HOUSE OF COMMONS

Environmental Audit Committee

Oral evidence: Technological innovations and climate change: negative emissions technologies, HC 738

Thursday 25 November 2021

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Watch the meeting

Members present: Philip Dunne (Chair); Duncan Baker; Barry Gardiner; Mr Robert Goodwill.

Questions 1 - 98

Witnesses

I: Jon Gibbins, Professor of Plant Power Energy and Carbon Capture, University of Sheffield; Ruth Herbert, Chief Executive Officer, Carbon Capture and Storage Association; Dr Stephen Smith, Executive Director, CO2RE.

II: Dr Daniel Quiggin, Senior Research Fellow, Environment and Society Programme, Chatham House; Jason Shipstone, Chief Innovation Officer, Drax Group; Mair Floyd-Bosley, Senior Policy Officer, Royal Society for the Protection of Birds (RSPB).

Written evidence from witnesses:

Jon Gibbins

Carbon Capture and Storage Association

Dr Daniel Quiggin

Dr Daniel Quiggin et al.

Chatham House

Drax Group plc

Royal Society for the Protection of Birds (RSPB)

Examination of witnesses

Witnesses: Professor Jon Gibbins, Ruth Herbert and Dr Stephen Smith.

Q1 **Chair:** Good morning and welcome to the Environmental Audit Committee for our first of two public oral evidence sessions on negative emissions technologies as part of our technological innovations and climate change framework inquiry. We are pleased today to have two panels. We will kick off our first by inviting each of you just to explain briefly the relevance of your work to the work that we are doing. We will start with Ruth Herbert, who has just been appointed as the new chief executive of the Carbon Capture and Storage Association, having worked previously in the Department in this area.

Ruth Herbert: That is correct. I am Ruth Herbert, chief executive of the Carbon Capture and Storage Association. We are the trade association promoting the commercial deployment of carbon capture, utilisation and storage. My background is that I have spent the last 10 years working on electricity market reform and, prior to that, on international carbon capture and storage policy in the UK Government. I am one month into my new role, so I am pleased to be here.

Q2 **Chair:** Welcome. We will try to be gentle. Welcome also to Dr Steve Smith, who is the director of CO2RE. Could you say what CO2RE does?

Dr Smith: CO2RE is the UK's research hub on greenhouse gas removal, as we are calling it, also known as negative emissions, which commenced in May of this year, funded by UK Research and Innovation. I am based at the University of Oxford.

Q3 **Chair:** Thank you very much. We are also joined by another academic, Professor Jon Gibbins, from the University of Sheffield, where he is the director of the UK Carbon Capture and Storage Research Centre.

Professor Gibbins: That is right. I have been working on and co-ordinating research activity in carbon capture and storage for about 20 years. I have to say that, not much more than five years ago, I nearly lost my job for saying that direct air capture was a very useful thing to be researching. It was not very popular even that recently.

Q4 **Chair:** We look forward to you explaining why you said that during the course of this session. I am going to start with Steve. Interest in these technologies has been around, as we have just heard from Jon, for decades, but there has been very little deployment. Could you just set the scene for us by giving us a quick tour d'horizon of the various technologies that are in different stages of development and which, in your view, are closest to market for the UK?

Dr Smith: Broadly defined, negative emissions technologies are activities that capture greenhouse gases—and we are talking principally about carbon dioxide—from the atmosphere and then convert and/or durably store them out of the atmosphere. This is different in kind from reducing

emissions, which is not putting the greenhouse gases up there in the first place.

It is also overlapping but not the same as carbon capture and storage, which is a term that I am sure we are going to be talking about as well. Carbon capture and storage can be applied to fossil fuel or fossil carbon sources, in which case it is an emissions reduction technology; you are avoiding putting that carbon into the atmosphere. When coupled to other methods, such as working with biomass or direct air capture, that is greenhouse gas removal, because you are taking it from the atmosphere, just to be clear on those terms.

In terms of which techniques constitute negative emissions technologies, or NETs for short, there is a really broad range, in a similar way to the fact that there is a really broad range of ways to reduce emissions. You could start with the very natural, well-known approaches such as planting trees or enhancing soil carbon, and work right through to what are viewed as more technological, less biological, more chemical approaches such as direct air capture and CCS.

It is important to highlight that there is a very broad range in between. There is BECCS, which is bioenergy with carbon capture and storage, and that is a broad term for a family of technologies, so it is also important to be aware that there are very different varieties of BECCS, using different feedstocks and different types of biomass, converting it into liquid fuels, electricity, heat or biogas.

There are also other approaches that are not BECCS or direct air capture and storage—BECCS and DACS—but involve, for instance, converting biomass into biochar, which you can plough into soils. People are looking at enhanced weathering, which is using alkaline minerals that soak up CO_2. You can spread those on the ground or use them in a variety of different ways. You can also use biomass not for energy but in construction, for instance. It is worth highlighting that there is a very wide range. Essentially, all of these are at zero or close to zero levels of deployment, certainly in the UK, arguably with the exception of planting trees, but even there the Government have a policy and targets that we are not meeting.

A lot of pathways and—essentially, all pathways, certainly at the global level—to achieving our goals as set out in the Paris agreement involve scaling up these negative emissions technologies, alongside very wide-ranging cuts in emissions, of course.

Q5 **Chair:** You said that there has been zero deployment at this point. If you just use the TRL descriptor of progress, for technological readiness levels, do we have any that are close to being deployable?

Dr Smith: "Close to zero" is the more accurate answer. If we look at direct air capture and go to that end of the spectrum, for instance, there are something along the lines of 19 plants that are in existence and

operating, but they are very much small scale and pilot scale. There is quite a lot of excitement about a new plant in Iceland, which is hoping to capture 4,000 tonnes of CO_2 per year, but that is the largest-scale project that we have at the moment. There is one in the pipeline in the States—not built yet—that is hoping to capture a million tonnes of CO_2 per year. That is the really cutting edge of deployment for direct air capture.

When you use the technology readiness scale, people say that that is in the region of four to seven or thereabouts, in the mid-range, but I defer to my fellow expert here, who may have a bit more on DACS specifically.

Professor Gibbins: I would agree that there is a plant for a million tonnes being planned but still to be built. The point I was going to make is about BECCS. There is a significant-sized BECCS plant running in the US at the moment. It is based on ethanol production by fermentation and taking the carbon dioxide from that. It is not something that we are likely to do in the UK, but nonetheless the technology is there.

Where I disagree is on saying that particularly technologies like direct air capture are not distinct from carbon capture and storage. If you do not treat technologies that are, essentially, unlimited by natural constraints as just another way of capturing fossil carbon, you introduce perverse incentives. It should be a matter of judgment as to whether you choose to capture at point—with, in many cases, disadvantages because you have distributed sources, small sources and intermittent sources—or to capture via the atmosphere, where you can do it anywhere in the world, operate 24/7 and achieve economies that way. It could well be a lot cheaper to do it that way in very many cases.

Q6 **Chair:** Is that arguing in favour of direct air capture as a more universally applicable technology?

Professor Gibbins: I am arguing only in favour of not treating it as something different from point source capture, because it is inconsistent and may introduce perverse incentives. I am not saying that you should do it. You should do it if it makes sense, but you should be allowed to do it in whatever quantity you want to achieve the purpose. It may be cheaper and more saleable than doing point source capture from fossil fuel use.

Q7 **Chair:** I am going to come to Ruth in a second, but sticking with you, Jon, if I may, you have been working on carbon capture, usage and storage for, as you said, 20 years. What is it that has been holding back the development of that technology? Is it the case that the UK is quite well placed to be able to participate in such schemes, given our depletion of oil and gas reserves and the fact that the caverns in which such storage might take place are available here, whereas they are not in many other countries in Europe?

Professor Gibbins: What has been holding it back, in a sense, is the change in the targets that we are trying to achieve. Originally, CCS in the

UK was a matter of keeping coal in the mix. After the recession and shale gas came in, new coal plants were no longer considered to be necessary. We then had CCS looking at an 80% reduction target for 2050. Again, it was necessary but it was further down the line. We now have a net zero target, which makes CCS much more obviously required than the negative emissions technologies.

I might add that, if you look at all the IPCC predictions for 1.5°C, they all go net negative immediately after 2050. On past performance, as policy catches up with science, I would predict that we are going to be looking at how you deliver net negative within another decade. That is all that has been holding it up. We have been trying to get different targets. The coal one was all ready to go, and then, as I say, coal disappeared because of the recession and shale gas.

Q8 **Chair:** It is more a policy issue than a technology issue.

Professor Gibbins: It is policy as delivering climate science. It is an understanding of the climate science that is required. As regards assets for CO_2 storage, we are very well favoured with that. We could use old oil and gas reservoirs, but we also have a lot of aquifer storage in areas related to those geographical areas. We have the right geology for it, but it is a lot more than oil and gas reservoirs.

Q9 **Chair:** I am sure we will come on to a bit more of that shortly. Ruth, given your prior role at the centre of Government on many of these issues, how important are negative emissions technologies for the UK in delivering a net zero Britain by 2050?

Ruth Herbert: They are really important. As Jon said, in the net zero strategy that was recently published, the Government set a short-term target of 5 million tonnes a year of CO_2 from these technologies being stored by 2030, and also a pathway that ramped that up to 23 million tonnes by 2035 and 75 million to 81 million tonnes by 2050, so a real ramp-up of these technologies. They are essential for decarbonising hard-to-abate sectors like cement, chemicals and agriculture, where, as Jon said, at the moment it is difficult to abate the source of the emissions. Therefore, these technologies allow us to have negative emissions that can offset those sectors.

Q10 **Chair:** Without wanting to stray into my colleague's next set of questions, can you just give us a flavour of whether the Treasury is fully behind that kind of trajectory? One would imagine that this is going to require a certain amount of pump-priming.

Ruth Herbert: With all the carbon capture, usage and storage technologies that were announced with targets in the net zero strategy, including blue hydrogen, which is hydrogen production in CCS, and CCS on industrial emissions point sources, it has been recognised that all of those things need support from the Government. In some cases—for example, industrial carbon capture—they will have upfront capital as well

as a business model that gives them operational funding for the period of operation of the technology.

What has not been announced is how that is going to be funded, so the Treasury's net zero review did not announce how it was going to fund those business models. Business models for dispatchable power generation with CCUS and industrial CCUS have been developed and are on track to be agreed. The challenge is that business models for these technologies—BECCS and DACS—that have a negative emissions potential are behind and have not been developed yet. They are trailing the others and yet they have a target for 2030 and a ramp-up that is just as challenging as the others.

Q11 **Barry Gardiner:** The 10-point plan said that £12 billion was going to be coming from the Treasury. How realistic are the targets? I take it that, if one could put you in a box, it would be the box of believers, but there are those who are non-believers. Sceptics such as the National Grid Electricity Systems Operator have said, "NETS should therefore be a technology of last resort, as trying to remove carbon dioxide once it's been emitted is, in most cases, much harder and more energy intensive than avoiding emitting in the first place". The European Academies Science Advisory Council said that the modelling in this area has been overly optimistic.

Professor Gibbins, your biography says that you have been going at this for 40 years. I do not know whether that is accurate or not.

Professor Gibbins: It is 20 years.

Barry Gardiner: 20 years is probably more generous.

Professor Gibbins: 40 years in power and energy.

Q12 **Barry Gardiner:** You have seen how Governments have successively promised in this area and then rowed back from those promises.

Professor Gibbins: I have seen a lot of things started and, in a lot of cases, it has not been that Government have pulled back; it has been that things have changed or that projects were, in fact, not pointed in the right direction when they started. Clearly, the industry does need to happen, to happen at scale and to prove itself. That goes without saying, but, as I explained, the biggest failure in the UK was around putting carbon capture and storage on new coal plants. Government did very well. I do not know if any of you were there but, at the end of the session in 2009, the 2010 Energy Act was passed, which included the CCS levy, with £11 billion in it, which I think is still on the books, if anybody wants to use it, by the way. That would have paid for carbon capture and storage on a fleet of new coal plants. It was all there and the Government were behind it. As I said, we had the recession, we did not need the coal plants and they did not get built.

Q13 **Barry Gardiner:** What happened was the £4 billion for the pilot projects

at White Rose—

Professor Gibbins: No, this was before White Rose; this is the wave before that.

Q14 **Barry Gardiner:** But that £4 billion was pulled, was it not?

Professor Gibbins: No.

Barry Gardiner: Yes, it was. It was taken out of the budget. Ruth Herbert may remember it. She was at the Department at the time.

Professor Gibbins: It was pulled, but at the stage it was pulled, White Rose had not got storage sorted out and there was only one project—essentially, Peterhead. We can discuss why that project might not have been funded, but there were reasons why it did not necessarily meet the criteria that were around at the time.

Q15 **Barry Gardiner:** So the modelling was overly optimistic.

Professor Gibbins: To be honest, partly because of the terms and conditions under which it was implemented, the project was not a very attractive one by the time it came to be considered. It was a relatively small project, it was undersized to be economic, and the way it was implemented did not easily allow expansion, even to more units on the same site.

Dr Smith: That is carbon capture and storage specifically. If we are talking about NETs generally and the pathway that you outlined in the Government's strategy, Ruth, is it realistic? If your metric is whether the Government's pathway is consistent with the range of studies by independent experts such as the Committee on Climate Change, then yes, it is realistic. Clearly, it is very stretching, but an awful lot of things across the board are stretching to achieve net zero by 2050.

How do we find out more? There is an awful lot of learning by doing to be done with negative emissions technologies. There is a lot of scope for innovation. We do not really know the precise forms of direct air capture, bioenergy with CCS and the broader range that I touched on that will really work, but we find out by trying them. The other way that we make it realistic is by really keeping going with emissions reductions, so this is not a get-out.

CO_2 is a waste problem and, in other forms of waste, we have a waste hierarchy, where the first thing to do is to cut emissions. We do not just leave it at that. We also sweep streets and we have bins. We need to get to the same place with carbon dioxide.

Ruth Herbert: I would support that. In terms of what you quoted there, when you look at the graph of what is needed by 2050, this is always the bit at the top, because it is the more expensive bit. When you cannot do anything else, you do this, but to get to that point, you have to be developing it from now. The really exciting thing is that industry is up for

this. The two clusters that have been announced as part of track 1 CCUS clusters have projects within them. Drax has a BECCS project that can connect to the East Coast Cluster. Within the HyNet cluster, there is the Viridor project in Runcorn, which is an energy-from-waste project that will also capture the emissions and store them within the HyNet cluster.

There are some projects like Velocys, which is looking at waste to sustainable aviation fuel conversion with permanent carbon capture and storage in the Humber region. You have these projects coming forward, so the 5 million tonnes by 2030 is stretching, but there are projects there. We need to see if they succeed in the phase 2 competition.

Q16 **Barry Gardiner:** Let me ask you more about the investment, which is going to be critical. In their 10-point plan, the Government have £12 billion to do this development and pump-priming, but they also say that there will need to be a total of up to £48 billion, including £36 billion from the private sector. It is difficult to see that sort of level of funding coming in from the private sector for the development of something, because £36 billion without knowing how you are getting your return on that investment is really challenging for an investor. Which financial directors are going to sign this off? Where do you see that coming from?

Ruth Herbert: That is where the business models are really important and very similar to what we did with offshore wind under electricity market reform. That worked before. We had contracts for difference, which were long-term, private law contracts that provided, essentially, revenue stability for those projects. They topped up the difference between operating an equivalent technology. The carbon-based CfD is being designed for industrial carbon capture, for example, which will use the carbon price and then provide a top-up to the cost of running that plant. That is the way that we believe investors can have confidence in investing.

Q17 **Barry Gardiner:** What is that going to do to energy prices? Ultimately, I take it that it is going to be the consumer who is therefore going to pay for that.

Ruth Herbert: I was talking about industrial carbon capture there, so it is relating to the carbon price. It is nothing to do with energy. That is completely separate from energy. It is a similar concept to what was done in electricity market reform, but instead of the electricity price, it is the carbon price. As I said before, the Government have talked about announcing the funding envelope in 2022, which they said, in their net zero strategy, they would announce in the coming year, to set out how they will fund those payments under the contract. We do not know.

As I said, the Treasury's review on who should pay for this kind of thing—whether it should be general taxation or levies—has not come out with firm conclusions yet about how they will pay for that differential, but that is the business model that has been proposed, and industry are confident that they can move forward to invest on that basis.

We need to see a similar business model for these technologies, which, at the moment, do not have a proposed business model. Something like a CfD against the carbon price could probably work for these technologies as well, and that is what we are advocating for.

Professor Gibbins: It is very important to get the transport and storage infrastructure there. That is something that industry really cannot manage for itself. It is a classic problem. That is well in-hand.

Particularly with technologies such as DACS, I recently heard somebody in what is called the offsetting business, although I prefer to call it the indirect capture business, saying that DACS with geological storage is the gold standard for carbon dioxide removal. You have CO_2. You can see it. It is there and quantifiable, and it is permanent.

One very big thing that you have to worry about is that, if you are going to have to go net negative in the second half of the century, a tree you plant now might be dying in the second half of the century. You have to worry about what happens long term, or relatively short term, to the carbon. Underground geological storage is intended to be permanent and, in most cases, it really will be.

There is some possibility there, but if you have access to transport and storage, you will find that there is a limited but nonetheless significant market for premium-quality carbon dioxide removal with permanent storage. At the moment, we have people going to the ends of the earth, to Iceland, because it is one of the few places where they can put carbon dioxide permanently underground. The UK could do that.

Just going back to the previous point about old oil and gas wells, whatever you do, do not combine air capture with oil production through EOR, because that will destroy the brand, but we are not going to do that.

There is a distinct possibility, if we provide the place for people to operate, a certain amount of Government pump-priming and quality storage, that, for a while anyway, the technology can be helped, not entirely but quite a lot, by people who want to make a difference and to genuinely neutralise their own personal emissions.

Q18 **Barry Gardiner:** Ms Herbert, you said that the UK is particularly well placed to be an international leader for NETs. Perhaps you could expand on that. It may well pick up from what Professor Gibbins was saying.

Ruth Herbert: It is the fact that we have a theoretical volume of something like 78 gigatonnes of storage. That storage needs to be appraised to a commercial level in order to understand its true potential. We have great locations also for industrial clusters in terms of the geology for the UK, so we have a really good opportunity for these clusters to prove the model. That cluster model is really important for us,

as well as the opportunity to import CO_2 from Europe, for example, where there are not as many stores. That is what Norway is doing, as Jon said.

We are seeing a lot of DACS technology developers. Our member, Carbon Engineering, has just announced that it is going to be partnering with Oxy Low Carbon Ventures to do—

Q19 **Barry Gardiner:** We are the BBC rather than the commercial channel.

Ruth Herbert: Yes—to do a 1 million tonne project in Norway. Again, that is because there is a lot of storage potential in Norway at the Longship site, for example.

Q20 **Barry Gardiner:** Is that the reason why other countries are ahead of us in NETs?

Ruth Herbert: The Norwegians have been doing storage for a long time. I worked on this 10 years ago, and the Sleipner site, which was an aquifer site, has now been running for over 20 years. It was really just about proving that geological storage was permanent. There has been a lot of experience there. They have also funded the Longship storage site. As Jon said, you need to get the storage site going and to fund it, as well as the infrastructure to connect to it—whether that is pipeline or ships. Norway has gone in for those in a big way, and that is something that we need to look at in the UK, so that we can ship CO_2 to our northern—

Dr Smith: You said that we are behind in NETs, and I would just say that we are towards the front of the pack. Not many countries are thinking about this, but a few are. It is a very low bar, so things can change very quickly. Just to give you another anecdote, in the States, where the infrastructure Bill was passed in recent weeks, they have included $3.5 billion for four regional direct air capture hubs, over $4 billion for CO_2 transportation and storage, and $115 million for pilot projects, in addition to managing their trees, so looking at wildfire resilience and things like that, so this is changing quickly.

Q21 **Barry Gardiner:** That is not very much, given that we have announced $12 billion and that what you have just talked about amounts to less than $9 billion.

Dr Smith: We might be conflating CCS and NETs a little here. We have about £100 million of funding for innovation on direct air capture. We are looking at business models.

Professor Gibbins: It is hard to follow all of the different forms of funding in the infrastructure Bill. There is a lot going into carbon capture and storage in various directions.

Q22 **Mr Goodwill:** In an earlier session, we heard Rolls-Royce talking about its modular nuclear reactors and how they could produce hydrogen, capture carbon and then produce a synthesised fuel, which is, I suppose, the "U" in carbon capture, usage and storage. Your technologies do not

have an end product. You will, presumably, be expecting somebody who is burning carbon somewhere to pay you to snatch it from the atmosphere or capture it in some way, and to pump it into some storage. Although Professor Gibbins said that we do not want to be linked with the oil industry, we can, in some ways, justify continuing to use kerosene in airplanes, because we can capture the carbon.

I will ask my first question to Ruth Herbert. All of this will require that infrastructure. You think that there are opportunities in the UK to develop this infrastructure for CO_2 transport and storage, so how can the UK make the most of these opportunities? We were talking about shipping carbon dioxide from various places to the UK. Surely, it blows on the wind. If we are going to capture it, why do we not capture it at Teesport, where there is a gas line coming in, and pump it straight out, rather than expecting somebody in Norway or Germany to capture it and then ship it to our oilfields? Do we need this infrastructure?

Ruth Herbert: The most important thing about what we are hoping is third time lucky with CCS in the UK is this cluster model, because it starts with the storage sites. We need to get those stores operating and the infrastructure around those, such as pipelines. A lot of them are in ports in industrial heartlands, so it is easy access to those sites. That is fundamental, because it is then easy to scale up and connect more and more capture facilities. The Government are definitely taking the right approach with the clusters model.

I would argue that, if we are to meet the 2030 net zero strategy target of storing 20 million to 30 million tonnes, we need to be progressing more than two clusters in parallel. We understand that there is going to be a bit of a delay between track 1 and track 2 clusters, but we would argue that they need to progress almost in parallel. There are also industrial sites that are not near geological storage sites and where shipping is an option. It needs to be developed in tandem with the storage and pipeline infrastructure.

Q23 **Mr Goodwill:** At the moment, if I was to put in a solar panel farm or a wind turbine, there is an obligation to connect it to the grid. Are you envisaging that if somebody wants to start capturing the carbon from their steelworks or power station, there will be a similar obligation for that to be connected to a carbon grid, or would there need to be more of a co-ordinated approach and not necessarily co-locating the capture of the carbon with the place where the carbon is being produced, in Drax or wherever?

Ruth Herbert: Over time, what we will see—and we are already starting to see it with the first few clusters—is them getting calls from businesses, maybe overseas, asking, "When you would be able to take my CO_2? We might site our business near your store". It could be a real inward investment boon for these areas over, say, the course of the next 10 years. We will start to see people siting nearer to these stores, if they are going to be heavy industrial emitters, but we still need to have a solution

for other sites that are not near to that, for which shipping is a good solution.

We are seeing demand outstrip supply at the moment. We have talked about Norway, which is four times oversubscribed for its site already. The Government will, hopefully, be having bilateral discussions with other Governments, like the German Government, because I know that there are German regions that are really interested in the Scottish cluster at the Acorn site, and they have been having discussions there. Again, that is a reserve cluster and is not progressing now as the other two, but there is interest from abroad to store CO_2 there. It feels like we should be progressing that quickly, so as not to lose our opportunity here to be one of those that take CO_2 from elsewhere.

Q24 **Mr Goodwill:** Professor Gibbins, we have the two clusters. What is the timescale? Should we draw lessons and then make a decision or is it imperative that we keep the ball rolling, despite the fact that we may not have all the technology in place and all the lessons learned?

Professor Gibbins: We certainly have all the technology in place for the CO_2 transport and storage, and I am sure that we have enough technology in place to provide adequate amounts of carbon dioxide to justify the clusters and to test out the storage, which is important. I do not see a technology limit there. We do need to be careful about the technology and to make sure that we do not make technical errors. It is something new, and people really do need to pay a lot of attention to that. I am certainly taking a lot of interest in that. With regard to negative emissions, as everybody says, this is a new area, but you can start to think about scaling up if you have somewhere to put the CO_2.

If I might just go back to where you started, looking at nuclear reactors and making fuels, all of this relies on taking carbon dioxide from the air. If you want to be net zero, you want to use a hydrocarbon fuel. The carbon in that hydrocarbon has to have come from the air or at least the equivalent amount has to be taken from the air, otherwise it is not net zero. The same technology is used, whether you use fossil fuel like kerosene or whether you make artificial kerosene with hydrogen. Again, it is a matter of choice and economics. Negative emissions technologies removing carbon dioxide from the air can be used in different ways.

What you do not want to do is to put artificial restrictions by saying, "We will allow you to use negative emissions technologies to make synthetic fuels but not to use negative emissions technologies to continue to use fossil fuels with exactly the same climate effect". You should look for the climate effect, not for anything else, because that is how you get the lowest cost and the most flexibility.

Q25 **Mr Goodwill:** Some academics at Manchester University have questioned the economic sustainability of capturing the carbon and then disposing of it. I may be slightly paraphrasing what they have said, but at least if you are making a synthetic fuel, you have something to sell and you have

income.

Professor Gibbins: That is true. At the moment, the models probably push you towards what you can get funding for. Fundamentally, in both directions, you have to take carbon dioxide from the air, so that cost is the same. To make a fuel, you have to get hydrogen that is produced by electrolysis, which will cost what it costs. It may be a low cost in the future or it may not be as low as people expect.

The other way, you have to take fossil fuel, which will cost what it costs and you have to pay for the storage. It is just economics. As far as the climate is concerned, it cannot tell the difference. You should just, essentially, allow both routes and let the market decide, rather than saying, "We have something to sell. Doesn't that look good?" because it might have cost you more than doing the alternative. If it did, you should not be doing it.

Q26 **Mr Goodwill:** Just turning to storage, if we had been discussing today storage of spent nuclear fuel, I suspect there would be a lot of very serious questions asked about how safe it is down there and what if there is an earthquake or some other unforeseen effect. What evidence do we have to demonstrate that clearly? Iceland has the situation where it can be very quickly mineralised, but if we do pump CO_2 into those oil wells in the North Sea, what evidence is there to show that that will be safe there for many decades and centuries to come?

Professor Gibbins: For a start, the fact that that geology has held volatile gases and liquids for millions of years is a pretty good indication. We have been doing CO_2 storage in Norway for over 20 years, with no significant issues. There is a fairly large demonstration site in Japan that had a major earthquake, and nothing happened, because the geology was shaken but not broken. There is pretty good evidence that it will stay there.

We are not talking about nuclear waste. They are often conflated, but they are totally different. In fact, the biggest thing that people worry about, justifiably, with geological storage is that what happens is that some fraction is released. What happens, for example, if an old oil well leaks? This is where negative emissions technologies come in. On average, we might get 99-point-something but it is not 100% retention. If you have lots stored, that last fraction of a percent is still something. If you can take CO_2 out from the air and put it back again, that is the answer to that. It does give you, effectively, guaranteed storage.

Q27 **Mr Goodwill:** Is that technology pumping gaseous CO_2 or is it in super-critical liquid form?

Professor Gibbins: Super-critical CO_2, which is a dense-phase liquid. It is always more than a kilometre deep underground. You will pick a porous rock layer and something on top. I was hearing people talk about some of the southern North Sea formations, where they are underneath a very

thick salt layer, which is a nice plastic material under those conditions, and it will provide very good sealing.

Q28 **Duncan Baker:** I am known as the one who does not like concrete and steel very much, which is why I am bringing in a 10-minute rule Bill to look at embodied carbon in the construction sector. For my first question, I will give you a break, Professor Gibbins, and go to Dr Smith first of all. If we look at those different sectors, where it is very difficult to decarbonise, we have a new inquiry that is incredibly interesting on aviation and shipping. Of course, there are great challenges in those industries alone. Should NETs be limited to very hard-to-decarbonise sectors such as aviation, as we have just suggested, but also agriculture?

Dr Smith: In the pathways and analyses that you find from the likes of the Committee on Climate Change and other academic studies, those sectors that you mentioned tend to be the ones that have the residual emissions. We have, effectively, fully decarbonised the likes of power, transport and buildings, so those are broadly perceived to be the hard-to-abate sectors.

One point that I would really like to make as an addendum to that is not that that means that those are sectors that get out of jail free. You are still doing an awful lot of abatement in those sectors. They are just not getting to zero themselves in those pathways, so we still need to look very closely at all the options available. It may turn out that we can get those down to lower levels, which reduces the pressure on the need to roll out these NETs very steeply in order to offset them.

Whether those are the sectors that pay, that is an ethical and political decision. Ruth mentioned the idea of a contract for difference, and we had the discussion about whether the funding comes out of general taxation. Another idea out there is that you put an obligation on emitting sectors that they have to tidy up their own waste. In that case, if it is a sector such as cement that is still emitting, it would be obliged to pay for the negative emissions to offset that on the path to net zero.

Just to pick up on something else that has been said, it is really important to realise that, even though these negative emissions technologies are not necessarily being deployed at scale now, they are built off of a lot of things that we know how to do or that are linked to other sectors—the carbon capture and storage element, the direct air capture element, and the use of biomass for energy, which we are already doing at scale. A lot of the technologies that we would use to decarbonise some of these sectors, such as cement and steel, have very strong links and will be co-developing with NETs, so there are quite a lot of synergies across sectors that are worth exploring.

A few people are looking at very low-carbon or even potentially carbon-negative forms of cement production, for instance, because cement, after all, is a mineral. You can use it to soak up CO_2.

Duncan Baker: Do not say that; you will ruin my 10-minute rule Bill, but that is okay.

Dr Smith: That is at a very early stage of development, so it is probably further on the horizon, but it just points to the fact that, again, there is a lot of scope for innovation here and we might find some really interesting synergies as we learn by doing.

Professor Gibbins: Cement is really interesting, in the sense that you take limestone, you cook the CO_2 out of it and then get that CO_2 coming out, and you get some CO_2 from the fossil fuel used to do the cooking. The only thing that makes it difficult to capture is that cement plants have traditionally been located in limestone areas. You take the fuel to the limestone, and so they tend to be remote. There is a remote one which is very near Sheffield, in the Hope Valley, and people are looking at connecting it to HyNet.

If you can capture the CO_2 at point source, that lime, now in the cement, will eventually pick up CO_2 from the atmosphere. You do not want it to do that while it is in construction. You deliberately do not want air penetration into the concrete. At the end of life, if you crush the concrete and disperse it, it will pick up CO_2, so it may be that, if we run the cement industry properly, we can get negative emissions from it. It is over a period of time, but the climate integrates over very long periods of time.

We can also use limestone, essentially, to make lime. One way or another, that will pick up CO_2 from the atmosphere. Once you have made it, it is a devil of a job to stop it picking up CO_2. Again, timing may vary, and you can speed it up or slow it down, but it will happen. Cement, and lime in particular, is a very interesting industry in terms of negative emissions.

Q29 **Duncan Baker:** As you say, we have to do it properly. We have 50 million tonnes of carbon emitted simply in the construction materials industry, which we are not even dealing with. You will get me on to my hobbyhorse, so we will come back. Ruth, what is your opinion on that? Should we be focusing NETs on those particularly hard-to-decarbonise areas? We have talked a little bit about construction. What about in agriculture and aviation?

Ruth Herbert: Those sectors are going to be the ones that will want to be finding ways to offset. As the carbon price rises, there will be incentives on the heavy industries to do so, but many of them have a number of free allowances and things like that. Looking at the longer-term policy framework is really important for driving behaviour, but there are real opportunities, as Jon was saying, not only to do things like geological storage but to have CO_2-heavy materials and to develop those as a way of sequestering the carbon dioxide.

It is just that those things are at an earlier stage of development, so I would say let us press ahead with the geological storage and infrastructure there now, while continuing to research other ways of sequestering carbon dioxide. As Jon said, it does not matter who pays for it or where it is sited, to some extent. Obviously, it needs to be near a permanent storage solution. It can be used by anyone.

The one thing that I would say about biomass is that, in the biomass policy statement, there was a really clear position from the Government that supports what CCSA has been saying for some time, which is that biomass should be used with CCS where feasible. There are lots of potential uses for biomass, but it is a finite resource, so trying to use that with CCS, so that you get the negative emissions, is really important.

That means that BECCS is a good solution, as are other uses of biomass with CCS. It is important to maximise the emissions reductions from biomass, but there are many other solutions as well. We need to develop all this stuff, and those industries need to be motivated to start finding other ways to sequester CO_2 as well. It is there now. They can do it now and apply to the phase 2 competition, which is open now, and get point source capture support from the Government.

Q30 **Duncan Baker:** Can I just ask you one last question? How would a market of purchasing carbon credits from NETs work in practice?

Ruth Herbert: At the moment, we do not have that arrangement. There are two things that are needed to stimulate this. The first is abatement. For example, for BECCS plant, you need to say, "We want to have clean electricity and we will pay for it". The other element of that is, "We also want to pay for the negative emissions". Both of those things have a value, and so there are, essentially, two things that need to be incentivised. They could be incentivised in different ways.

Q31 **Duncan Baker:** Who does that incentivising? Who drives that?

Ruth Herbert: At the moment, we are waiting for the Government to come forward with business models for BECSS and DACS, but what we are hoping is that, for BECCS, perhaps there will be a CfD, because there is electricity production. It will be a baseload, steady amount of electricity production and CfD, and that will pay for the clean power, but then you need a financial model that provides a revenue stream for CO_2 removal. That is true for DACS too. Without that, you are not incentivising it. It is a debate about whether and how the carbon market can incentivise these things, but right now it is not. The desire is that we have something that incentivises these early investments, whilst the longer-term regulatory framework is put in place.

Q32 **Barry Gardiner:** It is really interesting that you say that at the moment we do not have that in place. What should the Government be doing now to put that incentivisation in place, given the very tight timescales that we need to be operating under in order to achieve the emissions

reductions that we need?

Ruth Herbert: Industry's view is that we need a delivery plan for this. It is not sufficient. We know that the business models are being developed, but it is that scale-up plan, so we need to understand frequency of allocation of projects and what the allocation scheme looks like over, say, the next 10 years at least in terms of visibility for investors, to understand whether we are going to double what we allocate every year in terms of projects, and to understand what the funding envelope for those projects is, so that we can get supply chain scale-up in the UK. There is a huge opportunity for elements of this to be UK-based supply chain as well.

Q33 **Barry Gardiner:** You started the session by referring to 5 million tonnes by 2030 and 23 million tonnes by 2035. When do we need clarity on that pipeline of projects and funding?

Ruth Herbert: The Government are planning to award, under phase 2, which is for the two track 1 clusters that have been announced, and conclude that in May next year. As I said, there are some negative emissions technologies—DACS and BECCS—projects within that, which could apply for that, but the business models are not ready yet, which is a concern. The business models need to be got ready on the same timescale.

The funding of those business models needs to be confirmed, but that is the same for all of the CCS clusters. That is really critical. We really want to see, as soon as possible, this funding.

Q34 **Barry Gardiner:** You are no longer a civil servant and I asked you a direct question. Give me a date.

Ruth Herbert: In the next 12 months, all of this needs to be really clear, otherwise we are going to lose our advantage in terms of being a world leader in this. We have already heard about the 45Q regulations in the US, but those tax benefits are driving people to now look more favourably at the US for siting their DACS facilities, and it would be a shame if we did not have those in the UK.

Q35 **Barry Gardiner:** Professor Gibbins, how can NETs produce by-products for other sectors such as hydrogen and sustainable aviation fuels? Can you just take us through the process of how that happens?

Professor Gibbins: In the last question, you asked what the Government can do. It is very important, particularly for direct air capture and, to some extent, for BECCS, to allow people to use carbon dioxide removal from the air as an indirect form of CO_2 capture. That will be a really big deal. At the moment, saying that you can use it only for constrained purposes really restricts the market. You should be allowed to use it as you would use, as I said before, capture at source. There should be no restriction, particularly for DACS. It is just a matter of

money. If it is a matter of using a scarce natural resource, that is something else.

Q36 **Barry Gardiner:** Can I just press you on that? I listened to what you said about that earlier, and it strikes me that you are right—it is a matter of money—but surely what others who are not coming from a DACS perspective might argue is that, although it is a matter of money, that money could be better spent and be more productive in terms of emissions reductions if it was spent in other areas. There is always a constraint in the source of money as well as other resources.

Professor Gibbins: That is always true, but I will give you an example. If someone wants to fly to the Canary Islands to have a holiday, perhaps they could spend their money on something better. It is a very easy emission to avoid. They could go to Bognor Regis.

Barry Gardiner: You remember what King George said about Bognor, do you not?

Professor Gibbins: I am afraid I was not alive at the time, so no, I do not.

Barry Gardiner: It was his dying words.

Professor Gibbins: Please tell me.

Barry Gardiner: I do not think I am allowed to use expletives in the Committee.

Professor Gibbins: What I am saying is that, for somebody doing that, you can say, "You do not need to spend that money, but if you want to spend it, that is your privilege at the moment, but I really do not think you should be putting carbon dioxide into the atmosphere". Either pay for the carbon dioxide removal to capture those emissions directly or pay for somebody to have taken the CO_2 from the air, directly or via biomass or biogenic waste, and reacted it with carbon produced from electrolysis to make the fuel that flies the plane.

As I said before, when you say you could do it more cheaply those ways, in that particular example with flying, it may be true but it is not obvious that making a fuel is cheaper than using a fossil fuel. In both cases, you have to take the CO_2 out of the air.

Q37 **Barry Gardiner:** I understand what you were saying about the cost-effectiveness of making aviation fuel, but I do not think it meets the objection about the limited financial resources and the fact that others could argue—

Professor Gibbins: I understand what you are saying. If you are getting the taxpayer to pay for the cut, that is one thing, but if you are getting the whole system, which, in many ways, is not optimised to cut emissions or save people money—people spend money to have fun, and this is not essential spending—then you should allow, encourage and require people

to use direct air capture in particular, which does not use as many natural resources, to indirectly capture their emissions.

Barry Gardiner: I still do not think that you are meeting the objection, but I have heard what you have said.

Dr Smith: I would agree with Professor Gibbins on the point that, from a hard physical science point of view, the atmosphere sees the same effect. In practice, these high-quality removals are expensive, so it makes a lot more economic sense to switch to electric vehicles, insulate your home and do these kinds of obvious things.

Q38 **Barry Gardiner:** That was my point about Government funding. You say, "Give us the money in this sector", but the argument is always, "Can we spend it more effectively in another area?"

Dr Smith: If you look at these overall cost-optimal paths to get to net zero, you end up doing direct air capture and BECCS as well, so they become part of the mix. We have not really talked much about the role of the public in all of this, and there are some limited studies of what the public think about removals. Generally, there are very low levels of awareness, so there is a bit of a story to engage the public in here, because there is also a sense, in the detailed work that has been done, that people view this as not solving the root cause of the problem, which is emissions. There is a time horizon of urgency: that these new technologies might not come onstream in time to help us solve the problem.

Those opinions are very malleable, and one way that the Government can work to help address this is to show that they are still really serious on emissions. You have this tension of providing the economic, cost-optimal way of fixing the climate problem, but also this fairness issue about who pays and whether these technologies are being done in addition to the emissions reductions that have to happen across the board. That is another thing to be aware of.

Q39 **Barry Gardiner:** Briefly, because I am conscious that we are up against time now with this panel, Professor Gibbins, you balked at the idea that there should be a restriction of the use of DACS only to specific sectors. I understand that, but would you, inversely, say that specific sectors or industries should be required or encouraged to invest directly in NETs in order to ensure that they are developed and deployed in time?

Professor Gibbins: Yes. That was the point I was also making about a moderate amount of Government funding. Given that, as Steve said, you will need these technologies in the long term, it is a way of buying the cost down. It would also be industry that should do it, but you are investing now. You are paying over the odds, as we did for wind. Wind was tremendously expensive, but, through use, the cost came down. A certain amount deliberately at uneconomic rates is useful.

Q40 **Barry Gardiner:** If this Committee were making recommendations in

that area, would you have an appropriate recommendation about some sort of levy on those industries or some sort of requirement on them to be investing in some of these clusters?

Professor Gibbins: That is a very good idea, and I would also, if it is industries, extend it to people who are emitting CO_2 for frivolous purposes. The industries you are talking about would cover that.

Q41 **Barry Gardiner:** One person's frivolity, of course, is another's essential, but there we are.

Professor Gibbins: Yes, but it is everybody's CO_2.

Q42 **Barry Gardiner:** Indeed. What are the avenues for the reuse of CO_2? Are there any risks that need to be considered and mitigated there?

Professor Gibbins: The biggest risk that I can see is that, at least on the continent, the reuse of CO_2 is used as greenwashing. They will take fossil CO_2, react it with green hydrogen from electrolysis, and then call it a renewable fuel or an e-fuel, and it is not. It is essentially a fossil fuel, as far as the carbon is concerned. We need to make sure that the CO_2 that is used for products has come from the atmosphere, either via direct air capture or, more likely in the near term, from biomass, as colleagues have said.

Dr Smith: Generally, the scale of use is much smaller than the scale of removals that we need. In the case of BECCS, you are using the biomass to give you energy, but you are disposing of rather than recycling the CO_2 into a product. Those are the larger-scale options. There are definitely niche markets where you can use the CO_2, but they deliver much smaller-scale NETs than these other options.

Ruth Herbert: I would agree. We are not talking about, say, permanent utilisation—for example, CO_2-heavy concrete or something like that. That needs to be looked at, monitored, measured and verified to make sure that it really is equivalent permanent storage to, say, the geological stuff that we have been talking about.

I was visiting a capture site recently, and there was a turkey farmer there, looking at the equipment and thinking about getting that equipment, so that he had a steady supply of CO_2 for his business, and also to supply other businesses with CO_2 for packing food. He said, "Why not? When that cluster is built, I can also, if I have any left, send it to be stored under the seabed". He was not a big climate proponent, but he was thinking, "Yes, I need CO_2 and I might invest in this technology". If there are people willing to invest in the technology, and that helps the technology move and scale up to bigger applications, that is a good thing and we should not be stopping that, but what we are about is geological or other permanent storage for climate change avoidance.

Q43 **Barry Gardiner:** In that use of CO_2 in products that you were talking about and, as you said, in certain cases on the continent, it has been

presented as more environmentally friendly than it is—

Professor Gibbins: It is mainly in fuels, not products, but yes.

Q44 **Barry Gardiner:** Are there categorisations that we should be introducing here in the UK that discriminate in that way to make sure that investment is not being channelled down those sorts of pathways as opposed to others? What would those categorisations or discriminations look like?

Dr Smith: A level of permanence is a really important point. In terms of what matters for the climate, you could discriminate by how quickly the CO_2 ends up back in the atmosphere or not. Certainly, if you look at using a fuel or something like pulp and paper or very short-lived plastics, the CO_2 is back in the atmosphere within a year.

Q45 **Barry Gardiner:** Again, if this Committee were to be making recommendations to Government on that, what should they look like?

Professor Gibbins: If I can just go very quickly, for fuels you should get the CO_2 from the air. There should be a traceable path that the CO_2 has come from the air. I would not bother making fuels with anything else. It is unnecessary.

Dr Smith: We have talked a lot about BECCS and DACS specifically that involve geological storage, but I would like to underline again that there is a lot of scope for innovation on mineralisation. Setting out a set of principles that are required in order to incentivise things appropriately is really important, and then allowing people to innovate and come up with new ways of doing things that meet those principles. The principles can be about scalability and cost. Permanence is one of those key criteria, as well as alignment to our other socio-environmental goals like good jobs, improving the environment and so on.

Ruth Herbert: I agree on the principles but backing those up has to be monitoring, measurement and verification process that is auditable, so that the public can have faith in it.

Q46 **Barry Gardiner:** Have we enough investment in that monitoring and verification?

Ruth Herbert: The regulatory regime for geological storage is already set out. It is regulated by the OGA and there is a full monitoring, measurement and verification plan required for that, so that is all very well developed. In other areas, because the technologies are still developing, perhaps those standards have not been agreed EU-wide or globally, like they have for geological storage. There is work going on on that, but colleagues might have more.

Professor Gibbins: The private sector is very active in this area. Just going back to the question about use, it is very important to differentiate fuels, which are impermanent and intended to be so, from other things that have some measure of permanence. That is where you need to get into the gradations.

Q47 **Barry Gardiner:** I want to go back to the investment and the role of Government in the monitoring and verification. Again, for this Committee to be making its report to Government, what are the recommendations that we could make to improve that monitoring and verification?

Ruth Herbert: I would say that there is a lot of work going on in the private sector, but when it comes to standards and things like that, there is a role for making sure that those things are properly reviewed and assured, and consistent with each other. There is a lot of work going on in relation to global carbon markets and article 6 of the UNFCCC or Paris agreement.

My view would be that we would want to see progress in those areas internationally so that there is consistency on these things internationally, so there is a clear role for Governments there. As I said, the industry is doing a lot of work to develop auditable standards, and standards bodies that are involved in that have background in doing this with other, similar sectors.

Dr Smith: They still need to be set up for things like direct air capture, but physically and technically, they are relatively simple. Where they get more complicated is where they involve the land. For the other methods that we mentioned, such as biochar and enhanced weathering, there is a job to do to get robust MRV systems in for those.

Then there is the question of Drax. There is real opportunity. Drax has set itself fairly high standards. We have relatively high standards in the UK, but there is a real opportunity and a need to continue to improve those, and to improve having systems where we can really monitor the full supply chain, completely or near completely.

Professor Gibbins: Just going back to a very early point, do you think that there is even enough attention given to the issue of permanence? If you go to the fundamental climate legislation, it just talks about natural removals. It does not talk about geological removals. There is just no question of permanence; it is just assumed that everything is permanent. I do not know if we have the last word, but even recognising that permanence is an issue and trying to quantify it—for example, if people had to say, "How permanent do you think your removal is?"—

Chair: That is a very helpful summary. We are going to have to stop it there, Barry, if that is okay.

Barry Gardiner: Sure. We will be going on to—

Chair: Indeed, we will be going on to Drax shortly.

Q48 **Barry Gardiner:** It was helpful to get those remarks. Chair, I just have one very quick thing. I just wanted to pick up on what Ms Herbert said about the shipping solution. What, if any, additional port infrastructure do you believe is required in order to get that connectivity that you were talking about earlier in response to Duncan Baker?

Ruth Herbert: CO_2 is already shipped, so there is already the capability to do that. I do not think it is really a case of physical infrastructure. It is not difficult to put that in place. The challenge is the fact that this is cross-border and how that is treated. There are a number of international agreements around that, like the London protocol and OSPAR agreement, which set out how the CO_2 can cross borders as a waste; it is treated as a waste under those.

There are also discussions going on at the moment within the EU, which our Brussels office is engaged in, around the EU taxonomy, making sure that CO_2 shipping is something that is captured in that set of regulations, as well as the TEN-E network regulations in the EU. Just making sure that we do not put barriers in the way through legislation is really crucial at the moment. We envisage that there will need to be bilateral agreements between member states and third countries like the UK to do that.

Chair: Thank you very much to our first set of panellists, Ruth Herbert, Dr Steve Smith and Professor Jon Gibbins. It has been most helpful. We are going to now move swiftly on to the next panel, so thank you for being with us. The next panel will focus specifically on BECCS. We will be looking at DACS at our next session on 5 January.

Examination of witnesses

Witnesses: Dr Daniel Quiggin, Jason Shipstone and Mair Floyd-Bosley.

Q49 **Chair:** Welcome to our second panel. Again, I would just like you each to introduce yourselves briefly, if you would, before we start the questioning, starting with Mair Floyd-Bosley, who is the senior policy officer for bioenergy and BECCS at the RSPB.

Mair Floyd-Bosley: Hi. My name is Mair Floyd-Bosley. As you say, I am the senior policy officer for bioenergy and BECCS at RSPB. RSPB is Europe's largest nature conservation charity and works across a range of policy issues, including climate and land use, domestically and abroad, through the BirdLife International partnership. We have worked on bioenergy research and policy for over a decade, and we have longstanding concerns about the damage that bioenergy is doing to the climate and nature and, subsequently, the risks of BECCS.

Q50 **Chair:** Dr Daniel Quiggin is a senior research fellow at Chatham House on environmental issues.

Dr Quiggin: Thank you very much for having me today. As you say, I am a senior research fellow at Chatham House. Chatham House is an international affairs think tank. It is quite important, in terms of what I am going to be saying today, to think about this in terms of the world, the globe and scaling. That is the element that I will bring to this. My background spans a vast array of different organisations. I worked in BEIS on Brexit, energy and climate policy; for the second largest

investment bank in fossil fuels and helping them develop a renewable pure play fund; for Greenpeace; and for Chatham House, so policy and investment.

Q51 **Chair:** Jason Shipstone is the innovation leader at Drax.

Jason Shipstone: Good morning. I am Jason Shipstone, chief innovation officer for Drax. I have been in the energy industry for about 35 years now. I have been privileged to be involved in many climate change and emission reduction projects during that time, early on in reducing emissions from coal and, for the last 10 years, helping our business transition away from coal to sustainable, renewable biomass. For the last five years, I have been looking at how we can take that pioneering biomass technology and develop it to allow us to have a negative emission or BECCS technology, which you have heard various references to already this morning.

Q52 **Chair:** Thank you very much. We are going to have a very interesting discussion. This is focused on bioenergy and BECCS. We heard from the first panel about some of the aspects of BECCS, which is a very wide umbrella term covering a lot of different technologies. It would be helpful to set the scene for this panel, Daniel, if you would give us your view, in particular, on the most promising and forward technologies within BECCS that the Government should be focusing on if they are looking to prioritise early adoption. Or is that a mistake, and we should allow technologies to develop at their own pace?

Dr Quiggin: BECCS can produce a range of energy vectors, hydrogen and power being the main ones. My research has principally focused on BECCS to power, because it is the forerunning technology that is most likely to be developed sooner in time, and that the IPCC and many international organisations proffer as the most promising version of BECCS.

I will come out straightaway and say that I broadly support the need to ensure that BECCS is developed at some limited scale, such that we have the empirical evidence as to whether it should then be scaled or not. My principal concerns are around the global scale at which you start to get externalities and tensions, at which point we may see land tensions, food price rises, loss of biodiversity and so on. Whatever the UK Government do in terms of setting their initial level, they need to be cognisant and aware of the fact that, if they are going to be scaling up globally and wanting to take a global leadership role in BECCS, there are going to be limitations before those externalities start to arise.

For instance, the IPCC currently estimates, in its middle-of-the-road scenario, that about 1.5 gigatonnes of CO_2 should be sequestered from BECCS. These are all in relation to residual emissions. As soon as we start to move out of residual emissions, as Duncan Baker MP said earlier on, in terms of agriculture, steel and cement—those hard-to-abate sectors, and that 1.5 gigatonnes from the IPCC is in relation to those

sectors globally—and start to offset sectors such as the right hon. Robert Goodwill said at one point in terms of power stations, which, to be clear is not a residual emissions sector, that 1.5 gigatonnes that the IPCC is projecting would go up and up.

At that 1.5 gigatonne level, you would see the amount of wood pellets being burned increase by 126 times, relative to what Drax currently burns. That is a lot of wood pellets. To put that into context, that would be 16 times current global supply. That sort of pressure on the wood pellet supply industry is likely, although not categorically, to lead to the sorts of pressures and tensions within that supply chain that mean more and more of what I define as mature or old growth trees being used. Those sorts of trees come with a large carbon debt that takes many years to pay off, so there is a problem in terms of blowing the carbon budgets globally as we scale BECCS, and a problem around biodiversity and food prices if we start to use more and more land.

I will start to draw to a close because you want to hear from other people, but the UK Government are in a position where they need to ensure that the types of legislation, regulations and key performance indicators that are wrapped around the first demonstration project of BECCS are really key to gathering the evidence as to whether it should then later be scaled. Setting a future target at this point should be done in the context of global scaling and the limitations that should be around that.

Q53 **Chair:** We are going to get into land use and biomass during the course of our discussion today. Jason, you are the individual within Drax who has been responsible for the transition from coal to biomass. Last year, you used 7 million tonnes of wood pellet. Could you just explain, given your current role of innovating the next phase of development of Drax, what you are looking at doing and the extent to which you are looking to generate biomass domestically rather than import it all? What kinds of innovations are going on at the moment?

Jason Shipstone: We have a goal to deliver a zero-carbon, lower-cost energy future, and biomass underpins a lot of that. We have been working with biomass since 2004 and using biomass at large scale since 2013, so we have a lot of history as to how our supply chain works, how to source biomass and how to do that in a sustainable way. We have been piloting BECCS technology at Drax for the last two years. We have been running two technologies in parallel at pilot scale to understand how this technology can work in a biomass power station, and it works really well. The next stage of that is to turn that piloting technology into at-scale negative emissions technologies.

Just to answer your point around UK sourcing, we are working with various bodies across the UK—Defra and other organisations—to look at how we can maximise the potential of biomass in the UK. To my fellow panellist's point, it is very important when you take biomass, you take from forests that are growing and not from those that are reducing. The

whole process is about ensuring that we take the growth from forests and we do not remove primary forests. That allows us to have this negative emission concept that we are developing.

We are working very closely with various authorities in the UK to do that. The UK does not have quite the same potential as some of the other areas that we take biomass from, because of the scale required, but we are very keen—we have done it before with energy crops in the UK—to maximise the potential of biomass sourced within the UK, and we are working very hard to do that.

Q54 **Chair:** You said the pilot BECCS work is showing promise. Can you just describe what you mean by that? What happens with the by-product? Is it used to fuel the power station or is it being liquefied and used for storage?

Jason Shipstone: One of the pilot plants that we have running at the moment is a UK-based technology, so it is quite innovative, and the other is a more established technology. One is at up to one tonne a day of CO_2 removal, and the other is much smaller, at about 350 kg a day. The real purpose of these pilots is to understand how the two solvents used to capture CO_2 react with the flue gas from biomass. They use a small amount of energy to run that process. As we scale the project up to full-scale commercial development, we need to understand what those energy numbers are.

The CO_2 that we have from those processes at the moment goes back into the flue gas that we release from the power station. In the longer term, on a bigger-scale project, as you have heard from various panellists this morning, that CO_2 would be captured and transported in a T&S system into long-term, permanent geological storage. The UK is very well placed for that. We have about 80 billion tonnes of capacity, mainly off the east coast of the UK, and that is the infrastructure that we will connect in the longer term.

Q55 **Chair:** I was going to come back to Daniel in a second, but just on that point, you are part of the east coast initiative and one of the two pilots that the Government are helping to fund in terms of the cluster. Can you just explain how that is intended to contribute to the decarbonisation of the economy and what kind of timescale the cluster is looking at?

Jason Shipstone: We are part of the East Coast Cluster, which includes Zero Carbon Humber and Net Zero Teesside. We are a founding partner of Zero Carbon Humber. We have been working with our partners in the cluster for the last three years to develop the infrastructure required. The transport and storage infrastructure is large-scale infrastructure. It is relatively new in the UK, although this is not new infrastructure. As Professor Gibbins mentioned earlier, this is common in the US and other areas, where they transport large quantities of CO_2.

In terms of the timeline for that, we very much welcomed the Government's cluster development process. We were one of five clusters that entered into the phase 1 process. The East Coast Cluster and HyNet were the two successful clusters taken forward for development by 2027, so that timescale is very important to us. We also welcome the next stage of that, which is phase 2, whereby the emitters within those clusters will be selected. That process happens over the rest of this year and the first half of next year.

Dr Quiggin: It does not necessarily need to be now, but we should pick up, at some point, on the amount of energy that is required to do the process of CCS at Drax and what the early results show. We can talk about that now or you may want to come on to it later, but it is important, just because Jason mentioned it.

Chair: I am happy for you to pick that up now.

Dr Quiggin: The published results in a report by Baringa, which Drax commissioned, show that, for each turbine, you lose about 170 MW per 650 MW turbine. Drax can speak to these numbers better than I can, but from my maths, I find that their power efficiency drops from 36% to about 21%.

That efficiency may improve over time—all power stations have improved in their efficiency over time—but to give you some context in the UK, the efficiency of power stations over the period 1990 to 2010 improved by about 7%. The CCC is anticipating that BECCS power efficiencies are in the 35% to 37% range, so it is unlikely that we are going to see the sorts of efficiencies that the CCC is desiring within its modelling, based on the current trials at Drax and, indeed, the efficiency improvements that are likely to happen.

It is important to say that those low power efficiencies will mean that it is very expensive for Drax to sell that power into the wholesale market, which is likely to drive up the subsidy that Drax requires in terms of—

Q56 **Chair:** You have made your point. Jason, do you want to respond to that? Do you recognise those figures?

Jason Shipstone: No, I do not recognise those figures. They are not the correct figures for Drax or for any other new-build BECCS-fired power station. It is really important to think slightly differently when you think about efficiency. If you apply negative emissions technology to a biomass power station, you are getting two goods—renewable, dispatchable, clean energy and a negative emission product, biogenic CO_2, which can be used, as you heard in the previous panel session, as a useful ingredient for things like biofuels or bioplastics. It can also be geologically stored along with non-biogenic CO_2. You get two things for one, so some of the energy input to the power station is being diverted from electricity production to produce biogenic CO_2 or negative emissions. You cannot make or destroy energy; it is just split in a different way.

The way power station efficiency is measured is traditionally through fuel input to electricity output. That model does not really work in a BECCS power plant, because you have two outputs, so the numbers change but the overall efficiency—

Q57 **Chair:** It would be helpful if you could respond in writing, perhaps, to the challenge that has been laid, so that we have the two points of view clear before us.

Jason Shipstone: I would be very happy to.

Q58 **Chair:** Thank you very much. I am going to move to Mair before we move on to the next set of questions. Given the debate that you have just heard, would you give us your view about the role that BECCS can play in helping achieve the Government's net zero strategy?

Mair Floyd-Bosley: It is important for us to take a step back to start with and to understand how we have ended up with these significant proportions of BECCS in our net zero strategy. First, it is important to understand that large-scale BECCS remains unproven. In terms of the design of the models that have given us these BECCS projections, it is quite simply a mathematical formula that has been applied. We have assumptions regarding the amount of residual emissions that our society will continue to emit. We can change those, depending on what policies we implement and how hard we mitigate.

That then leaves us with a bit of a deficit in terms of getting to net zero, and that is where BECCS has come in. We have retrospectively fitted BECCS into the model in order to get us to zero. It is not because BECCS has been evaluated to be feasible on those scales. It simply helps us to add up to zero.

I would like to start by outlining three major concerns about why this particular situation that we have found ourselves in could lead to a costly mistake when it comes to BECCS, which may not be able to deliver negative emissions at that scale. First, in these current models, major emissions from the total CO_2 impact of BECCS are being left out. The stack emissions are totally ignored, as are foregone sequestration and carbon debt from the forest, as well as soil carbon loss from the forest. It is important that, going forward, we start looking at the whole lifecycle of the BECCS process, which is currently missing substantial, uncapturable emissions.

Secondly, the models may not reflect reality in terms of the feasibility of the CCS technology itself. We have seen fairly common failure of CCS technology over the last decade to deliver at scale.

Finally, there is a fairly likely need that we will have to downscale the amount of BECCS that we are relying on, simply because of planetary boundaries. It is likely that the pressure on ecosystems to extract all this biomass will lead to unacceptable impacts on biodiversity and on land and water use. There is evidence to show that that does push us towards

unacceptable impacts, and it is likely that we would have to downscale that.

Chair: We are going to get into some of this now, so I am now going to move on to Barry Gardiner.

Q59 **Barry Gardiner:** Before we do, Mr Shipstone, you said that you do not recognise the figures quoted by Dr Quiggin. You specifically said that this operates in new power stations in a different way. Correct me if I am wrong, but the Drax power stations are converted coalfired power stations, are they not? Would you recognise Dr Quiggin's figures for those power stations? Are they correct in regard to that part of your operation?

Jason Shipstone: No, I do not recognise the figures. The point I was trying to make is that it is not that the power station operates in a different way, but that we have to think in a different way when measuring efficiency. If the power station only produces electricity from fuel, then the calculation of efficiency is fairly straightforward. If you produce electricity and negative emissions, there is some energy used to create the negative emissions, so you have to think a little differently to a traditional efficiency calculation.

Dr Quiggin: I do not disagree with what Jason has said. The key thing here to think about is that the CCC and many other bodies think about BECCS in the context of producing power and CO_2 sequestration at the same time. Therefore, they think about the cost of that sequestration being lower, because there are going to be revenues from the power sold. Essentially, what I am saying is that the power produced and power sold is going to be lower and, therefore, the cost of that sequestration is going to be higher.

Q60 **Barry Gardiner:** That is the 36% and the 21% that you quoted.

Dr Quiggin: Yes.

Barry Gardiner: I understand. Thank you. Mr Shipstone, Drax was recently dropped from the green energy companies index because of what were called "uncertainties and poor practices". Do those uncertainties and poor practices relate to the fact that only 20% of your feedstock is currently sourced from pellet mills that you directly own and ones on which you report, rather than on the suppliers that you have from the sustainable biomass programme, which you do not report on?

Jason Shipstone: I am not aware that those were the reasons.

Q61 **Barry Gardiner:** What were the reasons then? I am sure you have seen the fact that you were dropped from that index, so what do you believe the reasons were for their quote of "uncertainties and poor practices"?

Jason Shipstone: I do not know what those reasons were.

Q62 **Barry Gardiner:** Have you not tried to counter that? I am sure that, when that report came out, Drax was concerned to see that it had been

dropped from the index and, therefore, would have wished to have countered the statement that there were those "uncertainties and poor practices". How did you go about countering that?

Jason Shipstone: We source all our biomass to the same high standards. Our standards are internationally audited. They are not our standards but are gold standards set by other people.

Q63 **Barry Gardiner:** You cannot quite be confident of that, can you, because, in fact, you do not report on those elements that come from outwith your own directly controlled feedstock plant?

Jason Shipstone: All of the biomass that we buy and that we make, whether it comes from third parties or from our own production, is done to the same standard. We have a very clear and internationally robust audit process for our biomass. It is not just us who audit it, although we do have an independent advisory body, chaired by the former Government chief scientific adviser, Sir John Beddington, who presides over our practices and audit processes.

Barry Gardiner: I remember him well.

Jason Shipstone: We also have third parties who audit that, so it is completely independent from us. Any practices that we find through that process—and we do not find very many—that are not as they should be, we rectify immediately. We have been offered biomass in the past that we have refused to take, because it does not meet those standards. I am not really sure where the concerns have come from, but I can assure you that all our biomass is independently verified to come from a sustainable source.

Q64 **Barry Gardiner:** Maybe you could follow up and write to the Committee setting out your rebuttal to the report from the green energy companies index. That would be helpful.

Jason Shipstone: I am happy to do so.

Q65 **Barry Gardiner:** Ms Floyd-Bosley, you were talking about land use. I believe that, if you take the IPCC's middle assessment of use of BECCS in particular, the land use would be 0.8 billion hectares. I think that that is the figure that is quoted in RSPB's report. Can you cash out for us what that would look like in terms of the south-eastern states that are currently the source for Drax's biomass?

Mair Floyd-Bosley: Dr Quiggin may want to correct me, but I think the figure of 0.8 billion hectares comes from a Chatham House report, so he may have more knowledge of that. I think that was calculated on the basis of expansion of energy crops. We are looking at the conversion of agricultural land.

Q66 **Barry Gardiner:** That would be required in order to meet the middle assessment of the IPCC.

Mair Floyd-Bosley: Yes, that is right. Currently, Drax, as we have touched on, imports 7 million tonnes of wood pellets every year, sourced mainly from North America, as well as eastern Europe. Just to put that into some sort of scale with regard to the UK, if we are talking about land use, it requires about 13 million tonnes per year of fresh greenwood, stem wood or harvested wood to create those pellets. The total UK production of all timber and wood products is 11 million tonnes a year, so the amount per year that is required currently, just to supply Drax, is more than the UK produces in total from its timber industry. Those are the sorts of scales we are talking about.

In terms of the global pellet market, one projection estimates that the market size is expected to double between 2019 and 2025, before we have even locked in any investment for BECCS.

Q67 **Barry Gardiner:** I believe that the 0.8 billion hectares, though, related to the 2050 middle assessment target of the IPCC.

Mair Floyd-Bosley: That is correct.

Q68 **Barry Gardiner:** What I am trying to establish is what the global footprint would be of meeting that middle assessment. I understand what you have said about what the doubling of UK consumption of pellets would be by 2025, but what I am trying to get at is what the global footprint would be in 2050.

Dr Quiggin: The complicating factor here is that biomass is supplied to various end types, be that BECCS or others, and there are many different competing demands over that land. The easiest and most comprehensive number to use is from the IPCC special report on 1.5°C, which indicates that 1.5°C compliant pathways would require around 25% to 46% of arable and permanent cropland in 2100. That is a vast amount of land that would most definitely have significant impacts not just on food prices but most likely on food availability, which will impact the poorest and most vulnerable in the world and also have impacts here on food prices.

Barry Gardiner: That is not to even mention the impact on biodiversity.

Dr Quiggin: Yes, precisely. Just to go back to the 0.8 billion hectares, I do not recognise that number. However, just to put into context Drax's current supply, it comes from about 0.37 million hectares. If that was all transposed into the UK, that would represent about one tenth of our forest area.

Q69 **Barry Gardiner:** I will ask you to come back in a second, Mr Shipstone, unless you want to come in specifically on that point.

Jason Shipstone: Specifically on the growth and scale point, our forests are hugely important carbon sinks. You heard in the previous panel about natural sources of carbon capture and carbon absorption. The forests that we take from in the southern US have grown by about 50% since 1950. They are increasing in size all the time. We need to keep that going.

Q70 **Barry Gardiner:** A lot of your pellets come from Louisiana.

Jason Shipstone: The southern US, yes.

Q71 **Barry Gardiner:** If you look at the timber reports going back to 2011, you will find that that is not the case. The baseline year that was used in Drax's own projections was an anomalous year. I do not think you can say that at all. If you can, please back it up with written evidence to the Committee.

Jason Shipstone: I would be happy to do so.

Q72 **Barry Gardiner:** Of course, 50% of the pellets that you bring into the UK come from whole trees—either 21% from low-grade roundwood or 30% from thinnings. Is that not correct?

Jason Shipstone: We use thinnings and low-grade roundwood. 40% of our biomass comes from sawdust residues from sawmills and things like that. We take limbs and branches—things that would otherwise be either left to waste or, in some cases, even burned.

Q73 **Barry Gardiner:** Or, indeed, increasing the carbon stock within the forests. Dr Quiggin, you wanted to come back.

Dr Quiggin: I feel like somewhat defending Drax here. Why not? The evidence in the US south-east as to whether the carbon stocks are increasing, stabilising or declining is yet to be fully determined. The jury is out. There are early indications that, if you look just at the trees and that carbon stock, they are probably stablish. In terms of soil carbon, however, which is most healthy and least likely to leach into the atmosphere, if you have old growth forests that have biodiversity and are not monoculture plantations, the soil carbon is vast. If we include the soil carbon in our calculations in the US south-east, the picture changes again, but again the jury is still out.

What we can say categorically is that, as we increase the amount of biomass that is burnt for BECCS—which, to be clear, Drax is not asking for, because they already burn biomass and, up to 2030, they were talking about converting only the units that they currently have operating, so they are not necessarily talking about increasing the amount of feedstock going into them—

Q74 **Barry Gardiner:** If we go back to September, the front page of the *Financial Times* reported—and it may not have been a correct report—that Drax had offered to co-fire up its existing turbines with coal at that stage.

Dr Quiggin: The point here is that, as we expand BECCS globally, both within the UK if we are looking at a 50 megatonne target or globally at a 1.5 gigatonne target with the IPCC, those pressures that we are starting to see and that the jury is still out on in the US south-east are going to grow. Whether it is the carbon debt from use of mature trees or decreasing amounts of soil carbon and decreasing carbon stocks within

the trees, all those trends will exacerbate and are likely to decline over time.

Q75 **Barry Gardiner:** If I can go to Chatham House's own research—I do not know whether it was yours, but it is certainly from Chatham House—the estimates were that, in 2019, US-sourced pellets burned for energy in the UK were responsible for 13 million to 16 million tonnes of CO_2 emissions. None of those emissions is included in the UK's national greenhouse gas inventory. Had they been, they would have added between 22% and 27% to the emissions from total UK electricity generation. That would have been between 2.8% and 3.6% of the total UK greenhouse gas emissions in that year. That would be equivalent to the annual greenhouse gas emissions from 6 million to 7 million passenger vehicles.

I do not know whether that was your own personal research, but that came from Chatham House. Can you explain why it is that those emissions were not included in the emissions total for the UK?

Dr Quiggin: I will do so briefly and then hand over to Mair, if that is okay with you. I do recognise those numbers. They were put together by a colleague of mine, Duncan Brack. I broadly agree with those numbers. The point here is that biomass is rated as being carbon-neutral at the point of combustion in a UK power station. There are good reasons for that. You also need to account for the CO_2 in the land sector where that biomass originates.

The key question becomes whether your third country—in this case, we have been talking about the US—is reporting those land-based emissions correctly, such that, when you view it from the atmospheric climate perspective, the maths adds up. There is growing concern, near to consensus, that that is not the case and that we are not adding up correctly.

Therefore, the point source emissions at combustion at the power station—in this case, Drax—should be included in the UK inventory of greenhouse gas emissions, because we cannot rely on third countries to do so, particularly when we are sourcing from so many different types of countries, which may or may not be reporting robustly to the UNFCCC. I am sure Mair might have something to add to this.

Q76 **Barry Gardiner:** Just to be absolutely clear on this point, these are the UN's accounting rules.

Dr Quiggin: Yes.

Barry Gardiner: It is not to do with our Government's basis of accounting—I am getting them off the hook here—but this is in accordance with the UN's accounting rules. The fact of the matter is that the originating or harvesting states or nations are not properly accounting for them, in your view.

Dr Quiggin: Either they will not be reporting, which is an abject failure, or they will be reporting in a way that does not fully account for them.

Mair Floyd-Bosley: I would reiterate Dr Quiggin's point. Just to quote from the IPCC on this particular accounting convention, it says that its approach of not including bioenergy emissions in the energy sector total "should not be interpreted as a conclusion about the sustainability, or carbon neutrality of bioenergy". As mentioned, this convention is purely to avoid double-counting. There is a legitimate reason to do so. There potentially are other solutions to avoid double-counting.

There are two major issues that this convention throws up for us. As mentioned, land use accounting is a seriously flawed process under the UNFCCC, so countries are able to build harvesting projections into their baseline, and can account against a baseline while continuing to harvest, without any of those emissions being reflected in their land use emissions. That is one key flaw. The UK could be advocating for this convention to be changed, but it is UNFCCC guidance.

Q77 **Barry Gardiner:** If we did advocate for that convention to be changed, which would entail us then accounting for those emissions in our production emissions, it would absolutely bust through the fourth and fifth carbon budgets, which we are already not meeting, would it not?

Mair Floyd-Bosley: Yes, I imagine so. That is true. Especially with those numbers that you quoted from the Chatham House report, we have potentially 16 million tonnes of CO_2 emissions in 2019 that went unaccounted for from the smoke stacks of biomass plants. Drax is also in receipt of significant renewable energy subsidies and carbon tax breaks as a result of this zero-carbon rating, so the financial case for bioenergy in the UK would potentially be undermined if the carbon were to be accounted for here as well.

Q78 **Barry Gardiner:** Mr Shipstone, we heard in the first panel, which I believe you were here for and heard, that BECCS should be used only with CCUS. If it needs to be that the carbon is captured and stored from BECCS, does that in any way undermine the idea that woodfired pellet, Drax-style BECCS is renewable, in your view? It is classed as renewable, but does the very fact that we have heard evidence to say that it must always be used with carbon capture and storage not rather undermine the fact that it is renewable?

Jason Shipstone: I do not think so, no. With bioenergy with carbon capture and storage, you are applying a proven technology like CCS on to a proven technology like bioenergy. You get to a negative emission standpoint on that basis.

If I could just turn to the comments made earlier by one of the other panel members, we do not set the international accounting rules around biomass and the treatment of scope 1, 2 and 3 emissions. They are set by the UN IPCC and we follow them. The UK Government have

greenhouse gas emission limits for supply chains for biomass, and they are very clear and we comfortably beat them. In fact, we are at around half of that current emission limit.

Our supply chain emissions for biomass are probably some of the most open and clearly documented in any of the energy sector. We are very transparent about what our supply chain emissions are, where they come from and how they are made up. We report them annually. They are in our annual report for everybody to see. We do not hide this. We follow the regulations and we are comfortably within them.

I guess what you are saying is that, if you interpret the science in a particular way, biomass is not carbon-neutral and, therefore, CCS cannot make us carbon-negative. I do not agree with that. We are strongly carbon-negative. Our supply chain emissions make up only about 15% of our total emissions.

Q79 **Barry Gardiner:** I accept that Drax is operating within the regulations. Whether I want the regulations changed is another matter. We heard from the earlier panel that permanence was really important and that the time period is essential to calculate here. Surely, the carbon payback period that we are looking at with a lot of the forests and the 50% of the whole trees that you are using is critical here. Given the timeframe in which we have to make gains against climate change, and the window that we have to meet 1.5°C closing rapidly towards 2030, wood pellets do not meet that payback period. Is that not one of the fundamental problems that your industry has?

Jason Shipstone: The thinnings and trees that you talk about would be removed from the forest anyway. This is part of good forestry practice. Many working forests are run, effectively, as tree farms, so the timber is grown for other purposes. It is grown not for biomass but for construction or for other reasons. The by-products from that industry—the thinnings, the management and the preparation of those trees to go into that industry—are what we take to use for this.

In terms of the forests in the US south, for example, where much of our material comes from, the climate there is very appropriate for growing timber and fibres, so the trees grow and regenerate very quickly. The whole basis of a sustainable forest is that the material you remove is replaced by other areas of the forest that have been replanted and regenerated to allow those trees to go back. Younger, growing trees are much greater carbon sinks and absorbers than mature trees. Over the early part of a tree's life, it absorbs much more CO_2 than it does when it becomes static. That regular churn of fibre across a managed forest is vital for increasing and improving the carbon sink of those forests.

Q80 **Duncan Baker:** We have covered lots of these bits before, so forgive me if we need to cover some of them for the record. Mair Floyd-Bosley, we have heard them and we know what they are, but can you just go over your overall concerns about the potential impacts on biodiversity from

growing biomass domestically for BECCS, on which the RSPB has submitted work to the inquiry? You talked about water earlier on and there is a whole range of those issues. Can you just flesh some of those out a bit more?

Mair Floyd-Bosley: Do you mean for domestic supply specifically?

Duncan Baker: Yes.

Mair Floyd-Bosley: At the moment, we supply very little of our biomass from the UK. Any increase due to demand for BECCS would mean having to establish new patterns of land use. The first concern regarding expansion of bioenergy crops is land use change. We do not have very much space in the UK. You will be displacing either food production or natural ecosystems. Elsewhere, you might offshore the food production to increase our global footprint or, as Dr Quiggin mentioned, affect food prices. There would also be indirect land use change, so the knock-on impacts of expanding a particular industry at the cost of other industries.

We simply do not have much spare land. Given that we are in a biodiversity crisis as well as a climate crisis, we desperately need to be restoring—for example, re-wetting all of our peatlands, expanding our woodlands, restoring saltmarsh and creating more natural habitat to save those ecosystems that are currently under threat, as well as trying to supply sustainable food and farm sustainably in the UK.

A strategic approach to land for domestic biomass sourcing is absolutely vital. As explained, you cannot simply expand one land-based industry and assume that it will not have knock-on effects.

Q81 **Duncan Baker:** What I feel I am getting from you is that we just do not have the landmass to be able to do this at any scale. No matter how strategic you make it, we have an overriding limiting factor.

Mair Floyd-Bosley: That is correct, yes. I am tempted to pass to Dr Quiggin, because this was a topic of his particular recent report on the land use impacts of domestic sourcing. The scales at which we are talking about BECCS deployment simply are not compatible with trying to shrink our footprint. It would increase pressure on imports, which is something that we need to be reversing at the moment, so it is taking us in completely the opposite direction as to where the land use footprint of the UK needs to be going.

Q82 **Duncan Baker:** Jason Shipstone, if we look at what we achieved with COP26, one of the major announcements was the central pledges from over 100 countries on deforestation. We know that, globally, that is an immense problem of the scale that we have seen. How can you guarantee that the growing demand that we are seeing for biomass—I heard everything you said in your interchanges with Mr Gardiner—will not just keep driving deforestation? Of course, we want to do things in a sustainable manner, but we all know that different jurisdictions around the world do not necessarily adopt the same rules and regulations as

countries that do behave in a manner that is sustainable and acceptable by our standard. Where are the guarantees there?

Jason Shipstone: It is important to make that clear differentiation between biomass that is good and biomass that is not good. Any biomass that causes deforestation is not good and we should not use it. As a technology coming from grown products, certainly in the timber industry, BECCS is not infinite. It is finite. There are various global authorities that have looked at this and various reports have been written. A number of around 4 gigatonnes is often used, which is something like four times the global emissions from aviation. You heard earlier this morning that BECCS is not the only negative emissions technology. We have direct air capture and natural methods as well, all of which will be needed in order for us to meet the climate change requirements that we have in order to get to net zero 2050.

We would very much support and have been the driver of very high and tight standards that govern what sustainable biomass is. I mentioned earlier that we have been working with Defra, the NFU and others in the UK, to the point that one of the other panel members made, on how we maximise the potential of that in the UK too. We do have to be very careful about land use and how that might change, but there is untapped potential within the UK and we are working very hard with the NFU to see if we can explore and maximise the benefit of that.

Q83 **Duncan Baker:** I am going to come to Dr Daniel Quiggin in a moment. This is fascinating, because I can remember, probably 12 years ago, biomass boilers being the new rage and, in north Norfolk, which I am the MP for, working for one of the first companies to install one. We could not find anybody to install it. In terms of how our attitudes have changed to the environment in just over a decade, it is extraordinary listening to the changes. What we thought we were doing back in those days was absolutely the right thing to do. The RHI payments were making it sustainable. It was fantastic. The ridiculous notion was that you could have the doors of the builders merchants fully open in the depths of winter, trying to cool the place down, because it was incentivised to keep running the damn thing all the way through the winter. It was just ludicrous.

When we publish the biomass strategy, what safeguards would you like to see in it?

Dr Quiggin: First off, we should be sourcing a reasonable and sustainable amount of biomass domestically, because you can regulate and enforce those regulations much more easily and robustly.

To touch on Jason's point around the NFU and biocrops, that would be a brilliant way to go. Biocrops cannot be mature trees in disguise. It is much easier to verify the carbon payback period, of which there is not one for biocrops, but let us be clear that, at the moment—I think I am right in saying this, Jason—about 3% of Drax's feedstocks come from

agricultural waste rather than woody biomass residues, which comprise about 97%.

A key question to ask Drax is what their upper limit is on the amount of energy crops that can go into their turbines. There are some technical constraints around that, and the NFU should be aware of what those limitations are.

In terms of your direct question around what should be in the biomass strategy, we should make sure that we are accounting for carbon debt. We should make sure that we are prioritising reductions over removals, but that is probably something that needs to be slotted into the net zero strategy. The biomass strategy needs to sit alongside net zero legislation, and they need to speak to each other.

In terms of net zero, we need to ensure that there is an appropriate split between reductions and removals; at the moment, it is opaque and ambiguous. We also need to ensure that a body—it could be the CCC; it could be another body—reviews what that split is over time, that the split is in relation to how BECCS and other NETs are performing, that there are KPIs wrapped around the operators of NETs, and that, if their KPIs are met and improve over time, you could see in a world in which removals play a greater and greater role.

That also needs to be in relation to the real residual emissions that are very difficult to abate, rather than an offsetting of greenhouse gas removals by BECCS or others ending up allowing a coal or gas-fired power station to offset its emissions. My understanding at the moment is that that is completely feasible, and there are quite a lot of companies queuing up to go down that route.

There is a whole plethora of things that need to be in the biomass strategy, but in terms of the supply chain of biomass, the types of regulations that we need are going to be much easier to achieve in terms of enforcement if they are domestically supplied within the bounds of what is feasible and sustainable to produce in this country. Just to give you a few numbers, by my calculations, for a 50 million tonne target of CO_2 removal by BECCS, you would need at least 10% of UK forests. For a 5 million tonne target—we are talking about a 2030 timeframe—you would need at least 1% of UK forests.

If we were to do that through wheat straw—a by-product of wheat grain—which we have lots of, you could meet that 5 million tonne target with only about 25% of current UK production of wheat grain. We are already producing it. It is already there, but then the key question becomes whether Drax can accept that amount of wheat grain. To get to the 50 million tonne target with wheat grain, that would require a big scale-up of wheat grain production, by about 2.5 times, which we might not necessarily want to do, and would also require about 40% of the agricultural land in this country. Again, you can see that there is a scaling

limit when we move from the 5 million to the 50 million tonne target, and we start to come up against barriers again.

Q84 **Mr Goodwill:** In the meantime, what we are going to bed all our pigs up with if we use the straw in the power stations?

Dr Quiggin: There are absolutely limitations. I would just add that that calculation includes leaving 20% to 40% of the wheat straw in field to prevent phosphorous and nitrogen leaching, but you would probably need to take a bit more off of that for other uses that farmers have, such as, as you say, bedding up pigs. They are illustrative numbers, just to give you an idea.

Q85 **Duncan Baker:** If you could keep this to 30 seconds—I am going slightly off piste—what would you do with the renewable heat incentive as a scheme, particularly relating to biomass? I gave an instance at the very beginning of this. The scheme does not seem very fit for purpose, given the way it can be interpreted by small-scale homeowners and businesses.

Dr Quiggin: We need to ensure that we are not double-counting.

Q86 **Duncan Baker:** There needs to be some sort of regulation and parameters over it.

Dr Quiggin: We need to make sure that we are not double-counting. As mentioned by Ruth Herbert in the previous session, biomass is a limited resource, so what we do with a limited resource has to be really carefully thought through. In my opinion, to a limited and reasonably scalable amount, BECCS is a pretty good way to use biomass, if you ensure that the carbon debt and supply chain emissions are minimised, and that it does not result in loss of biodiversity, land use tensions and food prices.

There are quite a few problems there, but if you sort those out, using biomass to sequester CO_2 and create negative emissions is a good way to go, although there is probably not enough biomass also to do renewable heating or to produce hydrogen and so on. In my view, it is probably best used for BECCS, but the regulations around it need to be tight and domestically enforced.

To answer your direct question, heating needs to go down the heat pump route.

Q87 **Mr Goodwill:** Could I ask you, Dr Quiggin, about some indirect land use changes that we have not looked at? For example, we are very keen to replace steel and concrete in construction with wood. If we are using wood to fuel our power stations, would we make that more difficult? When I was last in Iran, they were building papermills and harvesting quite low-grade forestry to turn into paper. Have you concerns that, if we start sourcing wood from all around the world to produce energy here, it could mean that other uses of that wood would be ruled out, or that other people would be using forestry in other ways?

Dr Quiggin: You should probably also turn to Jason on this one, because he will have a much more detailed understanding of the different end use types of the wood that results in the wood pellets that they burn. The key thing to remember from my perspective is that wood pellets are just one end product of the wood that comes out of a forest. You would not use high-grade wood that you could construct furniture or build a building with for wood pellets. From the harvesters' and mills' perspective, that would be economically suboptimal and bordering on insanity.

Q88 **Mr Goodwill:** You were talking about having to scale up by 126%, which would mean going into some forests that we had not—

Dr Quiggin: That is in relation to wood pellet supply now, which is about 55 million tonnes globally. I am talking about scaling up wood pellet supply by 126 times, but that wood pellet supply has to be produced at the same time as you produce wood for construction or furniture, and that would put more pressure on those supply chains. Therefore, the price of wood pellet goes up, and mills, harvesters and forest managers are going to start to say, "Why do I not just start producing more wood pellets?" from mature trees—that is my concern—that have a large carbon debt, because the price of wood pellets has gone up because of an imbalance between supply and demand.

Q89 **Mr Goodwill:** Jason, do you have a comment on that? We heard that using waste wood or sawdust from sawmills is clear cut. As the timber gets thicker, it becomes more difficult, possibly, to justify using it in a power station.

Jason Shipstone: The energy sector cannot afford to pay roundwood timber prices for fuel. The demand you have talked about increasing from construction, furniture manufacturing and other sustainable building methods is going to drive the growth of forestry and the demand for fibre. The residuals from that fibre, which I mentioned earlier—the sawdust from the mills that process that timber into construction grade timber, and the forestry leftovers, thinnings and residues—are the things that we use for biomass. The two will almost go hand in hand.

Just to pick up on a point that Dr Quiggin made earlier about the different types of agricultural residues that could be used, and the wheat straw, we have tried probably nearly 400 different types of fuel, so we have not used just wood for biomass; we have used other biomasses as well. We used to have a UK energy crop scheme, which Drax used to participate in fully, not that long ago. There are sources of bioenergy other than wood.

I have a team working for me that are actively exploring these and have done for many years now. Over the last two years, we have increased the amount of this material that we can use from the 3% to 5% numbers that Dr Quiggin quoted, up to between 10% and 30% with some of these. These could become active sources of alternative fuels for us in the future, and we are progressing some of those now.

Q90 **Mr Goodwill:** Are those things produced in the UK, like miscanthus or willow?

Jason Shipstone: Some of it is in the UK and some of it is international. There are different types from different areas, but all of it is being considered as potential fuel use. We have had several active trials over the last year to understand what those limits are for blending with wood.

Q91 **Mr Goodwill:** If I could change tack and turn to Mair, do you think that there is too much reliance on NETs in the Government's net zero strategy?

Mair Floyd-Bosley: I do, yes. I would like to bring that question back to the original points that I raised in terms of the problems with the models that we have currently. The models are omitting several significant sources of CO_2 from the supply chain. If we were to integrate a full lifecycle assessment of the CO_2 impacts of BECCS, from the forest, the soil carbon loss and the foregone sequestration, all the way to the smoke stack and including those lost from the smoke stack, I have a significant suspicion that the models would rely much less heavily on BECCS as a solution. In fact, BECCS would not be able to fill that gap.

I would just like to offer one piece of evidence. A 2021 model ran this calculation and created a model based on current supply chains from the US south-east for wood from forest sourcing, as Drax's current supply chain uses. It includes all those sources of CO_2 and finds that BECCS cannot mitigate emissions from burning those wood pellets before 2060. It takes about 30 years to even get to carbon neutrality, even accounting for forest regrowth. That model was very generous in assuming that 90% to 100% of the carbon was being captured at the smoke stack.

If we were to re-run those models based on the empirical evidence that is available to us about the supply chains and the CO_2 emissions that are currently being missed, we would see that the negative emissions reliance could push us towards emitting more carbon. We cannot plug a model assuming that something will be a negative emission when it is actually a positive emitting source. It just does not work.

Another study that I would like to bring to your attention is from 2021 in *Environmental Research Letters*. They developed a model to account for the small risk of negative emissions failure or under-delivery. As I referred to at the beginning, our current models assume that all of these technologies will run perfectly and that we have 100% certainty that they will deliver. That is not true in the real world, so this model embedded a 10% chance that BECCS would not deliver.

This model changed its outputs to the extent that it recommended decarbonising twice as quickly over the next 10 years to account for that risk of failure. That is where we need to be looking. We need to be assuming that these might not deliver. They might increase CO_2 in the atmosphere—we need to be very cognisant of that, because that is an

extreme risk—or they simply will not deliver as we hope they will. We cannot risk getting to 2030 or 2035, which are our next legally binding carbon budgets, and the legally binding net zero target in 2050, having increased the amount of carbon in the atmosphere because we have relied on these technologies.

In conclusion, we need to mitigate, over the next 10 years, in the context of the assumption that we cannot rely on NETs. If we continue to develop and gather empirical evidence on a small, pilot scale, which includes all these CO_2 sources, eliminates forest biomass that risks biodiversity, and has really strict sustainability criteria, we may find ourselves in a position where we can develop some negative emissions technologies, but that is not something that we can rely on.

Q92 **Mr Goodwill:** I assume from what you say that you see NETs as to be used only in the most difficult-to-abate areas and not as an alternative to reducing emissions generally.

Mair Floyd-Bosley: Yes, absolutely.

Mr Goodwill: Dr Quiggin, you are nodding as well.

Dr Quiggin: That is a really good way of summarising it. I would just like to highlight one particular bit of research, which shows that, if all NETs—not just BECCS, although it is the major technology that is most often relied upon—fail to deliver in terms of the negative emissions that we are baking in, and that failure looked like carbon debt payback periods expanding as supply chain pressures build, a worst-case scenario, with lots of caveats, would result in temperatures rising globally by 1.4°C due to a delay in action, as Mair described, in near-term decarbonisation.

Essentially, if we rely on a technology that is not yet proved to deliver in the future, it delays action now, resulting in a greater temperature rise than would otherwise have happened. That is really key to remember, at the same time as we also accept that we need the evidence as to whether BECCS does or does not work. We need to have pilots, either at Drax or elsewhere, that allow us to gather the evidence as to how it performs across the entire supply chain, which is more easily achieved if done domestically. That requires good governance and regulations put around whatever projects are decided to be given subsidies or the go-ahead, in order that we can make an informed choice, such that we do not overly rely on those technologies.

One last point—I know that Jason wants to come in—is that we have to remember that the integrated assessment models that the IPCC and others use are cost-optimising models that make an assumption that demand cannot be reduced, be that eating meat or people having their homes at a lower temperature.

Essentially, what they have done is say that demand and GDP have to continue in this direction, and you get a gap in terms of what we need for 1.5°C or 2°C, which then needs to be filled by NETs, including BECCS.

There is a growing realisation through the pandemic and others that some people will accept, to a certain degree, a lower-demand consumption-based lifestyle. Some of the model assumptions that require NETs need revisiting.

As a very last point, if you look at what the CCC has done in terms of its modelling, you can see that it has taken the upper range and the most optimistic parameters when it comes to BECCS, every time. There is a trade-off between many of those parameters. What the CCC, the integrated assessment models, the IPCC and others are concluding in regard to NETs and BECCS is that it is broadly correct that we need them. Do we need them to the scale that we are baking in and does that create a reliance that then results in increased temperature rises? We still need the evidence that was going to come through plants like the one at Selby, but the Government need to put that good governance around it, such that we make informed decisions.

Q93 **Mr Goodwill:** Jason, you deserve a comeback on that.

Jason Shipstone: Can I just go back to the UN IPCC? This methodology was established in 2003 and verified again in 2019. This is thousands of scientists agreeing on the right way to do this, so we have to give that the credit that it deserves. It is a very solid methodology.

To some of the other points, to say that BECCS is an unproven technology—it is bioenergy. We have been doing this at scale in the UK since 2004, scaling up significantly in the mid-2010s. We have very well-established sustainability practices and very clear audit processes. That part of it is not new.

On the CCS part, I have walked round 1-million-tonne-plus CCS projects in various parts of the world. They have been up and running for several years—many years in the case of some of them. BECCS is simply a combination of the two, so this is not a new and risky technology. There are risks like there are in any new infrastructure, but this is two proven concepts being brought together to deliver a climate good.

To Dr Quiggin's point, there may be conversations to have around the ultimate scale of this and how big this is. I mentioned earlier the 4 gigatonne number that many scientists have agreed on. It is a valuable and necessary way to deliver that quantity of negative emissions that we have to have in order to meet net zero 2050.

Dr Quiggin: I disagree with Jason. We do not know how the supply chain is functioning. We might know how CCS or bioenergy functions in a traditional sense—fine; I will accept that—but the supply chain is incredibly important in terms of the emissions, the carbon debt and the carbon payback period. Are we sourcing that from third countries or domestically? What is the feedstock choice? All that stuff needs to be worked out.

If BECCS in totality, just in terms of the power station itself, was so well defined, why is it that we are only recently finding out what the energy penalty might be? If we do not know what the energy penalty is and, therefore, what the power production and therefore the subsidy is going to be, how can we be drawing conclusions that BECCS is a well-known, defined technology that we can bank on? That does not make any sense to me.

Q94 **Barry Gardiner:** Just very briefly, Dr Quiggin, you spoke of the fact that the CCC, in its modelling, had chosen the most optimistic outcomes for BECCS and for Drax. Do you believe that that has anything to do with the fact that, on the CCC group that looks at this, there was a director of Drax employed as one of the people on the Committee on Climate Change? Do you think that somebody coming from that position has a conflict of interest?

Dr Quiggin: I know exactly what you are referring to. There may be a conflict of interest. It is not for me to say. I will be really clear on that. I am not in a position to analyse that and I definitely cannot comment on whether that individual influenced the modelling of BECCS.

Barry Gardiner: I have not suggested that.

Dr Quiggin: No, but I am just being clear that I do not want to go anywhere near that.

Q95 **Chair:** We will move on from that point. You made the point, thank you. I just have a couple of final questions for Jason. You have explained very clearly that there are two elements—the energy generation and the carbon sequestration and storage. What I am not clear about is how much of the energy that is generated by the power station is being used to drive the CCS. You have these two pilots that you are running at the moment, but once you are into full production, what proportion of the energy will be consumed?

Jason Shipstone: I am happy to provide that to the Committee in written form. I am a bit nervous about talking about it in a public forum. We are entering the phase 2 competition process, so some of this is quite commercially sensitive, but I am very happy to provide written evidence of that.

Q96 **Chair:** That would be very helpful. Could you also include in that what proportion of your CO_2 emissions you would expect to capture?

Jason Shipstone: The answer to that is 95%.

Q97 **Chair:** As a final question, the subsidy arrangements for biomass come to an end in 2027. Can you give us an estimate of what Drax's subsidy expectation is for BECCS, once it is at commercial scale?

Jason Shipstone: Again, these are commercially quite sensitive numbers. I am very happy to provide them. We are working closely with UK Government on what the costs for this might be. We are very

confident that we can bring the cost of the electricity produced down. We have been working hard on that over time and working hard to reduce the cost of biomass. The CO_2 capture number is a fairly well-understood number. If you take industry norms, around £100 per tonne is a reasonable yardstick to use for the cost of CO_2 captured.

Q98 **Chair:** I appreciate that the Government have not declared their position yet on what the CfD arrangements might be, or any kind of rate, but some quite wide ranges have been estimated by observers.

Jason Shipstone: We would be very happy to give you Drax's up-to-date view on numbers and costs for the project in written form.

Chair: That would be very helpful, thank you. I would just like to conclude the panel by thanking our panellists Mair Floyd-Bosley, Dr Daniel Quiggin and Jason Shipstone for joining us today.