make money». The new drive to a «no frills» approach in exploration and development was apparent in many of the papers presented.

Impact of oil and gas prices: Domestic topics have dominated the presentations of the convention. With the present low oil price, hitting particularly the relatively expensive unconventional developments, there is some rethinking of global strategies: some companies that until a year ago have followed a back-to-domestic focus, have realized that it makes sense to have a leg also in international business. The approach to new deep-water exploration and remote areas, like the arctic, is nevertheless very cautious. Many of the deep-water developments are in the present low price environment a much higher risk than the domestic unconventional production, where savings through more efficiency and technological progress can be much faster achieved than in the very long-term, high tech and high cost deep-water business.

In the US, gas is presently valued under 3 USD/MCF, i.e. well below the 4.50 USD/MCF that was achieved a year ago. For most producers the present prices do not cover life-cycle costs, except where wet gas can be produced since condensate still adds value in spite of the equally low oil price. «Money forward» (i.e. not counting the sunk drilling costs) it is in most cases still attractive to

[1] Holbeinstrasse 7, 4051 Basel, Switzerland [peterburri.geol@bluewin.ch]

continue producing the wells. This is the reason for the still high levels of gas production. Also on a global level there has been a steep drop in gas prices during the past 12 months, though not to the level of the extremely low American prices: European prices are double the US market and Far East prices are 3–4 × higher (Fig. 1).

As an effect of the depressed US market, European E&P companies have partly been divesting US interest and the shale scene continues to be controlled by US independents. 95% of the 45,000 wells drilled in 2014 in the US were drilled by independents!

The low costs of energy continue to stimulate the US economy; the N-American industry enjoys today the lowest energy prices of any industrialized country. Nevertheless, the country is more advanced towards reaching the Kyoto Protocol CO_2 targets (which they have not signed) than any European country: the per capita CO_2 emissions of the US are today back at the level of 1960. This is largely the effect of a switch from coal to gas in power generation: Between 2006 and 2014 the use of gas for power has almost doubled to 23 TCF/year, in striking contrast to Europe (e.g. Germany) where coal consumption is rising. Industries with a large demand for gas as a raw material (synthetic fibre, fertilizer, base chemistry) and as fuel continue to move back to the US to take advantage of gas prices that are a fraction of those in other parts of the world.

Reserve and Production growth: The gas and oil reserves of the US continue to grow. The country added over 35 TCF in 2013 (production 24 TCF). Remaining proven gas reserves have doubled in the last 20 years.

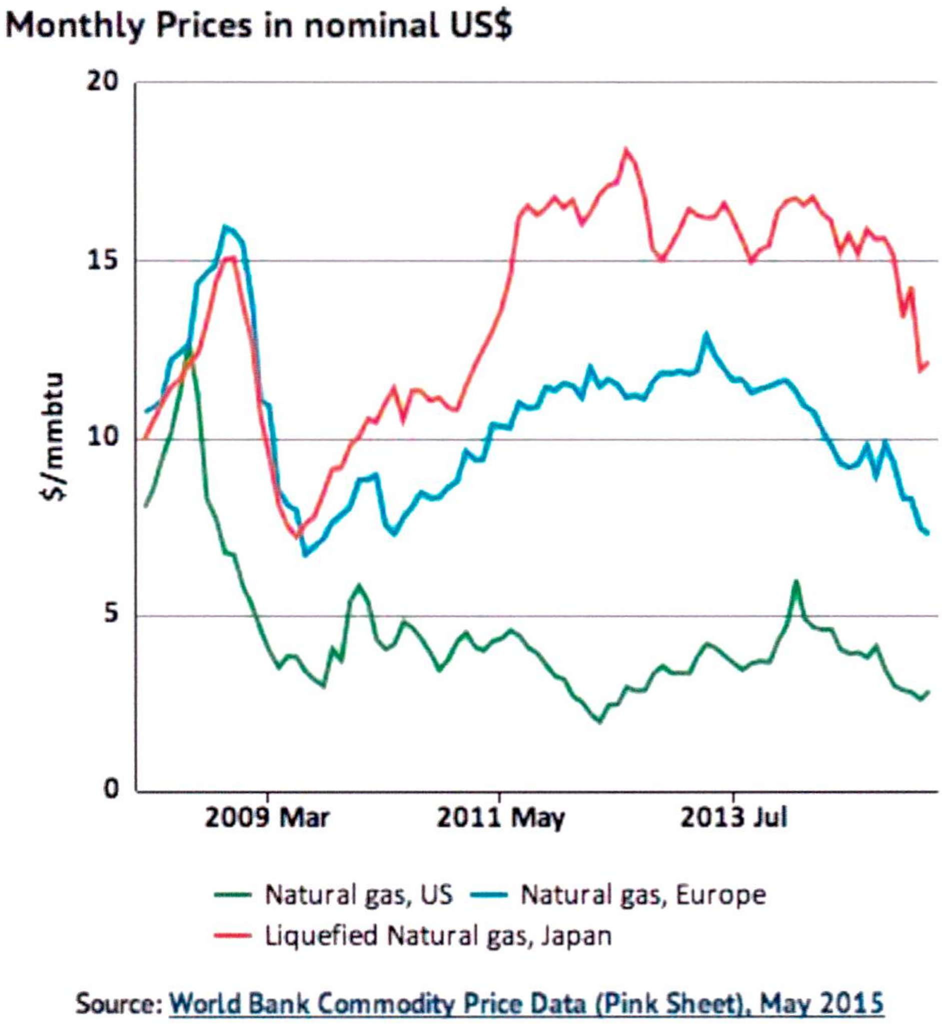

Fig. 1: Gas Prices US, Europe, Japan 2007–2015.

Oil reserves and production grew even stronger. The country is presently approaching about 9 Mio BBL/D in total liquids production (including NGL) compared to 6.8 Mio BOPD in 2006. This rise is about to stagnate under the effect of low drilling efforts in the face of the oil price drop and will turn into a slight decrease by 2016.
Energy self-sufficiency for the US is a still a topic; presently the US import some 10% of their primary energy. Though it is unlikely that the US will reach total self-sufficiency in oil, the US do in principle not need any imports from the Middle East or North Africa. North America (USA and Canada) will most likely become a net exporter of oil by 2020.

3 Oil and gas Industry worldwide

Oil price and costs: The low oil price is having a severe impact on investments throughout the industry, particularly on exploration drilling. Yet, some 15 years ago oil prices were around 20 USD/BBL; it is therefore somewhat surprising that a 40–60 USD/BBL environment is being perceived as hardship. Four aspects have, however, changed since the start of the millennium.

- Prices for drilling and other services have soared since the oil prices started to rise after 2004 and service price levels have receded only moderately now, being still far away from the levels of the early 2000's.
- Most new oil and gas discoveries belong to the high cost category: they are located in remote areas, deep water, the arctic or they require higher development costs, as in unconventionals; the majority of today's wells is horizontal and a many require complex completion and stimulation.
- A large part of new reserves is «reserve growth in existing fields», requiring more complex and thus more expensive technical efforts for the recovery.
- Costs for environmental and safety measures have risen steeply since 2000 and insurance premiums have exploded, particularly in the offshore after the BP Macondo incident.

4 Peak Oil and Peak Gas

A major change of paradigm in the Industry has occurred almost unnoticed during the past decade: the long-term outlook for the availability of fossil energy has changed fundamentally. The reason is that the domestic North American oil and gas industry continues to be extremely successful. An analysis by Pete Stark (IHS) shows that, when looking at giant fields (> 500 MMBOE), North America discovered from 2000 to 2010 a total of 194 Billion BOE vs. 246 Billion BOE discovered in the entire rest of the world. Taking the timeframe up to the year 2014 the ratio would be even more balanced towards N-America, since the largest unconventional volumes have been added after the year 2010. For any explorer this situation is truly amazing: it implies that in the most mature exploration area of the world, where geologists have crawled over every square mile of the continent, almost as much hydrocarbons have been discovered as in all the other areas of this planet combined, areas that mostly have a much lower exploration maturity. It tells us that the world's endowment with oil and gas is probably still grossly underestimated. The important consequence is that Peak Oil and Peak Gas will not be determined by the amount of oil and gas in the ground – as always claimed – but by demand, i.e. by us. It is the further global development, the preferences and the behaviour of mankind that will determine the peak production of fossil energy and not just mother-nature. This is a radical change away from the old Peak Oil theory, which predicted that exhaustion of the limited oil and gas volumes, available in the ground, would determine the end of the hydrocarbon age.

Nevertheless – and almost in contradiction to the above – there has been a shortfall of newly discovered global volumes of conventional oil since 2010; and a production volume of 30 MMBOPD will have to be added by 2020 to replace declining fields. A significant part of this will come from reserve growth (higher recovery factors) but major new exploration successes are needed as well. One prime reasons for the decline of discoveries outside N-America could be the fact that much of the industry is now controlled by National Oil Companies (Majors control today only some 6–7% of world oil production). In financially challenging times state companies have to aliment the coffers of their governments rather than spending money on risky exploration. The other reason is the reorientation of investments by American companies away from international conventional projects to domestic business. All this has led to a noticeable slowdown in global exploration activities. This, together with the slowed down investments in development and improvement of fields is likely to erode the present oversupply during 2016.

The Hubbert Curves and Peak Oil Lessons learnt (*mostly from lecture by Pete Rose*): King Hubbert forecasted in 1956 and again in 1962, that the annual US crude oil production would peak in the late 1960s or early 1970s at around 3 billion bbl, and decline thereafter, implying growing American dependence on imported oil. Hubbert estimated that ultimate domestic crude oil production would total about 200 billion bbl. At that time the USGS had consistently estimated that domestic crude oil resources were some three times larger than Hubbert's forecasts – totalling as much as 590 billion bbl. The dispute spilled over into the US National energy policy. When US crude oil production peaked in 1970 at about 3.2 billion bbl, Hubbert's forecast seemed to be confirmed, and he was hailed as a prophet: the director of the USGS and a part of his team were fired. Today we know that the USGS figures were much closer to the truth.

Hubbert subsequently developed analogous estimates of future domestic natural gas production, as well as global crude oil production. He forecast that US natural gas production would peak in 1975, at about 18 TCF per year (actual production in 2014 is 25.7 TCF/y), and predicted a total ultimate gas production of about 1.050 TCF (ultimate recovery for the US stands today at 1,600 TCF for conventional gas and may approach 3,000 TCF with unconventional resources, i.e. 3 times the Hubbert estimate). Hubbert also predicted that global oil production would peak at a rate of about 40 MMBOPD in about 1995 (actual production in 1995 was 68 MMBOPD, 2014 89 MMBOPD). The ultimate cumulative world production was put by Hubbert at about 2,000 BBO (cumulative global production has in 2014 reached 2.350 BBO, remaining proven reserves stand at 1,700 BBO and conventional resources at 1,400 BBO).

Examined with the benefit of an additional 50 years experience, Hubbert's forecasts were all far too pessimistic by at least a factor 2–3, primarily because he failed to anticipate the effects of technology and price. Large new volumes were added when technological breakthroughs made E&P possible in deep water or at great depths and when new drilling and stimulation technologies allowed the development of rocks, previously thought unproductive. New geological concepts have only in the last 10 years made source rocks a huge new target.

Hubbert's erroneous forecasts had also a major negative impact on the formulation of U. S. and global energy policies, which have been misdirected by the very suggestive but eventually wrong conclusions drawn from the Hubbert curves (Figs. 2, 3).

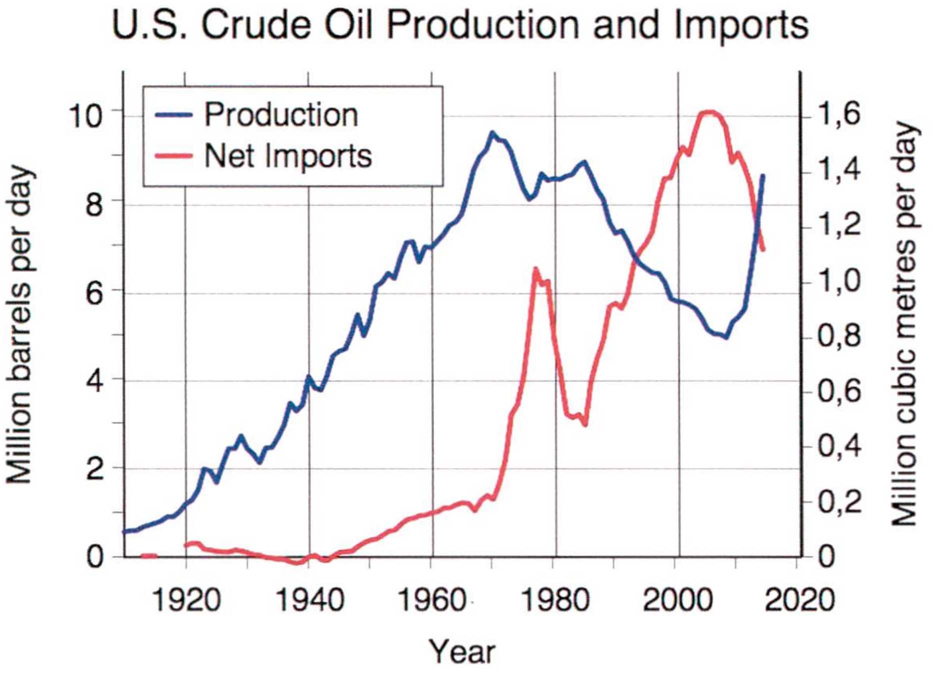

Fig. 2: US Crude oil production and imports 1910–2015 (Source US DOE).

5 Unconventional hydrocarbons

Unconventional oil and gas in the US: Drilling activity in the US has received an enormous boost from unconventional exploration, first in gas and after 2010 in oil (here with an almost 10 fold rise in rigs), each of these rises was followed by sharp downward corrections. It is interesting to see that the two declines in rig counts have completely different reasons:

Drilling activities for gas witnessed a first steep drop in 2009 and a further 60% drop in 2012, i.e. long before the oil price drop. Over 1,500 onshore rigs were drilling for gas at the end of 2008 but only 217 in July 2015. In spite of this, the production of gas has continued to grow and is still climbing at present. The drop in gas drilling activity is not primarily a question of oil and gas prices but is proof of

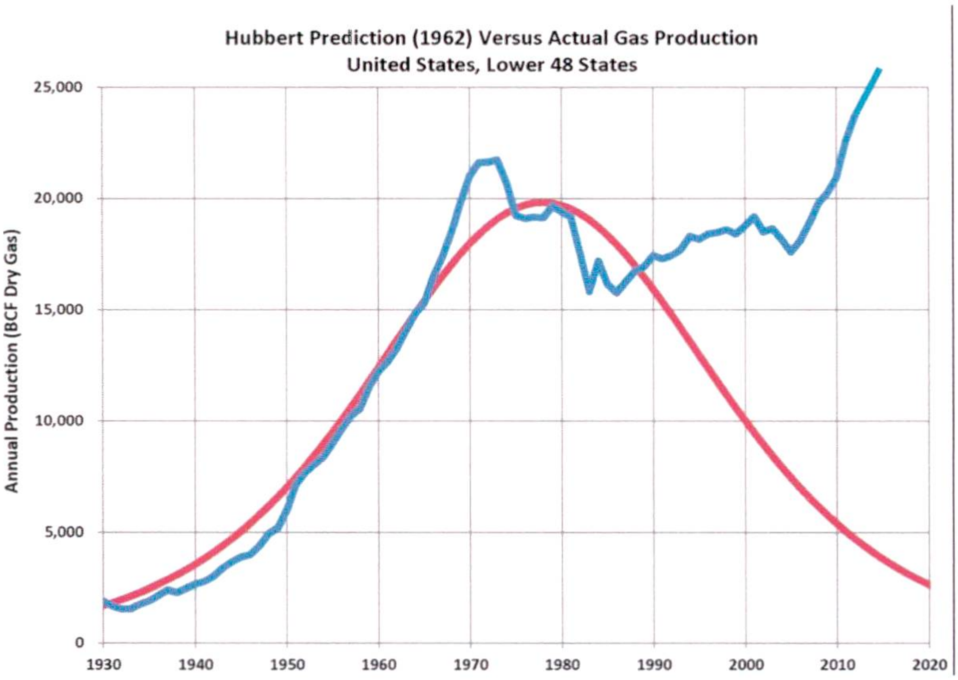

Fig. 3: Hubbert curve and actual gas production of US 1930–2012. Note: gas production 2014 was 25,700 BCF and rising, giving for 2015 almost 10 × the amount, forecast by the Hubbert curve.

the much higher drilling efficiency (3,000 m deep wells are being drilled in one week or less), better and faster completions and more intelligent geological well placement in sweet spots.

In oil the decline occurred over a much shorter time period: oil drilling activity dropped dramatically from 1,600 active rigs in late 2014 to some 600 rigs in July 2015, a drop that appears to level out at present. Interestingly the oil rig-count is even now still more than double the rig activity during 2000–2009. Contrary to the drop in gas drilling, the 2014–15 decline in oil drilling is primarily price-controlled and the effect on production volumes is much more immediate, accordingly unconventional oil production will decline by the end of 2015 (Figs. 4, 5).

Unconventional gas provides today by far the majority of the consumed domestic gas and early 2016 sees the first LNG, exported from the US.

Geology replaces drilling-mania: 13,000 wells were drilled in the Marcellus in the last 10 years, only a fraction per area compared to other shale gas plays. Production is no longer a question of the number of wells but of where the wells are drilled. The drilling

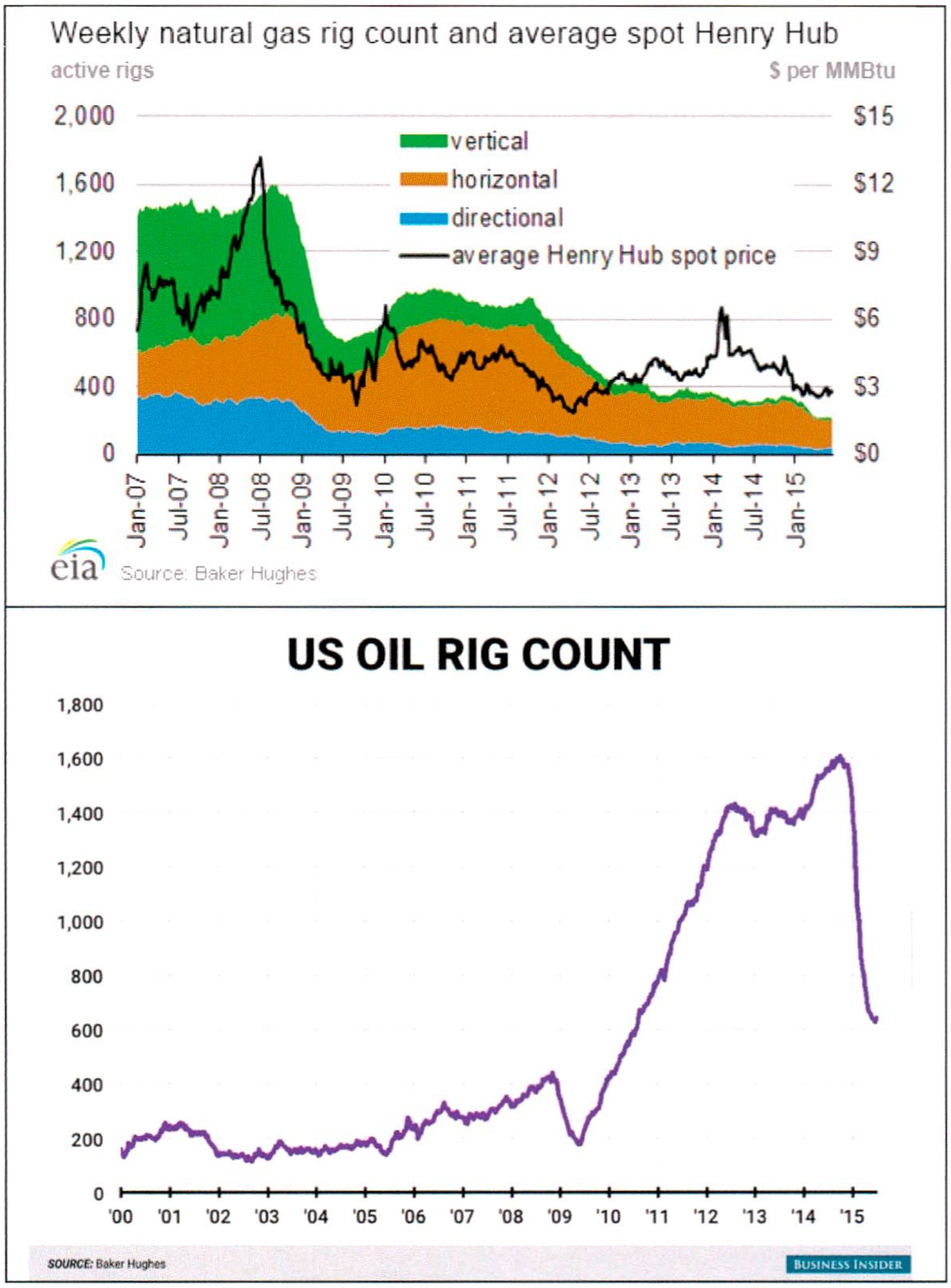

Fig. 4: US Rig market in oil and gas drilling.

performance and well completion/stimulation technology are continuously improved. Average ultimate recovery per well has been improving by double-digit percentage points every year. This explains why gas production has kept rising in spite of a dramatic reduction of drilling activity (Figs. 5, 6).

Limitations to the unconventional production in N-America are increasingly coming from the lack of infrastructure, primarily the lack of pipelines. Pipelines from new production areas as well as gas gathering lines within producing areas are missing. This has led to unacceptable flaring of gas in many of the unconventional oil plays. Flaring is a waste of energy and a big environmental problem that is costing the Industry a lot of good will. Given the lack of pipelines, the transport of oil has been transferred to rail. Oil carloads have increased about 100 × since 2006, volumes that the old and often poorly maintained US rail infrastructure cannot handle (Fig. 7). Several rail disasters have led to public outrage and political opposition against these oil transports. Gas and oil transport infrastructure is the single biggest problem of the US E&P Industry: flaring has to be reduced drastically and fast if major damage to the Industry's image is to be avoided.

Unconventionals worldwide: In spite of the big potential, the development of unconventionals outside N-America is still very slow and the present oil-price slump has led to further caution in the Industry. Argentina and China are probably most advanced towards an own unconventional production but in both cases the activities are still in a pilot phase and not yet economic. While operations in many countries are gaining momentum, exploration for unconventionals is in Europe primarily blocked by public- and political opposition. In spite of the fact that none of the European Academies of Science or other competent scientific organizations has supported a ban of shale gas, the authorities in France, Germany and other countries have been delaying or blocking progress. Even in the geologically most promising UK, where the government is supportive, only one shale gas well has been drilled so far and approval processes are painfully slow. If Europe is not improving on its legislative hurdles and on the efficiency

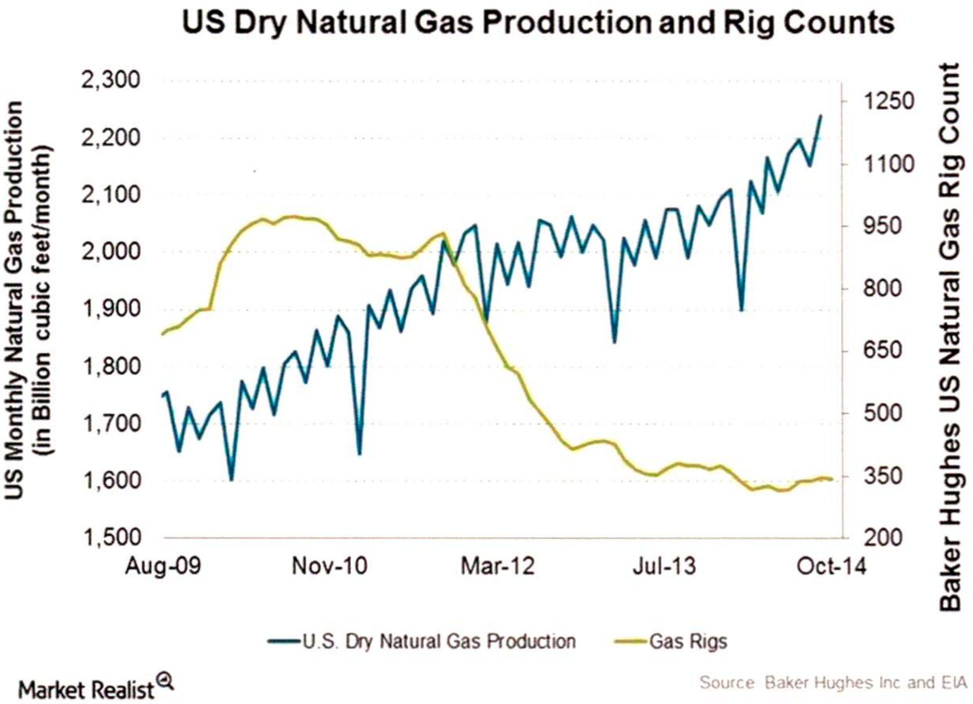

Fig. 5: Gas rig count and gas production (mostly unconventional). Note lack of correlation between drilling activity and production.

of its red tape plagued processes it will become increasingly dependent on imported energy. At the same time the Industry has to make much bigger efforts in communicating merits and challenges of their technologies and processes to the public. At present the European public is mostly receiving heavily distorted information through media and politicians.

Environmental and safety concerns: A large number of papers were treating risks linked to unconventional exploration with the main focus being induced seismicity, water contamination and gas in groundwater. A large study by the US Environmental Protection Agency (EPA), published in 2015 shows conclusively that hydraulic fracturing is not a significant risk for drinking water. The very large majority of water contamination by drilling fluids and gas is not related to unconventional gas activities, quote: «EPA did not find evidence that these mechanisms (of fracking) have led to any widespread, systematic impacts on drinking water resources» [...] «The number of identified cases was small compared to the number of hydraulically fractured wells». The talks during the conference (from Industry, authorities and environmental offices) confirm that when good operational standards are applied, water contamination is not really an issue. The same is true for methane. Methane from natural sources is common in groundwater, originating from deep thermal sources, bacterial activity or coal seams.

Induced seismicity: A large number of talks dealt with man-made seismicity. A dramatic rise in larger seismic events, up to M > 5, in the previously seismically calm midcontinent states of the US, has originally been attributed to hydraulic fracturing. Many studies by the authorities have now shown that these seismic events have nothing to do with fracturing but are caused by disposal / re-injection of waste-water. The water comes from the oil industry, other industrial activities or public waste-water. There is a strong correlation between induced seismic events and deep faults, which in most cases involve basement. A good understanding of the regional stress field allows a reliable prediction of active faults that should be avoided. In Ohio, the injection of fluids is now forbidden by law within 2 miles of identified faults.

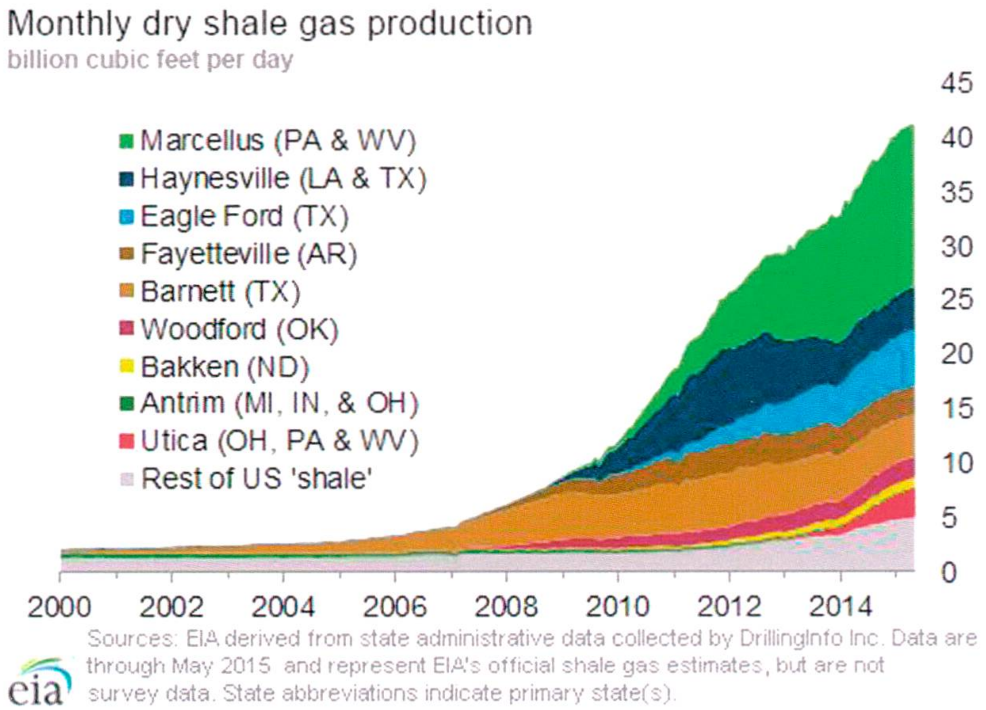

Fig. 6: US Unconventional gas production 2000 – mid 2015. Gas production was rising by almost 80% since 2008 in spite of the decrease of active rigs).

Even though some 3 million hydraulic fracturing jobs in sediments have been carried out worldwide, there are only a handful of seismic events that can be related to fracturing (the Quadrilla Blackpool event in the UK, two not well documented events in the US and a possible event in Canada). None of these events has caused any damage. Induced seismicity is therefore – contrary to all rumours – not an issue when fracturing sediments. Seismicity needs, however, be closely watched in disposal of fluids as well as in deep geothermal wells, especially within or in proximity of basement rocks.

6 Worldwide Gas

Worldwide Gas-market and LNG: LNG exports start from the US in 2015 and from Canada in 2016. Mexico is at present still importing gas from the US, but North America will become a net gas exporter well before 2020, adding significantly to the world LNG availability. The effect of the global abundance of gas can be seen already in the rapid decline of global LNG prices, which have been almost halved between 2013 and 2015. In spite of the increasing global gas-to-gas competition, very large price differences in LNG remain. Compared to the landed LNG prices on the East coast of the US, LNG prices in Europe are 2 × higher and in East Asia 3 × higher. With further LNG plants coming on stream in N-America as well as in East Africa and the eastern Mediterranean, worldwide gas prices are likely to stay depressed and a further globalization of prices has to be expected (Fig. 8). This will only change if countries like China and India (and why not Europe?) follow N-America in pursuing a deliberate policy of replacing coal by gas to improve air quality and lower their greenhouse gas emissions.

7 CO_2 Sequestration

CO_2 sequestration projects remain on a small flame worldwide. The foremost reason is that sequestration has so far proven to be very costly and small in volume, compared to the quantities that would be needed to make a significant impact on the CO_2 balance of the earth. In addition, pilot projects suffer increasingly from NIMBY citizen protests. CO_2 sequestration may also have a significant risk of induced seismicity, given

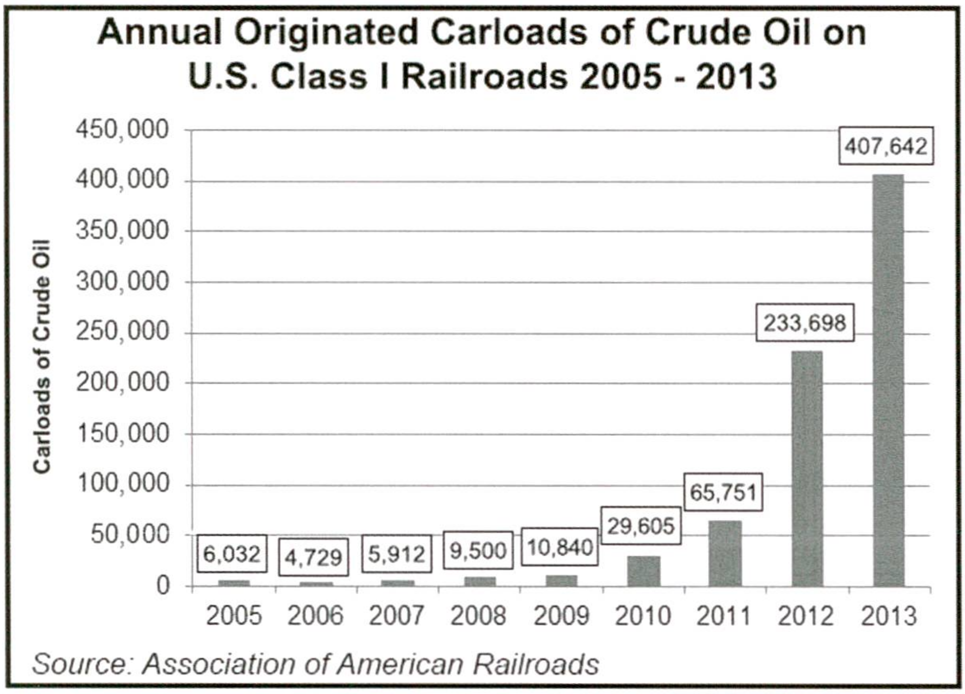

Fig. 7: Increase in oil carloads by US Railroads 2005–2013.

the fact that large volumes of fluid have to be injected. The country with the so far biggest effort on sequestration, Australia, has had a change in government and funding of most projects has been stopped or drastically reduced.
The only positive exception was the use of CO_2 in enhanced oil recovery. This is a commercially and environmentally attractive opportunity, especially in the US where CO_2 pipelines from power plants to oilfields already exist. Pumping CO_2 into aging oil and gas fields has virtually no risk of leaking since the existence of the hydrocarbon accumulations is proof that the system is sealing.

8 Renewables

As last year, the US E&P industry is so focused on the technical and financial challenges of the unconventional revolution that renewables were not an important theme at the conference. Many of the wind, solar and geothermal projects in the US are struggling with economics, unless the projects are subsidized.
Geothermal use of well fluids in oil and gas fields is still being pursued. New technologies that would allow a much more efficient heat extraction (also at temperatures presently marginal for power generation) would give a much-needed boost to these

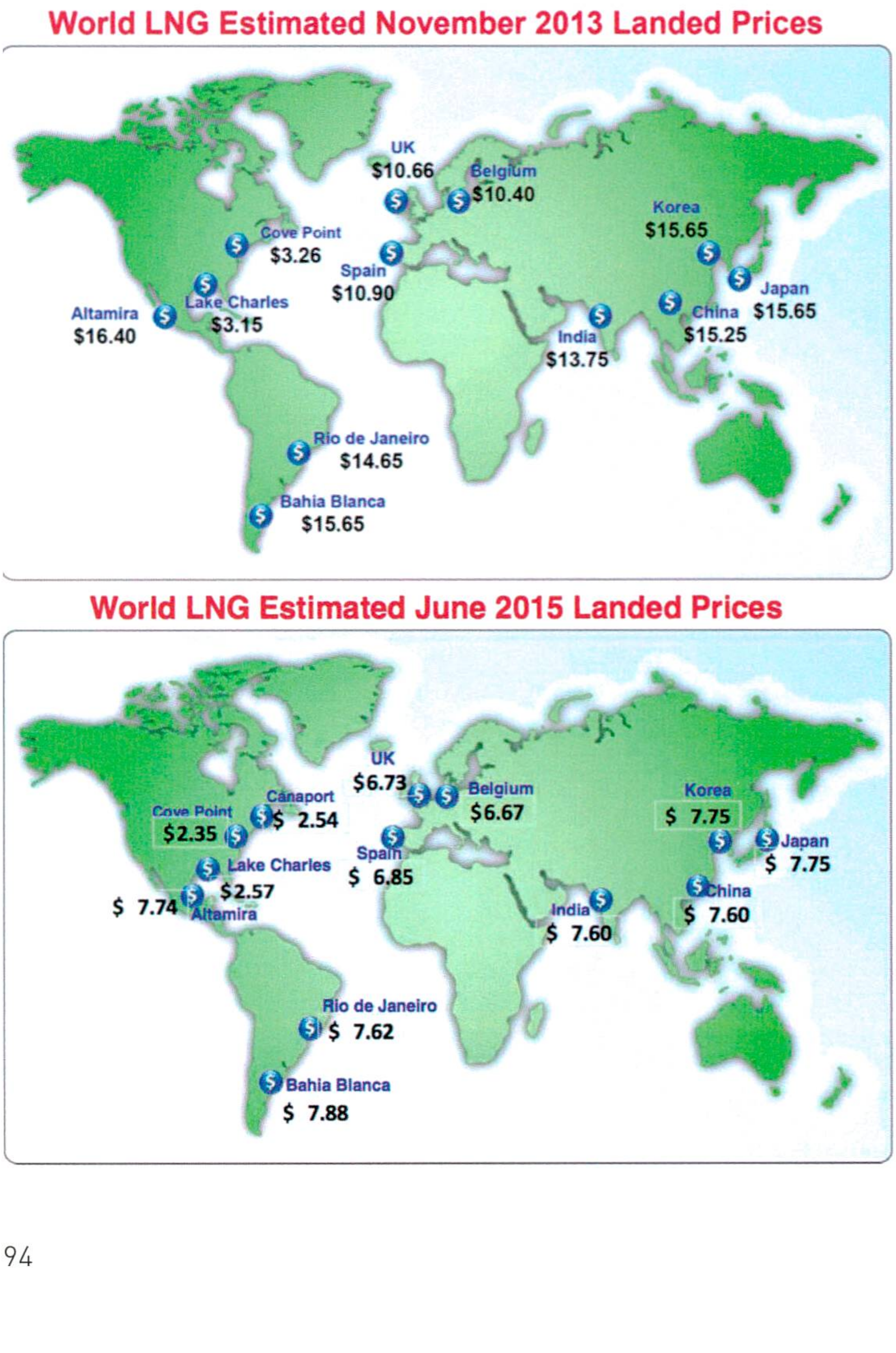

Fig. 8: Worldwide landed LNG prices 2013 vs. 2015: A rapid fall in prices but large global inequalities remain. Units: USD/MMBtu (Source: Anastasia Shcherbakova. Waterborne Energy, Inc.).

efforts. Deep geothermal activities are still concentrated predominantly in volcanic areas with little investment or research going into creating artificial deep heat exchangers. Given the large areas with shallow volcanic heat in the US, deep geothermal projects with enhanced geothermal systems (EGS) are not a prime target and the development of EGS is advancing more slowly than in Europe.

Acronyms and terms

B: Billion (10^9); BBO: Billion Barrels Oil; BOE: Barrel Oil Equivalent; BOPD: Barrel Oil per day; BBL: Barrel; BCF: Billion Cubic Feet (10^9); BCF/D: Billion Cubic Feet per day; BCM: Billion Cubic Metres; BTU: British Thermal Unit (1 MMBTU equals MCF); CF: Cubic Foot; DHI: Direct Hydrocarbon Indications (from seismic); E&P: Exploration and Production; GIIP: Gas initially in place; Industry: Here always meant as the Oil and Gas Industry; M: Thousand; MCF: Thousand cubic feet; MM: Million; Majors: The category of the largest multinational private oil and gas companies; mD: Millidarcy (permeability measure); SR: source rocks; RF: recovery factor; T: Trillion (10^{12}); TCF: Trillion Cubic Feet (10^{12}); TCM: Trillion Cubic Metres (10^{12}); TOC: Total Organic Carbon; USD: US Dollar; USGS: US Geological Survey; 3D: Three dimensional seismic.