

## Slide 1

Unconventional gas - Is it good for the planet? Is it good for the economy?

First, what's meant by unconventional gas? Conventional gas is normally exploited by drilling a vertical hole into a gas reservoir and allowing the gas to come up the bore under its own pressure. In contrast unconventional gas requires advanced techniques to free the gas from the rock and actively pump it to the surface. The production of unconventional gas therefore generally uses far more energy compared with conventional gas. Usually the term unconventional gas includes shale gas, coalbed gas, tight gas and underground coal gasification. I'll briefly introduce these in the next four slides. All four resources are exploited by directional drilling and hydraulic fracturing (known for short as fracking).

## Slide 2

Shale gas is exploited by horizontal drilling and hydraulic fracturing using prodigious quantities of water. The water is forced into the shale under very high pressure to fracture the rock. A cocktail of chemicals, some very unpleasant, are added to help release the gas from the rock. This water forms a slurry with the broken rock particles and must be pumped back to the surface. It is contaminated with fracking chemicals and with radioactivity extracted from the rocks, and must be stored in settling lagoons before ultimate disposal. Restricted flow of slurry through the horizontal bores necessitates drilling more wells per square kilometer than for conventional gas. All this means that according to the widely respected energy analyst David Hughes, shale gas only has an energy return on investment, or EROI for short, of 5; that is 5 units of useable gas energy are obtained for one unit of energy used in every aspect of the production process and in pumping the gas to the consumers. To put this value in context Charles Hall, the father of EROI, has just published a book, "Energy and the Wealth of Nations" in which he considers that advanced societies such as our own require an EROI greater than 15 for all energy production to provide enough net energy to sustain food production, water supply, housing, culture, transport, communications, advance science, health care, defence etc.

## Slide 3

This slide shows coalbed methane production. After fracking, water and gas are pumped together up the lined bore and separated on the surface. The EROI is probably in the region of 10 as gas is somewhat more readily freed from the naturally-fissured coal seams than from shale.

## Slide 4.

Tight gas is tightly trapped in low porosity sandstone. Hydraulic fracking is used with advanced fracking liquids, often oil-based. The higher gas concentrations in tight gas deposits tend to be higher than those in shale and may give an EROI as high as 20 according to David Hughes.

## Slide 5.

Underground coal gasification involves drilling two boreholes into a coal seam and linking them, by drilling horizontally and fracking. Air and/or steam are passed down one hole, the coal is set alight and the gases from its controlled, partial combustion emerge from the second hole. Underground coal gasification produces a mixture of gases including hydrogen, carbon monoxide, carbon dioxide and some methane in contrast to the other three forms of unconventional gas which are largely methane.

Underground coal gasification or UCG for short potentially allows access to coal resources that are not economically recoverable by other technologies. According to some estimates, UCG could increase economically recoverable reserves by 0.6 trillion tonnes of carbon with important implications for climate change as we are already in a pickle with the first 0.6 trillions that's been added to the atmosphere. According to David Hughes the EROI for underground coal gasification is only about 8.

The next three slides start to put total global gas production into the context of peak global oil and gas, and of global warming.

Slide 6.

The huge pressure to exploit both unconventional and conventional gas comes from governments' and multinational energy corporations' hopes that unconventional gas will make up for the post peak decline in conventional gas production. This 2008 prediction shows conventional gas production peaking in 2020 and unconventional gas unable to stop the decline in total gas production beyond 2025.

Slide 7

This Shell advert suggests that gas will contribute significantly to solving the problem of peak energy and climate change. The advert states that generating electricity from gas rather than coal produces around half the CO<sub>2</sub>. It further claims that innovation could provide gas for the next 250 years. Elsewhere Shell claims that a switch to gas from diesel and petrol for transportation would help tackle climate change. Are these claims correct? The evidence I'll present shortly strongly indicates that Shell is wrong on all counts. But even if Shell was right, gas is a fossil fuel and switching to it would only make sense if the planet needed only a small and gradual reduction in Greenhouse gas emissions. As we shall see in the next two slides, this is emphatically not the case. A switch to gas maintains society's addiction to fossil fuels and is heading in completely the wrong direction.

Slide 8

This edition of Nature contains four articles about how much fossil fuel it would be safe to burn to have a reasonable chance of staying beneath a 2°C global temperature rise.

The conclusion is that 95% of the estimated, remaining 3.2 trillion tonnes of carbon in fossil fuel reserves must not be added to the atmosphere as CO<sub>2</sub>.

In addition, it is now generally agreed that green house gas emissions must start to fall now and the planet must transition to zero emissions by 2050 and that in addition, it will probably be necessary to withdraw from the atmosphere much of what we have emitted since 1987 to go back to what was then the relatively safe concentration of 350 ppm CO<sub>2</sub>.

So how much of problems are the conventional and unconventional gas reserves in this respect? The next slide seeks to answer this question.

Slide 9

This slide is adapted from a very recent Nature Climate Change article by Swart and Weaver.

It shows on the left, the estimated size of different fossil fuel resources and on the right, central estimates of their potential for warming the planet assuming no carbon capture and storage. It only considers the effects of CO<sub>2</sub> emissions, omitting those of methane and SO<sub>2</sub>. The red line indicates the limit to stay beneath 2 °C warming from a 1790 baseline.

According to these estimates by far the greatest problem is coal, producing an estimated 15 °C of warming. The second greatest is unconventional gas, giving 3 °C warming.

But CO<sub>2</sub> emissions from burning are only part of the global warming impact of unconventional and conventional gas as we'll see in the next four slides. Although methane is completely converted to carbon dioxide in the atmosphere within a 20 year period, it's warming effect per molecule in this period is said by the IPCC to be 72 x that of CO<sub>2</sub>. It is therefore necessary to take into consideration methane releases as well as CO<sub>2</sub> from burning gas.

Slide 10

In this context, methane leakage from conventional and unconventional gas production appears to be a serious and widespread problem:

In 2000 the US Mineral Management Services department found [eight thousand gas leaks in the Gulf of Mexico](#).

In 2006 the [Norwegian Petroleum Safety Authority found 18% of North Sea gas wells leaking](#)  
[Schlumberger](#), the world's leading supplier of oil and gas extraction technology noted 60% of offshore gas wells leaked after 30 years  
A study of a [coal bed methane wells in Australia recently revealed 44% of wells leaking](#).  
In 1992 the [US EPA estimated that, of the 1.2 million abandoned oil and gas wells in the US, 200,000 were leaking](#), a 16.7% failure rate amounting to 2.4% of gross U.S. gas production.

Slide 11.

Contrary to what Shell say, might methane leakage make shale gas worse for the climate than coal and mineral oil? George Howarth's team from Cornell in a 2011 paper thought it might. They compared the warming effect of CO<sub>2</sub> and methane emissions at 20 years from generating electricity from different fossil fuels. By running your eye along the top of this bar graph you can immediately see that a switch to shale gas from coal or oil for generating electricity wouldn't appear to significantly reduce warming. Nor, Shell's "around half the CO<sub>2</sub>" mentioned in the advert. The latter misleading figure is based on a power station gate-to-atmosphere comparison, not a full life-cycle analysis.

Howarth has been criticised by the industry for overestimating total methane emissions for Shale gas.

Slide 12

However Howarth's position is at least partly vindicated in this article which appeared earlier this year in Nature. The article reported measurements made by NOAA, the US National Oceanographic and Atmospheric Administration, of atmospheric methane from a US shale gas field. They indicate that the "best guess of 4% [ for methane emissions ] is slightly higher than [Howarth's] estimate of 2.2–3.8% for shale gas drilling and production." The bar graph top right shows that NOAA's estimate of 4% given by two different sampling methods is approximately twice the industry's statutory inventory of methane releases from this gas field. Looks like the Industry may be economical with the truth!

The popular press described this article as a bombshell for the industry.

Slide 13.

There have been two further recent blows against the suggestion that a switch to gas would be better for global warming. The first was struck by Tom Wigley of the US National Centre for Atmospheric Research.

Wigley added a new dimension to the argument, that of SO<sub>2</sub> emissions. These have a powerful global cooling effect by seeding cloud formation and there is no doubt that burning coal generally emits much more SO<sub>2</sub> than burning gas. Wigley concluded that even if shale gas methane emissions were zero, the cooling effect of SO<sub>2</sub> from coal would make the latter's total warming effect less than that of shale gas for generating electricity.

The second blow comes from a very rigorous paper published by Alvarez et al in February 2012. These authors showed that a switch to gas for transport would only be beneficial if methane leakages were capped at a level 45-70% below current estimates! The evidence cited earlier suggests that this is not going to be easy.

Slide 14

So in summary, the answer to the question, "is unconventional gas good for the planet?" is, "no" for two reasons:

First

We need to completely stop dumping all fossil fuel CO<sub>2</sub> in to the atmosphere by 2050 and the only possible way to do this is a massive transition to renewables together with a large

demand-side reduction. Pursuing unconventional gas would only delay this transition and help maintain society's addiction to fossil fuels.

Second

The evidence presented here suggests that a switch to gas for transport and electricity generation would be worse for warming.

**Slide 15.**

So moving to the second question addressed by this talk, is unconventional gas good for the economy?

What can we learn from North American experience? Arthur Berman is a highly respected analyst of US shale gas production. This is what he wrote in 2010:

“Shale gas plays are at best, marginally commercial.

The plays have consistently contracted to a core area that represents 10-20% of the resource that was initially claimed. The production model has failed.

These are not low-cost plays: the marginal cost of production for most companies is over the past 5 years \$7.5 per million cubic feet, based on disclosures required under federal law . I'd update this adding - [ These costs are much higher than April 2012 US Henry hub gas prices of around \$2 per million cubic foot].

Reserves have been greatly over-stated and 80% of licensed reserves are undeveloped. The value of undeveloped reserves is low.

Shareholder equity has been consistently destroyed.

Because of good hedge positions the cost environment has been favourable. But this is no longer the case.”

Three additional factors make it unlikely that unconventional gas in the UK and Ireland will be more economic than in US: 1. Lack of economies of scale; 2. Mineral resources in the US belong to the nation while in UK they belong to numerous small land owners making drilling consents more difficult to obtain; 3. Some gas fields in the US are on desert or bad lands while in UK potential ones are on good agricultural land with a high population density. Unconventional gas fields aren't pretty and there are numerous questions about local environmental effects and loss of amenity. Some local residents are already having something to say about this!

Slide 16

The industry has exaggerated global shale gas reserves. Proven reserves are a tiny fraction of estimated global resources.

Slide 17

This data from the Industry shows that initial productivity in Alberta gas wells fell dramatically from 1996 to 2004

#### Slide 18

This slide from Arthur Berman indicates the percentage of wells, started at different dates shown along the bottom, that were dry or producing little gas by the end of 2008. It contradicts the industry's claim of a 40-65 year production life for the Burnett Shale.

#### Slide 19

This slide taken from "Chesapeake energy's 2010 Institutional Investor and Analyst's meeting" shows no evidence for the industry claim that Shale gas production from different gas fields can be maintained even for 10 years.

#### Slide 20

Back to Arthur Berman who shows that major operators' cumulative production on the Burnett Shales is unlikely to reach advertised ultimate recoverable gas (shown as two red dotted lines at the top). It certainly won't reach it within 5 years and this is not soon enough to add value.

#### Slide 21

Another of Arthur Berman's slides shows how production in 2 years contracted down from what was estimated to be the 4<sup>th</sup> largest gas field in the world to a core area around a few sweet spots.

#### Slide 22

US unconventional gas production reached a peak in 2006. This plot taken from US Energy Information Administration data up to 2010 tells a story of declining average gas production per well (red trace) despite an increase in the number of producing wells (blue trace).

#### Slide 23

This slide from Charles Hall's group tells a similar story. It shows how the EROI for discovering oil and gas in the US has hugely declined and is now about 5.

#### Slide 24

This astonishing slide from Charles Hall's group shows how extreme linear extrapolation gives EROI of 1 by 2022 for global oil and gas production! The recent rate of EROI decline doesn't look too promising from an economic perspective!

#### Slide 25

This data was taken from 10 gas production companies' annual reports for 2010. It shows 5 out of 10 companies unprofitable, with break-even production costs per cubic foot (dark red) greater than the weighted sale prices they obtained for the gas (pink). Berman considers that the five companies who claim to be making a profit are fraudulently discounting some of their costs.

#### Slide 26

"Six year operating highlights 2004-2009" for a typical US Shale operator show a plateau in the value of proved reserves (red), an increase in debt (blue) and a decline in share holder equity (green).

#### Slide 27

Berman's conclusion "Shale gas plays in the United States are commercial failures and shareholders in public exploration and production (E&P) companies are the losers."

#### Slide 28

So what makes shareholders and governments including the British and Irish ones think that they can buck the American trend and make money on unconventional gas?

I think there are three reasons:

1. As shown in this illustration gas like other fossil fuels is heavily subsidised compared with renewables.

2. Shareholders and governments are fooled by the hugely powerful , multinational energy giants with their exaggerated claims about size of resources , the length of time the reserves will last and the cleanness of gas. Their highly successful PR implies peak energy is a myth or that they have the answer to it.
3. Few in government understand the significance of low EROI's

#### Slide 29

What can be done about this?

I'm reasonably confident that rationality about global warming, and cash and energy flows will eventually win the day but not without a massive effort. We need to spread the arguments about gas. We need to win friends and influence politicians and play David to the Energy Giant's Goliath.

It is, I think, still too early to be sure whether the effect of peak energy on the global debt-based economy will cut gas and other fossil fuel use enough to prevent totally disastrous warming and whether the descent from fossil fuels can be managed rather than chaotic. There appears to be no simple technological fix to the warming problem posed by the burning of fossil fuels including gas. Carbon capture and storage for oil and gas would make the global EROI even less sustainable than the present value of probably around 10. A massive investment in renewables and demand-side reduction is the only possible answer but this involves the negotiation of a large energy and capital investment hump.

We need to continue to lobby for cap & share. This talk may have implications for how the size of the permit quotas for each fossil fuel should be determined. Should this be done separately for each different fossil fuel on the basis of the total warming effect of all life cycle emissions rather than simply on the carbon content? This would ensure that the dirtiest fuels could be cut faster than the less dirty ones. However this requires more certainty about relative dirtiness than we have at present.

Thank you very much for listening. My thanks to Arthur Berman for the use of several of his slides and apologies to him for my dreadful American accent.