DECC Unconventional Gas Submission

Where and how great are unconventional gas resources outside of North America?

Unconventional gas resources comprise a spectrum of different resource types all with different characteristics and challenges.

BP considers 4 categories:

- **Tight gas:** is gas production from poor quality conventional reservoirs – typically with permeabilities of < 0.1mD. In most cases, these are associated with conventional hydrocarbon systems and represent the 'tail' of the more difficult spectrum of hydrocarbon accumulations within a basin. Artificial stimulation by means of hydraulic fraccing techniques are normally required to deliver commercial flow rates.

- **Shale Gas:** is gas production directly from mature organic rich source rocks typically with permeabilites several orders of magnitude lower than tight gas (<0.0001mD). The production is a combination of free flow and desorption directly from organic material. The shales must have retained their gas charge and must be brittle enough to be fractured artificially. The initial flow rates determine commerciality.

- **Coal Bed Methane:** is gas production directly from coals, requiring the depressuration of the coals to allow the desorption of gas from the organic material. Depressurisation is normally achieved by dewatering the coals beds ahead of gas production. High rank coals and coals that have been buried deeper than around 1500m typically have very low permeabilites that preclude commercial flow rates. Flow rates from coals are typically an order of magnitude less than flow rates from tight gas or shale gas wells and hence low cost shallow wells are key to commerciality.

- **"Ultra-unconventional gas resources":** include hydrates and gas produced by in situ gasification of coals (Underground Coal Gasification). Commercial scale production has yet to be demonstrated from either of these resources and technological breakthrough is needed to achieve viable production. These resources are for the next decade or beyond.

The potential and location of these resources is a function of combination of factors, both geological and commercial.

Geological factors determine the global resource potential. Tight gas and shale gas typically occur in older rocks where reservoir quality has deteriorated through deeper burial in the former, and where organic shales are buried deeply enough to be within the gas window in the later. In both

cases, this tends to exclude rocks younger than the Cretaceous age. However in both cases commerciality is a function of well cost and depth of burial – and hence both tight gas and shale gas benefit from uplift.

These simple criteria can be used to screen the globe geologically ruling out many of the recent continental margins and focusing more on the older continental cratons.

For CBM, the opposite is the case. Older coals are unlikely to have acceptable permeabilites. This downgrades many of the Carboniferous coals of Europe and the eastern US, and focuses on Permian, Jurassic and Tertiary coals in Asia, Australasia and parts of North America.

At a high level we can therefore draw broad conclusions regarding the unconventional potential of the globe.

North America as has already been proven has significant potential for all categories of unconventional gas.

South America has significant tight gas and shale gas potential in the Southern Cone – principally in Argentina.

Europe is geologically much more complex and tight gas and shale gas potential is most likely limited to relatively restricted areas where older rocks are preserved and uplifted. These occur in Northern and Eastern Europe and some isolated areas within the tectonic belts. CBM potential is minimal.

North Africa is highlighted as having significant potential for both tight gas and shale gas.

Russia and Central Asia can be expected to have significant unconventional gas potential, although the large endowment of conventional gas deposits suggests these are unlikely to be exploited in the short to medium term.

Middle East has tight gas potential on the margins of the Arabian plate where older rocks are at drillable depths. The main oil and gas bearing areas of the Gulf has limited unconventional potential.

Indonesia and Australia both have significant CBM potential, and Australia in addition has tight gas and some modest shale gas potential.

China has significant tight gas potential already proven, with possibilities for shale gas and CBM.

India has limited CBM potential and no significant shale or tight gas potential.

From a geological perspective, the distribution of unconventional resource around the globe is heterogeneous as is the case for conventional resources. It does appear, however, that the abundance of unconventional resources in North America is relatively unique, and unlikely to be replicated at that scale elsewhere in the globe.

What do the economic factors of developing unconventional gas look like?

Commercial factors are critical to exploiting unconventional resources. Well flow rate is one or more orders of magnitude less than conventional gas wells. In addition the ultimate recovery from a single well is significantly lower. The result, therefore, is that well costs are the most important cost driver in the economics of unconventional gas.

Well costs are a function of the depth of the well and the efficiency of the supply chain. This latter factor offers a significant advantage to the US, where an ultra efficient and competitive supply chain has developed over the years of conventional hydrocarbon exploitation. No where else in the world currently compares.

The other critical factor affecting economics is **gas price**. Unconventional resources require a premium gas price to be competitive. Cost of supply for most unconventional resources is in the $4-6/mmbtu range. Hence, countries where domestic gas price is regulated and artificially held down in order to subsidise local users are unlikely to be attractive for investment in unconventional resources.

Access to an extensive **pipeline infrastructure** network has also been critical to the success of unconventional gas in North America. Gas is typically sold at the well head direct into the grid. Wells are drilled and tied in quickly and easily. Areas without infrastructure require a greenfield development approach in which the infrastructure investment normally has to be underpinned by a minimum gas profile.

Water handling is also another key factor for all unconventional resources. Access to water and disposal of produced water are both essential to the drilling and development of unconventional resources. This can be an emotive subject with environmentalists and local communities, but in most cases with the application of the right technologies (for example reverse osmosis water purification and waste injection for disposal) these issues can be managed at modest additional cost.

Overall the economics for unconventional resources can be attractive to investors where gas prices are broadly in line with international gas prices and where there is an established oil or gas industry infra-structure.

Greenfield developments will always be more challenging. In some cases fiscal incentives may be needed to kick start activity.

Where and what magnitude are current and planned unconventional gas projects?

Outside of North America, most industry active is in concentrated in Europe, China, Middle East, Australia and Indonesia.

Tight gas projects are most advanced, with production established in Europe, Algeria, and China, and further project developments underway in the Middle East.

Coal Bed Methane is not delivering any material production outside North America and Australia, although further developments are underway in Australia, China and Indonesia. There is active exploration activity in UK, France, Germany, Poland, India, and Vietnam but in BP's view none of these are likely to deliver material production.

There is no shale gas production outside North America to date. Most exploration activity is focused on Europe and China.

BP's unconventional portfolio is growing steadily. Unconventional production accounts for around 10% of our oil and gas production today – mainly in North America. However looking forward around 30% of our hydrocarbon resources are unconventional and these can be expected to feed through into production over the next two decades.

Outside North America BP are actively involved in unconventional projects in Oman, Jordan, Algeria, Indonesia and China.

What are the barriers in each region to the further development of unconventional gas?

	Geology	Gas Market	Infrastructure	Supply Chain	Regulatory Issues	Environmental Issues
Europe						
UK						
N Africa						
M East						
China						
India						
Indonesia						
Australia						
Russia						