Geo Factsheet

www.curriculum-press.co.uk Number 292

Shale Gas – long term energy security saviour or environmental nightmare?

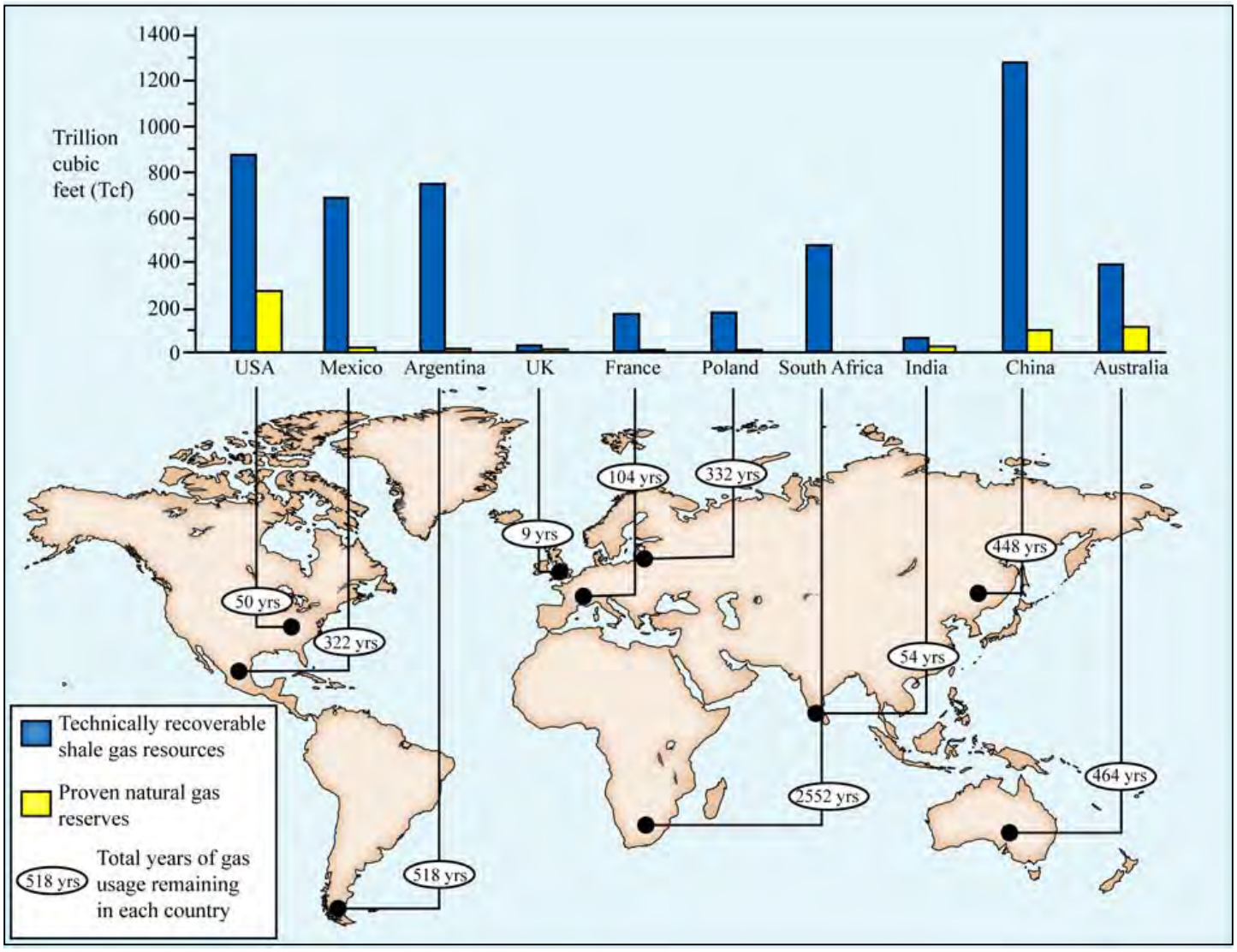
Introduction

Shale gas is just one component of vast, newly accessible oil and gas reserves. Oil shale, tar sands and shale gas are called **unconventional sources** and these combined with **tight oil** and offshore deep water discoveries are transforming the energy security situation in many parts of the world, especially in North America.

This Factsheet will look at shale gas and assess its economic potential and explore the environmental concerns which have caused some countries such as France and Germany to ban exploitation.

Statistics for how much shale gas the world may have, take some believing, even if more conservative estimates are used. The IEA (International Energy Authority) figures suggest that there are around 400 trillion cubic metres of natural gas (equal to over 120 years at current annual usage). Yet shale gas has over 200 trillion cubic metres (2011) with figures rising as new discoveries are made and new technology enables more efficient recovery methods.

Figure 1 shows the global distribution of shale gas (2011)



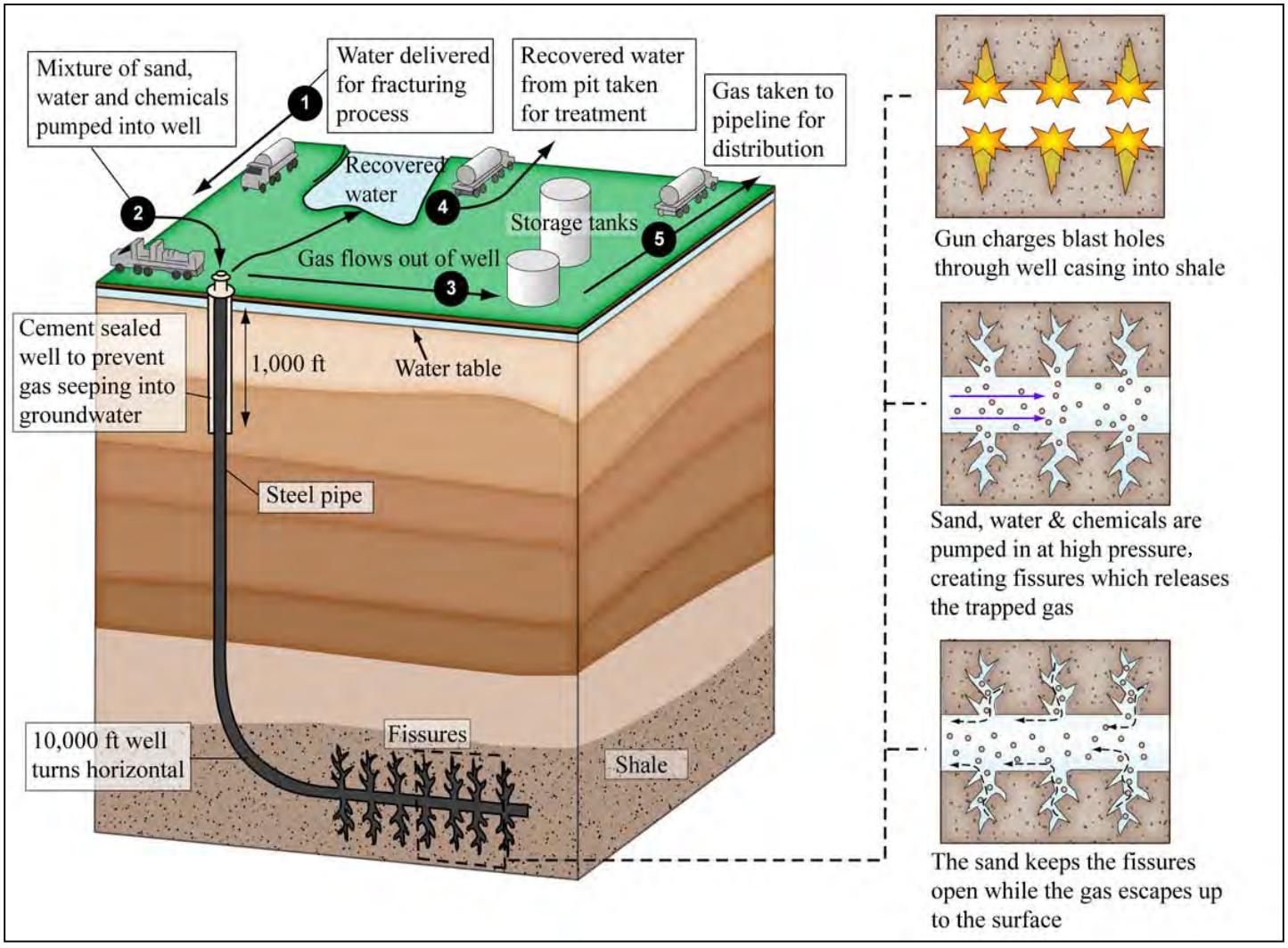
- China has the largest resources of technically recoverable shale gas (some 12 times greater than conventional sources). In 2011 engineers drilled the first well in Sichuan province with a target to produce 6.5 cubic million metres by 2020. Experts consider this target unlikely to be achieved. Issues include very high population densities (5x higher than in USA), water availability at only 20% of US supplies and an immature oil service support industry with a low level of pipeline infrastructure. A catalogue of environmental disasters leading to emerging concerns for health and safety has compounded these disadvantages.
- USA shale gas production leapt from around 1% of gas production to around 23% in 2012 with a target of nearly 50% by 2035 with a probability of self sufficiency and over a 100 years of security by 2050 (see case study 1).
- Poland has the largest supplies in Europe – enough for 300 years at current usage rates. It is currently locked in to a coal based economy largely using home produced coal.
- France too has significant supplies, but is currently committed to nuclear based electricity supplies.
- UK has some supplies, with prospecting currently occurring in Lanarkshire (Central Scotland), N. Ireland and S. Wales (Vale of Glamorgan), the Mendips and part of the Downs as well as exploitation in Lancashire. Estimates vary 'widely' but there is possibly enough for up to 75 years at current usage rates. Shale gas could play a vital role in topping up the dwindling North Sea gas supplies (see Case Study 2)
- Globally, Mexico, Argentina, South Africa and Australia all have large supplies of technically recoverable reserves with estimated energy security for many years.

To frack or not to frack – the technical process

Shale gas is not such a new source, as it was a cottage industry in Eastern USA in the 18th century. Now however, technological advances using horizontal drilling enable the drill to be 'steered' along a bed of shales. Advances in drilling technology also mean you can have 20-30 wells coming off a small drilling rig which can be easily screened. The sites cover only about one hectare, very small in comparison to massive nuclear complexes or open cast mines.

Figure 2 shows how the process of hydraulic fracturing, ('fracking') works. It involves pumping a mixture of pressurised water, sand and chemicals into the well, creating tiny fissures in the shale, so allowing the gas within it to escape. After about 3 – 6 months the fracking is complete and the gas starts flowing up the well to the surface.

Figure 2 Fracking



Environmental concerns

There are considerable environmental concerns about the fracking process which were vividly publicised by the OSCAR nominated film, 'Gasland'. The most vivid image shown was a homeowner igniting his fracking contaminated tap water.

Figure 3 allows you to consider some of the environmental issues raised by 'Gasland'. How well supported are they by scientific investigations?

Figure 3 'Gasland' – True or False?

Claim 1: Fracking is polluting underground sources of drinking water	**Claim 2: Fracking is exempt from the Safe Drinking Water Act, leaving it largely unregulated.**	**Claim 3: Wastewater from fracking sites is contaminating rivers.**
The film highlights the risk but overstates it at times. At least three contamination cases from faulty gas wells have been confirmed since 2007. In all three, the problem was flawed cement used in well construction not the fracking itself. Pennsylvania and other states have since toughened construction standards. The main risk is that drilling can allow naturally occurring methane to seep into a water source. Naturally occurring methane can contaminate water even without drilling, and Energy in Depth, a natural gas industry group, says that may explain the flammable tap water.	States and regional authorities such as the Delaware River Basin Commission regulate fracking. The Environmental Protection Agency is conducting a study of fracking and performs some oversight, but a clause in the Energy Policy Act of 2005 excludes fracking from portions of the Safe Drinking Water Act. The EPA cannot, for example, regulate drillers' underground injections, except when diesel fuel is used in the fracking mix. Gas exploration is exempt, but it's debatable whether extraction is, too.	The film suggests that wastewater from drilling killed fish in Washington County, Pa. The EPA pointed to discharges from coal mines as the fish kills possible cause. Josh Fox, the film's director, says the EPA overlooked testimony from locals who claimed that gas drilling wastewater was being dumped into the mines prior to the fish kill. Also, *The New York Times* reported on Feb.27 that drillers were trucking wastewater laced with radioactive chemicals to treatment plants that were unable to remove the carcinogens.

- The process can cause earth tremors up to Richter Scale 3.4 – too weak to cause structural damage. This has led to a huge debate in the UK where Cuadrilla are drilling gas shale sites near Blackpool (see Case Study 2). Methods could be modified to reduce tremors and seismic detectors could be installed to monitor fault slippages and warn people of potential incidents.
- Underground fracking operations use unsustainable amounts of water (cf mining tar sands). They have the potential to pollute aquifers (groundwater supplies). Some experts argue that there is potential for methane to seep into household water supplies. Waste disposal is an added pollutant. However, experts argue that this is only the result of bad industry practices and could be rectified.
- The chemicals used in the fracking process are potentially a very serious issue as between 20 – 30% remain underground. Although in most cases, fracking operations are usually thousands of metres deeper than the aquifers which supply local people, there is some evidence of water being contaminated with fracking chemicals and toxic metals which pose a significant health risk to humans (carcinogenic) and aquatic life.
- There is also potential for air pollution (as with any energy installation) from these toxic chemicals although evidence remains limited.
- Locally a major concern is the heavy lorries often on narrow rural roads. Building and supplying a shale well is estimated to require around a 1000 visits to each site.

Globally the **key concern** for environmentalists however is the long term impact that a dash for shale gas could have on global climate change and carbon targets. Burning shale gas will contribute to greenhouse gas emissions and lead to exceeding the 2010 Copenhagen targets and acceleration towards the 'tipping point'. Whilst less coal will be burnt, shale gas could also displace investment in renewables and innovation in radical technologies so hindering the transition to more sustainable energy use.

Whilst shale gas is relatively clean compared to other fossil fuels it is still a carbon based fuel and any increase in fossil fuels will further exacerbate climate change impacts. These issues will be considered in the case study of the USA which leads the charge for shale gas. The speed of exploitation is of huge concern, although many experts argue that the development process for shale gas is low risk compared to other sources and that the impact on the environment is quite limited. What do you think?

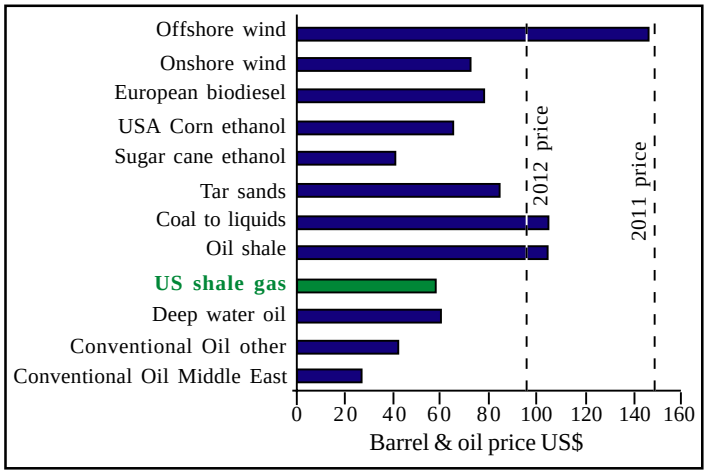
Economic benefits

Nationally the most compelling arguments for exploiting shale gas lie with **energy security**. In the case of the USA there is above all a desire to change 'the geopolitical oil and gas map' whereby the nation is more 'shockproof' against the volatility of OPEC and Russia supplies. The development of North American based unconventional sources of oil and gas will have a huge impact on energy security.

In the case of the UK and countries such as South Africa there is a major concern that 'the lights will go out' unless long term planning provides viable options to the decommissioning of ageing nuclear and dirty coal-fired power stations. Gas has always been seen as a relatively clean and flexible means of bridging the energy supply and demand gap until renewable and a new generation of nuclear plants come 'on stream'. Hitherto the gas would have come from the dwindling North Sea supplies or imported LNG from Qatar or Australia, but significant supplies of UK shale gas would be a boost for this dash for gas strategy. Clearly any cutting down of imported oil and gas supplies is a huge boost to the balance of payments and therefore the national economy of a country. The rising price of oil and gas and other fuels such as nuclear and renewable make unconventional sources such as shale gas increasingly viable economically.

Figure 4 summarises the impact of oil price per barrel on the various energy sources. It explains how long term investment in energy sources is so dependent on the fluctuating price of crude oil (currently down from over $150 per barrel to around $100 [June 2012])

Figure 4 Economic viablilty of energy sources



Regionally and locally there are very strong economic arguments for the development of shale gas – the boost to the local economy, with investment, employment and new infrastructure can be clearly seen in Case study 1. The maxim 'drill, baby, drill' has spread across many areas of the US.

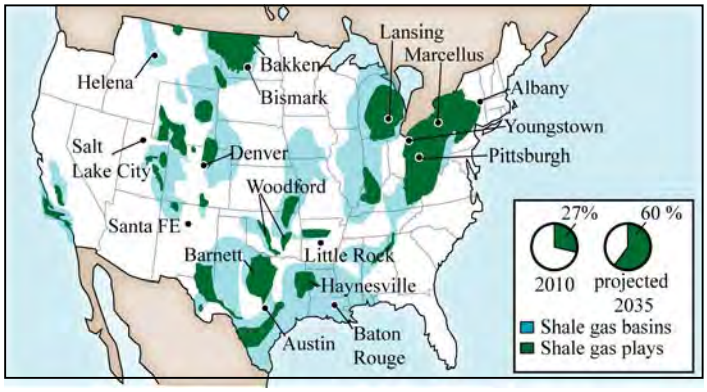
Case Study 1 Shale Gas in the US

Transforming US energy security, but at what cost?

In 2010 600,000 workers were employed in the shale gas industry across the USA and by 2015 shale gas is likely to contribute $118 billion to the US economy. Low cost natural gas from the shales is turning many parts of the US into boom areas and many of these states such as Pennsylvania and Ohio were areas hard hit by the recession.

Figure 5 shows the distribution of shale gas 'plays' (as the deposits are known) in the US. Note they are very widely spread and often in areas hitherto unaffected by energy exploitation.

Figure 5 Distribution of shale gas



However many of these states are new to hydrocarbon wealth and need to develop environmental laws to regulate the drilling and taxing systems to ensure their new found wealth is not just shipped in pipelines to Louisiana, Texas and Oklahoma. In order to keep local people happy and pro-shale gas drilling, shale severance taxes are needed to keep other taxes low.

For example, in an extreme case, Alaska taxes the oil and gas drilling companies between 25% and 50% of profits and so Alaskan residents pay no sales or income tax and get a payback from the hydrocarbon profits (over $1000 per taxpayer in 2011) and the State has very healthy finances with reserves of $44 billion.

All veteran energy States tax their energy resources (Oklahoma 7.1%, Texas 7.5%). Among many boom States only North Dakota (Bakken shale oil boom), and West Virginia, levy tax whereas New York, Pennsylvania and Ohio currently do not have tax laws in place to charge the exploiters so that infrastructure can be upgraded and money invested into badly needed services.

Locally shale gas has led to booming economies – for example Towanda, Pennsylvania which had been suffering rural depopulation, is booming because of in-migration with new hotels and restaurants and huge pressure on local roads, local schools and health services, and major traffic congestion which creates noise and dust. Farmers also benefited from royalties paid and unemployment fell to below 3% with high schools developing vocational courses in detail to ensure local students could take up highly paid jobs such as welders and diesel mechanics.

Regionally the shale oil boom has led to new industrial jobs, for example, the building of a steel mill in Youngstown, Ohio or plans for Shell Chemicals to build a 'Cracker Plant'. Moxie Energy is seeking to build gas fired power plants in Pennsylvania's **Marcellus** shale field. These are huge projects employing thousands of construction workers and providing many blue collar jobs, currently 60,000 in the Marcellus shale region with the prospect of 200,000 jobs by 2015.

Nationally the gas and oil boom has had an impact on the Gulf Coast with new steel works at Baton Rouge and also petro-chemical plants (ethylene) in Louisiana. Low cost natural gas has also been described as 'the Viagra or elixir of gulf Coast growth' with the US seen as the new Saudi Arabia for gas.

Companies that built import terminals for LNG in the early 2000s are now spending billions to remake them into export facilities to serve the new realities of the global petro revival as American producers can sell gas to Europe and Asia, even with shipping costs for about a third less than the current price of gas in these markets.

However, there has been local adjustment to the pace of the boom in terms of environmental issues, in particular, concern about water use and waste issues which has led to changing views on impacts in Pennsylvania and also to ensure better deals for famers selling their land rights. In some areas such as Wayne County, Pennsylvania, an attractive rural area, where fracking seemed only to favour farmers who sold land to the energy companies, opposition to fracking has grown so there is now a moratorium on development.

In an assessment of the impact of the shale gas boom on the US economy, its impact on other fuels must be investigated.

(a) Is the US coal industry doomed?

In 1985 coal accounted for 57% of all US power generated but by 2012 this is estimated to have fallen to 40%. Prices for Appalachian coal are down 25% with the huge opencast area of Powder River Wyoming down 50%. This is tied up to the huge fall in natural gas prices, and an unprecedented rate of switching both by electricity generating companies (eg Southern Cross Electricity – in 2000 coal 70%, 2012, 32% of generation) and of course by consumers. There has been a 30% increase in gas fired power stations which can be built relatively cheaply and quickly.

This was exacerbated by the need to replace a number of old, dirty, coal fired power stations. This switch has had a huge impact on coal mining employment in West Virginia and Kentucky where miners are being laid off in their thousands. Mines are cutting back on production, reducing worker's hours and overtime in areas with already high structural employment potential.

Although some coal is being exported to China which has a voracious appetite for all fuels, the future of coal could at best be described as 'rocky'. So does the rise in shale gas investment and employment compensate for the decline in coal?

(b) What will be the impact on renewable and alternative fuels?

Shale gas is being championed by many environmentalists as a good substitute for coal as it is cleaner and emits about 50% less greenhouse gases. The debate is whether gas is a bridge fuel to buy time while the technology to ensure successful scaling up and greater economic viability of renewable is developed or whether it will be a permanent major source of electricity and a default option to provide for rising power demands (up to 20% per decade).

It will certainly challenge nuclear – whilst globally 20% of electricity is produced by nuclear energy, partially because of the 2011 Fukushima meltdown and the high cost and slowness of building nuclear power stations, very few nuclear power stations are being built in the US in spite of an earlier initiative in 2009 from President Obama.

Wind and solar power have had a hard time competing in the US – currently only 3% of electricity is generated by renewable (largely wind). Solar and wind investment, albeit from a low base, is growing by 30% per year, but it is heavily dependent on government and state support, eg tax credits for wind farms – this expires at the end of 2012.

The answer is that shale gas is just too convenient and too cheap – but it is still a hydrocarbon.

Therefore the answer is that the headlong expansion of gas is hindering the research and development of renewables.

When looking at the rest of the world, of which the UK is a typical example, the situation is completely different. With all the buzz about fracking and the 86% fall in US natural gas prices, you would think that the boom would spread and that the rest of the world would be bound to follow. Yet shale gas development even in China, which has the world's biggest unconventional gas resources, is slower than predicted and early enthusiasm has faded. Equally in countries such as Poland, France and Germany there is downright opposition largely on environmental grounds.

The economic costs of gas extraction are up to 15 times higher than in the US as the geology is less accommodating. In Poland and China even with large deposits the costs would be three times as much as in the US, so other fuels can be more economic.

In conclusion, the environmental concerns about fracking, versus the economic benefits for increased jobs and investment, as well as increasing energy security are a classic resource development conflict. So much depends on the local and national situation and the perceptions and actions of the main players. The question is will the amazing case of the US shale gas boom be repeated around the world and if so how will it affect global energy geopolitics?

Case Study 2 – UK - Frack off?

In the UK fracking is slowly coming after a moratorium in drilling brought about by a series of earth tremors in the Blackpool district, the pioneer region. On investigation, DECC (Department for Environment and Climate Change) found that although the tremors such as the one at Preese Hall could be linked to movement along small faults brought about by fracking, better mapping of these faults, and real time monitoring of tremors during drilling so operations could be temporarily halted would help the better understanding of their impacts. The tremors were highly unlikely to cause structural damage, but they acted as a focus for burgeoning environmental concerns in areas of unspoilt countryside such as contamination of water supplies and heavy lorry traffic in largely rural roads.

Whilst there are strong arguments for the drilling of shale gas to offset the declining yields from the North Sea and the need to import the high cost LNG from Qatar, these are seen by many as secondary. Cuadrilla have six potential sites in Lancashire and if they were to go ahead the potential for 80, wells providing around 2500 jobs. There is also considerable discussion as to how much gas could be extracted with estimates varying widely.

The UK has a long tradition of very detailed and thorough planning permission and a history of localised protests (NIMBY) with relatively strong support nationally for campaigns against climate change issues (e.g. the proposed Kingsthorpe coal fired power station)

There is also concern that UK shale gas will not slash the price of high energy bills as the extraction costs will be higher and the mineral rights are owned by the state, not local farmers on whose land the developments will take place. It is therefore the multi-national companies involved in drilling or the government who will get the profits, thus reducing the incentives for local landowners to consent to drilling.

The UK also lacks a large scale, experienced and properly kitted out onshore drilling industry which will again increase costs and slow down development of shale gas.

Just as North Lancashire protest groups have formed REAF (Ribble Estuary against Fracking) and RAFF (Residential Action against Fracking), the highly polarised public enquiries could be repeated all over the UK as many of the potential sites are in areas of very attractive countryside with high quality farmland, inhabited by 'savvy' media and environmentally conscious middle class commuters and retirees.

So here the situation is very contrasting to that in the USA and perhaps more typical of the rest of the world.

Further Research

www.guardian.co.uk For details of the British shale gas exploration see Guardian G2 18.04.12
Dossier on Hydraulic Fracking in Geographical Magazine volume 84/04 April 2012-06-20
http://bitily/blue World Shale Resources
The United States of Natural Gas Fortune May 14 2012-06-20
Environmental Science Factsheet 143 Fracking
Special Report on National Gas The Economist July 2012

Acknowledgements; *This Geo Factsheet was researched and written by Sue Warn.* ***Curriculum Press, Bank House, 105 King Street, Wellington, TF1 1NU***