



Transcript

Chatham House Debate: Is Nuclear a Sustainable Energy Option?

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Oliver Morton:

Good evening, and welcome to this Chatham House event. There are journalists present. I am one of them. I'm Oliver Morton. I'm an editor at *The Economist*. I've no idea who the others are, but in case you don't recognise them, this is being held not under the rule, but on the record.

Our topic this evening, which our panellists have bravely agreed to tackle for us, is whether nuclear can be a sustainable energy option – and I'm going to try and keep things fairly focussed on sustainable, but we will obviously wander around a little. Our format is that we will have some reasonably short presentations from the panel. I will be the arbiter of reason and shortness in this regard. We'll have four of those, then we'll draw out a few topics, I think topics specifically... and have questions trying to go into those topics, particularly rather than just have a free-for-all Q&A session. But it's quite possible that this plan, like many of my plans will not survive an encounter with people that I obviously do not think of in any sense as the enemy.

Our first speaker is Stephen Tindale, who is an associate fellow of the Centre for European Reform. He's worked in energy and climate NGOs for a long time, but also done consultancy work for electricity utilities. He's been an executive director of Greenpeace UK and has been director of the Green Alliance and head of IPPR's environment group. Stephen, why don't you start us off?

Stephen Tindale:

Thank you very much. I'm afraid I'm going to disobey you straight away. The title is 'Is Nuclear a Sustainable Energy Source?' I think it is not, even though I favour nuclear power. It is not sustainable and it is not without its problems. It is not without risks and it is certainly not cheap. But it is a necessary low carbon bridge technology.

The disadvantage of supporting nuclear is that it will take money away from renewable expansion, and therefore slow the movement to 100 percent renewable energy, not just electricity but all energy. That will take many decades. WWF have produced a good report saying that that can be done by 2050, which of course is 38 years away, so we need a bridge technology to get us there.

If we go for nuclear as that low carbon bridge technology, it will take money and it will take political attention and therefore it might push back the time we get to 100 percent renewables from 2050 to perhaps 2060, 2070. Which is a

disadvantage, and it's an understandable position to say that we must get to 100 percent renewables as quickly as we can. I certainly understand that position because it was my own position for 20 years, but I then decided that that was wrong, because we needed the low carbon bridge technology.

The problems with nuclear; radioactive pollution is not a very serious problem. It's very worrying for people, as we saw in Fukushima, and people are very worried about pollution that they cannot see, radioactive pollution. But the recent studies [which] have charted leukaemia rates around the UK nuclear electricity plants didn't find any significant or any increase in leukaemia rates around there.

Waste is not great to have, but it's better to keep the waste down here where we can at least do something about it than to put it up into the atmosphere which is what happens with carbon dioxide from fossil fuels.

Terrorism and security; that is an issue. Proliferation is an issue, in my view, the major issue as we're seeing now in Iran. What can be done about proliferation? Well, Henry Kissinger has been wrong about most things, but he's right on this one. That we need an internationally controlled nuclear fuel bank. And secondly, the nuclear powers that signed the non-proliferation treaty back in 1972, I think, which promised to give up their nuclear weapons – which includes the UK – should meet their international obligations. So Trident shouldn't be renewed; it should be scrapped.

On the cost, nuclear as I've said will never be cheap. But the Committee on Climate Change recently came out with their report, which argued that nuclear will be cheaper than carbon capture and storage, which is kind of 'how long is a piece of string?' How much is that going to cost? But also, significantly, they said cheaper than off-shore wind.

So nuclear is a necessary low carbon bridge technology. And it is, according to the UK Energy Research Centre, the carbon emissions per unit of electricity from nuclear are a quarter of what they are from gas. So gas is better than coal, but it is not a sufficiently low carbon fuel to be a bridge technology.

Oliver Morton:

Okay, Stephen, thank you very much indeed. Our second Stephen is Professor Stephen Thomas, who's a Professor of Energy Policy and Director of Research at the Public Services International Research Unit at the University of Greenwich. Stephen was for a long time a luminary of the

Science Policy Research Unit at Sussex. He's been at Greenwich for the last ten years, and has worked as an energy policy researcher throughout that time. Stephen.

Stephen Thomas:

Thank you. I think if you're going to ask the question, is nuclear a sustainable option, then you have to consider issues of waste disposal, decommissioning, uranium reserves, and whether uranium mining is a sustainable activity. I'm not expert in those, so I'm not going to say anything about those. But if you're going to answer the question, you need to talk about those.

Is nuclear necessary to de-carbonise? Well, some simple arithmetic; nuclear is 15 percent of our electricity. Electricity is 20 percent of our energy. So we're getting about three percent of our energy from nuclear power. So if we're being very ambitious and increased the proportion of electricity we get from nuclear by, say a factor of four, and we doubled the percentage of electricity in our energy, we'd still only get up to about 25 percent of our energy from nuclear power.

Which is not to say we shouldn't do nuclear power. But it does mean that it's just one of many policies that we need to deal with global warming. Socolow talked about seven policy wedges, and nuclear could be one policy wedge. But no more than that. So it's not a necessity, and it's worth saying to get to an eight-fold increase in nuclear in this country, we'd need about 60 new reactors. And I think citing 60 reactors in this country would be an interesting exercise.

So the two main questions I want to talk about, is it competitive? And what's the impact of Fukushima?

And I think the question is not so much is nuclear a sustainable option, but is it an option at all. And I think you need to go back to the promises of the nuclear renaissance ten years ago, when people started talking about the new generation of nuclear reactors, these generation 3+ designs that were going to solve all the problems.

And the promise of generation 3+ was that they would be safer, but they would be simpler, because the layers of safety systems that had been successively added on could be stripped away and rationalised. And because they were simpler, they would be cheaper, and because they were simpler they would also be more easily built. So you wouldn't have the problems of cost and time overruns that nuclear power plants have typically run into. And

the benchmark figure they talked about at that time was that you could build them for \$1,000 a kilowatt, so an EPR would cost you about \$1.6 billion.

So if we look at the economics now, and you can make nuclear economics very complicated if you want, but if you look basically at the construction cost, and the cost of capital, that will tell you effectively what the economics are. Well, remember, the promise was \$1,000 a kilowatt. The latest estimates are generally not less than \$6,000 a kilowatt. So in ten years, the estimated cost has gone up by a factor of six, and that's before we've completed building any of them.

I think the second issue is the cost of capital and finance. And I think the last decade has made it clear that banks won't take the risk of financing nuclear power plants, that someone else has to bear that risk. In the past, that was easy because consumers effectively signed a blank cheque. Whatever it cost to build over the 20-odd years it took – and God knows how many billion pounds it took to build – consumers just kept paying. And as a bank, that's perfect.

Now it's a bit more difficult – with competitive markets – to make consumers sign up for a cost plus deal. So who else could you sign up? Well, one option was the vendors. The vendors could offer a fixed price for the plant, but of course that's after the experience of Olkiluoto where Arriva signed a fixed price deal, and immediately reneged on it as soon as it went wrong. As a banker, I would assume that a fixed price deal wasn't worth the paper it was written on.

Another option might be taxpayers. And the Americans are spending a lot of time trying to apply government guarantees to the loans for nuclear power plants. But these basically don't solve the problem, because loan guarantees, their price has to reflect the risk. So the risk is the same whether you're a bank or a country.

So the nuclear power plants that might go ahead in America don't require loan guarantees because they've got consumer pass through, cost pass through. And those that haven't got consumer pass through, loan guarantees aren't enough. So loan guarantees aren't going to make it. So the only one that will really do it is consumers, and I think that's what we have on the table in this country with contracts for differences, under terms that nobody will know.

I think the third issue is licencaeability [sic], and that was expected to be a very simple thing for these new generation plants, because they were designed with a full knowledge of all the accidents that had gone, so they would be a clean sheet of paper and it would be a year or two to get them through the

regulatory process. After ten years, none of the generation 3+ plants has completed a comprehensive design review anywhere in the world, and we're probably in this country maybe two years away even before Fukushima from completing a design review. So licenceability [sic] is an issue. And Fukushima gives that a new twist.

The final issue is of course buildability [sic] and the promise that these simpler designs would get over the problems of cost and price overruns and course we have two examples in Europe, both of which are four to five years late, and 100 percent over budget.

So things are not going well for the new generation. And I think the question that the nuclear industry has to ask itself – and I don't think it has the courage to ask itself – is, is it possible to design light water reactors that are cost competitive, that can survive a loss of coolant accident, and can survive a loss of power, a loss of sight power? It's the same question that's been around for 30 years, and I think if the answer to that is no, then the nuclear industry is in a very bad position.

Oliver Morton:

Louise said you were going to say something specifically on Fukushima?

Stephen Thomas:

Well, yeah. On Fukushima, I think it didn't change very much at all, that I think like Three Mile Island, like Chernobyl, it will be a convenient excuse for a nuclear revival that was already failing. I think it certainly won't do the nuclear industry any good, but the signs of failure were there already, that the problems of cost escalation, the problems of licenceability were already there. It just gives it a new twist, that's all.

Oliver Morton:

Thanks very much. Our third speaker is Jeremy Leggett, who is the Founder and Chairman of Solarcentury, and also the Convener on – I suppose this may be relevant – the UK Industry Taskforce on Peak Oil and Energy Security. He's also the Chairman of an African solar charity, SolarAid, and has written a number of excellent books including *The Carbon Wars* and also, like Stephen, used to work at Greenpeace. Jeremy?

Jeremy Leggett:

Thank you, Oliver. So I'm obviously in the camp that considers nuclear to be unsustainable, and rather than sort of rehearse – we've only got a few minutes – the long list, I think the short list would be three things with an afterword. The three things are, not necessarily in order of importance: economics, timing and proliferation, at the top of my personal list.

Economics we've already heard about, I won't dwell on that, but just a little bit of colour to illustrate. I'm sure people coming here tonight know an awful lot about this anyway, or you wouldn't be interested enough to come. But you can see this playing out in the markets, and there are days, believe it or not, when it's quite difficult on the clean tech frontlines. And if I want to cheer myself up, my top tactic is to imagine I'm the finance director of a nuclear company. And you know, you can see it in the press, you see it in the pressure that Centrica are under to get out of their particular consortium. You can see it actually in the weakness of the utilities, the most recent development being some of the utilities trying to persuade the builders to take equity stakes in the venture projects.

So the economics are very dodgy and I've got to the point now, I'm so cynical about it, where whenever I hear arguments like Stephen's that you can get down to being cheaper than off-shore wind, you really do have to then start asking questions. Just exactly what is being shunted off the balance sheet in this particular version of the economics, because any version of the economics requires vast quantities to be shunted off balance sheets.

And this is very distorting in energy markets. I think you just have to look at the deck to see that, where if you judged the name of a Department of Energy and Climate change by anything approaching its budget, it wouldn't be called DEC at all. It would be the department of nuclear commissioning, because that's where almost all their money goes. So that's, I think, all I would add by way of colour to the economics piece.

The timing piece, I'm in the gloomy camp, I fear, on both climate change and energy security. I think we have dire problems in both areas that have to be dealt with – if we're collectively capable of it, which is increasingly an open question – by rapid deployment measures. And I'm talking months and years, not the decade-plus that the industry by its own admission now, can do provided things don't go even further wrong at Olkiluoto and Flamanville in terms of bringing a reactor on-stream, on-stream from the time of its first airing as a project.

So we have to do the types of things that we know we can do very quickly. And of course top of the list here is energy efficiency, and at the risk of sounding like a salesman, for people like me on the frontlines of microgeneration and energy efficiency, it's a very tough sell, nuclear. You can imagine. I mean we can, with the right partners, go out tomorrow and put up, within weeks – we've done this, we're doing it on a regular basis – buildings that are zero carbon; that need no oil, no gas, no coal, no nuclear, at all, and do it very quickly. And that of course is marrying up energy efficiency with microgeneration technologies. We can do it in retrofit as well as new build.

So naturally, the focus is there. You might say, 'You would say that, wouldn't you? You work for a solar energy company,' but I set up the solar energy company because of my concerns – as anyone who knows me knows – about the issues of energy security and climate change.

On the proliferation issue, I was for a while the token young scientist on the board of Pugwash in the UK. Many people here will know that organisation. I spent far too much time with nuclear weapons designers for a young scientist, and I'm talking about Soviet ones as were; I lived through the last years of the Cold War doing the things that Pugwash did. And also Americans and not liberally inclined people on either sides as necessarily as I was.

And I have spoken to too many nuclear weapons scientists who have some version of... you cannot really hold a cigarette paper between a civil nuclear programme and a military one, and we will start losing cities, I'm sure, if we keep going down this track, if we can't solve our own problems without decommissioning, literally and metaphorically, our own nuclear industries. Which I think is what we should do.

And my final thought, perhaps by way of chipping into the discussion, is actually despite everything I've just said... you know, I like to think of myself as a slightly pragmatic person, and if you asked me to then rank my three concerns about nuclear, along with my list of concerns about everything else, spilling into water, and many other societal problems, I would not have nuclear anywhere near the top of that long list of concerns. So therefore, that's code for saying, 'If I were forced to live with nuclear in a genuine energy mix, this would not be something that would worry me too much.'

But, the question is, can we co-exist? And as renewables and clean tech have begun to [inaudible] up their curves, such that in Germany now even though solar is only doing three percent of energy, it is impacting the mid-day curve, the peak, and bringing that down. And therefore affecting the profits of the big utilities.

Of course, what we're encountering is an increasingly fierce push back. And it's led by the nuclear industry and the gas industry – different narratives to government. Behind closed doors, the nuclear industry's narrative is, you know, you can't do 20 percent renewables. You've got to go slow on this stuff, because you will mess up our renaissance if you do that. The gas industry's line is, as I'm sure people will know here, we've got fracking, we've got unconventional gas, there's so much down there that actually is going to be so cheap you don't need renewables at all.

And you might say, 'Well how do you know this?' And the answer to that is, I've been in this business a long time. I have a degree of trust with people who don't necessarily think the same way as me. And I have had so many people in Whitehall and Westminster, in the financial services industry, in the PR industry, that actually works on the payroll for some of the nuclear companies, with their wrecking brief to frankly speaking a narrative involving - I can't find another word – lies, in the Daily Mail, to sort of spin the story as being 'who is responsible for these soaring energy bills?'

You must have seen some of these stories. It's not just in the Daily Mail. 'The answer is these dreadful, expensive green technologies'. Sort of Goebbels-like stuff when you know about what's happening, about wholesale gas markets and the rest, not to mention the international oil price.

So it's going to be very difficult for us to coexist. And from where I'm sitting, the nuclear industry has declared a form of war on us. It's a form of civil war. And we are fighting a very difficult battle, and in the discussion maybe we could explore that a little bit more. But I just raised the term 'feed in tariffs' in these introductory remarks by way of prefacing it.

Oliver Morton:

Thank you very much, Jeremy. Our last speaker will be Paul Stevens, who is a senior research fellow here at Chatham House. And also a Professor Emeritus at the University of Dundee. Paul has an extensive background in all sort of energy economics, but he'll be talking today I think mainly about how nuclear and gas get along.

Paul Stevens:

Thanks very much, Oliver. Yeah, I was asked to talk a little bit about the role of shale gas in the renewable nuclear debate. And I want to look at a

particular issue, which follows on from what Jeremy was saying, and the issue is this. The story goes as follows.

Because of the shale gas revolution, we have the prospects for huge amounts of incredibly cheap gas forever and ever. Gas, as we know, is very much lower in CO₂ emissions than oil or coal. And therefore, people are saying, 'Well why should we spend so much more money on these horribly expensive renewables and nuclear, when we have this prospect for so much shale gas?'

I want to focus on two aspects of that discussion. First of all, to answer the question, is shale gas actually such a low greenhouse gas emitter? And the second one is, what are the prospects that there actually will be lots and lots of cheap gas forever and ever?

If I take the first point, shale gas is methane. And methane, when it's burned has a lower CO₂ emission than oil and certainly coal. However, if we're talking shale gas, of course you have what almost amounts to a manufacturing process. And therefore the CO₂ emissions associated with shale gas you would expect to be a lot higher than for conventional gas, because you're driving large trucks around, the technology involves hydraulic fracturing, which means injecting water and chemicals at very high temperatures. So you would expect there to be much higher, relatively higher CO₂ emissions.

Also, the other point is that methane itself of course is a very potent greenhouse gas. And if you have shale gas operations and methane is leaking into the atmosphere, then this again is going to be a problem.

Now as far as I'm aware, there have only been two studies published that have looked at these issues. The first was produced by the Tyndall Centre from Manchester University, which looked at the issue of how much more CO₂ is emitted as a result of shale gas production operations by having large lorries driving around the place full of water, etc.

And the conclusion they came to is that, actually, it doesn't really increase the CO₂ emissions very much at all. It was sort of, the range of magnitude is between .2 to 2.5 percent of the combustion emissions. So it's not a particularly big deal. However, the Tyndall study didn't look at the methane emission. It quite explicitly excluded that. The study that did look at that was the Cornell University study, which came to the conclusion that shale gas was actually worse than coal.

Now, it hurts me to attack another university, but that Cornell study was one of the most disgraceful pieces of work I've set eyes on in many a long year. I

could give you a long list of what was wrong with it, but it was seriously flawed and I believe even Cornell now is in the process of disowning it. But what this is basically saying is, we actually don't know what the CO₂, the greenhouse gas emissions [are]. And we need some serious rigorous studies to look at this issue. That's the first point.

The second issue, very briefly, is are we going to get lots and lots of sheet gas? Is the shale gas revolution going to allow us to float on clouds of sheet gas forever and ever? And the two key questions here are, first of all, can the shale gas revolution continue in the United States? And secondly, can it be replicated elsewhere?

The first question; there are uncertainties, because one of the consequences of the shale gas revolution in the United States is that the US domestic gas price has more than halved over the last two or three years. Now that's not just entirely because of increased supply, it's also to do with something called a recession as well. And we won't know which is which until – if – the US comes out of recession.

But there's a lot of concern that those low prices will inhibit the economics of some of the shale gas operations. There is also significant concern about hydraulic fracturing and the environmental implications of that. And as I speak, there are a number of studies being undertaken. Because one of the difficulties was that hydro-fracking was excluded from the EPA's clean water act, and so there have been very few environmental impact assessments on the implications of hydraulic fracturing.

These are being undertaken. The big one is being done by the EPA, which originally was supposed to be reporting early next year. But little birds have been telling me, we may not see the results of that much before 2014. We'll have to wait and see how that goes.

In terms of replication elsewhere, certainly there's a lot of resources out there for shale gas. But if you look, for example, at the European situation, Europe is not the United States. There are very significant differences. I'll just mention a couple.

First of all, property rights. If I am a landowner on the Marcellus shale plane in the United States and somebody comes to me and says, 'Can I mess up your backyard by looking for shale gas?' I will say 'With the greatest of pleasure, and here are my bank account details.' Because in the United States, subsoil hydro-carbons are the property of the landowners. So if any is found, it's mine, and I make money. Elsewhere in the world of course, it's the property of the state. So if you come to me and say, 'Can I mess up your backyard? Oh,

and by the way, all the benefits go to the government,' I think you'd probably get a rather dustier response.

One other difference is the service industry capability. Just a simple number. In 2008, at the height of the Barnett Shale plates, there were 199 rigs drilling. In 2010 in the summer, in the whole of Western Europe, there were only 34 drilling rigs. So the idea that you're going to see this huge replication of the shale gas revolution in Europe is simply a non-starter.

So what I'm basically saying is, we need more studies to establish, is gas going to solve the sort of climate change issue? And the second one is, we really should not be depending upon expecting much cheaper gas forever and ever. Because it's not likely to happen.

Oliver Morton:

Okay, thanks very much. Now, I think one of the first cross-cutting issues I'd like to pick up on is obviously cost and price. It's clearly the case that building nuclear power stations in Europe is currently very expensive. Is it clearly the case that building them in China is very expensive? I was struck, Jeremy, when you were saying that you wouldn't mind a mix that was piling on renewables and nuclear. That's what you're getting in China at the moment: is that a problem? Are the Chinese simply misguided in thinking that they should be investing in both rather than all in renewables?

Jeremy Leggett:

I'm sure we have people in the audience who know an awful lot about China in an institution like this. But yeah, I think there are a number of key countries that will be vital in how this drama plays out. Obviously there are the governments that have decided or are hovering on the edge of deciding to go non-nuclear. So we're talking here Germany, Switzerland, Belgium, and probably Japan – the politics look pretty dire for the nuclear industry in Japan. And how they manage I think is going to be very interesting. And one reads things in the *Financial Times* like, don't tell anyone, but the lights haven't gone off yet in Tokyo. And with most of their reactors down, all but a handful of their reactors down, who would have thought that was possible? And a really interesting narrative about how energy efficiency plays out there.

In China, it's different. I think – my understanding of it, others may have a different view – is that they're sort of throwing, as somebody put it to me, they're throwing spaghetti at the wall to see what sticks. They can afford to do

that with energy. And of course, it's too early yet to say how that is going to play out. But I, maybe I'm indulging in wishful thinking, but I do take heart from the fact that they shut down their build programme in the wake of Fukushima, pending this review of what they've done so far in their existing operations, and that still hasn't been opened up yet.

So let's see how this goes in China. Meanwhile, they're going gangbusters on renewables and clean tech. So, resolution of drama pending, I think. But these will be some of the key countries where all that will be played out.

Oliver Morton:

Stephen Thomas, I just wanted to bring in and ask you, is it really fair to judge nuclear as a global proposition in terms of the first two EPRs? Which were really what you were arguing about – the high cost overruns.

Stephen Thomas:

Well, two out of two going wrong is not a good start. I mean, until I start to see one going right, then I think the question marks are against it. We don't know what's happening with the two in China, but EDF is clearly very worried about the EPR, and I think they would rather not be building any more, because they are now engaging in a fairly significant redesign of the EPR. Whether the design is viable at all, I don't know.

As I say, it doesn't prove, they could have just been very unlucky with two bad projects. But you would think that the utility that has built twice as many reactors as any other in the world would know how to build them by now.

Oliver Morton:

Quite possibly. Stephen?

Stephen Tindale:

Well, I won't comment on the capacity of the nuclear industry to screw things up, because I think that's fairly self-evident. But on China, and Jeremy is right – what was your phrase? Throwing spaghetti at the wall? Very good phrase. Going for nuclear and they're also unfortunately going for coal. And basically, nuclear is a lesser evil than coal, in my view, for climate reasons. But on nuclear, they are not only going for uranium reactors, but also for thorium

molten salt reactors. Now thorium is an element that is much more plentiful than uranium, so we may or may not be at peak uranium, but we're certainly nowhere near peak thorium.

But the molten salt reactor bit of this has other advantages. You can use uranium in molten salt reactors, but you can also use thorium. And the advantages are that it's more inherently safe because it's a liquid and if it overheats, then it flows out of the core. So you can't have meltdowns in the way that you had at Fukushima, you had at Chernobyl, you had at Three Mile Island. So in terms of inherent...

Oliver Morton:

Because it comes pre-melted.

Stephen Tindale:

Yes, the fuel does, yeah. You can also – if you've got a molten salt reactor working – you can also use plutonium, which we have a stockpile of in the UK and many others do, and you can also use nuclear waste. So it is a way of dealing with stockpiles that we have. I'm not saying that it will be cheap. It certainly won't be cheap. Nuclear never is. But it is a way of dealing with the stockpiles, and it's much better than reprocessing, which is a complete waste of time and money.

So I think the molten salt reactor approach that the Chinese are using is the kind of exception to my general rule, which is that as this is a bridge technology, let's stick with what we know works. In France, for example. So generally, well we certainly shouldn't be going for nuclear fusion which is 30 years off and always will be. Don't know however many billions were spent on it.

And so we should just stick with what we know works, but the exception to that rule is thorium molten salt reactors.

Oliver Morton:

Right. Does anyone want to come in on these questions about cost and possible new designs? If I could ask anyone coming in to – and you will be first, sir – to identify themselves and their affiliation, that would be great.

Question 1:

Could I ask Professor Paul Stevens, who has a huge knowledge of shale gas – which he's given us a great update on this evening, and he's given a great presentation in the last year or so here at Chatham House – could he address just in a couple of sentences, the main issue tonight. Is nuclear a sustainable energy option? Which it may not be his special area of expertise, but what is his gut feeling about it? Does he think it's sustainable, either financially as being addressed by Professor Steve Thomas, or environmentally?

Paul Stevens:

I have problems with both of those. I gave up looking at nuclear in the early 1980s when I started my career as an energy economist, and the reason for that was, to me it had just become like a theological debate. God exists, no he doesn't, yes he does. Nuclear is cheap, yes it is, no it isn't.

My instinct is to say, however, and I'm a great sort of fan of the wedges idea, that if we believe in climate change and we believe in our role in climate change, we're going to need everything in the armoury to try and deal with it. And insofar as nuclear comes into that, yes it is.

The problem I have with it, is that the private sector and nuclear are not happy bedfellows. And there is a tendency, certainly among some governments and this government in particular, to say, 'Well, we will build nuclear stations.' Well, who is we? Is this the royal 'we'? Who's going to put the money up for this? And this I think is going to be a problem.

So I'm not anticipating seeing a huge increase in nuclear power generated, outside of China. China I think is a different case, because they can operate by a different set of both economic and political rules. But I'm not holding my breath.

Question 2:

I've seen how the law works in questions of security. Wrote with an American on the atomic bomb project in America, and I knew you, Jeremy, in '84. We were organising a committee. And I haven't split with you on this. I think there is a civil war in progress. I think nuclear reactors and energy questions are simultaneous with proliferation questions. And I would like to ask you, actually Jeremy – I'm sorry to see you arguing with economics and all those sort of factors – we're way down the line now losing the civil war against the energy and greed lobbies. Why are we losing it? And what can be done about that?

Jeremy Leggett:

Well, I mean, it's not a simple civil war. There are multiple scraps and it's obviously not just nuclear. It's the fossil fuel... and also, elements of the financial services industry know that bankers would far – I often think of it actually – prefer to think of it as a decentralised energy versus centralised energy problem.

So you know, that way you can see very clearly patents, cultural patents in the financial services industry, where financiers prefer big projects. So you've got this whole cultural thing right through the energy sector. And this is what we're struggling with. I don't think we're losing, neither do I think we're winning. I mean, you just look at the amounts of money that are going into renewable energy and energy efficiency year by year, going up substantively. And as of the last few years I'm sure you appreciate more capital going into renewables and efficiency relative to the market share. It's over 200 billion in renewables alone out of maybe 1.3 trillion globally last year.

So we're not losing, but neither are we mobilising on anything like the footing that ought to be possible given the disruptive nature of the technologies that we're involved in, as many of us who were motivated through the social mission, like myself, see it, the survival technologies.

But what I would say is that over the last 18 months, it's become vicious. Whereas before it was irksome, now one senses existential threat. And I have a friend, an American investment banker who I was talking with about all this the other night, and he sees the whole world in terms of American football. And so he stopped me and said, 'Stop whining, Jeremy. What do you expect? Up to now, all you've seen is the fancy footwork from the forwards of the opposition. Now their defence is on the field, and they are there to kill you.'

And you know how this works. There will be PR agencies that have been hired, that are on the payroll of the lobby groups, and they map out the narrative of what they want the public to believe, and one of the things they want them to believe is that, incredibly, the soaring energy bills are down to green nonsense technologies. And off they go to spread that, to perpetuate that lie machine in the places they know they can do it – the *Daily Mail*, obviously, but occasionally they get this stuff into the *Telegraph*.

And it hurts. I mean, it really does hurt. Yesterday I testified to the Environmental Audit Committee in the House of Commons, a joint session with the Energy and Climate Change Bill, and found myself accused of being, in the undercurrent of the questioning, a greedy profiteer, troughing on the

gold rush that is the UK solar industry. Now, you know, this is the type of thing that we have to deal with. This is why we're perhaps under threat.

So don't say we're losing, please. That will depress me. But we're not winning.

Oliver Morton:

Can I just ask a question: decentralised versus centralised? There's certainly an active debate on that, as there should be. Some renewables should be centralised. I mean, off-shore wind is very big and very expensive and therefore by definition I think centralised, and the **Seven** Barrage which sadly won't be built but should be, would be centralised. And DESERTEC, the proposal to get a massive amount of electricity from concentrated solar power in the Sahara in North Africa, obviously some political issues around that at the moment. But that would be centralised.

Do you think that centralised versus decentralised is a good way for those in favour of renewables, as I am, should throw in the debate?

Jeremy Leggett:

Let's put it another way. I mean, obviously I'm in favour of centralised renewable power. It just depends on the scale that you're talking about. But as it's being put to me by civil servants with a component of sympathy for the problems that we're suffering in the renewables industries at the moment in the UK, latterly the Big Six or major elements of the Big Six have come through DEC saying, 'Guys, if we've got to do renewables then we've got to do big project renewables.'

So off-shore wind, fine, give us a couple of rocks. We'll make that work. Marine, if the technology is ever going to work, we need a few more rocks. Let's have them. But all the rest of it, we're not that interested. It varies a bit by company but that's the story and there's some undercurrent as well of, if we don't get our way, we're not going to do any renewables and you won't hit your targets. And of course there's this constant undercurrent that people report of from the foreign owned ones, four of the Big Six. You know what, if this gets too irksome for us, we're going to go back home.

And if you look, I had a debate with the energy minister, Charles Hendry, in his constituency about a month ago. And if you can bear the exercise of your blood pressure that's involved in watching this, whichever way you swing on

energy, he said something really interesting right at the end, questioned by one of his constituents.

His response, and anyway, think of it this way. We're really dependent on the big energy companies to keep the lights on. And if they go home, we are in real trouble. He actually says that as if it's some kind of justification for the policies.

So this is what's going on. This is why I see it in such melodramatic terms. I mean, sometimes you'll find yourself talking to someone who doesn't know anything about the energy market, and you feel like shutting up because you sense you're beginning to sound like a mad person or someone with a huge conspiracy theory complex. I don't think it's a conspiracy theory. I think it's deeply cultural stuff, institutionalised culture. And it's a battle of ideas that we're dealing with, but it's deadly serious. And we don't have the budgets they have to swing things in the *Daily Mail*.

Oliver Morton:

I want to take forward a little bit actually the other part of that question, which was the proliferation part. And actually turn it around slightly and go back to my forlorn attempts to look at the word 'sustainable', which I'm basically giving up on. But is it not the case that the existence of military national security in nuclear insulations does make nuclear power in those countries which have such insulations very sustainable?

Is it not actually the bulwark on which the industry is largely built, because if you don't have a civil nuclear power industry, then you don't have any cover for anything else? And so, Germany and Japan we looked at as countries that might go non-nuclear, though I have some doubts about whether Japan will actually go non-nuclear, partly because some Japanese people are making actually precisely this point, that you lose a certain level of deterrence if you no longer have a virtual weapons programme. That's a small view in Japan, but it's a real one.

But don't you think that the... I would be interested in any of the panellists' views, that the military application of nuclear power will keep it sustained? They will be the crutch that it limps on on, even if it can't compete on price?

Stephen Tindale:

Well, it certainly has in the past. I mean, just going back to thorium molten salt reactors – one of my obsessions, I'm sorry about that – the US did develop and operate one in the 1960s, but then shut it down and went for uranium and it was never publicly said. But everyone knew that it was because that led to bombs, which they needed. And that is why France, the UK and so on have gone down the same route. And India, Pakistan, North Korea.

So it has been economically what has sustained the nuclear industry. And it is difficult but not, I think, impossible to argue that it needs to be sustained economically for climate reasons. But not for military reasons, and the military reasons should be rolled back.

Stephen Thomas:

I think... I mean, I have a problem with the nuclear lobby, because I don't know what it is anymore. If you'd asked me 30 years ago, I would have said, 'Well there's the CGB, they love nuclear. There's GEC, they'll make bucket loads of money selling reactors. There's the AEA that's got the ear of the government and the BNFL, similarly.'

And what those four institutions have in common is that none of them exist anymore. So it's very difficult to know what is actually driving the nuclear lobby now, and of course that leaves you with, I suppose, defence. But it seems a massive tail wagging a dog. I mean, you look at the countries that have weapons; they got the weapons pretty much at the same time as they were getting their civil programmes. I mean, Israel never had a bomb. India got its bomb about the same time as it opened up its first... Same for Pakistan, same for South Africa.

So it's a pretty... I don't find the military argument very convincing as a driving force for civil nuclear power. I can't see... it's not needed. You don't need that much to get a weapon.

Oliver Morton:

I was actually thinking more about its political cogency rather than its rationality as an argument. Jeremy?

Jeremy Leggett:

Well, I mean, we could get into some semantic wrangles about what is sustainable. And I was interpreting that word in its broadest possible sense, including economics. You wouldn't think so, especially these days, that are economically as sustainable. So I would argue that nuclear weapons themselves are not sustainable.

We survived the Cold War but those of us who read the books about how close we came as the secrets trickle out over the years go like this thinking, 'I'm lucky to be 57 years old!' We can't keep going that way.

Paul Stevens:

I completely agree with you, but I am reminded of the famous exchange between Donald Rumsfeld and a journalist at one of the press conferences before the invasion of Iraq, and the guy said to Rumsfeld, 'Why are you doing Iraq and not North Korea?' And there was a silence and Rumsfeld said, 'Because we can do Iraq.' And unfortunately that message has gone round the world and a lot of people are thinking, 'Ah, yes. There's something in that.'

Stephen Tindale:

I think oil might have had something to do with that.

Question 3:

Just one comment and one question I might make. Firstly, on investment appraisal, somebody mentioned banks. Of course at a discount rate of anything over about seven or eight percent, hardly any long-term project is worth doing, because the present value comes down to pretty much zero. You have to have some government intervention at some point there.

The main point I'd like to make is that, as somebody said, I think Stephen said that fusion power is 30 years off. And of course fusion power will always be 30 years off when we spend such a pitiful amount of money on research. According to the latest statistics, we spend something like ten billion euros worldwide on fusion research, which is a figure about two thirds of City bonuses. According to Professor Steve Cowley, that's 0.2 percent of worldwide energy use. I think there's a very strong case for a bit of long-term thinking here, and certainly more investment in fusion research. I'd like to hear what the panel has to say about that. Thank you.

Oliver Morton:

I was surprised actually that Jeremy didn't come in with what I always thought was the good line which is that fusion power isn't 30 years away, it's eight minutes away. It takes that long to get from the sun to us. But Stephen, justify your horrible dislike of fusion power, which is clean and nice and happens in the south of France.

Stephen Tindale:

Well, okay, it may be less than bank bonuses, but most things are. And I think tens of billions or ten billion is quite a lot of money. And even [inaudible] is saying it will provide electricity for the grid in, I think 2041 is their latest proposal. So yes, 30 years off. And I've been working in this area for 20 years, and 20 years ago it was 20 years away. And so 20 years later it's 30 years away, despite the ten billion.

And because we can be 100 percent renewable, particularly if we use DESERTEC and so on, by 2050 or 2060 or 2070, my bet is that that will be before fusion is working.

Oliver Morton:

Any supporters for fusion power in any way?

Jeremy Leggett:

We need to be mobilising the technologies we have, the on-the-shelf technologies we have at the speed, with which my parents mobilised fighter aircraft and tanks. That's what we need to be doing. And I think the nuclear industry, for a long time in these debates – it hasn't happened yet tonight and probably isn't now – but the line, this is all very well. Maybe renewables can do a bit, but you can't run the railways without nuclear power.

And I'm sure everyone here knows that a couple of weeks ago Deutsche Bahn announced its targets and timetables for 100 percent running the German railway system. More than a billion people transported around at speeds of up to 150 miles an hour, 100 percent on renewables. And they're German. The chance they're going to hit that target... by 2050, but of course with ramping up.

Oliver Morton:

Chris, I'll let you come back very quickly, but then I do have another question over here.

Question 4:

Just a quick one. In the last World War, the Allies felt that they had to crack fission power, and the Manhattan Project managed to get an atom bomb out in three years, three or four years. And that was because we couldn't be sure that Germany wasn't developing one as well. When the pressure was on, we did it.

Question 5:

I am not with the nuclear lobby, and I concur with what you say that it will take long for the gas to be developed in Europe, contrary to the States. But nevertheless it could be a source of cheaper energy along the line. When I hear you, I have heard that you all share that we need a voice towards a better world without nuclear and without carbon, even better.

But in the meantime, we depend on that. And on that, to a certain extent, France has 60 percent of its nuclear energy providing the electricity, exporting it. And my biggest worry and maybe that's where I would find a way to support the lobby of nuclear is that these guys have to deliver safely the energy for the next 30, 40 years from their power plant.

And I think it would be very dangerous if we start telling, you know, putting a lot of uncertainty on the end of nuclear. We know that some plants will have to be in operation for 30 years, more. And the utilities company, you know, they are public companies, they are asked to make profits. And if we just cast a doubt about the end, they could simply stop investing on what is necessary for retrofitting the system.

I'm not a specialist, but I know what is an oil field that is going to be decommissioned, it's not when the oil company is spending most of its money. So you have to be careful, and I think the politicians have to be careful not to let develop a kind of debate where there is an uncertainty on when plants will be decommissioned. There should be a clarity on that.

Oliver Morton:

I think that's very interesting... just, didn't Total, weren't Total part of the French bid for the UAE reactors? I thought that you had a small piece of equity in that.

Question 5:

I think the bid was lost because it was an [inaudible], more costly than the current technology and it was outbid. I'm again, don't quote this, you ask me... I think it is.

Oliver Morton:

An interesting question, and this is almost a question of a noble lie. Is it important to pretend that nuclear is sustainable, because the idea of a rump nuclear industry with sweated assets is the nasty sort of nuclear industry you can think of?

Jeremy Leggett:

Well as I heard it was a bigger point than that. I mean, it was... let's feel terribly sorry for the poor old energy utilities because... there was a bigger point, wasn't there? Not just nuclear. And my response to that was going to be, these guys are doing a very, very good job of undermining their own business models just with their status quo behaviour in consumer markets.

Now there was an analysis, a thinkpiece in the *Financial Times* a couple of weeks ago where one of the correspondents – I forget who, you may be able to help me here – but one of them said things have got so bad with these companies in the consumer surveys, the levels of hatred among consumers for the Big Six are so high that what these people have succeeded in doing is imperilling their own business model through their – they didn't use this word in the article, but – their quasi-cartel behaviour. But that's basically what they were saying.

So you know, we have a big problem with that, with the big energy companies. We have a big problem with financing. So yesterday I was talking to another investment banker, not the American with the football, but someone who has invested a lot in renewables, one of the top renewables investors in this country. And we were talking about the feed-in tariffs.

He made the point that the Director-General of the CBI made in a speech the other evening, that this ambush that the solar industry has experienced on the solar feed-in tariffs is really a terribly dangerous thing. Not because you're creating one month, thousands of jobs and then getting rid of them the next, because of representations that have been made to you by the Big Six energy companies about what they want to see. And not because of the wider renewables implications. But because of the message you're sending to investors about the investability of Britain when it comes to the £200 billion that is going to have to be deployed. Now you're going to have to trust me on this, but if anyone wants to twist my arm afterwards and see if I can introduce them to this banker by email so that it's not just an anecdote, this is a serious point.

And the CBI DG didn't just make it quite so pointedly as that, but you talk to DEC officials about this fiasco that's going on in feed-in tariffs at the moment, and they will say, 'We haven't done anything retrospective. We haven't done anything that we didn't flag that we might do if there was too much of a take-up of this disruptive technology.'

And his response to that, the banker's response was, 'It doesn't matter what civil servants who fly their desks in Whitehall think about what's retrospective. It's what the markets think is retrospective.' And the financial services industry thinks this is retrospective, and they are now looking at rocks and wondering what the government will do to move the goal posts on rocks, and they're wondering about what a government like this will do to move the goal posts in just about anything that they're going to have to invest in when it comes to the... So we're in a mess. And you know, the Big Six energy companies, in my opinion, do not deserve a grain of sympathy. They deserve a lot more...

Stephen Tindale:

It's not necessary to describe nuclear as sustainable. The best way to describe it is the way that Angela Merkel described it before her post-Fukushima u-turn, which was that it is a necessary low carbon bridge technology. And to be fair to the British government, which is quite difficult, Chris Huhne has also said it's necessary until we can be 100 percent renewables.

Question 6:

I work in private equity, and we invest in energy through various forms around the world. And we've touched on it slightly, but my understanding is that gas and gas technology – fracking, horizontal drilling, etcetera – is getting exponentially cheaper as we go along the curve. Whereas nuclear technology is not. Is that correct? Or do I misunderstand this?

Paul Stevens:

Well, certainly in terms of shale gas operations, the technological change over the last ten years has been absolutely stunning, and the result of this is that the costs of shale gas and unconventional gas generally have come down and are now generally regarded, certainly in the United States, as cheaper than conventional gas.

So yeah, in terms of gas, and it's not just gas, but oil as well – because of course the technology that's being developed in shale gas, horizontal drilling and fracking, is now being applied to fallow oil fields and people are talking about the US domestic oil production going up 2.5, three million barrels a day by 2015 as a result of this, and that again is because the cost of the technology is coming down.

As to nuclear, I have no idea. I come back to my point about the theological debate of the 80s. Is it cheaper or not? I have no idea.

Oliver Morton:

I'm aware that we started slightly late, but I just wanted to ask the panel one of the questions that strikes me. I pulled it out of Stephen Thomas a little bit, but does it strike you as interesting how little Fukushima has changed these debates? Or has it in fact changed it in a huge way that I haven't noticed? I mean, it seems to have had very little impact here. Is this appropriate or not? I'll come back down the line.

Paul Stevens:

My response to the notion it hasn't changed much is, let's wait to see the first public inquiries into commissioning new plants, because my sense was before Fukushima, that people here were beginning to say, 'Oh, nuclear's not too bad and we might be able to live with it.' I suspect after those events, that view will change. But you won't be aware of that until somebody says, 'Right,

we are going to stop building plants in your back yard,' and see what the public response is.

Jeremy Leggett:

I think it's segmented. It certainly had a massive impact in Japan. I know a bit about Japan. I go there often; my wife is Japanese. I mean, it really is affecting the zeitgeist there. Here in this country, we've got such a multi-variate community of pro-nuclear supporters, I mean I know, I've got lots of friends in it. But you know, the push back is very strong. Let's keep it all in perspective. Well I think, we're not indicative of what goes on in many other countries.

And the fact that governments have been quick to say, 'That's it.' And even if it is only four governments so far, three or four governments so far, the fact that that can happen with one disaster, you sort of think, how many more can this industry absorb without it being set back terminally in this regard?

I do think our culture is particularly strange. In Whitehall, people will have seen on day two of the Fukushima disaster, the emails that were subsequently leaked from high levels within DEC, presumably by some civil servant who was just, it was too much for him or her. We haven't heard anything about the denouement of it, but they were leaked anyway to the *Guardian*. And if you didn't see this story, it's so instructive.

These are senior civil servants sending emails to each other saying, 'Right. Nuclear incident in Japan. Day two. What should we do? Need to invite in the Japs from EDF and Arriva and the others and need to sit down, work out a joint programme, government industry programme. How are we going to explain to people that this is an incident that we really don't have to worry about too much? And certainly it's not an incident that would in any way pose a risk to the nuclear renaissance in this country.'

On day two! Can you imagine the progress of the British renewables industries if we had had anything like that kind of high level institutional support from within DEC? And also, may I say, the gross irresponsibility of this. Grotesque irresponsibility. Those reactors were in the process of melting down, three of them, at the time they wrote those emails. And you would think that they would have had at least a little bit of circumspection about waiting until they knew the outcome. But this is what we're dealing with in Britain.

Stephen Thomas:

I think it's too early to tell. I mean, if you go back to Chernobyl, the aftermath was all about an eccentric design operated in a very strange way in a decaying Soviet Republic. In the same way with Fukushima, it's all the thought is about massive earthquakes and tsunamis. And therefore not particularly relevant to us.

But if you look at Chernobyl and look at what came out of it in the long term, you're looking at the generation 3+ designs. Yet 25 years later, we still don't have one of them through the regulatory process. So it's going to be a long time before, and people will start to think that here again is another beyond design basis. Nuclear accident, and it's going to send shivers through the nuclear designer's spine, I would think. And regulators who have to sign off these designs as safe enough.

Stephen Tindale:

Okay, yes, it is too early to say, but the initial reaction in the UK public is that there isn't much change in terms of hostility or support for nuclear. The most worrying thing on that, from my perspective, is that a lot more women oppose nuclear than men. They're kind of 'boys' toys'. There's nothing I can do about that, so we need some women to speak out in favour of nuclear power, which is quite difficult to find.

But in other countries, I mean Germany obviously, where there is a kind of theological opposition to nuclear among the Green movement. I should say in the UK, the Green movement is quite balanced or split on this. And they don't all hate me because I've done a u-turn. Some of them do. And in Germany, it's just unthinkable and similarly in Switzerland, Austria, which has always been anti-nuclear, and it had a big effect in Italy. That Berlusconi was the supporter was not helpful. But Europe-wide, it does look like it's been very, very country to country.

Oliver Morton:

Well I'm afraid we've overstayed our welcome. I hope not overstayed your patience. I'm wrapping things up now, so thanks very much to Paul, Jeremy, Stephen and Stephen. Thank you all for attending.