HOUSE OF COMMONS

Science and Technology Committee

Oral evidence: Technologies for meeting clean growth emissions reduction targets, HC 1454

Tuesday 15 January 2019

Ordered by the House of Commons to be published on 15 January 2019.

Watch the meeting

Members present: Norman Lamb (Chair); Vicky Ford; Bill Grant; Darren Jones; Stephen Metcalfe; Carol Monaghan; Graham Stringer; Martin Whitfield.

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Witnesses

I: Lord Deben, Chairman, Committee on Climate Change; and Chris Stark, Chief Executive, Committee on Climate Change.

II: Malcolm Brinded, Fellow, Royal Academy of Engineering and allied institutions; Guy Newey, Director of Strategy and Performance, Energy Systems Catapult; Professor Jim Watson, Director, UK Energy Research Centre.

Written evidence from witnesses:

- Royal Academy of Engineering and allied institutions
- Energy Systems Catapult
- UK Energy Research Centre

Examination of witnesses

Witnesses: Lord Deben and Chris Stark.

Q1 **Chair:** Welcome, both of you. Thank you very much for coming along this morning.

In its most recent update to Parliament, the Committee on Climate Change reiterated that "the UK is not on course to meet the legally binding fourth and fifth carbon budgets." Is that still your assessment six months on?

Lord Deben: Yes, it certainly is. Nothing has happened in the six months that changes that.

Q2 **Chair:** Do you have any additional comments, Chris?

Chris Stark: No. When we assessed the progress so far, our primary concern was that there was lots of risk attached to those policies that the Government had already made. It was not clear how you would deliver them, and there were gaps in the policies that needed to be filled if we wanted to meet the fourth and fifth carbon budgets.

Q3 **Chair:** There is uncertainty about what is in place and, even with all those things working, there is still a gap.

Chris Stark: That is correct.

Q4 **Chair:** How urgent are new policies and actions to fill that gap?

Lord Deben: They are very urgent, for three reasons. One is that, the further you put it off, the more expensive it is to do these things. Secondly, the further you put it off, the more complex it is to do these things, because you will have done other things in the meantime that were not properly aimed at the decisions you should make. Thirdly, the fact is that, out in the wider world, business, institutions and all sorts of other organisations are doing the things they need to do. The Government have to be in the leadership role; otherwise, whatever they do, it will look as if they are hanging behind.

I think that there are three good reasons why it is urgent—apart from the overall urgency, which is that we are in a very urgent situation, as the IPCC has shown. If I were to put my finger on the thing that I am most worried about on climate change, it would be the lack of urgency. We have moved from a position in which there was an argument about whether climate change is happening. I do not think that there is any argument any longer that it is happening. We are now in a position in which people are perfectly happy to say, "Well, it is happening, but we are not going to do things as fast as we need to."

Q5 **Chair:** That suggests to me that you are not particularly satisfied with the Government's response to your last progress report. Is that the case? Do you see any grounds for hope and optimism?

Lord Deben: I am optimistic in the sense that we have a Government who are clearly committed to do these things and have begun to have a holistic approach in terms of strategy, which we have never had before, and that we have a Minister who is manifestly committed and is pressing these issues in a very remarkable way. We have also retained cross-party support. All those are reasons for optimism.

There are two things that we lack. One is precise policies that add up to the budgets that are now statutorily required. The second is a sense of urgency not just in BEIS and DEFRA but through the whole of Government. I have never heard the Secretary of State for Health make a speech on climate change and explain what the health service is doing. After all, there is a huge impact as far as health is concerned. I do not hear enough noise from the Department of local government. In the end, the housing issue is one of the central issues that we have. You can go through the whole of Government and see that it is almost siloed in the two Departments that have the most direct, but still only partial, control over the issues of which we speak.

Q6 **Chair:** Chris, what is your analysis specifically of the Government's response to the progress report?

Chris Stark: I support very much what Lord Deben has just said. There is a very good strategy in place to decarbonise the power sector. That has been working extremely well for some time. We would say that it could go even faster, but it will not be enough, if that alone is the strategy. Just as Lord Deben says, unless policy stretches out in a very fundamental way beyond the Department that is responsible, BEIS, we will not see the kind of step change that is required to meet the carbon budgets, let alone the long-term targets.

What I would characterise as the incremental-style policies that we have seen in the last six to 12 months are very welcome, of course, but they will not take us to the eventual goal. The real secret lies in having genuinely strategic policy from other parts of Government, to allow us to have confidence that we will make the carbon budgets.

Q7 **Chair:** You said that the Government should not be using the flexibilities that are available to them under the Climate Change Act. The Act clearly offers and provides those flexibilities. Why do you take the view that they should not be used? Do you think there is a case for amendment to the Act, or at least a voluntary recognition that the Government need to go further than what the Act provides for?

Lord Deben: First, they have already made the statement that they were not going to use them. They did not use them over the first carbon budget, and they made quite clear that they were not going to use them over the next one. Indeed, that has been the policy up to now. If they were to use them, they would be changing the policy that we have had up to now.

Secondly, most of this over-achievement is a statistical matter. Two things could happen. One is that, in the future, it could go in the opposite direction statistically. Therefore, to bank that which may well be largely a statistical issue is very dangerous, because then you have absolutely nothing in hand for the reverse.

The third thing is that, partially because of what the Government had said and partially because it seemed to us to be right, we framed these budgets, which we put before Parliament and which Parliament then voted on, on the basis that the statistical and other over-performances would not be used. If we had thought that they were going to be used, we would have made a different budget.

The problem then also comes that the demands that we are now going to have because of the Government's perfectly proper and very supportive position at Paris must mean that we stretch the budgets more. They certainly do not mean the opposite. At the moment, we have been able to say that we do not need to revise the budgets—that was our interim decision—but that was because we were looking at the budgets without any kind of diminution and because the budgets are bound to be on a kind of arc, so that you are talking about a range of outcomes. If you keep those outcomes at the top end of that arc, you are on the right trajectory to reach the new demands that will be made.

We will, of course, be refining that in the work that the Government have asked us to do on getting down to zero, but that is the position at the moment. Therefore, we think very strongly indeed that it would be to distort everything if we used these flexibilities in the way in which some have proposed.

Q8 **Vicky Ford:** I want to pin down a bit more where you see the biggest gaps in the clean growth strategy, when you take into account what impact the policies could have on emissions. You have talked about the need to have a cross-Government approach and about the NHS. Where do you think that other big gaps lie?

Lord Deben: First, in housing. We are building houses now that are not fit for the world in which we live. That is barmy. There is no other word for it. If you do that, you just build up your problems in the future.

There is no reason why you cannot have sensible policies to produce housing that is much closer to the passive house standard. I use a very general phrase for that. The cost of doing that is marginal. In any case, once everybody did it, the price would fall very considerably. The biggest problem is the training of builders and such like for it and the fact that the less effective pieces—I have used the word "crap", but in this case I will say "less effective"—that you use in modern building are mass produced, whereas the sort that you need for the kinds of standards that we ought to have are much less mass produced and, therefore, much more expensive. If you have a standard that is higher, the increase in cost is much lower.

The last thing, of course—this is, I think, one of the problems—is that the price of land for building is dictated by what the house builders can get at the other end. Frankly, if you have a marginal increase in the cost of building a house, the price of land will fall by that amount. That is where the money will come from. The difficulty is that house builders have become land operators, rather than house builders—sometimes they have as much as five years—and that they have bought their land on the basis that they are not going to have to build better houses. I am sorry, but, when you look at the present situation, it is not unreasonable to ask Persimmon and others to build houses that we will not have to retrofit in 20 years' time. That is the first and prime issue.

Secondly, we have to move much faster on the electrification of transport. Our figures at the moment will not deliver. That is why we have said that we really have to bring this whole performance earlier. We are in a difficulty. If we are not careful, other countries will do that. Then, if we do not have a disaster over Brexit, this will be the market in which people who have stocks of old-fashioned cars, so to speak, will be able to dump them, so there is a very real reason to be ahead of others, rather than behind them. The biggest reason, of course, is that we have to meet the targets. We do not believe that we can meet the targets unless we do some serious things on that.

The last of what, for us, are the three urgent issues is the whole question of land use. You will know from your own constituency histories that agriculture is the product of a very significant amount of the emissions. The fertility of the soil has dropped very considerably. Unless we do something about the fertility of the soil, it cannot absorb the carbon that it needs to absorb. This is a long-term matter. We have only just got suitable base figures from DEFRA. Therefore, this is a really important issue for me. That is why we have done a preliminary report and are going to do a second report next year. We think that we need to get started in a serious way, particularly with the changes that might arise if we leave the European Union. This all has to be part of what is then done for agriculture.

Q9 **Vicky Ford:** On housing, is the issue more the energy efficiency of new builds, which was the focus of your last answer, rather than improving the energy efficiency of the existing housing stock or having more sustainable energy generation for those homes?

Lord Deben: You are quite right to raise the three of them. The sustainable energy part is the one area where we are well ahead of ourselves, compared with others. That has tended to hide how little we have managed to do in other areas. There is no doubt that we must have an effective way of improving the energy efficiency of the present housing stock. We are doing less well on that now than we were doing a period of time ago. That really has to be put right.

The reason I concentrated on new build was simply that it is the stupidest part of the whole situation. We are making things worse for ourselves in

an area that you can put right. That is what really concerns me. That is why I put it first. You are quite right—the biggest problem is all those houses that will still be there in 2050, when we are supposed to have reduced our emissions by 80%.

Q10 **Vicky Ford:** Chris, do you want to add to that?

Chris Stark: I can add some colour to that. When we look at the world, we think about various sectors as we know them. One of the things we look at is buildings. I would throw into the discussion that the acid test of whether we are serious about addressing our emissions targets in the UK is the second of the big energy challenges. We have been doing pretty well on decarbonising electricity generation. The question then arises, where do we get our heat from in the future? Can we remove ourselves from the requirement for fossil fuels for that heat? That stands as one of the biggest and most unanswered questions so far.

The clean growth strategy has a lot in it that discusses the topic, but we are lacking detail on policy for how we will get from here to there. In our recent publications, we have said to Government that there is now no barrier to Government making a proper strategy for carbonised heat. Were that to be in place, I would feel much more confident about our progress towards the carbon budgets and the central target.

Q11 **Chair:** Of course, there is a great win for householders, in that their living costs reduce dramatically.

Lord Deben: That is certainly true. One of the things that I have been proposing would be very simple: they should never be allowed to have big posters up saying, "Buy this house for £400 a month," unless that is the price of the heating as well. That is really what the price is. The mortgage companies should be much more in the forefront of seeing what the real outgoing is. It is those two things: the mortgage and the price of heat.

People ought to be told the facts about their house. I did a bit of private shopping. I went around a Persimmon estate with a young person who looked as if they might be buying a house. When I asked the lady who took me about the energy efficiency, she said, "Very high." I asked, "What do you mean by 'very high'?" She said, "Very high indeed." Then I asked, "If you take the traditional one-to-six measurement, where does it come?" "Oh, right at the top," she said. I asked, "Can I have that in writing? It doesn't seem to be in the document." She replied, "They haven't given us the figures yet."

The whole thing is obfuscation. There is no system to enable people to see that buying this house will cost them less per month than buying that house. That is another part of the nonsense we have got ourselves into.

Q12 **Vicky Ford:** Are you saying that the energy performance certificates are not clear enough?

Lord Deben: They are not there at the time. They do not provide them. The other bit is that they work only if the gas condensing boilers that these houses very often have have been properly set. Local authorities are supposed to inspect this, but so far I have not seen a great deal of evidence that those inspections are really detailed. Unless the boilers are set properly, they are very carbon-inefficient.

Q13 **Vicky Ford:** That sounds like two recommendations—to get your energy performance certificates and to get your carbon boilers checked.

I want to come back quickly on what you said, Chris. You said that there should be no barrier to making a strategy for carbonised heat.

Chris Stark: Decarbonised heat.

Q14 **Vicky Ford:** Can you give some examples of what would be in that?

Chris Stark: Yes. This has always been too big an elephant to consume, if I can put it in that way. We on the committee have always said that there are two broad choices when it comes to how one can decarbonise the heat system. One is to go down the route of electrifying heat and to use things like heat pumps, in particular. The other is to take what we predominantly get our heat from at the moment, which is natural gas, and to decarbonise that as a fuel, with something like hydrogen. Both of those are enormous steps in infrastructure terms.

More recently, we have been looking at whether there is a middle ground, where you bring hybrid technologies to bear. Basically, these are places where you can get electrical heat. Remember, the electrical system is becoming more and more green over time, as we decarbonise that. You bolt them on to existing heat systems like combi boilers, which are what we mostly have in our towns and cities at the moment. That has presented some really exciting modelling for us. It points to a third way through this, which means that there should be no barrier to making a strategy to decarbonise that heat now.

It is worth saying that we will not make the central target in the Climate Change Act—the 80% target in 2050—unless we decarbonise the heat system. As that is one of the really big infrastructure challenges, the sooner we start on it, the more quickly we can be confident that it is on the right track.

Q15 **Vicky Ford:** That leads into my next question. In your latest report, you highlighted some actions that needed to be taken now to keep some of the long-term options open, particularly in three areas: carbon capture and storage, heat pumps and floating wind. What do you need the Government to do now to keep those long-term options open, so that we can move into a decarbonising heat strategy?

Chris Stark: We know quite a lot about each of those three technology areas. In particular, we know that they work. There is technology that can be developed and implemented to address the challenges in those

three areas. What we do not have is information on how they would be rolled out at scale or on how costs might fall if there were a bigger market for those things. What we really need the Government to do is to demonstrate that through a large-scale pilot of each of the areas.

I would draw out the heat pump question and carbon capture and storage, in particular. Carbon capture and storage has long been understood to be a really important, if not essential, part of the long-term challenge. It is worth mentioning that the Department, under Claire Perry, has really focused on CCS recently, in a very helpful way. I am feeling much more confident about the way in which CCS—carbon capture and storage—is playing out at the moment.

I am far less confident that heat pumps, especially the hybrid heat pumps I have just referred to, have the same support. They are the really important technology in the long run, given all that I have said about heat. I would very much encourage the Government to begin a large-scale trial and to start testing the market mechanisms we will need to see these things deployed at scale.

I should say that "heat pumps" is a terrible name. Nobody knows what they are. Most of them take the heat from the air. They are air-source heat pumps. Think of them as a reverse—

Q16 **Chair:** Are there far more air-source pumps than ground-source pumps these days?

Chris Stark: Yes. Ground source is a very efficient technology, if you have it, but it is very expensive to employ. It is a much larger installation. Ground-source pumps are very useful, but they are unlikely to present a technology solution that we will need for every day, right across the country. Heat pumps really need to be tested properly. We need to understand how the market will deliver that.

There is good reason to think that there is a green economy benefit from some of these things. We have impressive companies here in the UK that are ready to deliver these products, if there is a proper market for them.

Lord Deben: The issue of financing is crucial. There are mechanisms already out there that enable people to enter into relatively long-term contracts whereby they can get the new hybrid equipment themselves. That operates on electricity for most of the time, but it can turn over to gas if there is a need to do so. It is a very good way of replacing the need for base-load. You enter into a contract with the Government that that is what you will do if there is a shortage, because there is not enough wind or not enough sun.

Q17 **Chair:** You have to be a bit of a geek to go out and find these arrangements, don't you?

Lord Deben: Exactly. That is why I am so concerned that the Government must have a full-blown pilot programme to show how that

could happen. The other thing that would happen is that we bring much more sophisticated people into the heat pump market. There is a problem with the heat pump market. Because it is an incomprehensible concept, they are not terribly good at selling it. I had one of the senior people in to explain what they said. After all, I know a bit about this. By the time he had finished, I was more confused than I had been at the beginning. I feel that it needs to become a mature industry in this country, as it is in others, in order that people do not have to be geeks. In other words, I want to get into the Apple situation, rather than get stuck in the old-fashioned Microsoft one.

Q18 **Chair:** I would be interested. I have no idea how to go about finding out about these things. That is depressing.

Lord Deben: As you do not live far away from me, when I have the information, I shall pass it on to you.

Chair: Absolutely—do.

Q19 **Vicky Ford:** You have talked about CCS and heat pumps. In your report, you also talked about floating wind power. Do the Government need to do anything about that now? We are an island.

Chris Stark: Floating wind has always presented an incredible opportunity for deep waters around the UK. I am a Scot, so I know some of the best resources up in Scotland are in places where you could not credibly put fixed offshore wind. Of course, it carries with it a whole host of other benefits, including the fact that these things are much easier to consent. They are in far less sensitive areas.

Q20 **Chair:** Is it a top technology that is deployed anywhere?

Chris Stark: It is. It has been deployed in Scotland and other parts of the world. The biggest barrier to its full-scale deployment is cost. This is a classic case of where the Government can support something at a larger scale, with the full intention of bringing that cost down. They have demonstrated very well that that has worked with the fixed offshore wind market. Were we to see cheaper floating offshore wind, we could be very confident indeed that we could have a great deal of green energy being generated in the waters around the UK.

Q21 **Vicky Ford:** My final question is about onshore wind and solar. What would be the consequences of not increasing support for them?

Lord Deben: This is a really straight answer. The fact is that the Government must either allow this to be part of the structure—I am putting it as generally as that—or tell the public the extra cost that we are paying for our electricity because we do not do it. It seems to me unacceptable for the Government, for what can only be political reasons, to stop people who want to build these things, in communities that want to accept them, from doing so. That is what happens, in effect.

I have had a row with the BBC, which says that, somehow or other, I mislead people by saying that you cannot do them. I want to make it clear that you cannot do them, because the Government have committed themselves, in their electoral manifesto, not to allow onshore wind. What they have done is give the planning power to local authorities, but not allow the connections, and the advantages of those connections, with the system. Unless you can get a very long-term contract with somebody who is not going to go bust in 30 years, nobody can do it.

We have to bring these into the system. If we do not bring them into the system, it is only fair that we should know the extra cost of electricity that comes from not using the cheapest method of generation. There are many communities that do not want it, but there are many other communities that do. They should be allowed to have it.

Q22 **Bill Grant:** I am intrigued by your enthusiasm for new-build houses, where we are stacking up problems for the future. Are we sure that we are using the right materials to build houses today? Should we be indulging in more research into what materials should be used? In the not-too-distant future, do you see houses coming with solar panels and heat pumps as standard for sale to the general public?

Lord Deben: I am sure that we should be doing much more of that. It is a very conservative industry. It is also a very consolidated industry. Nine companies are producing 80% of the new houses that are built. It is quite difficult for smaller companies to involve themselves and to compete. It is a very difficult industry to deal with.

In my view, there is a great deal to be said for much more use of wood in building, because that is one way in which you continue to conserve carbon. There are many things that happen elsewhere that we are not doing—for example, on heat exchangers. If you think about a shower, it comes hot over you and then goes away hot. If you have a heat exchanger below, you can take that heat and put it back. There is a whole range of things that can be significantly cheaper, and give you much lower costs of occupation, if you put them into a house when you build it.

We have to do the experimentation, but there is an awful lot around now that could be used. We could have better taps, so that when you turn the tap on, you always have the water at the heat that you want, instead of having to turn on one and then the other. Very small things like that can be done today, with absolutely minimal extra cost, and are just not being done.

Q23 **Chair:** You referred to the need for electrification of transport, as you put it. Was that a reflection of what the committee has decided—that there should be electrification, rather than alternative low-carbon technologies, such as hydrogen?

Lord Deben: It is generally recognised that the most important area that electricity can serve is the motor car industry. It is quite clear that that is what the industry is going with, with one major exception. That is the direction in which it is going. That is what the Government have agreed to and have dates on. We were commenting on those dates. The fact is that, if we do not bring those dates forward, the contribution that is necessary from the electrification of motor vehicles will not be sufficient to meet the requirements of the budgets. That is why we have said that we must get on with both the provision of charging facilities and the dates at which people will have to stop selling damaging motor cars.

Chris Stark: We do have a broad view of the whole transport challenge, and hydrogen does indeed play a role in our future modelling. It is particularly useful for heavy goods. Our most recent report on hydrogen pointed out that it looks very much like one of the best solutions, if not the only solution, for that challenge. It appears that the market has moved on, as Lord Deben says.

Q24 **Chair:** We should go down different routes for cars.

Chris Stark: Yes. Both of these can be viewed as infrastructure challenges. The question is: how quickly can you have that infrastructure in place to allow you to meet the target laid out in the Climate Change Act?

The challenge for heavy goods is very difficult because it is an international one and not one the UK can solve alone, because you have heavy goods vehicles making their way right across Europe. Therefore, you need a solution that would work for the vehicles that make those journeys. Moving from depot to depot with the requirement for a quick refill works very well with hydrogen infrastructure and would not require the whole country to have that infrastructure; it would be needed only in certain places, so it could be matched quite well with the industrial strategy that has localised production of hydrogen.

That is not necessarily the case for electric light vehicles and cars where an electric solution with charging more readily available throughout the country would work extremely well; indeed, that looks the way the market is headed.

Q25 **Vicky Ford:** You have mentioned more electrification of vehicles and the need to manage demand on the electricity grid. Are the Government doing enough to make sure that the grid is smart enough to manage fluctuations in demand?

Lord Deben: It is always difficult when one is asked whether somebody is doing enough. The fact is that in this area it is only when you do the other things that you have to get this right. Therefore, they are doing enough to do what is happening, but they are not doing enough to meet the demands that will happen if they do enough to meet the targets in the end, so all these things run together.

There is a great deal of mythification around all this. People talk as if this is a huge problem. If you manage it properly, it can be delivered. If you leave it until the last moment—this is why I am very much in favour of your question—it is very expensive, but if you are constantly upgrading and looking at technological ways of reducing the pressures and handling distributed energy supplies, instead of centralised ones, the difficulty is that we have a grid that was built for centralised large supply. It does take time to move that, but if it takes time, you have to get on with it, and I do not think there is the impetus at the moment.

Q26 **Darren Jones:** Drawing on Vicky's point, when we talk about the smart energy grid, I understand it from the national grid and the distribution network perspective, but when we think about our constituents' homes, it feels nowhere near ready to deal with flexibility, digitisation and decentralisation. We have the ongoing smart meter roll-out. What is your view on where we are currently and how long it will take before my smart washing machine, for example, turns itself on and off with lower prices on smart energy tariffs?

Lord Deben: That is if you have not been frightened by certain newspapers that this is a spy in the cab. At the present rate, it will be far too long until we get there. This is a mixture of making sure that manufacturers and suppliers are all in line. The best manufacturers are quite a long way down this line, but there is a great deal more to be done by electricity suppliers. Until you have the proper roll-out and completion of smart metering, there is the difficulty of servicing an area. There is a real differential between those who can use it and those who cannot. All sorts of issues arise there.

I come back to the very first thing we said: urgency is the issue. If we do not get on with it, we will not be there at the time we need to be there. If we are not careful, we will have a decarbonised electricity supply but we will still be using all sorts of other things because we have not moved as we should, and we will not get the maximum use out of that decarbonised electricity supply because we will not have got the connections or balancing right. That is why I am personally a huge enthusiast for the hybrid boiler, because it seems to me to be a very clever way of ensuring that we get base electricity but, instead of spending it on building great big institutions, we pay people themselves to upgrade and therefore change their own habits and carbon footprint.

Chris Stark: Maybe 10 years ago we thought that the smart meter roll-out was an essential component of making the system smart overall. It is true that when we have smart meters rolled out we will be able to do things that we cannot do without them, but the whole area is one of the most exciting ones to look for innovation at the moment, particularly service provision to customers.

You can have all sorts of smart connected devices now that do not rely on smart meters and offer the energy efficiency improvements and smarter energy system that we did not think we would have 10 years ago without

them. This is an area where I am very optimistic about how technology can drive improvements.

It is worth thinking about the world from the perspective of the national grid, remembering that we have to have an electricity system that can deliver the peak whenever that peak is. If we continue down the route we have pursued in the past, we will simply add to that peak, so the big challenge overall is for the system to smooth out those peaks and for us to have a less peaky electricity system in future. That will be cheaper overall for the consumer.

These technologies—in particular, the ones we have been discussing today, like heat pumps—offer the prospect of smoothing out our consumption of energy in a way that means it is cheaper overall. The crucial component missing at the moment is the time-of-day tariffs that would make all that work.

Q27 **Darren Jones:** This inquiry is specifically about technology and how we meet our climate change objectives, but the challenge with the energy system is probably more about regulation than technology. It seems to me that, broadly, the technology exists for what we need to do today, but we should hurry up the way the market responds to it and build the regulatory framework that incentivises some of the infrastructure companies to do that.

My understanding is that the way the national grid operates in incentivising non-traditional companies that provide power to the grid has not worked particularly well in the past—for example, the fast frequency response or the recent problem with auctioning markets based on the European decision, where we have done it in the UK. Is there an easy win? Have you been able to advise the Government on how they should structure the regulatory framework to speed this up, or is that still a debate to be completed?

Lord Deben: We have been rather careful about our remit, and there is an element here of this not being our remit. Our major purpose is to say what levels people have to reach, and scenario planning to show how you can do it, but we have to be a bit careful about moving into an area that ought to be the result of those targets. It ought to be Ofgem and others that set that.

I want to underline the first thing you said. We have to remember that, although people are paying £9 a month more for their electricity because of the green measures, they are spending £20 a month less because they are using less electricity, and that is the result largely of technological advance. If you have a smart boiler, toaster, kettle and all the rest of it that do not use as much electricity, and put it all together, you are using less electricity. That is the route.

One of the reasons technology is so important is that you can reduce people's energy demand, and that effect on bills is really important. Until

the Committee on Climate Change started working out what the bills were instead of the price of electricity, nobody understood it, and when we did put it out, those who do not believe in climate change were extremely cross because it revealed the opposite of their last remaining policy, which was that it was all very expensive for people. It is the opposite; it lowers the cost to people, so the technology bit is absolutely crucial, in our minds.

Q28 **Darren Jones:** We have talked about some of the hard things. In terms of the "no regret" technologies, we have talked a bit about taps already. What are the easy wins that we are not doing at the moment that we ought to be doing?

Lord Deben: Onshore wind is obviously a very simple, easy win, and we should be doing it. If you are to redo your house—people do that in a big way—there is no place you can go to ask, "Will you give me a list of the things that I might consider to make my house more efficient?" The Government ought to ensure that anybody who is thinking of doing renovation can do that. Regulatory changes about what energy efficiency measures you have to take if you extend your house and such like could certainly be made. Those regulations could certainly be tightened up a bit.

My view is always that, if you can help people to spend money in a way that reduces their energy costs and carbon footprint, that is the moment you apply it. That is why we have been so successful with white goods. We told them what the energy efficiency was. It is another example of the value of the European Union. It is there every time you go out and buy something. The result is that, whereas you used to have G and H on some of them, they are now A, A-plus and A-plus-plus, because at that point people will make that choice.

The biggest easy win for me is to ensure that people have a ready understanding and do not have to be geeks. Mr Lamb might want to think about changing his energy system. I am about to try to do it myself. I find that, even with the connections one is bound to have, it is quite complicated. You need to have confidence in the person who installs these things. We have to look again at the way installation happens, and whether people are qualified to install some of this equipment. I mentioned that, even in the gas situation, setting is crucially important. There is a whole area where we could make easy wins.

Q29 **Chair:** One scandal with a failed installation brings the whole thing into disrepute.

Lord Deben: Yes.

Q30 **Graham Stringer:** Before I come to my main questions, may I follow up the interesting points you were making about housing? At the moment, a huge row is going on in Greater Manchester about the Government's spatial framework. You made sensible points about insulation and

improvements in heating houses, but is not the really big win not to be building new estates miles from other centres but to have more densely populated cities where you get benefits from shorter and more efficient journeys, better use of sewers and so on? Yet the Government, partly from the Conservative party manifesto, are insisting on building so many houses miles from urban centres. Do you have a view and policy on that?

Lord Deben: I am not sure we have a policy, but I have a view that I am prepared to give.

Graham Stringer: Maybe it will lead to a policy.

Lord Deben: My view is that the whole history of civilisation is tied up with the city and that people should live decent lives. There is a choice: one is living hugger-mugger in the city, with all its advantages and such like; the other is living on your own a long way away in the country. I think there is something to be said for this.

The truth is that we ought not to be building on greenfield sites until we have used properly all the brownfield sites. I was Secretary of State for the Environment. I believe it still to be true that there is enough land on used sites to meet all the requirements in London, for example. I do not know the figures for Manchester, but I bet there is a good deal of land there that can be used for this purpose. It is a much better way of providing homes; it is very much better for the environment in terms of travel and such like.

Many of the people who want or need a new home want that accommodation. They do not want to be part of the new town concept, which, taking your own part of the country, is a very good example of what Liverpool did after the war—to put people into distant places without any of the satisfactory services they needed.

I should have thought we had learned that, but, if you are to do it, you have to remember that house builders do not like it, because it is much easier to have a flat piece of land on which to put a whole lot of houses; it is otherwise much more difficult to plan it.

If that is the case, there is a great argument for saying that this is an area where Government intervention would be very worth while—certainly allowing local authorities to provide the infrastructure and impetus to build in this way. If you allow people to build on greenfield sites, they will always do that first. That is why you have to restrict it, in order to force them, if you like, to look at the more complicated and difficult areas.

Q31 **Graham Stringer:** I refer to one other issue, on new technology and more efficient use of energy in the home. You referred to Helm. In "The Carbon Crunch," his latest paper, and at other times, he has said that you get the biggest wins from insulation and better use of smarter kit with the poorest people. When people have passed a certain income

level, they just buy another gadget, so you do not make the energy savings. In the examples you were giving, have you taken that into account?

Lord Deben: It is a much more complicated matter than that. The problem with the poorest people—I have always been a campaigner for dealing with pure poverty—is that they tend to heat their houses to a budget because that is all they have got. If, as we should, you insulate them and do the rest, what happens is that they heat their houses more and you do not get the maximum amount from that. This is perfectly understandable. I do not think it is as simple as that.

The truth of the matter is that you get benefit wherever you do it, and we should be doing it at every level. If you get a social benefit because children are now going to school without wet clothes—I saw a very good energy efficiency programme in Wales—that is one area, but when people upgrade they do not buy enough new equipment to make the difference.

This is a bit of a canard because, if they buy new equipment, it is very much more efficient than the old. I am not at all sure that there is the same balance. All the work I have seen in the past shows that you get the maximum efficiency from people who are already heating their homes as much as they want, but with insulation now have to spend less on energy. That is where you get most benefit.

Q32 **Graham Stringer:** In the reduction of carbon dioxide, is it not better to look at the consumption rather than emissions figures? The consumption figures are much lower because they do not take into account the carbon dioxide produced in shipping, planes and less efficient manufacturing in India, China or wherever?

Lord Deben: The fact is that internationally we do this by a measurement that you can control. We do it that way because we can control the way we do it now. If you do it on consumption, you have a real problem with double counting and you do not have a proper comparator, but you need both.

The Committee on Climate Change regularly produces a report on the consumption figures so that you can compare them. That is a very important element. They are more difficult for the reason you mentioned. You have to work out the energy efficiency of the stuff you are bringing in from China, or wherever else it is. You have no control over that so it has limited help, but it is very good as a reminder to people that it is their total use and purchase of energy and all the rest of it that is the difference, because this is a world problem and we will solve it only on a world basis. I think you need both, and that is why we do both.

Q33 **Graham Stringer:** On the amount of carbon dioxide being produced in the world—you are right; it is a global phenomenon—we had this debate a long time ago on the Floor of the House of Commons. This country's impact is relatively small. When I pointed that out, your answer was that

we should take the lead; it was a leadership issue. India has cancelled its nuclear programme and is building lots of coal-fired power stations, as is China. Carbon dioxide emissions are increasing globally. What do you think that says about the efforts we are making and their relevance and significance?

Lord Deben: We have to be careful about picking examples. China is doing overall more than any other country at this moment; it has made a huge difference and will meet targets that we would have thought impossible for them to do.

As for India, you can see both sides. There are some good stories and less good stories, but these are happening. Partly as a result of what the European Union and we have done, the world has now signed up to something that you would never have imagined five years ago. Paris is a remarkable breakthrough and, therefore, it seems to me that the world as a whole is doing that.

As far as we are concerned, there are three reasons why this is crucial. It is not just our leadership. A very high proportion of the climate change that is taking place now was created by us. We were the leaders in the industrial revolution, so as a nation we have done this, and we have benefited from it. There is no question that we have a responsibility, moral and direct, to do our part.

If the people who have benefited from pollution by being rich—that is what has happened—do not take those measures together, there is no reason why India or China should think they should do it either, because all they will say is, "You rich countries are busy not doing it and still grabbing all the benefits."

We have to take that lead, and we have done it. We are in a very much better position today than we were five years ago. I did not believe we would ever get to the stage of the Paris agreement and have a mechanism. Even the most unlikely meeting in Poland turned out to be much more successful than anybody thought it would be, so I am optimistic but also demand urgency. I put those two things together.

Q34 **Chair:** Presumably, you would also say there is an economic opportunity by leading green industry.

Lord Deben: My own view is that there is no future for our economy unless we do this, because this is what we will be able to sell. I absolutely agree. I think that every now and again we ought to look at ourselves from a moral point of view and say, "What are we here for? What is our responsibility? What kind of people do we want to be?"

I cannot think of a better time to do this than this moment, because most of the discussion now is of a very ungenerous and extremely narrow, nationalistic kind. It is very important for us to say, "What kind of country do we want to be? What do we want our grandchildren to think of us?" This is the biggest challenge we have; let us treat it in that way.

Q35 **Bill Grant:** You touched on the Helm review of energy costs. Professor Helm made a number of recommendations, one of which was to introduce a carbon price across the economy. Would you concur with his findings and that recommendation?

Lord Deben: I think it is a perfectly reasonable mechanism and there are lots of arguments for it, as long as you do not think it is the only thing to do. I am always worried about silver bullets and saying that, with one bound, we are free. It is complicated. Getting it right and seeing how you weigh it in various bits of the economy—agriculture, for example—is quite complex. It is something one should work to, but we probably have to improve our present system as a preliminary to that.

Carbon price is clearly not a reflection of the real price. We have to think about that as well as internationally. This is one of those things that are very important internationally because of our competitive position.

Chris Stark: There are many ways in which the carbon price is levied already across the economy. It often has not been the point of the policy that levies it, but none the less it is the effect. Dieter Helm is correct that there has not been a strategic approach—the Treasury in particular should think about that. The transition we would advocate for our transport fleet, for example, would see loss of fuel duty at an astonishing level, which would require a full airing of a strategic approach to the tax system. I am pleased that Dieter Helm has raised these issues, because carbon pricing and carbon taxation may be very important for the next stage of what we do in the UK.

Q36 **Bill Grant:** Another of the numerous recommendations was replacement of the feed-in tariffs and contracts with equivalent firm power auctions, as I understand it. Is there value in that, or are we already on that journey?

Lord Deben: We have a system, and improving it incrementally as fast as we can seems to me to be the way forward—but all the time challenging it with other ideas from outside. I am very pleased that Dieter Helm has made those challenges. The way you do it is, probably, incrementally, recognising that we are already doing some of that. I think it would be a good thing to rationalise it and see it as a strategy, but I am not terribly in favour of the view that suddenly sweeping one thing away and putting something else in its place is going to be satisfactory.

Chris Stark: We said in our progress report in June that the mechanisms that had been put in place—in particular, contracts for difference and some of the other elements around that—are suitable, so they are delivering the outcomes the Government have said they should deliver and they are working. Our view is very clear that, if it is working, why change it?

Q37 **Stephen Metcalfe:** There has been talk recently and recommendations that we move from trying to keep global warming targets from below 2°

C, to 1.5° C, above pre-industrial levels. If that were to be adopted, what impact would it have on the efforts that the UK is making? Is it more of the same? Does that increase the urgency and the challenge for us?

Lord Deben: I am always loth to prejudge what we are going to do in great detail. As you know, as a result of the Government's request, we have started doing something because we knew this was going to come. In about April of next year we will report, but in advance of that the truth is that the only way you can meet these things is by a reduction in our carbon footprint. We have to change everything we do to reduce our carbon footprint.

There is also no doubt that we have to think of ways—let us take the example of trees—to take carbon out of the atmosphere. I mentioned earlier the fertility of the soil. It is crucial for agriculture that we improve the fertility of the soil, but it is also crucial for climate change—particularly when we get down to these levels—that the soil is able to absorb carbon more effectively. That means it must be more fertile. It is also a curious circular system, because, if it takes in the carbon, that also helps its fertility.

You are right that it is much more of the same. It is tougher because it is a tougher target, but it seems to me that we now have within our grasp the ability to do it, although, interestingly, the decision was a political one, not a scientific one, simply because people realised that, if you do not do it, countries like Bangladesh and those in the south Pacific will be affected. Not only is that devastating for them. I sometimes say to people who are very interested in immigration, "What is going to happen to those people?" Nearly 200 million Bangladeshis live below sea level. If the sea level continues to rise, what is the cost, let alone the social issues, of dealing with that? If you have 200 million people looking for a place to live and countries in the south Pacific buying land in other countries because they will not exist, which is where we are, it seems to me that we take these measures very seriously.

Q38 **Stephen Metcalfe:** You have painted a stark picture, but bear in mind that the Science and Technology Committee is looking for solutions to some of these issues. Do we need to be focusing the Government's mind on promoting and supporting negative emission technologies much more and, among the wider public, breaking down potential scepticism—getting people to embrace the technology because it is good for the environment and the planet, but also good for their wallets?

Lord Deben: I think that is absolutely true, but it is, as always, more complicated. For example, the trees that we should be planting are not always the ones that people particularly want, because broad-leaf trees are less effective than pines. We have to consider how we deal with that contrast and conflict in the way we think about the environment. The pines come from a very much earlier date and, therefore, are a lot better at taking out carbon, and they also provide us with building material so that, having conserved the carbon, we can use them in building.

It is more complicated than is sometimes said, but I think the Government can take a real lead in this. Indeed, to give Mr. Gove his due, the latest speeches and measures of DEFRA have certainly moved very significantly in that direction and should be encouraged.

Chair: Thank you very much indeed. We really appreciate your time. It has been a fascinating session.

Examination of witnesses

Witnesses: Professor Watson, Malcolm Brinded and Guy Newey.

Q39 **Chair:** Thank you very much for coming along. May I start by asking you to give your overall impression of the Government's clean growth strategy?

Malcom Brinded: It is very good; it sets out an intent. There is clarity around the technologies needed, and it is good in commitment to innovation. We share the view of the CCC. I am representing the Royal Academy of Engineering. We submitted evidence from seven institutes. I am president of the Energy Institute. Both bodies have a lot of expert feedback that agrees with the CCC view that we are not going to meet the carbon budgets on the trajectory we are on.

I would make two other points. There is too much emphasis on separate technologies and not enough on the system impacts, which was touched on in the earlier evidence. We think more consideration should be given to the global challenge of meeting climate targets from a development point of view, but especially because of the climate and export potential of developing technologies suitable for emerging economies in the developing world. It does not get much focus, but it is a huge opportunity to have much greater impact, probably at lower cost, than just continuing to drive down our own targets.

Q40 **Chair:** I should have asked all of you to introduce yourselves briefly for the sake of those watching. Perhaps you could quickly say who you are and where you are from.

Malcom Brinded: I have spent 40 years in the global energy industry. I am here as president of the Energy Institute and a fellow of the Royal Academy of Engineering, and we have brought evidence from seven engineering institutes.

Professor Watson: I am Jim Watson, director of the UK Energy Research Centre. I am also a professor of energy policy at UCL.

Guy Newey: I am director of strategy and performance at the Energy Systems Catapult, the Government-set-up innovation agency in the energy area.

Q41 **Chair:** I am conscious of the fact there has been some comment on Twitter that the two panels today are entirely male. We are not blaming

you for that. I would like to say to those people who are watching that we make strenuous efforts to get more diversity among the witnesses who come before us. Since the 2017 election 40% of our witnesses have been female, which is a significant advance. We try very hard on this panel, but it proved very difficult. I just want to make that point clear.

Returning to my opening question, do either of the other witnesses want to comment on their impression of the Government's clean growth strategy?

Professor Watson: I am probably going to be boring by echoing what others have said. The UK Energy Research Centre likes the level of ambition. I think it is taken seriously in meeting the climate change challenge in a way that benefits people and the economy, but there are a lot of gaps in policy in the short to medium term. I think those were well rehearsed in the previous evidence session.

I make one other point, which I do not think has come out yet. We make an annual assessment of where our energy policy is going. We published our latest one just before Christmas. One thing we highlighted in it was the need to implement this transition in a way that pays attention to equity, particularly to the fuel poor, thinking about things like implementing upgrades to homes and targeting them first. It may not give us the carbon benefits of targeting wealthier homes, as Lord Deben said, but it is right to do that, making sure we strengthen equity and address some of the arguments sometimes made that we are spending too much money and that there is a disproportionate burden on poorer consumers and citizens.

I think that is also about the industrial strategy benefits and jobs benefits, thinking about the regional economies and spread of those benefits in the way we implement those strategies. I do not think the UK Government are doing enough on either count. Scotland is doing much better. It has set up a commission to look at the whole thing—how we implement the transition in a just way, not simply to get to a carbon target.

Q42 **Chair:** In your submission, you indicated that you believe the Government were not spending nearly enough. The spend at the moment is £2.5 billion between 2015 and 2021. What is the right amount to spend? How do you assess that? Are you just making a general comment that it needs to be more? How do we assess the right amount?

Professor Watson: It is very difficult to assess, but the international evidence—we reviewed this in making our submission—is quite thin. There is a lot of work on this in the US, where people tend to conclude that budgets should be increased by about five times, sometimes 10 times. It is hard. You can use all sorts of modelling techniques to get to those conclusions. Sometimes, the conclusions are about a subset of technologies, so they are looking at just electricity; they are rarely looking across the board at all the technologies we might need.

The key point, as well as thinking about the overall number—it is welcome that UK spending has been going up, particularly if you add in innovation spend as well as basic R&D—is what you spend the money on. That is just as critical as getting a big number. A big number that is spent unwisely would be a waste, but with a big number spent very wisely you can make huge gains in technology development and market deployment.

Q43 **Chair:** I want to turn to Guy and then I will come back to you, Malcolm. What is your overall assessment?

Guy Newey: I should declare an interest because in my previous role I was involved in drafting quite a lot of the clean growth strategy. If you want me to wax lyrical about the elegant writing, I am more than happy to do so.

From a catapult point of view, on the substance there are a couple of things I draw out. There is good focus on innovation—a greater focus on innovation.

On Jim's point about the right level of innovation spend, it is important to stress that in a sector like energy, which is a relatively low-innovation sector—it takes a long time to get innovation happening—the public spend on innovation will always be a relatively small amount of the overall spend on innovation, so when you think about market design and how the Government spend money, the challenge is how you get as much private sector innovation as possible playing its role.

Q44 **Chair:** How you leverage it.

Guy Newey: Exactly. It is a lot about how you design markets to make sure there is going to be a market for the new product.

One area where the clean growth strategy was probably pretty honest about where more work and the greatest amount of innovation are needed is how we heat our homes and businesses in the UK—in particular, what consumers are going to accept in their homes.

Q45 **Chair:** You endorse what you heard from the first panel about the heating of buildings.

Guy Newey: I came in slightly late, but the recent CCC reports on hydrogen are in a very strong place on that.

Q46 **Chair:** Do you share Jim Watson's view that we should be spending more? I appreciate your point about how we spend it and how we leverage private sector investment, but do you think that the state, as part of that, needs to be spending more than it is at the moment?

Guy Newey: The scale of the challenge is so huge that the state should be spending as much as it can on that, but, if it does not get the market structures right, there is a real risk that it will just be supporting isolated

innovation projects, which will not lead to the kind of change you are talking about in your systems.

The lesson from the electricity system in the UK is that you need to get the innovation spend—the earlier-stage R&D stuff—lined up with the market mechanisms, and then you can see extraordinary cost reductions in technologies. If you do not do that, you will end up spending bits and bobs of money, but quite significant sums of public money, that will not lead to the kind of change you need.

Q47 **Chair:** There has been some criticism in the written submissions we have received about the amount of money being committed by Government to spending on projects that demonstrate technologies and get them ready for market. Do you share that view? Malcolm, I promised to come back to you anyway.

Malcom Brinded: It is a combination of the amounts of money. Given the scale of the challenge we are facing and the fact that in the next five to 10 years we need to polarise some big choices as a country, we need to be in a position where we have proven or tested what some of the big solutions are going to be around homes, heating, demand-side reduction and so forth.

Q48 **Chair:** As Guy suggests, does that mean testing new markets?

Malcom Brinded: I think it also involves testing at scale between early-stage R&D and final mature markets. You may not need to intervene in final mature markets—you should not have to—but there is a stage where you are scaling up and need to test at scale on an integrated system basis. Heating and decarbonisation of the gas growth is one such example. We have the integration of smart grids, electric vehicles, smart homes, demand-side management and price signals. There is a lot of theory, but to get to the result of how big an impact this is going to make, and at what cost, you have to test at scale. That will need more money than I think is allocated.

Q49 **Chair:** Does that also imply that we do not have the right balance between early and late stage?

Malcom Brinded: Yes. The view of all of our respondents was that more needs to be done on large-scale demonstrations and pilots. I talked about heating, AV and smart grids, and CCS. I think £100 million is allocated to that. That is pretty small in comparison with the scale of the projects required to be tested.

CCS is going to be an essential component of any negative emissions strategy for the world to get to 2 ° C and certainly to 1.5 ° C, and it is an opportunity for the UK to be at the front of that.

Professor Watson: It is welcome. We should give the Government their due that they have shifted towards funding more on demonstration,

which is classically where innovations fail and fall in what is sometimes called the valley of death.

We did a review and found over 120 demonstrators of local energy systems. One way or another, they are funded or co-funded through the public sector by regulatory rules through Ofgem, direct spending and so on.

There is already a lot going on. New programmes are being launched under the industrial strategy challenge fund on smart electricity systems, for example. The catapult is doing work on heat. There is potential for a new zero-carbon industrial cluster by 2040, so there is a lot of activity. I think they should do more.

For me, in answer to your question, the balance needs to be towards demonstration and creating the markets for deployment. That is where the action ought to be. Part of our argument for that is that, over the timescales we have to meet the kinds of targets we have, we cannot afford to rely on new breakthrough innovations to deliver commercialisation in that time. We have done a couple of evidence reviews; we are halfway through a second one. Our evidence is that those timescales are long; they can be on average 30 years from invention to getting to 20% of the market, and for some technologies it has been much, much longer.

Q50 **Chair:** We need to be making bigger commitments to bigger-scale projects to demonstrate how existing technologies can be deployed.

Professor Watson: It is that, and in some cases they will not work out; some may fail. We have to do a sufficient number of those, particularly for some of the very big decisions we need to make, such as large-scale hydrogen trials for heating real homes in a real city. Those are required to give us the kind of evidence we need to make those decisions.

Martin Whitfield: To continue that exploration of demonstration projects, I understand we were going to hear from Jonathan Wills, but unfortunately he is not well today. I hope he gets well very soon. Guy, if we look at the Energy Technologies Institute, I suppose the open-ended easy first question is: how will the catapult fill that vacuum, to use an engineering term, as it goes on?

Guy Newey: The institutional history is that the catapult is taking over a lot of the functions and staff of the Energy Technologies Institute. That process has been taking place over the past few years.

What do we see as the challenge in the catapult in being able to replace and improve on the ETI? We are still a relatively new institution, but the challenge for us is going to be: can we get the level of large-scale private sector investment that the ETI was able to do because of its unusual structure? When plenty of large-scale energy companies and engineering companies are under real pressure, that is a very difficult thing to do.

When the ETI was set up in 2006-07 it was a slightly easier time to get money, but that is one of the key challenges for us.

The second question is whether, as an innovation agency, we can achieve that at the same time as being—I am probably being a bit unfair to the ETI—as open as possible with our learning to make sure that society is capturing the benefit from innovation, because the risk with lots of private sector involvement is that it wants to protect its IP and does not want anyone doing it. That was part of the reason the catapult was set up. Therefore, it is about achieving those two things, which are sometimes in tension.

Q51 **Martin Whitfield:** Are there any comments about the Government's support for demonstration projects? What should they do? How should they go about supporting this? What would the ask be today?

Malcom Brinded: There are two domains to think about. The private sector is not going to invest in that scale because at the moment there is no clear economic or commercial driver for it to do so, but it is very important for the long term. CCS has been a prime example of that because there is no obvious clarity about the long-term market that will provide a return for it. That technology absolutely needs a level of Government support for it to be proven at scale and implemented.

It is also true where complex system issues are involved. It is not about testing the technology but about testing a system, and the discussion everybody has had about heating, not just for residential purposes but for commercial and industrial use. The choice between electrification of the heating system and decarbonisation of the gas grid is an enormous one with a lot of implications, and I think it needs some serious large-scale testing to understand and polarise that choice well before we are too far down the line.

Guy Newey: The large-scale demonstration capability that the ETI developed in lots of different areas, which the catapult has overtaken in some cases, is absolutely essential. There is a lot of early-stage research on a small scale, but you need to be trying things in the real world, testing what works and what does not—some of it will not work—and unless you have it at scale with serious money, which is just a step before commercialisation, you will fall into the trap.

Q52 **Chair:** Are we failing to do that sufficiently at the moment?

Guy Newey: The way I would characterise it is that, at the moment, we have early-stage research. As Jim said, we have dozens of projects going on. The key challenge for the new money that is being spent under the industrial strategy challenge fund and by institutions like ours is: how do we bring those together in big demonstrations testing the huge questions? That is going to be around heating, nuclear technology and CCS. Those are the technologies that the systems analysis says are the most important for meeting 2050.

Professor Watson: The reason I emphasised hydrogen in my earlier answer is partly because there is an asymmetry of evidence about the heat pathway. We have a lot of evidence both in the UK and internationally about the electrification route Lord Deben mentioned, but there is hardly any real-world evidence of the hydrogen route. There is a lot of talk about hydrogen; a lot of lobbying and desk studies are going on. I think the danger at the moment is that, at the political level, the lobbying succeeds and we decide to go down that route, but we have less evidence for that route than we have for some of the others. I am not saying that it should be one way or the other, but that is why I feel it is such an essential priority right now.

In other areas, such as CCS, which Malcolm has mentioned, I increasingly feel that we have got beyond the demonstration point. If you look internationally, demonstration has happened. I am more and more convinced by the Oxburgh review argument, which says basically that we know how to do this and that what we need is a market creation set of mechanisms for how to finance deployment of this stuff rather than keep going round the loop of demonstration, which has been a very unproductive and painful process in the UK over the past 13 years.

Q53 **Martin Whitfield:** To bore into that slightly, one very important cog is the role of local authorities, especially in strategic planning. Guy, you are the person to ask. What support do local authorities need from central Government to make this work?

Guy Newey: Some of the work ETI did, which we have taken over—our smart systems and heat work—did detailed local planning in three areas: Greater Manchester, Newcastle and Bridgend. I take a couple of points from that. The pathways for decarbonising in different areas are hugely different, particularly when you are not just talking about electricity for heating solutions, whether it is district heating, heat pumps, hydrogen and so on, suitable for a particular area.

We think that local areas at the right scale—it is quite a large scale, probably similar to DNOs or grid operators—need to have a view about how that works, but capability in those particular areas is pretty weak. It is about finding relatively low-cost ways of making the data more available, because data about what is happening at local energy areas are abysmal. I heard the earlier conversation about energy and smarts. You cannot overstress how early in the foothills of the mountain of data and digitisation the energy sector is; it is only beginning to realise the challenge and the data in understanding where things are, and people are not just pulling out physical maps and saying, "That's where our network is." The fact that that is not digitised is a big challenge.

Q54 **Martin Whitfield:** So would you put exploring and improving that data capture and use as one of the priorities in how to move this on?

Guy Newey: Yes, I think so. Improving the availability of data and access to it is really important. We have done relatively difficult early-

stage local planning, which tells you which are the best pathways for particular areas; we need then to scale that up and trial it in different areas. That is absolutely essential. To go back to the innovation question, that reveals which areas are best suited to particular interventions.

Malcolm Brinded: Again on heat, there are aspects where the role of local authorities could be really important in encouraging local heat networks. I think that there are some 14,000 in the UK, but they are nearly all focused on a few authorities that have paid particular attention to them. Yet the potential impact of that on the outcome is really significant, if they can be encouraged and local authorities understand what they have to do in working with developers and local industry to enable that to happen.

Again, it is not something that happens as an isolated decision by a single consumer; it is a much more complex outcome to achieve, which is why it is so important—it can have disproportionate impact and benefit.

Q55 **Martin Whitfield:** Who should be responsible for ensuring that that expertise sits within local authorities? Where does that responsibility lie? Who empowers the local authorities?

Guy Newey: I am not trying to dodge the question—it is a really tricky question. You have to think about what the right scale is. Obviously, within local authorities you have a huge variety, as they cover particular areas. It might be that there is only a relatively small number of sub-stations, but our starting point would be that the combined authority level starts to get to the scale that you need. It depends on the geography, but the area has to be large enough that you are making useful decisions. You have a view of the whole system there. If it was too tight, you could say, "Yes, it is absolutely right to put a factory connection there." But then, if you zoom out a bit, you may suddenly understand that you are about to get HS2 through the same area, for example, which will probably have some large electricity demands. You have to make sure that the two things fit together. So it is not a straightforward question, but it should be along the lines of where the distribution network is; that is probably a reasonable starting point.

Professor Watson: Ensuring that expertise is a shared responsibility. We have worked with local authorities, between the local authorities themselves at whatever level and central Government. The problem with many local authorities, even those that are doing quite a lot, is that they are very dependent on specific income streams via specific programmes. We had a conversation with the Treasury about the mechanism that allows them to build up a general capability in this area, whether it is about giving them obligations, or whatever, and the budget to match. When you talk to local authorities, you find that that is often the struggle—they get offices in place on the back of particular projects and programmes, but that does not necessarily mean that over a long term they will get the capability that enables them to make those sorts of planning decisions, unless they are very entrepreneurial and successful.

Guy Newey: This is an area ripe for trying stuff out in different local areas. You will learn a lot from the next iteration, we would argue, of what we have done already.

Q56 **Martin Whitfield:** It is, as you say, as much about the need for a demonstration, not necessarily of technology but slightly higher than that—it is a system that needs to be demonstrated. As you say, some may fail and some may succeed, but the local authorities and communities need the support, which has to come from central Government, to try it. Would that be fair?

Guy Newey: Yes.

Q57 **Graham Stringer:** Is the problem of the evidence base for hydrogen understanding the costs of producing the hydrogen going into the system, or is it something else?

Professor Watson: There are a number of aspects. One is the cost of producing the hydrogen. At the moment, people think in general that steam methane reformation—converting methane into hydrogen and capturing the carbon—is probably cheaper than electrolysis, which is splitting water through electricity. Clearly, one prize is that if you can get the cost of electrolysis down it might give you another option.

There is the demonstration of converting your network to use hydrogen. Most networks can use some share of hydrogen, but another interesting question is how far you can go there. Then there is the demonstration of the end user—appliances, what you need to do in people's homes or businesses to be able to burn hydrogen rather than methane. Attached to that are questions about the financial model, consumer acceptability and whether, with that much change, it will still be as acceptable and whether the service will be as good.

I would emphasise a need for system demonstration. Of course, there are particular areas of science that you need to do that for, with technology development in that chain, but there are a number of aspects, all the way from production through to use.

Malcolm Brinded: Jim has summarised it really well. The only other thing that I would say is that it is a bit like offshore wind. How much will the cost come down when you do this at scale? Hydrogen clearly will have to be done at scale, because we will understand the cost of every aspect of it—the production of the hydrogen, the CCS required for the CO_2, if you use steam methane reformation, and the infrastructure to deliver the hydrogen and get it into millions of households—only when we have tried it at least at some scale, not just on an isolated basis.

Q58 **Graham Stringer:** There has been huge consumer resistance, not just in this country but in Germany, to CCS. I do not know; I guess that there may be a great deal of consumer resistance to changing a gas supplier to hydrogen, because it goes boom sometimes, does it not? It is a more dangerous gas than methane. What evidence do you have on consumer

resistance, and what approach would you take to that consumer resistance?

Guy Newey: First, on the wider point about heating technologies and why heating is such a difficult problem, while we have changed the electricity system, ultimately, when I go home and I switch the light on, the lights still come on, whether it is powered by wind or whatever. With heating, you are talking about whether to have a hydrogen boiler versus a heat pump versus a hybrid system, and so on. People are not familiar with those technologies; people like and are used to gas boilers. So, we need to test all those heating technologies in the real world to see how people actually respond to them and, crucially, to see whether businesses can sell them to people in the real world.

We do a lot of that work on a relatively small scale, with 100 homes, testing those kinds of questions. Again, it comes back to where you should be focusing your innovation money. For understanding consumer acceptance, you can find that out on a relatively small scale; you do not necessarily have to switch an entire region to hydrogen. You may eventually get to that decision, but you should be thinking, when spending your innovation money, what relatively low-cost steps you can test to see whether consumers are ever going to want this stuff. That is a commercial challenge as much as a public sector demonstration challenge.

Professor Watson: The evidence base on alternative heating technologies and what citizens or consumers think of them is quite sparse compared with, say, that on electricity. The catapult has done some work. I think that there is a good case for doing some upstream engagement with people—not just surveys but citizens' juries or local focus groups—just to help people to understand what the different pathways to heat could be and to try to understand what the pros and cons are of those pathways. It also serves a function of awareness raising. Awareness that heating systems might have to change is probably still low. You get the occasional media story saying that we will all have to throw out our gas boiler, but without really explaining what would replace it.

To inform, and as part of some of these demonstrations, we need to have more of those conversations. We are certainly planning to do more work on this in the next couple of years on that system basis, really just to try to understand the pros and cons of the system changes.

Guy Newey: With the work that we have done on testing with people, you cannot stress enough that people's understanding of how their homes are heated is low. They get a bill in kilowatt-hours, and they have no idea what it means; they do not really understand how their bill relates to how warm they are. Most people's experiences are kind of a fight with the thermostat. I do not mean that happens between husband and wife, although our research has shown that thermostat wars are a real thing.

Ultimately, you are fighting your heating system, particularly with a sudden drop. That is not particularly satisfactory; potentially, there is a better way in which to do that, and digitisation and smart controls and so on are quite an exciting prospect—but you have to take people on quite a journey before you get them to a stage where they will change their heating system in a particular way. For most people, when the heating system goes down—

Q59 **Chair:** You talk about projects that you have been doing with the 100 homes. What exactly have you been doing?

Guy Newey: The 100 homes is our living lab. We have 100 real homes, with real people living in them; they are heavily sensored, with temperature and CO_2 sensors, just to try to understand how people actually use heating in their home. We have been trying to sell them heat as a service, for example, to see whether you can change how people buy their heating. Instead of buying so many kilowatt-hours, we say that they can buy so many warm hours.

Crucially, in the low-carbon context, you are also trying to understand whether you can start saying to people that if they want to reduce the number of warm hours, they need to improve their insulation. It is about trying to understand how people might actually improve things in their homes.

It is a publicly funded and base-funded project, which followed on from work that the ETI did. Of course, I am biased, but I would argue that that kind of demonstration is exactly the kind of thing that needs to be tested, to understand how people do things. I know that politics is full of segmentation analysis about different types, and you can do exactly the same with how people heat their homes, which is extraordinarily revealing, especially when you work out which type you are.

Q60 **Graham Stringer:** I would move on to the Helm review, but I do not know whether you want to comment—because it is not just consumer resistance, is it? There is also ministerial resistance. Whenever I asked Ministers how they intended to change the domestic gas supply, they were very reluctant to say anything at all. Is that your experience—that they realise that it is politically sensitive?

Professor Watson: The short answer is yes. We are doing a bit more work at the moment, including interviewing senior decision makers in the policy world, and that message is already coming out quite strongly. It is seen as a risky thing to do. To go back to Guy's answer, part of the issue is around awareness of alternatives and what they actually mean. Therefore, leaving well alone seems to be the default position.

Malcolm Brinded: As we have all said, the trajectories for how to decarbonise heat in the 2030s and 2040s are very unclear. There are lots of options, yet the work to understand how those options would play out in the real world with consumer resistance, behaviour, price signals and

all the other demand-side management measures that might go with it, has to be done in the period to 2025 to understand which trajectory we should be on. It is not an issue of saying that it will be about hydrogen, electrification or hybrid; it is about really understanding how those systems will work at scale, and the total system around that work. To touch on hydrogen, for example, will it be used in heavy freight transport, or not? That might make rather a difference to whether it is a good vector to introduce into the gas system.

Q61 **Graham Stringer:** I paraphrase, but Dieter Helm said words to the effect that the Government are rubbish at picking winners, but poor businesses were good at picking poor Governments to invest in them. Do you think that that is a fair conclusion from Mr Helm? Is a market solution a better way of arriving at the most efficient and effective technologies?

Guy Newey: Certainly that is what Dieter says, and there is a certain element of truth in that. Any innovation spending, if it is proper innovation spending, will give somebody some money to do something that does not work. If we knew that it was going to work, then it is not particularly innovation.

The more serious point on the back of that, to which I alluded, is that if you do not have the market framework working properly that pulls in these technologies, it does not really matter what you do on the demonstration. Innovation has to be both those things. You have to get the market framework right, and Dieter gives some ideas on how that might work, but then there is also a clear public sector role. Any successful energy technology that has developed in the last 100 years has had very strong public sector involvement.

What is important is that the Government set out clear criteria on which they make those decisions. Does the UK have a comparative advantage in this particular technology? With our current understanding, is it going to help to reduce the cost of meeting our future targets? Is there potential for cost reduction in that particular technology? Some of the criticisms of past policy are that, if you just spray money around without thinking about any criteria, you risk wasting a lot of it.

Professor Watson: I completely disagree with Helm on that point. I think that he did not do his homework properly on this whole issue, on innovation; he did not really cite much of the literature or the experience on where innovation comes from and the relationship between it and policy. The argument over picking winners is rather stale and tired. Markets are important in all the innovation that we have done and that has happened in the UK and other countries. But if you look at the experience of where some of the successful innovations that we now talk about have come from, such as onshore wind, solar, and batteries and EVs, with costs starting to come down, you see that they are all the product of successive interventions by particular Governments in different countries, often in very specific ways.

Where Dieter Helm is right is that that leads to risk; of course it does—it leads to risks of Government being captured by lobbyists to spend money on things that it would not otherwise spend money on. That is why Guy's concluding points are really important. Government needs the capacity to make independent decisions and to resist lobbying when it comes through the door—and that is hard.

Secondly, you need the clear criteria by which you make your decisions. To give Government some credit, over the last few years it is much more transparent than it used to be as spending on innovation has started to go up again. That is much clearer—they have done a lot more homework. Sometimes, still, it is not clear where particular announcements connect to that evidence base, but, certainly, we are in a better place now than we were before.

Malcolm Brinded: It is a stale argument. It is clear that you have to make choices in life, and that includes where you put your money for early-stage innovation funding. People may want to label it picking winners, but that is what successful economies do: they identify the things that are going to make a real contribution and back them. That also includes being mindful and thoughtful, when it is not going to happen through the private sector route, as I said earlier; that is when there are particular cases when you need to put more support into demonstrations and large-scale trials as well as into enabling infrastructure. The grids around electricity and gas, for example, would not have been built without that.

Q62 **Chair:** Or vehicle charging points.

Malcolm Brinded: Exactly—vehicle charging points today, and maybe CO_2 and gathering infrastructure for CCS, and so on. Enabling infrastructure is also really important. In the end, you want to create a market whereby the choices will be determined in the market with large-scale deployment and with externalities such as carbon costs and air pollution properly factored in. But getting to an understanding of how to design those markets, you have to back winners on the way to get the technologies ready.

Q63 **Graham Stringer:** Do you agree with Helm that market interventions have been too complicated and have led to the consumer paying too much? If Helm's recommendations on simplifying those interventions are carried through, will that have an impact on reducing the number of effective interventions? I am sorry: that was a very complicated question.

Professor Watson: Where he is right is that you should always review your policy framework and make sure that it is delivering good value. It is always easy in hindsight to say that we spent more than we should have done on subsidies for wind and solar, particularly in some of the administrative decisions that were made through contracts for difference, before we had auctions. There has been a good National Audit Office report on that. But when we responded to Helm, we were quite sceptical

of the need for wholesale reform in that area, particularly in supporting low-carbon electricity, for two reasons. One is that you have a framework that has worked, particularly when you have brought in auctions to bring down the cost of things such as offshore wind. You can build on those mechanisms and explore so-called subsidy-free, whereby contracts may need to be written for financing projects, but on a net basis you may not actually need to subsidise very much. The second point is that wholesale reform is going to take time—legislative time, and so on. Actually, if we have a set of mechanisms that work, why not build on them?

As for the equivalent for a capacity auction, which one of your colleagues asked about earlier, the risk is that it focuses on each individual generator and makes them all balance themselves; it does not think about the system as a whole and how you at least cost-balance it while shifting it to low carbon. The risk of that other approach is that it may end up costing us more, not less, by asking everybody to balance themselves rather than balancing the system as a whole, which is always inherently cheaper.

Malcolm Brinded: Simplicity is good, but energy is a complex world, so we should not over-simplify it. Stability is probably more important than simplicity, especially for the private sector to have clear long-term signals around investment. We should recognise and respond effectively to significant structural shifts in the global landscape. One example is that we did not in the UK see sufficiently early that there was a much bigger reduction in solar and wind costs coming than we thought. I am particularly thinking, in the nuclear context, about how commitments to how much nuclear would exist need to be thought about in the context of renewable costs coming down, and LNG costs coming down because of the US shale revolution. What was in our mind five, seven or eight years ago needs to be seen in that way; these are not just normal cycles of international gas prices—it is a fundamental change.

Q64 **Chair:** So we have to be quite good at identifying trends.

Malcolm Brinded: Absolutely. People are always saying that it is just cyclical—but we have had two structural changes in the past five to 10 years. There is a prolific availability of gas, which should change our perspective on being able to source gas at stable prices long term, and particularly the cost reductions for renewables. Those are fundamentally much different from anything that we saw five to 10 years ago.

Q65 **Graham Stringer:** Are you saying that the auction mechanism is now going to deliver the carbon reductions that were initially delivered by contracts for difference and other subsidy mechanisms?

Professor Watson: Certainly, they can continue to deliver them.

Graham Stringer: But they have made a terrific impact since they have been introduced.

Professor Watson: Yes, and we can continue to do that. I very much agree with what Lord Deben said earlier about broadening the range of technology. Onshore wind should be on the table as well, as one of those options. We can continue to use that mechanism for continuing to decarbonise the power sector; clearly, that is a sector that has already done quite a big share of the heavy lifting—and it is actually the other sectors on which we should spend more of our time. But for the power sector that set of mechanisms has worked well and can continue to work well for some time.

Q66 **Carol Monaghan:** We have heard a lot this morning about the need for a whole-system approach. What is lacking in our approach to a whole-system approach?

Guy Newey: I work for Energy Systems Catapult, and whole-systems thinking is one of those phrases that gets thrown around very easily. If you are at a conference, it is very easy to get a nod; everyone goes, "Oh, yeah, whole systems." But let us try to break it down so that it is actually useful.

It is a systems engineering term. The easiest way in which to think about it is that you have to understand how the various different elements of any system work in their own right but, crucially, how they interact with each other. The energy system has, for all sorts of sensible reasons, not been very good at that. I shall give you a few examples of why the technology changes make it really important to understand how everything fits together.

Crucially, you have to understand the whole chain, from the power station or gas supply, right down to the consumer. Traditionally, we have just said that, whatever the consumer does, we will supply as much power as is needed. But, now, if you have smart meters and smart technologies and, crucially, electric vehicles, suddenly that consumer is much more powerful. So the whole chain is one element of whole-systems thinking.

The other way to think about it is that the traditional silos between heat, transport and electricity are breaking down at the moment. You can buy your electric vehicle from your energy supplier, and your heating could be electric, and so on. Understanding what those interactions and those changes mean is really important.

The policy challenge that falls out of the bottom of that is how you join up your energy markets, your digital system layered on top of it, and your policy designs with the actual physical system. I work with a lot of old National Grid hands, and they keep saying that we should get the market design right—that is really important—but remember that, at the end of it, there is a physical system that has to work, otherwise we are going to create real problems.

We have to look at all those aspects to get there. Traditionally, we have just looked at little boxes and not at how they all fit together.

Q67 **Carol Monaghan:** Do you feel that we are moving towards the situation where the whole system is being considered?

Guy Newey: Government is at the start of that, but technology is driving it really. Because electric vehicles are starting to take off, suddenly that is putting pressure on bits of the grid that have not had pressure on them for a long time. Understanding that is going to be really important. But particular measures that the Government are taking, such as on the EV energy taskforce and the data taskforce, both of which we are involved in, as well as other measures, are the start of them trying to understand how particular changes in the sector are affecting other aspects. If you get it wrong, it could mean that your energy system is much more expensive than it needs to be.

Malcolm Brinded: Absolutely.

Professor Watson: I agree with what Guy says. The "whole systems" term dates back to the Natural Environment Research Council, which was one of our founding funders back in 2004. I have often been asked by NERC to define what I mean by the term, but I agree with Guy—it is about fitting all the bits together. The bit that we would add is about making sure that you are not just looking at the technology; you are looking at the technology and how it interacts with the market, the consumer, the policy and politics.

The politics is important—and I come back to my first answer. We can do a whole-systems approach and ask how all the bits fit together, and break down the silos between heat, transport and power, and that is great. But then, if we do not think about the equity implications of how we implement that transition, we are not really taking a whole-systems approach, or at least we are not for my money. We should be thinking not just about costs and benefits in the aggregate, but who the winners and losers are, trying to make sure that when there are potential losers—or people more at risk, or people who cannot afford to pay—we pay particular attention to how they can become part of that transition and compensatory mechanisms. For me, that is part of the whole-systems approach, not just getting all these technical and market interactions right, which, as Guy said, are also extremely important.

Malcolm Brinded: I completely agree with what has been said. All I would add is that you cannot do a big system design and understand what we mean by that without trying it. It is not something that you can do on a desk study and in theory; it is about how consumers respond and how all the integrated system reacts, particularly taking advantage of what big data, smart equipment and grids will enable consumers to do and how consumers will then respond, when it is coupled with clear price signals. We just do not know.

Q68 **Chair:** So we come back to the large-scale demonstrations.

Malcolm Brinded: Absolutely.

Q69 **Carol Monaghan:** May I go slightly off-piste for a minute? We are talking about consumers and about the source of the energy and where it has been generated, but we have not talked much about how we are getting from one to the other. At the moment we are still using fairly old technology in terms of the materials—copper cables to transfer the electricity. Has any work been done on getting more efficient transfer of energy or looking at more efficient materials with more resistance, for example?

Guy Newey: I am not an expert on this, but the national scale or large-scale transmissions are pretty efficient. One example that we are seeing now is more and more interconnections; there is talk of cabling to Iceland, Germany and Denmark, over huge distances. That is partly because the quality of the technology is improving.

The one area in the networks that is really important to highlight—and this comes back to the big innovation challenge—is that we have this relatively dumb system. Most people still have dumb meters, which just tick over and measure use. You put digitalisations and digital technologies on top of that, with Alexa and your washing machine being turned on and so on, and that is one element of it. You then put another layer on, using that better information to trade and so on, on top of a network that is very crude and dumb. There is not lots of metering at local level—people do not really understand where the electricity goes. If we get that wrong, we could have all those hugely exciting consumer-facing products that could be damaging to our networks.

One key innovation challenge is how to make sure that the risks of digitalisation are avoided and we capture the benefits. That is the biggest challenge in the network world—how to make sure that your electric vehicle is useful for the grid rather than creating grid problems. Those are potentially very difficult problems. If electric vehicles take off at the pace that we have seen in California, which in fact we need, it is a big challenge for the grid.

Q70 **Carol Monaghan:** Jim, you spoke a few minutes ago about successful systems, and you mentioned solar and onshore wind, but we know that the Government are not supporting those. How should the Government identify and support the transition towards designable future energy systems?

Professor Watson: That is a very big question. If you are thinking about a subset of that, about innovation priorities, I think it goes back to one of Guy's previous answers. It is about setting out some clear criteria about how to set priorities. The important bit of context here is that the UK is one player, although it is an important player, particularly in terms of science, technology and innovation in this area. What we support is going to interact with what other countries support—China, India, the United

States and so on. If you look at the story of many past technologies that are now successful, there is an interplay between what different countries do, although often it may not be planned, on things such as solar and wind. There are areas where the UK can specialise and make a bigger impact internationally than others. The offshore wind story, which everybody talks about, is one where we can.

For me, it is a matter of setting out where we are now, what our science base is and what our industrial base is, where those opportunities are, what we need to deploy for our own low-carbon ambitions, and which ones of those coincide with potential export and jobs benefits?

Q71 **Carol Monaghan:** Do you feel that an overview like that is being taken at the moment?

Professor Watson: As I said earlier, a much more transparent process is going on—a whole process of what we call TINAs, technology innovation needs assessments, done by the Department for business, or DECC before it. I know that it is revising those at the moment. That was the evidence base to look at many of the criteria together and try to put some numbers on them, which is hard, and then come to a set of priorities. The risk with that is that you still end up with what is called "all the above", with all priorities in the mix, because you do not want to upset anybody. One potential critique is that perhaps harder choices need to be made about where to put our money.

Q72 **Carol Monaghan:** Should we focus then on "no regrets" options—it is a term I have learned—or should we look at splitting support across lots of emerging technologies, with the potential that we end up spreading ourselves too thin?

Professor Watson: You then get into a discussion about what you are talking about. When you talk about early-stage R&D, and seeding lots of technology, you can afford to spread your resources quite widely, because having an R&D programme on an area is not as expensive as a demonstration or an early-deployment programme.

When you are innovating, demonstrating and really trying to push something at a larger scale, a medium-sized economy such as the UK cannot afford to do too many of those at once. That is where some of the tougher choices come in—and we have all emphasised that particular priorities need to be made, rather than having a scattergun approach, where the risk is that you do not support anything properly at all.

Malcolm Brinded: But I do not think that it can be the "no regrets" option. You have to make some choices based on the best evidence that you have and give them a real go.

Carol Monaghan: Thank you.

Q73 **Chair:** Presumably, we learn internationally the whole time about what other countries are progressing with and what success they are showing.

Professor Watson: Yes, we are. In Government, there is quite a high level of awareness—and there are actually specific collaborative programmes, such as Mission Innovation, which was launched at the Paris climate summit. At the moment, I am not quite sure what that is adding internationally; there are lots of reports out there about what each member country is doing—I think there are about 21 countries involved—and there are some collaborative projects going on between the UK and other countries. But it is a bit early to tell exactly what the outcome will be.

Q74 **Chair:** Are there any countries that you look at which you think are really ahead of the game and we can learn from them?

Professor Watson: It varies by area of technology. If you are having an electric vehicle conversation, you will talk about China and California, as well as Norway. There is less talk about Germany, which really needs to get its act together on market creation.

If you are thinking about wind, it is very much a Danish story, whereas if you are talking about solar, you can look at the early work and R&D done by the Japanese, feeding into deployment programmes in California, Germany and so on. So it really depends on the technology. As you can tell from the answers, a few countries come up quite a lot in those stories.

Malcolm Brinded: And it can be on a niche basis. Some places can do remarkably well on the retrofit of existing buildings—Hong Kong and so forth. We need to be much more open to learning globally, across the spectrum.

Q75 **Darren Jones:** I have a question about export opportunities through our clean growth strategy. Obviously, we have our own priorities domestically to fix, and the challenges associated with that. But Lord Deben said in our first panel today that we would be foolish to miss the opportunity to be able to get export income from what we are able to commercialise in the UK. Where are we at the moment? Are we good or bad? How do we compare to other countries with exports in the clean growth area?

Malcolm Brinded: I would like to have a go at this one, because I think that in all our clean energy strategy discussions we focus very much on our own climate objective—the 80% reduction and the debate over whether it should be more, and so forth. That misses the big picture of what is happening for the billions of consumers emerging into the middle class in lower and middle-income countries, and the fact that their CO_2 emissions and energy needs are going up. There is a development issue here; there are still 2 billion people in the world without reliable electricity and 3 billion cooking on open fires. Actually, developing those economies requires a lot more energy.

Everywhere, there is a very strong correlation between increasing GDP per head and increasing energy per head. We know that billions of people

in the world will be increasing their energy needs. How can we do that in a lower carbon way than the current trajectory? That is a major opportunity for UK plc to be involved in supporting the innovations, technologies, businesses and start-ups that can make an impact on that.

Actually, at a niche level the UK is quite good at this, but we could do much more. There are quite a number of companies. Let us say that 4 billion people in the world by 2040 will be living at the level that is the average in Brazil and China today—4 billion consumers whose energy needs are likely to be 30% to 50% higher than they are today. That needs to be met in a much lower carbon way. Assuming that the technologies are applied just for the UK's needs, and that developing them for the UK is going to solve and address their issues, is a misconception. Some of it may be relevant, but a lot more can be done in developing and supporting technologies and SMEs that are really focused on this challenge.

There are some programmes from DFID and so forth and some companies in the UK whose whole focus is on, for example, mobile home solar systems in Africa and south Asia, which are now attracting tens or hundreds of millions in support. The UK is very well placed here; we have a very strong reputation in emerging economies, and we have actually been a leader in some of the development activity in this area, but we could do much more to support an incubator system and infrastructure and the SMEs and innovators delivering these solutions on the ground.

That requires more money on a more sustained basis, and an integrated strategy between BEIS, DFID, the DFT and DIT. It is a much bigger opportunity than I think is given credit. Frankly, putting energy in that space would give us much more bang for the buck as part of our industrial strategy than debating whether we should go down by 80%, 85%, 90% or more in 2050. We would get much more by looking at this challenge. One example is Asia and Africa. By the 2030s, a 1% reduction in their CO_2 emissions will be more than all the UK's CO_2 emissions by that time. So it is about what we can do to deliver the technologies to help to enable that.

Q76 **Chair:** Do you think that there is not that much co-ordination between DFID and the other Departments?

Malcolm Brinded: I think that there are some good but rather fragmented efforts. There could be more money on a more sustained basis, and it could be an integrated part of the UK's industrial strategy and clean energy strategy. It does not come within the CCC remit or yours—the remit of how we meet the 2050 target—because that is a UK-only target. But I want to highlight that we will get more from a development and economic point of view, as well as a climate point of view, at lower cost, by supporting this area.

Q77 **Darren Jones:** You said at the beginning that we were good in niche areas. Which niche areas are we good at?

Malcolm Brinded: We have companies that are good, as I say, at the solar homes systems and mobile pay-as-you-go solar, which is really transforming east Africa residential. We have some companies that are focused on the refrigerator chain or cold chain, which will be transformational. We have companies that are obviously good in storage and smart household energy management. We have the skills and capabilities, and we also have an emerging enterprise culture in this country, which we did not have 10 years ago or more. We always used to vilify ourselves about our failure to commercialise technology; we actually have a much better culture and ecosystem for supporting small enterprises, but we could do five or 10 times more in terms of the benefits that it would bring to our economy as well as in climate and development impact.

Q78 **Vicky Ford:** But the clean growth strategy is all part of the industrial strategy. Your point is to tie that into trade strategy and development.

Malcolm Brinded: And to think about the different sorts of companies and technologies that we could and should be supporting, which will have huge global markets and will not just be directly linked to the UK market.

Q79 **Chair:** So there is enormous potential opportunity for us.

Malcolm Brinded: Yes.

Professor Watson: I agree with a lot of that; there are areas that we are good at, and we could do a lot more. All I would add is that we need to make a connection between this international export conversation and what we do at home, partly because of the first-mover advantage argument. If we can develop our own market at home, that often serves as a springboard for exports. Therefore, where there are industries where we are already quite big and export led, we should really be thinking perhaps quite hard, and more, about linking those two together.

The example that I would give is the car industry; we have a very big car industry, which faces a lot of uncertainty for various obvious reasons. One thing that is important for that industry is whether we are going to push it to decarbonise its products quickly enough to be a leader in an international market that has already proven to be very competitive. At the moment, that is one reason why the 2040 target for phasing out fossil vehicles is just not ambitious enough. It is partly because of the lines on the graph and how it fits into our clean growth strategy, but it is partly about whether we want an industry that is fit for purpose for the 21st century to compete internationally. We do not want a repeat of Detroit, which was let off the hook many times, and then, when the fuel prices went up, nobody wanted to buy its products.

Q80 **Chair:** And a more ambitious target is achievable.

Professor Watson: I think it is, yes. It is achievable, which is really shown by a number of other countries going to a more 2030-type timeframe, or one even more ambitious than that. So it is not like we

can't. I know that some car manufacturers say that it is terribly difficult, but that is what companies say when faced with something challenging. The challenge for them is whether they can change their product lines quickly, and which companies are going to be best placed to meet those ambitions.

Q81 **Darren Jones:** From an export perspective, what role does the catapult have?

Guy Newey: It is part of our remit to encourage innovation and SMEs in the sector. We are helping to co-ordinate that and we have lots of conversations with SMEs. How do they then co-ordinate with the Government activity that is happening? That is a big part of our activity. We are also involved in DFID and so on, in thinking about some of those problems.

I have just a couple of points that I would like to make about what we are good at and what we should be thinking about exporting. You often think about technologies, which is a big part of this—and there are lots of strengths in the UK in that regard. But we are a services economy; we are really good at market design, and we have plenty of lawyers and project managers—all that kind of stuff. That is a big part of it, and there is a question about whether the Government ever pick that up.

The other emerging area is the smart digital side. To go back to Jim's point, because we have quite a big market in the UK and are quite early adopters—we quite like playing with gadgets and so on—we should be using that and taking advantage of it. We develop companies, but are we then competing fully in other markets? It is a really exciting opportunity. But if you are doing it from a properly strategic point of view, you need to get your domestic market set up in the right way so that there is a large-scale test bed for people to try things, sell things and build their commercial side, so then they can do it internationally. That is what we have seen with some of the solar technologies: the fact that you have had a UK domestic market has allowed people then to build it internationally.

Q82 **Darren Jones:** This is one of the issues that we have touched on already, whereby you have policy responsibility in a number of different Departments—BEIS, the DFT, DIT and DFID. With our export strategy, who should be leading this from a departmental perspective?

Guy Newey: All those people have to be involved. In my experience of Government, the creation of the DIT gave that co-ordination a bit of oomph, actually, because it was identified as a much greater priority, as well as the clean growth strategy. Suddenly, if you have a few Departments swimming in the same direction, you have a much better chance, especially when you are comparing with rival countries which are very good at co-ordinating their efforts.

Q83 **Darren Jones:** Does the DIT have a strategy for this?

Malcolm Brinded: It is not really central. We have some fragmented but excellent work done in DFID, although I do not know how long it will be sustained. What we do not have is this as an integral and long-term part of the industrial strategy, integrated across all the concerned Departments, with a reasonable amount of money going into the incubation and patient support of early-stage SMEs that have the capability to grow to large-scale and successful ventures. We have quite a number of small examples that are growing fast; we should do much more to support that sort of ecosystem.

Q84 **Darren Jones:** So one of our recommendations should be that the DIT has a strategy on exporting clean growth technologies. Are you agreed on that front?

Malcolm Brinded: Yes, clean growth technologies, especially with a focus on lower and middle-income countries, which is where the real market is. You see that China, Germany and the United States are now increasingly focused on them, but we have a strong reputation and quite a lot of capability that could grow there.

Q85 **Bill Grant:** Following on from the subject of SMEs, there is evidence to suggest that investments have been reduced over time in low-carbon technologies. There appears to be a failing investment in low-carbon technologies. What level of concern does that give you? Does it give you any concern or significant concern?

Professor Watson: It is a concern. It is partly a function of those drivers for that investment starting to fall away as policies come to an end—for example, auctions for low-carbon electricity not being held as often as they might have been otherwise, and incentives for energy efficiency not being as strong as they were five years ago. A number of things have happened, just in the UK, which may then lead to that fall-off in investment.

One thing that it is important to be careful of when you look at headline figures for investment is, if the cost of technologies is falling, clearly the flow of capital to get the same amount of output is going to be less. So you have to be careful to interpret your statistics wisely. At the same time, there are some causes for concern, but they mainly come back to whether those markets are being created in a sustainable way and whether policy is doing enough. If those things are done, investment will flow in an adequate way.

Guy Newey: To make the 2050 targets, you are going to need a huge level of capital investment in all parts of the energy system, from how we drive our cars to how we get our electricity. Keeping an eye on that is very important—but it is always aligned with the point that, if the cost of the technology has fallen by 80%, that is a lot less investment, but that is fantastic, and we should celebrate that.

The key is why the work of the CCC is so important. We have to keep an eye on the carbon levels—but is that your warning light? It is too early to say, really, because there have been policy changes. But if you had low levels of capital investment for the next five years, you would be concerned. You are a seeing a move between sectors; you are seeing less investment in electricity after 10 years of a large amount, but you are starting to see a ramp-up in electric vehicles and those kinds of things. What we really need is a ramp-up in low-carbon heat; that is the biggest test.

Q86 **Bill Grant:** I would suggest that there has been a migration of investment to different spheres.

Guy Newey: Yes.

Malcolm Brinded: We talk quite a lot about heat, but there are a couple of other sectors. In the previous session with Lord Deben, there was a lot of discussion about homes and improving energy efficiency. I still think that energy efficiency is a pretty low-hanging fruit that needs much more focus in terms of how to drive consumer behaviour and what the right signals are.

Q87 **Chair:** What should we be doing that we are not doing now? Are there any other international examples where they have made a big impact?

Malcolm Brinded: We have the same number of fuel-poor homes as we had 15 years ago, as a percentage and a number. Of the fuel poor, only 8% of those homes are in band C or better. I think that you mentioned the equity issue about how you are going to upgrade those homes. There is the new housing stock that Lord Deben talked about—how could we miss that goal? But what are we going to do to actually provide and upgrade existing housing stock, for those who can and those who cannot afford it? I cannot say that you should look at X, Y and Z, but it is a burning issue for the country.

The other one that we touched on earlier is freight. We have talked a lot about light vehicles, and we can debate the opportunity and timescales for electrification of light vehicles, but freight is a much bigger question. It is much more of an international collaboration question as well. So there is a need to address that, and understand it, which is also linked to local air pollution, of course. It is not just a CO_2 climate issue—it is also a health and air pollution issue. I really think that needs much more attention.

Q88 **Bill Grant:** So that investment traverses a number of spheres, including health and the wellbeing of individuals, which could be not so much a by-product but a major benefit of new technologies.

Malcolm Brinded: You say that heat is a big issue, but I would say that energy efficiency is still a big issue in homes, and freight is a big and emerging issue that we should be tackling.

Q89 **Bill Grant:** Finally, I ask the panel for their thoughts on the Green Finance Taskforce recommendations of March 2018, and the Government's response to those recommendations.

Malcolm Brinded: I am not qualified to comment.

Professor Watson: My knowledge of that report is pretty high level, but what it highlighted is that there is an important role for finance in the innovation process, going all the way from R&D through to deployment. Again, there is quite a big body of research on this, showing that there is an important public sector role to play in financing innovation. I am not just talking about cost; I am talking about how you finance it and on what terms.

Q90 **Bill Grant:** The full journey of supporting it.

Professor Watson: Yes—and we need to do that at the deployment end to create markets, as well as at the R&D end. There is often a role for the public sector, which comes to state development banks and setting up finance structures.

My impression from the Green Finance Taskforce was that it was saying lots of good things about what needed to be done, but it was very much about the kind of supply-push area of finance and what the finance sector could do more of. Clearly, finance does not flow into an area of the low-carbon economy unless there is a market there for it to flow into.

To come back to the point that I made earlier, that is a function of policy, regulation and the rules of the game of that market. If you want more finance to flow internationally into the UK heating market, you will have to set up a series of big trials and, eventually, regulations for direction of travel, so that those financiers think that they can invest in something—converting a certain city to hydrogen, for example—and get a return because there is a structure in place enabling them to do it.

Q91 **Bill Grant:** So leading to the commercialisation of the onward journey is the ultimate aim, to encourage investment.

Professor Watson: Yes, so I think that you have to think about finance and investment and green finance in conjunction with your overall policy package, rather than in isolation from it.

Chair: Thank you very much, Bill, and thank you all very much. It has been an extremely useful session. We really appreciate your time. I hope that you are okay on time and with escaping now.