



HOUSE OF LORDS

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Witness: Professor Richard Muller

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Members present

Lord MacGregor of Pulham Market (Chairman)
Lord Griffiths of Fforestfach
Lord Hollick
Lord Lawson of Blaby
Lord Lipsey
Lord May of Oxford
Lord McFall of Alcluith
Baroness Noakes
Lord Rowe-Beddoe
Lord Shipley
Lord Skidelsky
Lord Smith of Clifton

Examination of Witness

Professor Richard Muller, Professor of Physics, University of California, Berkeley.

Q47 The Chairman: Thank you very much indeed for coming. I know that you have also given us some written evidence, which I am very grateful for, which we have all seen, and in particular for coming all the way that you have. In terms of some of the answers that you have just heard it is very relevant to have your experience as Professor of Physics at University of California.

Could I start by asking you if you would like to comment on some of the evidence you have just heard in our session, in particular some of the comments that were made about American experience, for example, in relation to fresh water, or the United States not being an effective regulatory regime? Perhaps after that you could also talk to us about what view you take about some of the NGOs' other concerns about shale gas development in the UK.

Professor Muller: Thank you very much for the honour of inviting me to come here and speak. I did enjoy that last session. I thought the questions were particularly very thoughtful and on point, and I did disagree with many of the answers I heard. I did not keep track of all

of them—my piece of paper was not big enough—so I hope you will remember to ask me some of them.

Let me make just a very brief statement. Today's newspaper has a story about what has happened in the last few days in the city of Harbin in China and it is horrific. The levels of air pollution there, which are attributed to the turning on of coal for heating in Harbin, are reaching a level that has now surpassed the incredible level that was in Beijing last January.

I looked up the air quality index in London this morning, it was somewhere around 25; it varies from place to place. If it gets above 50 people in the US get deeply concerned. Last January in Beijing it went above 800 and in the last couple of days in Harbin it went above 1,000. One knows how to calculate the effect of this on health—there have been some very good studies on that—and for Harbin I did the calculation this morning: we expect about 650 people to die just from one day of that air pollution in the city of Harbin.

Let me also mention that my expertise, unfortunately, is not in the UK on shale gas but I have been doing a great deal of work trying to understand shale gas in the United States. I have been close to several very large, and some small and medium, companies looking over the procedures of what they have done. The other country that I am now familiar with is China. I have had two trips to China in this last year, one just last month when I spent time in the gas fields of China, got to observe their fracking operations, got to talk to them in some detail about what they are doing about environmental concerns and also how well they are doing. So I have familiarity with both of those.

I got into this business because of a three-year study I led on global warming. Three years ago I was quite the sceptic and now I believe global warming is real and caused by human emissions of greenhouse gases. That is not the topic today but having done that work I became concerned about what we could do to slow it. If you look at it in an objective way and ask what are the big things you can do and what are the little things you can do, the

biggest thing is energy conservation and I think everybody in this room is in favour of that. It is a win/win and there is a huge amount that we can do. The second biggest practical thing we can do is to shift the world away from coal to natural gas. I have written a book on energy; it was published a couple of years ago, I looked at solar, I looked at wind, I looked at a tidal, I looked at everything. I looked at it as a problem solver, not as someone who has an agenda. I believe the only two big things we can do are to switch energy conservation, in a worldwide switch, from coal to natural gas. That will not solve global warming but it will double the time.

If we think that we are going to get to a bad situation in 30 years from now, if we could switch all future plants to natural gas—not even the past ones—then we double the time to get there, maybe even triple it. So I believe that any environmentalist who is thinking globally must support helping China switch from coal to natural gas. That is so much bigger than anything else. Certainly I hope that the US example is serving as a strong example. I would love to see the example set in the UK also serve as an example for this. Again, if one is somewhat ideological and says we have to go as soon as possible to zero emissions, then I believe you will not find the solution.

I brought some charts, and I made copies of these I can leave here, of emissions in the future. This is if the Copenhagen Treaty had been signed. This chart appeared in an article I wrote in the *Wall Street Journal*. It shows here the emissions of the US going down, here the emissions of the Kyoto developed countries going down, and here are the emissions of the developing world going up because they are in the developing world. I want them to develop, I want this kind of economic growth but this is the plot that you get if you assume they are doing 4% conservation per year. If you are concerned about global warming then you must focus on the developing world. Anything you do must be something that can be

adopted in the developing. If you are going to set an example you have to set an example of something that is profitable, not subsidised, because if it is not profitable it is not sustainable. So my main interest in China initially was to slow global warming and I felt that the way China goes the rest of the developing world will go. But once you have visited China—and it is not just Beijing, it is not just Chengdu, I have been all throughout the China—you know that the pollution is everywhere and it is not nearly at the level that it is going to be in 10 years. So given the sort of things that we are seeing every year, with new pollution levels being set, the reason we should be interested in helping China shift, and setting an example, from coal to natural gas is because firstly it is profitable to do so, as was shown in the United States. I know a lot about the shale in the United States. Secondly, for humanitarian purposes they need to do something right away; they need to develop this as quickly as they can because according to the most recent estimate in 2010 1.2 million Chinese died of respiratory illness caused by their air pollution. 1.2 million. That is not a speculative number put out by environmental groups; that is a solid number published in the proceedings of the National Academy of Science based on a joint study between China and the United States. Then of course there is global warming. Do not forget the word “global”. In the United States there is so much pressure to do little things in your own backyard but the United States is simply not going to be a major contributor. We can do those things but I have spoken many times against the introduction of expensive electric cars simply for the reason that we are not setting an example that the developing world will be able to afford to follow. Shale gas is a wonderful thing that has happened.

I looked very carefully at the long list of environmental concerns—again I made a copy of this I can leave behind—all the things that people mention. Many of them are mistaken,. Some of them are valid but can be addressed in a relatively straightforward way through regulation and heavy fines for people who do this.

You asked about the status of regulation in the United States? Part of it has been local, there are no national regulations on fracking. There are state regulations and many of the bad stories of things that occur came about in the early days when people were very sloppy. We call that the wildcatters. What I saw in China was in dramatic contrast. They are using industry best standards. When you do industry best standards then most of these problems go away. There are some problems unique to shale gas. The fresh water one: I spent some time visiting Apache, at the sixth largest formation in North America, their Horn River formation. They chose to use only salt water. It is basically the same salinity as you get from sea water. They did not want to use fresh water. Their reason for this was that it is in Canada and in the winter the fresh water freezes more easily. So they use saline water. They are one of the great innovators in this field and they are operating one of the biggest regions in the field. Their policy is to move everything to saline solutions.

Saline solutions, by the way, are abundant all over the US and China. I do not know how abundant they are here but there is a good geologic reason why they are abundant. In the same formations where you have shale, you have an impervious region, which is why the shale gas got trapped. You collect water and if it is 100 metres down it is fresh water and you use it for farming or for wells. If you get down 300 metres and below, that tends to be too saline and it has no value—no commercial value until today, because it is relatively shallow, well below the fresh water and you can use that for fracking. I have talked to Shell Oil's top people; Mr Ben van den Brule, who is in charge of their unconventional gas programme, says his goal is to use no more fresh water, but only saline water.

The issue of earthquakes is related to the issue of waste disposal. The other thing they are doing—and they are already doing this in China and they are beginning to do it more and more in the US—is to recycle the water. When you pump the water down it comes back and it is highly saline when it comes back and it used to be just let out to evaporate and then

trucked away; now they recycle it for the next frack. They can do this and they have been doing it. Basically you take the water, 30% of it comes back out, you can recycle 90% of that and then you truck away that last 10% of the 30%. So you truck away 3% of what you put in. So there are good technical questions. It is developing incredibly rapidly. A belief by the experts in the United States is that the efficiency of fracking is going to double in the next few years and in the next 10 years will double again. The UK and China has this enormous advantage that you can now build on our—depending how you count it—30 years or realistically 15 years of horizontal drilling, multi-stage fracking in the United States. So I believe it could go very fast if the resources in the UK are as good as people hope. Sorry for the long statement.

Q48 The Chairman: Thank you very much for that, and particularly for your opening comments. As you realise we are focusing entirely on shale in this particular inquiry and we are particularly interested to have your experience of what is happening in the United States. I do not know if you want to say any more about the regulatory system before we move on to other issues?

Professor Muller: Let me just say that the idea that you can regulate with heavy fines really does work. The thought that the regulators cannot cope with the huge number of wells that are being drilled is easily handled by whistle-blowers and sufficiently rewarding people who detect this. Let me also say that there were some very mistaken comments made about fugitive methane. There have been excellent studies done, I give a reference to one of them in my notes. Yes, there were many early studies which raised a red flag and got people very scared. I wrote an article about this in the *New York Times*, and nobody disagrees with me, that the level of fugitive methane that can escape before it becomes as bad as coal is 15%, not 3% or whatever was said here earlier. It is 15%. I can go through that number for you in writing very carefully. It has been published.

Secondly, the studies show that in the fracking itself the average amount that is leaking from the actual fracking—from the wells in the United States, and 140 wells were measured—was 0.4%. The report that came out I also have referenced in the letter that I wrote. So I believe that issue of fugitive methane is simply going to go away. Of course, what the public knows about are the flaming faucets and that also has now been clearly disproven to have come from hydraulic fracking. There is even a good movie, which I recommend, called *FrackNation*, that is almost as enjoyable to watch as *Gasland*, which has Josh Fox caught saying, “Well, of course, I know that there were flaming faucets decades before anybody did any fracking.” “Well, why did you not include that in your movie?” “I did not think it was relevant.” I believe that the terrible exaggerations and distortions of *Gasland* that grabbed the public make it very difficult for you or for any Government to act in a rational way. But there is a short lifetime when people are so deceptive; the public does not like to have been fooled.

The Chairman: We were going to ask you about *Gasland* but you have already answered that question.

Q49 Lord Lawson of Blaby: Professor Muller, it is very good to meet you and to hear you. You have answered most of the questions that I had. I would just like to underline, perhaps in the form of a question, one thing you said and also clarify something else.

All the evidence that we have seen, or I have seen anyway, is that the geology, certainly in the bit that has been surveyed by the British Geological Survey, in this country is very similar to that in the United States. The main difference is that the seams of shale seem to be thicker in this country than they are in most of the United States, which is rather a good thing. So all we need to do, as I understand from what you are saying and I would like your clarification, is to learn from the American experience as to what best practice is both commercially and environmentally. Is it not the case there is no reason why we should not

learn from the experience of the United States as to what is the best practice commercially and environmentally and then go ahead on that basis?

Professor Muller: I agree completely. These are not proprietary, they are not patented; it is widely shared in the industry. The people who work in this business know what is meant by best practice. There are issues, for example, on how much do you cement your wells and how do you do it, how many layers? It is straightforward and, yes, the US will be happy to share that information with you.

Lord Lawson of Blaby: There is just one other point. You spoke very feelingly about the appalling levels of pollution in the major Chinese cities, and you are absolutely right. But is it not the case that this has nothing whatsoever to do with carbon dioxide as such? The pollution is sulphates, nitrates and other particulates and it is possible to prevent those to a very large extent getting into the atmosphere, even if you are burning fossil fuels—your carbon dioxide. Of course, as Lord May said in the earlier session that you may have heard, carbon capture and storage is all very well in theory but it is not with us at the moment and goodness knows whether it will be, and if so what would it cost.

We had in this country in the 1950s the Clean Air Act and this had a miraculous transformation on the level of pollution in this country. We have continued to burn coal. It is still the major source of—

The Chairman: It is still worse in London than it should be.

Lord Lawson of Blaby: Maybe, but nobody is dying. It is not remotely like China. The fact is that it is important, is it not, to distinguish between the issue of pollution, which needs to be addressed—which, as I say, is sulphur particles, nitrates and other particulates—from the issue of carbon dioxide that is so far from being a pollutant its main effect is to stimulate plant growth?

Professor Muller: I agree with everything you said. In China there are a widely known number of all new coal plants—it varies from year to year, but it has been averaging 1 gigawatt per week, which is in every seven weeks they build the equivalent of an entirely new New York City. This is just for coal. So this is what they have been building. All of their new plants have exquisite and very effective scrubbers added in. A study that I can give you the reference to—

Lord Lawson of Blaby: Such as we have here.

Professor Muller: Yes, they are really good. The problem in China is soon after the plant is commissioned the local people who run the plant turn those scrubbers off. The reason is economic. This has been well studied and China is aware of it. It is very hard to fight, partly because of the corruption in China, which makes it difficult to inspect these things, partly because there is no local benefit to turning the scrubbers on. In any one plant the contribution to the air pollution is small enough that they cannot spend the money; they do not want to spend the money. So it comes down again to the extent that natural gas offers a cheaper alternative—the key number in all of this pollution, I am sure you know, is called PM2.5, particulate matter 2.5 microns or smaller. This is what gets into the lungs; this is what dominates the air pollution around the world. Natural gas produces 1/400th the PM2.5 compared to coal. 400. So this is a local issue but it is to our advantage around the world to lower the carbon dioxide in China. You may not agree with me that carbon dioxide is a dangerous thing for the future; it does have some benefits. My own thought is that it is something that we should control and at least limit the growth of it while we find out better whether it is beneficial or not.

Lord Lawson of Blaby: I am aware of that opinion; all I was trying to say is analytically that is a separate issue. That is the point.

Professor Muller: Yes, it is a separate issue. The main reason—I have spoken to many people in China, local people, Government officials, what is driving them I believe—is the need to reduce their air pollution. It is not just reducing it, but stabilising it. They are worried that it is going to get up so large that the kind of events we just saw today are going to become very common. That threatens their Government.

Our reason, other than humanitarian, for doing this is because it is the biggest contributor to global warming in the future.

The Chairman: You have already given us some responses to reassure us on American experience, I think what we would like to do, while we have you here, is to probe a little bit further in some of those particular areas and gain the benefit of your knowledge of American experience.

Q50 Lord Shipley: Can I use the word “safety”? You said earlier you did not know too much about the UK situation, not least because we are not doing what China and the US are doing yet. But there are a whole set of possibilities. I just wondered if there were things that you think we ought to look carefully at in terms of safety on the basis of the US experience. Are there things that you think might be particular risks in this country? Are there things that on the basis of US experience you think we ought to be very careful about?

Professor Muller: The major true environmental issues in the United States came from the dumping of the flowback water into the local region, polluting streams and such. For earthquakes, they came about not from the fracking. Fracking produces tiny earthquakes, magnitude 1 or 2, that cannot be felt on the surface by a human but can be measured scientifically. The larger earthquakes that were produced in the United States came from storage of flowback water in specialised sites and pumping far more water down into those than should have been done. That can be avoided by regulating the use of the flowback

water and how that is done with regard to particularly earthquakes. Again, recycling should help with that very much.

The main issues for my mind are making sure the flowback water is handled properly, making sure it is not dumped into the environment.

Q51 Lord Rowe-Beddoe: In a radio interview last year in the United States with yourself you emphasised the need for “developing and devising methods for clean fracking”. How do you define clean fracking and where are we in this particular development that you suggested?

Professor Muller: At that time I was worried about many issues. One of them was the fugitive methane issue, for which there were some very frightening stories. I believe that issue has now been settled. The fear was not based on calibrated measurements and now that those have been done I think we recognise that the danger is not so much.

By clean fracking I refer specifically to the handling of the flowback water and also the piping, although only 0.4% of the methane leaks from the well site, including from the flaring. There is problems with the piping and the storage of natural gas; it might be another 1% at least there. So that has to be looked at. I believe what I was most worried about, because a year ago we did not have the new data, was the fugitive methane. I do not think that now is a serious problem.

Lord Rowe-Beddoe: Can I just ask you something else? You heard I think, as I saw you sitting there, what our previous witnesses were saying about the water and the water problem. I think, if I recall correctly, none of them mentioned the word “saline”, the use of saline water. Is this because they would not know about it or they chose not to talk about it?

Professor Muller: No, it is because they did not know about it. I found in the United States that you go to Apache and they are planning to use only saline, I go to the experts at Shell

and they have worked out what kind of additives are needed to be put in when you are using saline water versus fresh water, but I go to a different division of Shell and they say, “Well, of course there is a problem; we do not have enough fresh water in many of these formations”. This is relatively new. It is getting a lot of public attention. There are some excellent books that have talked about this. I have even asked people in the industry who know about it, such as Apache, “Would you object to a law that said no fresh water could be used?” and they said, “Well, we would not object but the local farmers would”. The ranchers in Texas make extra money by selling their water and so they are not interested in the saline. But there are large areas of China. The whole Tarim basin, which may be one of the best areas in China, has very little fresh water. I have a map of buried saline in China that I was able to find, and I have shown this at their research institutes, and even in China they did not know anything about this. So I think it is just really new. Quite frankly, about three years ago almost nobody in the United States had heard of fracking. So I do not think it was done on purpose.

I am looking at each one of these issues and trying to see how we can solve them. So I am trying to find solutions to make fracking work.

Q52 Lord May of Oxford: I have read your response to the call for evidence and have enjoyed what you have just said, which as you will understand is more or less what I was saying to the three people who preceded you—that gas is a lot better than oil. However, you are completely silent, both in your letter and today, on the fact that the ultimate problem is we are putting roughly a million years’ worth of fossil fuel deposited carbon into the atmosphere each year at the moment and it is having consequences. I would have hoped that you would have some thoughts on it also. You do not present it the way I think—that shale gas is a helpful intermediate on the road to decarbonising energy generation. You are silent on that. Is that because you think it is hopeless?

Professor Muller: No, because that was not what I was asked to write about. I believe in the 30 to 50-year timeframe, there is enormous potential for affordable TAIEX solar. It is improving very rapidly, in part because of subsidies. I believe subsidies work in wealthy countries as a way of inspiring innovation, and it has worked in California. I believe that wind has an enormous future. The main objection now is coming from environmentalists who do not want the landscape to be industrialised. That is the term they used. I think they are beautiful but I understand that issue.

Nuclear power: I wrote an article in the *Wall Street Journal* on Fukushima, I can update that now. I calculated, rather carefully and I have shown this to experts and they nod their heads, the number of deaths expected from radioactivity leakage at Fukushima is—best estimate—28. 15,000 died from the tsunami and they are not erecting a 100-metre seawall all around the island of Japan; they are basically doing very little to prevent that from happening. What are they doing? Their coal use has been shooting up in Japan. In Germany the coal use is shooting up. This will kill more people than any nuclear reactors would ever kill. So nuclear has a great future. I like the fourth generation nuclear reactors that cannot be used in the United States because of our regulatory barriers, which is something I argued for. Within 30 or 40 years we may have a breakthrough in control fusion. Other things: geothermal is not going to work; waves are not going to work; tidal was too specialised. I could go through any one of those. But I am very optimistic about solar.

Lord May of Oxford: Thank you very much for an answer to my question. Incidentally the 28 presumably include the people who were killed in decommissioning Fukushima?

Professor Muller: No, who will die. These are in future from long-term cancers because of the radiation spread. I would be happy to give you the details.

Lord May of Oxford: Interestingly, to reduce the carbon associated with aviation we would do better to widely advertise that our chief scientist went and visited Fukushima and

he wore a radiation badge as he flew across to Japan and then he wore it during the day he was visiting and he got roughly an order of magnitude more exposure in the aeroplane.

Professor Muller: I liken it to something I call the Denver Dose. The Denver Dose is what you get if you live in Denver for a year. Denver is a location in the United States with a lot of granite and there is radon that leaks out and so you get about—forgive the old-fashioned units—100 milligrams a year from living in Denver. Much of the area evacuated around Fukushima—not all of it, some of it is still somewhat radioactive but much of the evacuated area—is below the Denver Dose. So either we should let them move back in to that area or we should evacuate Denver.

Q53 Baroness Noakes: Could I probe a little bit more on fugitive methane? You have given us a figure of 0.4%, which was new. Where does that figure come from?

Professor Muller: The reference is in the document that I gave here. This was a large study that shows more or less testing randomly 140—I think it is 140, it might be 120—wells in the United States. They went to the wells and triggered in a tracer so they could tell what fraction they were getting out. Then they went to the environment and measured it. By measuring it with respect to the tracer, they could get the absolute number for the leakage. No experiment like that had been done before.

Baroness Noakes: So 0.4 was an average. What was the range? Did some have large amounts?

Professor Muller: I am afraid I do not remember but I have the article on my computer and we can look it up.

Baroness Noakes: It is one of the areas that the EU is citing—fugitive methane—as one of the reasons to stop shale.

Professor Muller: Let me say that misinformation that was given here; he said 3 something per cent to leak. There is a simple calculation you can do that is mistaken. The global

warming potential is how much global warming is caused by a kilogram of methane versus a kilogram of CO₂. That number, if you average it over 100 years, is something like a factor of 30 or worse. The number has changed with time but I think the recent IPCC report puts it at around 30. Many people then mistakenly take that number and say only 3% can leak because it is 33 times better or worse. What they are missing is that the global warming potential is usually given in terms of kilograms. What you need is the global warming potential of a molecule, because if a molecule of methane burns, it produces one molecule of CO₂. It turns out that molecule of CO₂ is very heavy but it means you did not have as many kilograms of methane. This is well known.

Even in the famous article that scared everybody by Howarth, in his appendix, which was online, you could find that he had that correct. This is not a controversial issue. I talk about it in the *New York Times* article. The number turns out to be more like 15% to 18% has to leak before it is as bad as coal.

Baroness Noakes: That is because of the molecule rate?

Professor Muller: It is the molecule and also the fact that natural gas can be burned more efficiently for electricity production than can coal. The plants just work better because you have a gas in the first place and that gets you another factor. So the fact is, no one is going to let anywhere near that much methane leak because it is uneconomic.

Baroness Noakes: So if the EU use a methane argument to clamp down on fracking in the European Union, that would be a false reason?

Professor Muller: That was a mistaken number that he gave of 3%. It depends on whether you are assuming new plants or old plants what sort of efficiency you put in, but I would stand by the number of 18%. It just means methane is much, much better than coal for any conceivable plants that you build and any conceivable leakage.

The Chairman: Lord Griffiths. I think we have done *Gasland*.

Q54 Lord Griffiths of Fforestfach: Yes, absolutely. I was going to ask a question about the pace of technological change. In some things I have read about when it comes, for example, to shale gas production in terms of hydraulic fracturing and—I do not understand this—drillable bridge plugs, things like that, and also what you talked about recycling water, presumably in the next three, five, eight years we are going to see tremendous technological change in this area.

Professor Muller: Yes, it is happening.

Lord Griffiths of Fforestfach: We are now in 2013, but say by 2020, in which ways will technology change and make the case that you are putting forward even stronger?

Professor Muller: I think the economic case is going to get better. The cost of fracturing at great depths is going down—not that the cost is going down but the methane, the natural gas that you get back, will increase. I mentioned earlier improved efficiencies. Let me say a word about the geology of this because if you have the surface typically there are cap rocks and deep below that is the shale. The shale we think of as the source rock. Leakage from the shale has been caught in these cap rocks, accumulated, and that is conventional gas. It is like the gold rush where originally people found by panning, but where was this gold coming from? It was coming from them there hills. It was coming from the quartz, where the mother lode was. This is the mother lode. What you do now, you drill down and then you have a kick-off point, you start drilling horizontally. These pipes are flexible enough that you can then curve the pipe and drill horizontally. The typical number is go down three kilometres and then you may go three kilometres horizontally. Then they set off an explosive gun and fracture the rock a little bit, put down pressurised water and sand and that causes the fracture and the fracture grows, typically in a plane because of the way the rock is. It will grow in a plane. Then what they will do is they will pull that out, they will plug it right here, send in the fracturing gun again and do another plane. So these are the stages.

Many wells now have five or seven stages; some of them are having 20 stages. We already know that not all the stages produce equally well and there is great value in changing that. Why is that the case? We will find out and that will be improved.

Where do you do the fracturing? Right now they just do it equally spaced, and the real experts I know do not think that is optimum but the first gold panners knew that the optimum stuff was up in the hills but the easy stuff you go for first. So we are going to understand that better. When they put in the plugs they drill them out eventually so that everything flows together, but when they are fracturing they put a plug in so the water will only fracture this one and not go into the final frack. When they drill it out that is what they refer to. I have a wonderful movie I can show you on that that helps you visualise what is going on.

What most people do not appreciate is you are down three kilometres and the fresh water is at 100 metres. All you have to do is use decent piping techniques up there and you will not get leakage into the water, unless you dump it on the surface, which is where I believe much of the initial pollution concerns came from.

Q55 Lord Lipsey: Could I just ask an off-piste question? In Britain we have just seen one exploration attempt abandoned because of the number of demonstrators who were on the site, marshalled no doubt by some of the people from organisations we had up earlier. Was there a phase in America when similarly fracking was the subject of huge controversy, environmental demonstration and all sorts of problems, or was the wider population spread and the fact it was a long way away from most people keep all that under control?

Professor Muller: Fracking developed very rapidly in the United States before the environmentalists became fearful of it. Now we have a serious problem because the environmentalists are now raising issues, many of them valid issues. The issue of the fugitive

methane came about because of some early papers that suggested it could be very bad. That was a valid issue to be raised but I believe it has now been answered.

There were issues raised by the movie *Gasland*, which was designed to frighten you. That is still the strongest thing. I go to meetings with environmentalists in Berkeley and I say my thing, I do not go there and sneak in, but I also hear people talking about how the movie *Gasland* and the flaming faucets have really given them something to fight for. Quite frankly, it has also been what in the US we would call a cash cow. I do not know what the term is in the UK. But for many of the environmental groups their opposition to fracking has resulted in huge inflows of money, largely I think because of *Gasland*, Josh Fox is considered a great hero in *Gasland*. Just as Ralph Nader was for nuclear power, Josh Fox is taking that.

I have the sense it has been building in the United States and probably the opposition is now the strongest that it has been over the last 15 years.

Lord Lipsey: Is there any big corporate support for the opposition from other industries, for example the coal industry, which might think of gas as a threat?

Professor Muller: I do not know the answer but I do not think so. I think most of this comes from well-meaning people who found an issue in which they can fight and they believe it is an early stage for fracking so they can exert leverage and really do something and accomplish something, and they have misinformation and are doing it sincerely.

Q56 The Chairman: Can I ask you—it may not be exactly your area—do you think the United States will become a significant exporter of gas, and how soon?

Professor Muller: I do not know the answer to that. I know, of course, with LNG selling at \$12 to \$18 for a million BTU that could revive—but let me back off a little bit. There is a story that you probably do not know about why the price is so low in the United States. It came about because the leases were written in a way that you had to produce gas within three years or you would lose the right to do that. Meanwhile, there was a rush to buy up

these leases and then companies like Chesapeake—who are most famous for this—brought huge numbers of leases. They are still the dominant company in the Marcellus but they had to produce. The price of gas started going down because the demand was not there. Long-term demand is there but the immediate demand did not grow as quickly as this and so the price crashed down below \$2. At this point it was uneconomical to do any more drilling and Chesapeake had a great problem. Almost half the cost comes from the fracking, half of the cost comes from the drilling. Once you have done that it just sits there and just spews out the gas. So we have this great excess of gas and several of the facilities built around the United States were import facilities, and they quickly made plans to turn them into export facilities. In the last two months two of these have now been approved, one of them on the east coast, one in Texas. There is going to be one in Los Angeles.

Meanwhile in the United States petro chemical companies have moved their facilities to Qatar and to the Middle East, because that is where the natural gas is—natural gas is not easily transported, it has to be liquefied and that is expensive and it is energy expensive. So there are some technologies developing on that too to make it less expensive, to store the heat energy that you extract when you cool and then use that. So there is a lot going on there. Qatar had built a huge fleet of exports and now the US petro chemical companies want to move it back to the US and take advantage of the low price, which is still in my mind artificially low. I did not look it up today, I should have, but the price has been around US\$3.75 per million BTU. I am glad to be able to use BTU in a place where it originated—British thermal unit, the energy to raise one pound of water one degree Fahrenheit. But that is the unit that is used and I expect the price, which is now \$3.75, to go up to around \$4.50 and more or less stabilise there.

Whether the US is going to be using that internally for their petro chemicals, whether it is going to be exporting it, depends on whether the rest of the world develops their natural

gas. There is a huge thirst for this. It is not just China that has air pollution—India too. So the way that is going to develop, I do not have the vision to know.

Lord Lawson of Blaby: There is certainly an indication, as far as I am aware, that the petro chemical industry and other similar industries that would use this as a feedstock are moving to the United States, away from Europe, in order to take advantage of this.

Professor Muller: Yes.

Lord Lawson of Blaby: So obviously they have taken the view—they may be wrong—that a fairly low price is likely to persist, because they would not go through all the hassle of moving their production to the United States if they did not think that.

Professor Muller: I say I thought the price would go up from \$3.75 to \$4.50. I am not an expert on this by any means but I read articles by experts who do not ignore any clear issues and that is what they say. I think \$4.50 would still make sense to move to the United States.

Q57 The Chairman: Professor Muller, are there any concluding thoughts that you would like to leave us with?

Professor Muller: Well, right now we are fighting this information, and there is a huge amount of it. We are fighting some doctrines and one of the problems is that the general public finds all of energy to be too complex and certainly things like fracking have so many little facts that you are confused on. So they are looking for a simple principle. Several of these environmental groups have come up with one, which is to oppose all fossil fuels. That simplifying principle is one that is easily adopted by someone who wants to do the right thing and it sounds plausible.

We are in a situation where that simple mantra breaks and not all fossil fuels are equivalent. For global warming natural gas is much better than coal. The pollution issues with coal are terrible. I resigned from the Sierra Club in 1984 over the issue of them deciding to oppose

nuclear. The letter I wrote, which unfortunately I do not have a copy of, mentioned global warming because I knew Roger Revelle personally and I knew all about that issue, and said, “This is going to drive the United States to far, far more use of coal”. When I talked to the Sierra Club about this they said, “No, it is going to drive us to solar”. I knew solar was enormously expensive back then and they had this dream that you create this market and the price of solar will come crashing down and it will all happen. I call this optimism bias. For some reason people who are opposed to natural gas imagine the regulators will not be able to regulate, and that the local people will allow the fugitive methane. They are very pessimistic about natural gas.

I look at natural gas and I compare it to coal. Any engineer who wanted to solve the environmental programme, given coal or natural gas, would say that natural gas is just 400 times easier. But the public lumps them together and that is what we are up against. There is a great deal of information here but there are some very effective propagandists who are exploiting the public fear, as they did with nuclear. We in fact did not develop solar in the 1980s, but I am hearing similar things now. We are much closer. As I said, I am optimistic on solar in 20, 30 years.

One of the biggest oppositions privately from the environmental groups—it was mentioned here today—is the fact if we have a cheap alternative then there will be less of an incentive to develop solar. My answer is the same as it was in 1984, I said, “If we do not develop natural gas then it will be coal that will come in”. I have mentioned the rate at which Japan and Germany are both expanding coal now, and China of course continues to go for coal. China are very proud of the fact that they get 20% of their power from renewables. This is often cited. That 20% of renewables means Three Gorges Dam. This is a nice number, you will see this in the literature. 1.2 million Chinese citizens volunteered to leave their homes

and towns so the Three Gorges Dam could be built. It is a wonderful thing they can get that kind of consensus in China. They have many more dams in mind.

Lord Skidelsky: I have one off-the-record remark, and that is about the environmentalists. I think they want energy prices to rise because they want growth to stop. That is really at the bottom of it, I think.

Professor Muller: Certainly some environmentalists are that way.

Lord Skidelsky: Not all.

Professor Muller: Jeremy Rifkin, when cold fusion was invented, was quoted in the newspaper saying, "This is the greatest disaster of all time". Cold fusion would be completely clean and turned out to be completely wrong, but he was very upset this would mean more energy was available. I am much more optimistic about the future. Our population seems to be settling down. It will get up to 9 billion, with increased energy efficiency of 2% per year, which I think we can do. We can have the entire world population living at the European standard of living in the year 2100 and be using less energy than we are now. So I am very optimistic about it.

Lord May of Oxford: Can I give you one counterfactual? HSBC has been trying to trying to reduce the carbon footprint of their employees, per person carbon footprint. They have succeeded in every country except the United States.

Professor Muller: Interesting fact.

Lord May of Oxford: It has gone up year on year for the last 10 years. Do not be too optimistic.

The Chairman: I think on that interesting note, we have run out of time. Thank you very much indeed for a stimulating appearance. Thank you for coming.

Professor Muller: Thank you very much.