Cambridge University Press
978-1-107-12008-2 — Risks, Rewards and Regulation of Unconventional Gas
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The Rise of Unconventional Gas: The Story So Far

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Introduction

Natural gas has steadily increased its role in OECD countries over the last 40 years, rising from 19% of total primary energy supply (TPES) in 1973 to more than a quarter by 2013. More than half the gas is used in the residential and commercial sectors, where it is the preferred fuel for heating, cooking and hot water. Industrial activity accounts for a further quarter of consumption, notably in the chemical industry but also in non-ferrous-metal production and food processing, where its clean combustion and flexibility are valued.

While many gas markets in the OECD are well developed, notable recent growth has come from the power sector, where demand has almost trebled since 1990. Since that time, gas-fired power has become the fuel of choice for new electricity generation in many, if not most, major OECD countries, accounts for almost two thirds of new power output and in the most-developed regions is the marginal dispatch technology. Since 2000, gas-fired power has grown by 80% or around 1250 TW h, which is almost equivalent to the total power output of Japan plus Australia.

The rapid increase in gas-fired power has occurred because gas enjoys a number of advantages over alternative energy sources; these include its greater flexibility and efficiency. Furthermore, the use of gas is expected to increase dramatically, both in its role as a source of generation flexibility to complement increasing shares of intermittent renewable generation and also in its generally larger role in the energy mix of economically growing non-OECD countries such as China (where coal has been the dominant source of new power). This is likely to remain true even if aggressive greenhouse gas reduction policies are implemented, which would tend to increase the share of renewables while reducing the share of fossil fuels in the energy mix (IEA 2013).

In the United States gas has held an important position in the energy mix for many decades, supplying 28% of TPES in 2012. While markets in the residential, commercial and industrial sectors are relatively mature, gas-fired power doubled between 2000 and 2012. In Australia, gas use grew from 6% of TPES in 1973 to 26% in 2012, with gas consumption increasing sixfold in the residential sector and tenfold in the electricity generation sector.

Gas Production Looked Set to Fall in OECD Countries

Until recently the majority of natural gas was produced by 'conventional' methods, frequently associated with oil production. As recently as 2007, gas production in the OECD was predicted to decline as peak output was reached in the North Sea, the United States and elsewhere. Thus the outlook at that time was for increased imports, higher gas costs and declining energy security. As a result, in the period 1996–2010 large investments were made in importing infrastructure into Europe and the East Coast and Gulf of Mexico in the United States, with corresponding outlays in gas-liquefaction plant in Qatar and elsewhere. Liquefied natural gas (LNG) was therefore set to play a greater role, and not just in those countries where it had historically provided most, if not all, the gas supply such as Japan, Korea and Taiwan and increasingly Europe and the United States and other gas-hungry countries including China and India. Indeed, the original marketing plans for Qatar, currently the world's biggest LNG exporter, envisaged sales of roughly one third to each of the United States, Europe and Asia. Current planning in Canada relies on unconventional gas reserves for LNG exports and targets the Asia Pacific market beyond 2020 as the driver for new west-coast-port development.

Unconventional Gas in the United States has Changed the Game

While expectations for declining gas output have largely been realised in Europe, especially in the United Kingdom, the situation in the United States has taken a completely different course. Beginning in around 2005, but rapidly accelerating after 2008 and building on years of research and pioneering activity by a few medium-sized companies, the United States was able to tap hitherto uneconomic sources of gas, so called 'unconventional gas' (UCG). Starting first in Texas and then in adjacent traditional hydrocarbon provinces, the new gas extraction technologies spread rapidly to other geological basins in the United States to encompass new oil production. As shown in Figure 1.1, the Marcellus Basin, which includes West Virginia and Ohio and is centred on Pennsylvania, has seen production from shale gas rise from almost nothing in 2008. By early 2015 production levels had been reached where, had it been a country, the Marcellus Basin would have rivalled Qatar as among the largest gas producers globally. This region now accounts for nearly a fifth of the United States gas production.

A key impact of these developments in the United States is that the market price for gas has fallen below $4/Mbtu (see Glossary and Conversion Factors) for an extended period, only rising above this level as the result of a very cold winter. This price is equivalent to an oil price of around $25 per barrel, well below the global oil prices in excess of $100 per barrel prevailing over the period 2011–mid 2014. Such low energy prices have made the United States an extremely competitive location for energy-intensive industry globally, a situation likely to persist for many years. The beneficiaries are those who use gas directly and for electricity generation and include both households and industries. In early 2015, even as oil prices for US crude oil fell to $40–$50, gas prices at around $2–$3/Mbtu remained very low relative to oil.

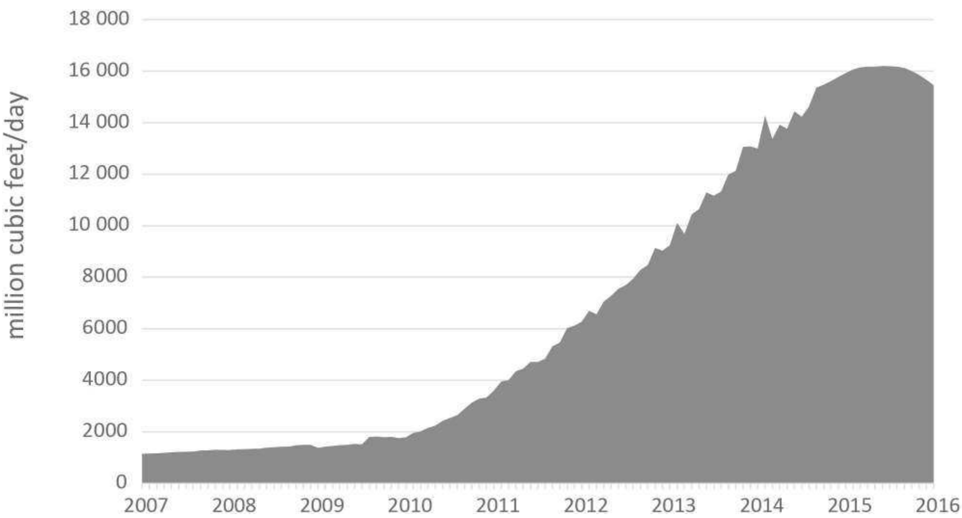

Figure 1.1 Marcellus region, natural gas production. *Source:* US Energy Information Administration (December 2015).

Unconventional Gas is Already Transforming the Global Energy Landscape

While other countries are known to have significant large resources of unconventional gas, bringing them to production is expected to take some time and will probably not happen before 2020, with exceptions in Canada, which is exploiting similar technology in its western provinces, Australia, which is rapidly growing its coal bed methane supply and possibly Argentina and China. Unconventional gas development in the United States has already had a major impact on global energy supplies and security. One notable example is the response of global gas markets to the 2011 Fukushima disaster in Japan. In its aftermath, and facing the loss of nearly 280 TW h of generation from its nuclear fleet, Japan purchased substantial extra quantities of LNG from Qatar, and elsewhere, albeit at a high price for such spot sales. This allowed it to make up some two thirds of its power shortfall. The LNG exported to Japan was effectively no longer needed in the oversupplied North American gas market. In effect, the United States had already become a virtual gas exporter.

The importance of the United States as a gas exporter will become even clearer when the first of a number of US LNG export facilities starts operation in 2016; it is based on the retrofitting of an existing LNG import terminal with a liquefaction plant. With four other such import terminals also receiving export approval, LNG exports from the United States could rival those from Qatar and Australia soon after 2020. Gas producers in Canada, previously exporting gas to the US, are also seeking new markets, generally in the Pacific region although the barriers to successful export projects there are higher largely due to limits on interprovincial pipeline approval and opposition to the construction of new port facilities.

Environmental Impacts are More Pronounced and must be Regulated

The rapid growth globally in gas reserves and production from unconventional gas is transforming the global energy landscape. As more countries join the ranks of unconventional gas producers, this transformation will become more evident. Nevertheless, the technical challenges to global unconventional gas expansion are formidable. In particular, the social, economic and environmental risks of gas extraction need to be managed if gas producers are to retain a social licence for their activities. These environmental challenges are exacerbated with unconventional gas, as a result of the higher drilling intensity required and the multiple use of hydraulic fracturing employed in some wells. These issues and the potential local or regional risks to water resources have led to growing calls for more active and specific regulation, with widely varying approaches being seen in jurisdictions worldwide. The nature of the current regulatory system, and what it should be, will be a key determinant in the longer-term future of unconventional gas development.

In this book we compare the regulatory approaches taken in a number of jurisdictions, including: Argentina, Australia, Canada, China, Colombia, India, Poland, the United Kingdom and the United States. Collectively, the volume brings together insights from these countries to provide directions for good or effective regulation in terms of unconventional gas production.

What is Unconventional Gas?

Unconventional gas is identical to natural gas, consisting essentially of methane with small concentrations of impurities; only the production methods differ from those for more conventional gas. The production methods differ because of the need to extract gas from geological formations in which the permeability is low and which may include tight gas, coal bed methane (CBM, also known as coal seam gas) and shale gas.

In the case of shale gas, economic gas extraction has been made possible by advances in the key technologies of horizontal drilling and hydraulic fracturing. The latter technique involves the injection of a fluid under pressure, typically more than 95% water with the addition of a proppant (commonly sand) to hold fractures open plus a very small proportion of certain chemicals. In the case of coal bed methane, usually the water must first be extracted and, given its often saline condition (typically 200–10 000 mg/l), needs to be treated before disposal. In coal bed methane extraction, horizontal drilling and fracturing are less widely employed, hydraulic fracturing being used in less than 5% of CBM wells, up to 2010 with that proportion increasing only to 6% (111 out of 1844 CBM wells) in 2012 and 2013. Nevertheless, hydraulic fracturing has been used in the conventional oil and gas industry for some decades in Australia, notably in the Cooper Basin straddling South Australia and Queensland. The use of hydraulic fracturing seems likely to expand, with the rapid ramp up as output in eastern Australia to meet LNG-induced demand; one LNG project is expected to use hydraulic fracturing in around 30% of its gas wells over the life of the project (i.e. 3000 to 4000 out of 10 000 wells) (APLNG 2015), with the use in other projects potentially higher.

The environmental issues, and associated regulation of the possible external costs, can differ between different methods of unconventional gas extraction, although some features are common. The focus in this book is on coal bed methane and shale gas extracted by unconventional methods.

Unconventional Gas Brings Higher Environmental Impacts

A common feature in many unconventional gas operations is higher drilling intensity relative to conventional gas developments. In unconventional fields there are often hundreds, or even thousands, of production wells being drilled in a given gas play or production area, thus increasing the actual and potential impact of drilling and associated operations on the local environment and residents. By contrast, in conventional gas fields there may be only tens or hundreds of wells. Drilling multiple wells from a single site or drilling pad, using horizontal or other drilling techniques, as is being practised more widely in US and Canada, reduces the surface impact of gas development as well as markedly reducing the costs of production (see Chapter 6 in this volume).

An aspect in the development of unconventional gas is that production wells need more complex, and sometimes ongoing, techniques to stimulate adequate gas production rates; these techniques include hydraulic fracturing for shale gas and extensive water removal or dewatering for CBM. The water extracted for CBM production may have various degrees of contamination with salt or other pollutants, which necessitates proper treatment and disposal techniques. The beneficial use, or release, of this treated water has a potential impact on existing water resources, both those on the surface and those underground. Further, the water used for fracturing can lead to a possible depletion of water supplies although newer approaches emphasise the recycling of so-called produced or formation water, which lowers the call on fresh water sources. Shale wells tend to be at a deeper level (typically 2000 metres or more) than the rather shallow CBM extraction (800–1200 metres), with potentially differing implications for water supplies.

Public concerns, and regulatory issues, while varying between regions and between gas-producing technologies, can be loosely grouped as follows:

(i) the question of land access, obviously most acute where settlement or existing land use is most intense;
(ii) water issues around the potential contamination of aquifers;
(iii) the water-treatment or disposal of the formation water and/or the fracturing or drilling liquids, which is especially important in areas of water scarcity;
(iv) conflict with other land uses or users, including loss of property value;
(v) air emissions, including fugitive methane (the oil and gas sector is a large source of methane emissions, a potent greenhouse gas and contributor to climate change);
(vi) possible seismic events triggered by high pressure hydraulic fracturing; and
(vii) surface issues such as habitat fragmentation and loss of aesthetic benefits.

The Industry is Expanding Rapidly

Many environmental issues and community concerns in the unconventional hydrocarbon industry are common to conventional hydrocarbon (oil and gas) production and have, to some extent, been addressed in existing oil and gas regulation, especially where the relevant regions have a history of such production. These include mandatory measures such as blow-out preventers and regulations to ensure well integrity through multiple cementing procedures. Where such a production history is lacking, existing regulatory coverage has, at least initially, been weak. In any case, the novel nature of production techniques and the speed with which they have been deployed in some locations have placed strains on most existing institutions, both in terms of the existing regulatory frameworks and also in terms of the resources of regulators. This is not unexpected because the acceleration of production and the rate of discovery of new locations of unconventional gas has surprised many global gas companies.

Many aspects of these gas extraction technologies have been around for decades. For example, hydraulic fracturing was first developed in the 1940s and 1950s, but the pace of its deployment has increased rapidly, especially in North America. Since first used, the hydraulic fracturing process has become almost standard and has been used on more than one million wells in the United States; it may be noted that the depth of drilling, and the need for and type of hydraulic fracturing and other components of gas extraction, vary site by site. Currently, an estimated 35 000 gas and oil wells in the United States use hydraulic fracturing annually (FracFocus 2014, EPA 2012), with an estimated 80% of shale gas wells also using it. Driven by these new techniques, the United States' shale gas output has jumped from 6% of US gas production in 2005 to more than half the US gas output in 2014, approaching 400 bcm. To date, this supply has strongly resisted the fall in gas and oil prices seen in 2014 and 2015.

Productivity has Continued to Improve Rapidly

In shale gas there has been a sharp decline in the cost of horizontal drilling and hydraulic fracturing technologies, coupled with an increase in the quality and decline in cost of advanced seismic techniques. In all these technologies, as companies have moved rapidly along the learning curve, costs have been driven down. The ability to recover natural gas liquids as co-products in the gas stream has also been an important part of the economics of gas production in North America. Low ethane prices are driving a new wave of petrochemical investment in the Gulf of Mexico region, while the United States is now the largest liquid petroleum gas (LPG) exporter. Other forms of UCG, notably CBM, rarely benefit from associated liquids, which reduces their overall profitability.

Ways Forward

The remainder of this book is devoted to examining developments in a number of countries possessing large unconventional gas resources. In most countries, the exploitation and regulation of these resources remain at an early stage, in some cases barely beyond resource identification; in others, such as China, commercial production has begun, but at a lower level of activity than anticipated.

Our attention is on those countries, provinces or regions where production is most advanced and regulatory policy, mechanisms and institutions are most evolved. Included in this volume are descriptions of the widely differing regulatory approaches adopted, often in regions adjacent to each other. We believe that the collective review and analysis in the chapters in this book provide valuable insights about the benefits, risks and opportunities of this important energy transition and about how best to manage a rapidly growing industry for the public good.

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Geopolitical Dimensions of Global Unconventional Gas Perspectives

FRANK UMBACH

Introduction

The US shale gas revolution has caused unprecedented changes in the country's energy landscape and in global gas markets. In 2009, the US overtook Russia as the world's largest gas producer. It was forecast to become in 2016 a net exporter of LNG and in 2018 an overall net exporter of natural gas (IEA 2014a). The US may even overtak Russia as the world's combined largest oil and gas producer (Gold & Gilbert 2013). It has increased global oil and gas supplies as well as diversification options for energy importers and decreased oil and gas prices, as highlighted by the oil price fall in 2014 and oversupply in the markets.

In 2013, US domestic gas production met almost 94 per cent of its gas demand. Net imports declined from a peak of 107 bcm in 2007 to just 37.1 bcm or 5 per cent of total supply – the lowest level since 1989 (IEA 2014a). Consequently, US foreign and economic experts were discussing the benefits and risks of increased US LNG exports to Europe and Asia and whether to use those exports as part of a pro-active energy diplomacy (Umbach 2014a). Those discussions have increased in the light of the Russian annexation of Crimea and the energy dimensions of that event (Gonchar *et al*. 2014; Umbach 2014g) and in the light of Russia's actions in the Ukraine's eastern regions (Lenard & Sautin 2014).

The projected self-sufficiency of US natural gas and oil (at least in the North American framework) raises the question of the geo-economic and geopolitical impacts on global as well as regional energy security.

Traditionally, energy security was defined as 'the availability of energy at all times in various forms, in sufficient quantities and at affordable prices', in the 1980s and 1990s. But with the rising importance of and need for environmental and climate protection, the IEA defined energy security after 2001 as 'uninterrupted physical availability [of energy] at a price which is affordable, while respecting environment concerns'.[1] But 'sufficient quantities' and 'affordable prices' have remained rather vague terms and thus 'energy security' has still not been defined precisely. For measuring 'energy security', more and more indicators have been created and framed in new complex energy security concepts (Löschel *et al*. 2010a, 2010b).

[1] Thus the definition of 'energy security' by the International Energy Agency (IEA): http://www.iea.org/subjectqueries/keyresult.asp?KEYWORD_ID=4103.

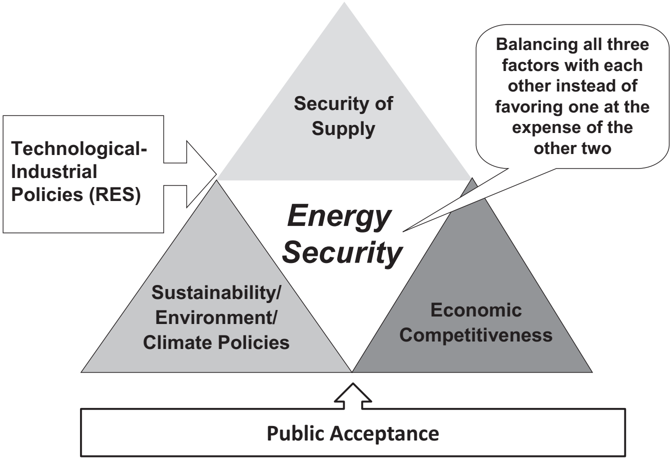

Figure 2.1 Energy triangle – objectives of energy security. *Source:* Dr Frank Umbach.

In the light of the economic–financial crisis in 2008 and the need for timely and sufficient investments in new energy sources and infrastructures to cope with the dual challenge of global energy-supply security as well as climate change, the IEA, for instance, is now differentiating between long- and short-term energy security:[2]

> Moreover, for a long time 'energy security' has had a different meaning due to the perspectives of the producer, consumer and transit states. Whereas consumer nations (like EU members) are primarily interested at security of supply, producer countries (like Russia) are more focused on security of demand from foreign markets. Transit states (like Ukraine and Turkey in the future), for their part, are often equally interested in their own national security of supply *and* security of demand from neighboring markets in order to benefit from stable and high transit fees. Furthermore the concept of 'national energy security' also depends on the individual country's geographical location and domestic policies and on the traditional state, economic and business ties it maintains with its partners.
>
> *(Umbach 2011, pp. 25–26)*

Since the end of the 1990s, international energy experts have also stressed the increasing strategic importance of energy-supply security within the 'energy triangle', whose three major objectives are economic competitiveness, environmental and climate sustainability and energy-supply security (Figure 2.1). In the view of many energy security experts, the biggest challenge is seen as maintaining a balance between the three objectives rather than favouring one at the expense of the other two. That, however, is often the case in Europe with the factor of environmental and climate sustainability, which appears often to dominate and determine all discussions of the energy–climate nexus in the EU at the expense of

[2] See the definition of 'energy security' by the IEA, at http://www.iea.org/topics/energysecurity/; downloaded on 3 June 2012.

the other two goals of the energy triangle. While the world has directed its attention to the manifold challenges of climate change and its security challenges, in Europe often the same attention is not paid to global-supply challenges and those of preserving economic competitiveness.

Maintaining the balance between all three objectives of the energy triangle has also become more difficult owing to industrial policies subsidizing renewable energy sources, as in Europe, or unconventional oil and gas exploration, as in the US, and also owing to the need to gain public acceptance in the light of NIMBY-attitudes, ideological positioning and new vested interests. This often creates ‘energy trilemmas’, which need to be addressed by an adequate institutional setting, above national government ministries, that can also take into account the various ministerial and vested interests, in order to obtain balanced national energy strategies and concepts (Umbach 2012).

Both US and international foreign and security policy experts are debating whether the United States will maintain its role as the ‘global policeman’ (‘Globocop’) and its stabilizing role in unstable political key regions such as the Middle East (i.e. the Persian Gulf) and the Asia–Pacific region. The Obama government, coping with a severe economic–financial crisis for years, has already redefined US foreign, security and defence policies in the light of its budget constraints and has focused its security policy more than ever on east Asia and China as its rising geopolitical rivals. These geopolitical questions center on four questions. (1) Will the United States withdraw its political and security commitments to allies in key, often unstable, political regions such as the Middle East, when in the future it will no longer be so energy dependent on this region as in the past? (2) What will be the political and security implications for global and regional stability in Europe? (3) Will the United States export its gas production surplus? (4) What will be the geo-economic and geopolitical impacts on global and regional energy security?

However, these questions are no longer related just to the US shale gas revolution but also to the geo-economic and geopolitical implications for energy security of the forthcoming worldwide shale gas development (Rühl 2014). In June 2013 the US Energy Information Administration (EIA) added nine more countries, to take the total number with technically recoverable shale gas resources to 41, in its second worldwide assessment of unconventional gas resources. This corresponds to a rise in estimated shale gas resources of 10 per cent in comparison with its first assessment, in 2011 (EIA 2013).

Indeed, the IEA expects that unconventional gas will account for around 60 per cent of the global gas demand growth by 2040 (IEA 2014b: pp. 135–170), if the industry can receive a ‘social licence to operate’ within stringent regulatory regimes designed to satisfy public environmental and social concerns (IEA 2012). Shale gas and other unconventional gas reserves have been identified in Argentina, Mexico, Australia, China, South Africa, northern Africa, the EU-28 (i.e. Poland, France, Germany, the United Kingdom and others), Ukraine, Turkey and other countries (EIA 2013).

However, the expansion of unconventional gas is facing grassroots opposition from environmental groups, which have concerns on ground water safety, adequate waste water