HOUSE OF COMMONS

# Environmental Audit Committee

## Oral evidence: Net zero aviation and shipping, HC 520

Wednesday 27 October 2021

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Watch the meeting

Members present: Philip Dunne (Chair); Duncan Baker; Mr Robert Goodwill; James Gray; Helen Hayes; Ian Levy; Caroline Lucas; Jerome Mayhew; Dr Matthew Offord.

Questions 1 - 80

### Witnesses

I: Dr Andy Jefferson, Programme Director, Sustainable Aviation; Dr Chika Miyoshi, Reader in Environmental Systems for Aerospace, Cranfield University; and Chris Young, Group Chief Engineer, Rolls-Royce.

II: Simon Bullock, Research Associate, Tyndall Centre for Climate Change Research, University of Manchester; Sarah Kenny, Chair, Maritime UK; and Anna Ziou, Policy Director, UK Chamber of Shipping.

Written evidence from witnesses:

Sustainable Aviation

Rolls-Royce

Tyndall Centre for Climate Change Research

UK Chamber of Shipping

# Examination of witnesses

Witnesses: Dr Andy Jefferson, Dr Chika Miyoshi and Chris Young.

Q1 **Chair:** Welcome to the Environmental Audit Committee for the opening session in our inquiry into sustainable aviation and maritime. We have two panels today. I am very pleased to welcome our guests for the first panel. I would like you to quickly introduce yourselves to us. Before we get into your evidence, we have declarations of interest. One is from me. I am a non-executive director of Reaction Engines Limited, which is a private company engaged in innovation in aerospace. It is in my register of interests. Does anybody else wish to make a declaration?

**James Gray:** It is non-financial. I am an honorary life member of the Baltic Exchange. It is more on the shipping side rather than the aircraft side. I have a younger brother at Trinity House. I wrote three books on the subject of fuel offset in the shipping industry, all of which are more or less out of print and the income from which is virtually zero, but if anyone would like one, just let me know.

**Chair:** Thank you very much, James. Does anybody else have any?

**Mr Robert Goodwill:** Yes. I should declare that as a former aviation and shipping Minister I know quite a lot of these characters.

**Chair:** Not in a registrable way.

**Mr Robert Goodwill:** Not pecuniary but I know quite a lot of them.

**Ian Levy:** To let the Committee know, I am now working as a parliamentary private secretary within the Cabinet Office.

**Chair:** Congratulations, excellent, terrific. With that, we will now introduce our witnesses. I will start with Chris Young from Rolls-Royce.

***Chris Young:*** I am the group chief engineer for Rolls-Royce, leading the engineering function for the company. You are probably all aware of Rolls-Royce, but we are an important company for UK aviation. We employ 22,000 people in the UK and our activities represent around about 0.6% of UK GDP.

**Chair:** Thank you. You are also involved in the maritime propulsion business as well?

***Chris Young:*** We are in maritime propulsion as well, yes.

**Chair:** Thank you. Dr Andy Jefferson from Sustainable Aviation.

***Dr Jefferson:*** I am an independent consultant but I am here in my capacity as the programme director of Sustainable Aviation. For those of you who are not familiar with us, Sustainable Aviation has been around since 2005. We are a coalition of the UK aviation industry, airlines, airports, air traffic control and the aerospace sector. I am pleased to say

that Rolls-Royce is a key member of Sustainable Aviation and is our current chair.

**Chair:** Thank you. Dr Chika Miyoshi from Cranfield University.

***Dr Miyoshi:*** Thank you, Chair and Committee members, for inviting me today. I am from Japan originally. I am reader in environmental systems for aerospace at Cranfield University. Cranfield University established a green initiative as a university as a primary objective. My position is in research for that. Together with my colleagues we are aiming to contribute to net zero.

Q2 **Chair:** Thank you very much. I will start with a general question, which each of you might like to contribute to, to do with the challenge that the British Government have set themselves by being the first country in the world to declare that by 2035 in the sixth carbon budget we will include international aviation and maritime emissions. Andy, maybe you are the right person to start this. Perhaps you could give us a sense of how big a challenge this is and why it is that no other country has yet made such a move.

***Dr Jefferson:*** It is a very good question. Net zero emissions for aviation is absolutely key, but there are a couple of bits of context. At the moment UK aviation emissions account for about 4% or 5% of global aviation emissions. UK aviation emissions contribution to the global carbon emissions is around 0.1%. That said, I think we have a really strong opportunity in the UK to demonstrate leadership around carbon reduction. In sustainable aviation, in February of last year we were the first aviation industry body to set the target of net zero emissions. I am pleased to say that subsequent to that we have now seen similar commitments across Europe and globally this month. The industry is committed to net zero emissions.

I think that we should not underestimate the challenge in the UK carbon budget. Your question is absolutely well made. It is a significant challenge and it requires dramatic investment in the new technology opportunities going forward. We set out in our plan that we believe that is deliverable through investment in modernising airspace and flying aircraft more efficiently, investing in the current generation aircraft that are available, which Rolls-Royce, Airbus and Boeing are making today, but also then the next generation of aircraft, particularly when we look at the electric and hydrogen aircraft and how they will dramatically affect and alter the shorter-haul flying market from the mid-2030s.

For longer-haul flying we think the switching of fuel from oil fossil fuel to true sustainable aviation fuels will reduce carbon footprints currently by 70%. In future, we think we can have sustainable aviation fuels that are completely zero carbon emitting. They will be a game changer for long-haul flying.

We think there will still be the need for some residual emission management, which we are looking at currently through carbon trading schemes, both UK ETS and CORSIA for flights outside of the UK, but increasingly, moving forward, how those schemes can move more into the carbon removal space, so carbon capture and storage and true carbon removal.

There are lots of interesting innovation opportunities. The challenge is there. It is not a small challenge but it is an achievable challenge. I hope that that paints a picture for now, but I am happy to expand on any of the detail.

Q3 **Chair:** Thank you. Chika, would you like to give us your view on how big the challenge is?

***Dr Miyoshi:*** Certainly. The UK has been a world leader for aviation so I really appreciate your and the Government's initiative to lead the world for net zero. Of course, it is very challenging. Sustainable aviation is a fantastic target in the net zero map: 42% is coming from market-based mechanisms, 4% from operational efficiency and 37% from SAF. Still, it is our target. The challenge is there. However, again as Andy said, it is achievable. Another thing is the fantastic business opportunity in this area that I want to mention today.

Q4 **Chair:** If I can pick you up on that, you say it is an achievable target. Have you done any research at Cranfield to support why you think that is an achievable target?

***Dr Miyoshi:*** I have done a short-term analysis. To be honest, the results show that the challenging side is particularly the market-based mechanism system. We had the EU ETS. Due to the lower carbon price it was not efficient to changes in demand or traffic. However, now the European Union has set a higher carbon emission and the UK Government also tried to intervene on the carbon price, trying to make those systems better. I will be very honest, in the current situation it is really difficult, particularly for hydrogen airplanes. We are not sure when we can get it. We are aiming for 2040. However, for long-haul flights we cannot have it. SAF, that is the technologies that are available.

For the UK side also, I hope you can put investment into investigating the nature-based SAF, agri-based or other nature-based SAF. Currently, the European Union as well as in the world, has said it is not low life cycle carbon emission. However, I think we have a value to investment that on the economy and society side it brings better opportunities for the future.

Q5 **Chair:** I am going to move to Chris Young for Rolls-Royce's perspective on the feasibility.

***Chris Young:*** First, I think it is great that the UK is taking a leading position in this. Rolls-Royce as an industrial company wishes to be in the leading position industrially to support the move to net zero. We have recently published our journey to net zero. You can see that on Rolls-

Royce.com. We have committed to get there by 2050 and we believe that it is eminently achievable through the use of the right technology.

Both of our previous speakers have talked about shorter-haul flights. Electrical is very feasible. Hydrogen is potentially feasible for shorter and regional flights. Through the support of ATI and other great Government initiatives that are supporting us, we have done electric flights. We should soon get the world record in electrical flight. We are making big technological advances in existing efficiency of our products. The advantage of all of our existing products is that with sustainable aviation fuels you can drop into the existing product base the sustainable aviation fuel and it is useable. We have committed that for all of our current in-production programmes we will make them all compatible with sustainable aviation fuels by 2023. The challenge is then to ramp up the availability of those fuels. Again, we are looking at technologies, along with partners in oil companies and so on, to look at ways of novelly producing the sustainable aviation fuels.

Q6 **Chair:** We are going to have some questions specifically on that. Going back to the bigger picture, you all talked about short haul having options for new technologies and making that possible without using fossil fuels. What about long haul? Is Rolls-Royce looking at transcontinental flight using new technologies or is that a long way off?

***Chris Young:*** On the challenge of new technologies on the very long haul side, hydrogen is a potential new technology as a fuel that has the advantage of being zero emissions at the point of coming out of the jet pipe. The trouble with hydrogen is that from a density standpoint it is four times the volume of kerosene to produce the same amount of energy. Of course, as you then relatively go on a longer and longer-haul mission, the amount of fuel you need to carry relative to the payload that you are carrying becomes much greater and volume becomes a big challenge. Hydrogen very much has good potential for very short range, but overcoming that volume challenge means that we have to get much more efficient in the engines.

There are a number of technical challenges around the use of hydrogen. It is a millionth less ignition energy than kerosene, so it is working out the safety issues with all of that. To get it to a volume that is only four times the amount of kerosene you have to have it cryogenic, not as a gas, which means it is at around minus 260 degrees. The challenges of that cryogenic system on a long-haul flight means that there is a lot of research and a lot of technology development that is required.

Is that feasible long term? Possibly, and we are working on research in that area. Even if by 2040 or so we came up with technology that would allow us to do that, we would still then need to replace the existing fleet of aircraft. Given that there are 25,000-odd aircraft out there, that will take a lot of years of production to be able to replace the existing aircraft.

That is where we believe that for long haul in particular dropping SAFs in means that we can do it quickly. We can make our products compatible with it now and that will best serve us to address the environmental challenge while on short haul and more regional moving new technologies in that can eventually scale up potentially into the longer-haul travel.

Q7 **Chair:** Thank you. That was a very helpful overview to set the scene for our discussion. I am going to ask a couple of questions of Andy before moving on to the next colleague. We have just gone through the pandemic. The aviation industry is one of the most affected by the pandemic. Could you give us a sense of how its impact has been felt and what you think the industry needs to do to recover?

***Dr Jefferson:*** It is an incredibly traumatic experience for everybody, for society clearly but also for the aviation industry. We saw over 90% reduction in flying immediately as the pandemic hit. Where are we right now? On the road to recovery, I am pleased to say, but by no means back to where we were, in the region of around 50% of where we were pre-pandemic. The latest forecasts are indicating recovery to pre-2019 levels by around about 2024, so this is not expected to bounce back overnight. Clearly, every company across the industry has had to take some dramatic action in curtailing business and unfortunately having to lay people off. I am pleased to say that we are now starting to see a return of that and people being re-employed, which is great, but we should not underestimate the financial challenges that that has imposed on all companies.

Particularly for Sustainable Aviation that is important because the companies are building up an investment pot of money through making profits, which they then seek to reinvest in sustainable innovation solutions. The pandemic has hurt that. It has not stopped it but it has hurt it. What I take heart from is that throughout the pandemic Sustainable Aviation and its membership grew. We got more companies joining Sustainable Aviation. We have a broader membership now. We have sustainable fuel producers and innovators joining Sustainable Aviation. We have carbon removal innovators joining Sustainable Aviation. The commitment and appetite to achieve net zero for aviation has not diminished, despite the pandemic, but the financial ability for the industry to fix this by itself has been damaged. I hope that gives you a flavour of where we are, Chair.

Q8 **Chair:** It is a difficult time to be investing in new technologies, given those circumstances. The Government published their transport decarbonisation plan this summer, within which is an important consultation on the jet zero strategy. Sustainable Aviation has done its own equivalent document. Can you compare and contrast where the Government are going and where you think they should go?

***Dr Jefferson:*** Yes, of course, Chair. I will say that broadly the Government have done a good job in their jet zero strategy consultation. It reflects what we see within industry as the important areas that we

should all be working on between industry and Government: modernising airspace, more direct flights, lower emissions, less airborne holding waiting to land. That is an important part of the jigsaw and will deliver us carbon savings almost immediately.

Then into the sustainable aviation fuel area and how we can scale up that market, to be frank we are starting from zero. I think there is hardly any sustainable fuel production here in the UK at the moment. Potentially, we think that you could have three sustainable fuel plants by 2025 and it goes up from there, with additional jobs and skill development. Then we have the whole aerospace story, as Chris was explaining, and how we can move into next generation aircraft and how that can change the story. Finally, what do we do around carbon removal for the bit that is left? For all of that, certainly the work we have done in Sustainable Aviation indicates that that can get us to a point by 2050 that we are significantly lower in carbon emissions than we were in 2019. When you take into account the carbon removal and the work to address residual emissions, we show a net emission pathway to zero by 2050. We have interim targets that we will be at least 15% below 2019 levels by 2030, 40% below 2019 levels by 2040 and then, of course, net zero by 2050.

I think that pathway sits, from the analysis we have done, in between the upper and lower boundaries of the DfT scenarios and also within the boundaries of the Committee on Climate Change work. We think that it is a sensible plan and we think we have an achievable way of getting there. I will not say that the jet zero strategy from the Government is wrong—it seems to be hitting the right notes. We need to make sure that we follow through on the support around the investment for the innovation and realising and commercialising those investment opportunities.

**Chair:** Thank you. I am now going to ask Jerome Mayhew to pick up a set of questions.

Q9 **Jerome Mayhew:** I realise that I perhaps ought to make a declaration as well. I am an alumnus of Cranfield University and I was a sometime guest lecturer on its MBA programme and on its business growth programme, but not on the aviation side.

I am going to kick off with Mr Young. We have read about a number of technical efficiencies, and you have already spoken about them a little bit. For Rolls-Royce, we have read about the UltraFan, reducing weight and thereby increasing efficiency. What can be done with the existing aircraft we have, given that they are going to last for 20 years, something like that? What can we do with them? What is the level of emissions savings that could be made through that foreseeable technical progress?

***Chris Young:*** I will answer that in a number of ways. Clearly, the biggest thing is back to sustainable aviation fuels. We have been testing our existing products for compatibility with the sustainable aviation fuels, again with great support through the ATI for doing that. We have tested

our Pearl product for business aviation and the Trent XWB engines. We have recently done a sustainable aviation fuel demonstration flight on our 747 flying test bed. There are some technical challenges. We use fuel to lubricate some of the seals within the engine, so you have to check that the properties are okay for that. So far, everything looks like we can just drop those SAFs into the engines. That means that we can have a pathway to net zero with the existing products.

Of course, the other thing we do is we keep investing in new technology all of the time to improve the efficiency of our engines. We often work on retrofits or upgrades to existing products to improve efficiency and make those available to the airlines so that we burn less fuel, whether that is sustainable fuel or conventional jet fuel. There is quite a lot that we can do for the existing fleets that are out there and continue to do with more research in efficiency.

**Jerome Mayhew:** Asking a stupid question, I am guessing that SAF stands for sustainable aviation fuel?

***Chris Young:*** Sorry, yes, sustainable aviation fuel.

Q10 **Jerome Mayhew:** Sticking with that, Dr Jefferson, it seems that the short to medium-term answer is SAF, but that comes from raw materials, presumably, and we need to know where those raw materials are going to come from and what acreage or hectarage will be required for the aviation industry if it is going to achieve its net zero. To kick that conversation off, are you aware of the volumes of aviation fuel that are currently used in the industry?

***Dr Jefferson:*** It is a very good question and I will share a couple of statistics of where we are on the journey with sustainable aviation fuels, for instance.

One thing to point out is that there is a natural concern that effectively we are talking here about growing crops to make fuel versus growing crops to feed people. We are not, absolutely not in the UK. We are talking here about using advanced biofuels. These use waste products to make jet fuel initially. We are looking at agricultural waste, forestry wastes and then also the black bin that we throw out every week that goes off and cannot be recycled. We can turn that into jet fuel and we have some great innovators looking at doing that here in the UK. The first plants are looking at using those products. It is not about taking land out of production to provide food; it is about using waste to make jet fuel in phase 1.

Interestingly, in phase 2—and Chris can perhaps talk about this as well—we are talking about what we call power to liquids or e-fuels or synthetic fuels. There are various different terms to mean the same thing. What they mean is that we can use renewable energy. We can link that renewable energy with captured carbon and green hydrogen that we are looking to make across the UK as part of the wider energy strategy

solutions. Put those three things together, linking it with carbon capture, and you can create zero-emission jet fuel. That is something that I know Rolls-Royce is looking at with a lot of interest at the moment and there is some interesting potential around that.

For some quick figures on sustainable aviation fuels, currently this year there has been 360,000 flights using sustainable aviation fuel globally; 100 million litres is being produced per annum, not in the UK unfortunately, primarily in the US and elsewhere; 36 countries now have policies that support SAF. We have seven technical pathways of making sustainable fuel. Can we make jet fuel from waste? Yes, we can. We have done that and there are seven pathways to do it. Those pathways have been proven to be reducing carbon footprints by 70%. At the moment, there is a forward purchasing commitment from the airlines that amounts to £13 billion globally. By 2025, they think that will go up to £30 billion.

We are moving in a strong direction. Globally, the industry is saying that it thinks sustainable fuels can reduce global aviation emissions by 60%. We in the UK have said around 37% so far, primarily because we are looking at stimulating UK-produced sustainable aviation fuel to create jobs and skills and expertise here in the UK, but obviously we could import fuel as well. I hope that gives you some background.

Q11 **Jerome Mayhew:** It is a tantalising answer because it begs a lot of other questions, but I know that Robert Goodwill will be developing that line of questioning so I am going to come back to air traffic management. That is another area where you have told us that you can make significant savings. How could changes to air traffic management reduce emissions from aircraft in the short term?

***Dr Jefferson:*** It is again an important question. As I said in my opening remarks, I think that modernising airspace and flying more efficiently sometimes gets forgotten about in the bigger scheme of sustainable fuel and new technology.

It is an area that we in the UK have some real expertise on. Between aircraft systems and air traffic control data analysis and capability we have enormous potential. I have a couple of points provided by NATS, the UK air traffic control provider here, that gives you some context. Later this year we are expecting to see free route airspace over most of Scotland. That means that effectively airlines will be able to fly their most efficient path through Scotland along their flight. NATS is estimating that that will reduce emissions to the equivalent of 3,500 homes worth of emissions every year. That is going to happen this year. The next step for us in the UK is the west of England and doing a similar exercise in the west of England.

Another example at the moment is work that NATS has been doing with neighbouring air traffic control centres using a cross-border arrivals management scheme. That shares information between us and France and elsewhere and basically says, "How many aircraft are coming up

through Europe into the UK? Do we have capacity for those aircraft to come into the UK and to land at UK airports without holding or to minimise the holding they are having to make?" That is already delivering positive benefits and there is more to come. To put a context to that, reducing airborne holding by a minute will take 15,000 tonnes of carbon out of the atmosphere every year.

**Jerome Mayhew:** Is that in the UK or globally?

***Dr Jefferson:*** That is here in the UK in minimising airborne holding and flying more efficiently through existing airspace.

**Jerome Mayhew:** Not annoying your passengers quite as much as well should not be forgotten.

***Dr Jefferson:*** Exactly. Yes, there are some enormous opportunities. Airspace modernisation is incredibly important. Where we are in the UK at the moment is the Government have been helping by providing some bridge funding through the Covid pandemic. It is primarily looking to help the airspace modernisation programmes happen at low level, so the work that airports need to do with communities and the broader analysis and consultation exercises. We need to continue to support that. At the moment, that funding runs through to the end of this financial year, and we will need to continue that support for another couple of years as we come out of the recovery.

Q12 **Jerome Mayhew:** Dr Miyoshi, with your academic interest in this area, you have a global oversight. We have been learning about the Government's jet zero strategy. We know that it requires improvements in efficiency to deliver between 25% and 36% of carbon dioxide savings. Is this achievable? How are we going to do this? Are we just being hopelessly optimistic?

***Dr Miyoshi:*** My area is aviation economics, so mainly I have been doing those short-term and medium-term targets. There are two. It is a market-based mechanism for aviation tax or a fuel tax. To be honest, I cannot provide any quantitative evidence regarding whether that is achievable or not. For assessing that, we need to assess the variable investment for R&D in the future. With the market-based mechanism or APD, my concern is that misuse of these economic tools might cause those passengers carbon leakage in the end. The UK might lose their competitiveness in those industries.

Aviation is not evil or bad, simply we don't have the technology yet to reduce carbon emissions like automobiles or others, that is all. Aviation brings more benefit for that to assess the variable R&D for new technology. Having that, we can estimate or evaluate if these technologies are achievable or not and by when. This kind of detailed comprehensive cost-benefit analysis is required.

Q13 **Jerome Mayhew:** Can either of you expand on that with the knowledge

that you have?

***Chris Young:*** Maybe on the efficiency front, continued investment in R&D has yielded big improvements in efficiency. From our first generation of large Trent engines in the 1990s to the latest engine, the Trent XWB, which powers the Airbus A350, it is 16% more efficient from a fuel consumption and a $CO_2$ emissions standpoint. Then with the continued investment into UltraFan, that takes us to 25% efficiency. We have carried on investing £1.2 billion a year to carry on that research and technology activity, despite the challenges of Covid. We feel that delivering more than 1% a year of improvement just through investment in that way in technology will give us big benefits in efficiency.

***Dr Jefferson:*** I agree. That is what has been assumed in our road map work. The other thing I would point out is that throughout the pandemic we have seen airlines retiring older aircraft and switching to the new and more efficient aircraft. On average, those aircraft are 15% to 20% more efficient than the aircraft they are replacing. We have already seen—perversely in some regards, but beneficially in this regard—that Covid has helped improve efficiency from airlines.

Q14 **Jerome Mayhew:** In your opening comments, you were rather complimentary about the Government's jet zero policy. From that, can we say that you think the Government are moving fast enough or do you think they should be accelerating further? How do you mark us?

***Dr Jefferson:*** I think you would expect industry to say you could always do better. I suppose—

**Jerome Mayhew:** Industry normally says, "We need more money".

***Dr Jefferson:*** Indeed. Of course, and we will happily say that, but just a point of context: sustainable aviation fuels is an opportunity that Sustainable Aviation identified in 2014. We are now seven years on. I am very pleased to say we have had a policy mandate consultation from the Government and we had a really good announcement last week about £180 million of investment in supporting sustainable fuels going forward. It has also clearly been identified as a part of the Government's decarbonisation 10-point plan. This is all good, but we still don't have a SAF plant operation in the UK. One of the key reasons for that is that we don't have a price certainty mechanism. While the mandate will encourage airlines to use sustainable fuels, the price certainty mechanism is required so that if you are a fuel producer of this new innovative fuel, which is currently costing at least three to five times the cost of buying fossil oil fuel, jet fuel, you have a way of making money.

We are saying to the Government, "Very good work, all heading in the right direction, but we have to make sure we get this price certainty mechanism right". If we don't do that, the risk is we don't attract the investment, the outside private sector investment, to create sustainable fuel plants and so on. As context to that, building a sustainable fuel plant

in the UK is in the region of £300 million. We are aiming to have three of those operational by 2025 and 14 by 2035, so there is a lot of investment.

Q15 **Jerome Mayhew:** Just so I understand it, I may be going up the wrong end of the street on this, but is that akin to a contract for difference in the way that kick-started the offshore wind?

***Dr Jefferson:*** It absolutely is, yes. That is where we think again the UK has some great learning and expertise from the work we did with that. If you look at the work that is going on with the hydrogen strategy and the carbon capture strategy and the work they are looking at around contracts for difference, again there is great learning that we can use to fast-track that solution for sustainable aviation fuels here in the UK. But we need to not take too long about it because in the last 12 months the US has fast-tracked sustainable fuel incentives. That is pulling the innovators and investors away from the UK and they are now looking to invest in the US because they are getting those incentives in a way they are not getting in the UK.

Q16 **Mr Robert Goodwill:** I think that leads quite neatly on. We just heard the Chancellor say basically, "Don't expect the taxpayer or the Government to do everything. Business is there to generate cash" but how helpful was the Government's announcement of £180 million for sustainable aviation fuels last week? How does that compare with the support that maybe other countries around the world—you mentioned the US—are getting?

***Dr Jefferson:*** We absolutely welcome that announcement. It is a real step change in what we have seen historically in the UK. We have been in the order of less than £10 million grant funding to support some research and development around SAF, which has been useful but it is not going to tip the balance in getting these sustainable fuel plants built and the market created in the UK.

We think the market is 5,000 direct jobs in the UK by 2035 and enormous billions of pounds of value to the UK economy. It is something we think the UK has the capability of and we should be doing. It also gives us fuel security around producing sustainable fuel in the UK versus importing it from elsewhere.

The £180 million—it is early days, so I think we need to understand more detail from Government as to what exactly they are thinking that £180 million is going to be spent on. We probably have our own view on that and we need to join forces. There has been a lot of good work in the last 18 months through the Jet Zero Council, where we have brought Government and industry together. We have developed a better understanding of the whole sustainable aviation fuel potential and hence those kind of collaborations I think have helped get us to this point where we are seeing that commitment from Government.

Is that it? Is that all that needs to happen? No, we need the price certainty policy and I suspect there will need to be some continued support to get these first of a kind sustainable fuel plants operational here in the UK.

Q17 **Mr Robert Goodwill:** Thank you very much. Turning to Chris Young, I got the impression from what I have heard already that basically if we can provide enough biofuel or fuel derived from waste or refractory gases, pretty much they will go in the aircraft we have and they will go through your engines. You have done trials and we are good to go. In effect, if we had enough biofuel available, we could do that sooner rather than later. Is that correct?

***Chris Young:*** We certainly could do that sooner rather than later and then I think the challenge is one of scaling up that SAF production. We have talked about taking it from waste and things like that. The route that we are trying to look at is the power to liquid, which basically says I can do direct air capture of carbon dioxide out of the air, taking the carbon dioxide that exists, which has already been emitted, back out of the atmosphere, combining that with an electrolyser for green hydrogen and then use a power source that is clean, like our small modular reactor power source, and combine all of those together into a plant that then basically is completely net zero, because you have taken all of the $CO_2$ out of the atmosphere.

We are working on looking at that direct air capture technology and integrating that into a plant with a small modular reactor. Early days, but the technology looks feasible. We clearly have lots of expertise in moving large quantities of air very efficiently. That is pretty much what we do to enable flight and we are working with partners looking at the chemistry of capturing the $CO_2$ and with academia around modelling some of the plant interactions and how that might work. Being able to have it and put it in engines is fairly immediate. Scaling up and getting the right technologies to allow us to scale up to have every single flight on sustainable aviation fuel is the challenge.

Q18 **Mr Robert Goodwill:** What you are saying is that you can make hydrogen using nuclear reactors. Is that going to be then synthesised into a liquid fuel or would that be a gas that you would use in the aircraft?

***Chris Young:*** It would be synthesised into a liquid fuel such that you could use it as normal jet fuel, but it is net zero completely because when the fuel is re-emitted as carbon, we recapture it using that direct air capture, then you have a closed loop cycle of fuel usage, emission and recapture and recreation into fuel.

Q19 **Mr Robert Goodwill:** I think we heard earlier that hydrogen as a fuel might be a solution for short haul. Last month I was at Spirit aviation in Belfast, where they are making the wings for your A220, but those wings did not look like—which are the tanks of the aircraft. They would be able

to be used to hold fuel. Would you then need a fundamental redesign of the aircraft if hydrogen was the fuel because of the cryogenic pressure tanks you need on there?

***Chris Young:*** Correct. For very short-haul flight you might feasibly be able to use gaseous hydrogen, highly compressed to something like 4,000 psi, but for long haul you need a complete redesign of the aircraft. The tank becomes much larger. You have to think about the aspects of managing the cryogenic nature of the hydrogen and then by the time it gets burnt in the engine, it has to be back to a gas as well, so you have to manage all of the heat exchange cycles that go with all of that. The tanks will inevitably be much larger, so relatively you would have to redesign your aircraft to still be able to cater for the number of passengers and cargo that you want with those much larger tanks and completely different systems associated with them.

Q20 **Mr Robert Goodwill:** These would be journeys that presumably you could also take by train if you were not crossing large bodies of water.

***Chris Young:*** Yes.

**Mr Robert Goodwill:** Understood.

***Chris Young:*** When you have to cross the large bodies of water. The other thing worth mentioning on hydrogen is of course the thing that you emit is water vapour and NOx. More science needs to be done on the effect of contrails of water vapour if you emit lots and lots of hydrogen in the upper atmosphere. That is another area where we have to understand more about hydrogen as a fuel and the potential warming effects of those contrails.

Q21 **Mr Robert Goodwill:** Understood. Turning to Dr Miyoshi, I remember an early report, Chair, where we were talking a lot about indirect land use change and people were talking about deforestation diesel, where you are sort of bulldozing the rainforest to produce more maize or sugar that you turn into ethanol. What are the sustainability challenges associated with fuels from biomass and can those be addressed? If you are going to produce a lot of crops, you would be using a lot of fuel in your tractors and you would use fertilisers, so it is not 100% gain even if you produce a first generation biofuel.

***Dr Miyoshi:*** Exactly. Currently the situation in general with the life cycle of $CO_2$ and if we consider the nature-based stuff, it will become higher. However, through fertiliser or a managed crop system using the satellite, we have a lot of opportunity to investigate to reduce the life cycle of $CO_2$ in this area too, but it is still really unknown. It is the area where we need to do the research and then to see the opportunity for that. The European Union currently considers that the $CO_2$ life cycle is too high. However, also it is looking for the opportunity for that.

Q22 **Mr Robert Goodwill:** Do you have any preliminary figures on the carbon gain from different biofuels, carbon in and fuel out, or is that early days

and the technologies are not so developed?

***Dr Miyoshi:*** I only know the area with SAF in an agri-based opportunity, so using the crop, one can harvest those trees and others to convert into the SAF. We can investigate that area further.

Q23 **Mr Robert Goodwill:** Thank you very much. Did you want to add something, Dr Jefferson?

***Dr Jefferson:*** If you wouldn't mind.

**Mr Robert Goodwill:** Yes, by all means.

***Dr Jefferson:*** I think one of the key things with that first generation crop-based sustainable aviation fuel is it is not something we are looking to promote in the UK. We are looking at advanced waste products to make jet fuel. There is a risk, however, that if we don't support advanced waste products in the UK we will import SAF. When you import SAF you are at the mercy of how that SAF was produced at the place it was produced. I think there are differing sustainability criteria and commitments when you go around the world on what is okay, what is not okay in how you make sustainable aviation fuels. Sustainable Aviation has been very keen to encourage a clear view in the UK but also to try to move that conversation forward globally.

There may be cases where you could use brownfield land, land that is not fit for making food crops, to make sustainable fuels, but I think we need to be challenging and clear across industry and across societies that we shouldn't be in a space where we are saying we are going to grow crops to make fuel versus food. Also on the sustainability criteria, we are looking at increasing the rate of carbon savings, so moving from the advanced waste fuels that are saving carbon around 70% and 80% compared to fossil fuel to the sorts of things Chris was describing, where you have power to liquid, which are completely carbon zero. That is where I think between Government and industry we need to work on the right policies that incentivise the right solutions.

**Mr Robert Goodwill:** Understood. It is certainly not the place we are at with our E10 petrol or the biodiesel, which is pretty much grown from crops that could be used for food in the main.

***Dr Jefferson:*** Agreed.

**Mr Robert Goodwill:** You don't want to, in effect, go down that route.

***Dr Jefferson:*** We are not looking to go down that road, no.

Q24 **Duncan Baker:** This next set of questions is particularly interesting, not just from what we are going to do in the future but from a technology point of view. It is not just the interest on this Environmental Audit Select Committee and all our cumulative interests in net zero, but I think the technology is absolutely fascinating of where we will be to where we will

go.

Chris, you have tackled some of this already, so perhaps it might be interesting to hear Dr Jefferson's and Dr Miyoshi's views on this. On hydrogen and electric flights, certainly the views on hydrogen were given. What is your view individually on both of those, on whether we will be able to make long-haul flights ever in the future?

***Dr Jefferson:*** A very good question. I think Chris has articulated very clearly the kind of challenges that hydrogen presents. When you talk across the aerospace industry, you have some slight differences of opinion. If I talk to Airbus, for instance, their ZEROe programme is committing to provide the first sort of hydrogen commercial aircraft by the mid-2030s. Up in Scotland, the Highlands and Islands and the Scottish Government have some very interesting projects, working with ZeroAvia, a company based at Cranfield, which could see smaller aircraft operational in a hydrogen or an electric capacity possibly before the end of this decade. Again, very interesting potential.

Longer term with long-haul hydrogen, if we go beyond 2050, it will be interesting to see how we could develop the concepts that have been produced for short-haul flying and how that can be matured. I think the longer timeframe gives Rolls-Royce, Airbus and others that bit more space to mature those ideas for long haul, but at the moment, before 2050, I agree with Chris, it is going to be very, very difficult.

The other thing to point out is we shouldn't forget the infrastructure challenges that these things present. If we are switching to hydrogen aircraft and electric aircraft, we are going to increase the electricity demand that is required to either produce the hydrogen or to be piped to an airport to be put on a plane. The electric provision is easier in some regards because there is already clearly an electric supply to airports and they have fixed electrical ground power to support aircraft on a turnaround. It is slightly different if you are then recharging batteries on a plane parked at an airport.

Hydrogen is even more complicated. At the moment we can't put hydrogen gas through the current fuel pipeline delivery system to an airport, so we need to think about a new infrastructure delivery pathway to an airport, storage on airport and then how you get it from the store and the airport on to the plane and how you do that safely. Then also from an airline point of view, if you are flying a route between A and B with a hydrogen plane, you need to know that there is hydrogen where I am departing from, there is hydrogen where I am going to, and in the unfortunate circumstance I might need to divert, that there is hydrogen at the diversion airport. There is a lot of complexity of infrastructure on the ground provision that we need to get right. We shouldn't underestimate that.

The Government have started looking at some of that already. There is a Connected Places Catapult piece of work with the DfT. That needs to

reach its conclusions, but I think there is a lot more work that will need to happen post that.

**Duncan Baker:** Any good news?

***Dr Jefferson:*** Wind back the clock five years, even three years, we weren't really in a place where we thought this was doable. I think what we must remember is the pioneering spirit and the art of the possible. There is a risk at times where we see aviation as the bogeyman of climate change and therefore it needs to be constrained and restricted. Just to say if we do that, we will constrain and restrict this pioneering spirit, in which we will potentially lose out on these innovative opportunities. They will come; they are coming. What I am pointing out is that we need to all work together to make sure that we have maximised the potential.

Q25 **Duncan Baker:** Yes, there is so much more to the equation than just simply this one, as you have so eloquently put, getting the fuel there, all the build process. I just thought that whole process of changing however many hundred thousand planes there are in operation is enormous, but you have 29 years to sort it out. Dr Miyoshi, what are your thoughts on this?

***Dr Miyoshi:*** Yes, I could just see the big movement for this new technology. At Cranfield we have many colleagues working on hydrogen and electric flight aeroplanes. Of course we need the investment to push this movement. However, it takes time, so meanwhile we need to do the most reliable, practical method too. Those are the two types of approach I think will be very important.

Q26 **Duncan Baker:** If I can go then back to Chris Young. We are seeing the challenges immediately, so let's just say straightaway that the Government are splitting out their targets from domestic and international flights, and I suppose that starts to conceptualise how much of a problem there is. In trying to do the easier bit rather than the harder bit, how realistic are we going to be to getting 2040 and domestic flights working?

***Chris Young:*** We are flying an electric aircraft at Boscombe Down. Hopefully we will get the world speed record with ACCEL, the Spirit of Innovation. This is what we are talking about here and we don't want to stifle that sort of innovation. That electric technology can be used very much for short haul, for urban air mobility.

Q27 **Duncan Baker:** How many seats are in that plane?

***Chris Young:*** That plane is just a single seater, so it is a demonstration.

**Duncan Baker:** I don't think it would be useful yet then for domestic flights.

***Chris Young:*** No, but we are working with various other companies. We are working with Vertical Aerospace, which is based in Bristol. We will

provide the propulsion for Vertical Aerospace, which is urban air mobility, so a flying taxi, effectively, that will be useable domestically. We are working with another company called Tecnam to create the P-Volt that has already had significant interest from regional airlines, particularly in Norway, Widerøe, where there is a lot of flying across fiords. If we do that purely with electricity, and the electricity is from green means, that is a zero-emission technology. We are developing right now today the batteries, the power electronics, the electrical motors and everything that enables zero emissions for the shorter-haul flights.

Of course it is not just useable for civil aviation. The MoD trainer aircraft could be all-electric. There are numerous pathways on the domestic routes for electric or electric hybrid aircraft. We are actively working on all of those technologies today, often supported by the ATI with matched funding.

Q28 **Duncan Baker:** Dr Jefferson, is there a case possibly that the industry is focusing too much on developing zero-emission flights, which we have just said is extremely difficult, when it is much easier to use drop-in fuels, as we have mentioned?

***Dr Jefferson:*** I think Sustainable Aviation would be a strong advocate for there is no single solution to decarbonising aviation. It needs to look at the technology for zero-emission flight, sustainable fuels, airspace modernisation and investment in carbon removal. Those four key areas coming together is what will get us to a place where aviation is not contributing to climate change.

The challenge is which one do you push at what kind of timeframe. I think what I have heard from Chris today is that SAF feels like the kind of thing that they need now, certainly for long-haul flying. We have a little bit more to do to finish the airspace modernisation flight efficiency piece and then we have these next generation of aircraft coming online for short-haul flying out from the mid-2030s, as I understand it, from the broader kind of mindset in aviation. I think Airbus are talking of a short haul, up to a 100-seater type aircraft initially, then moving into the kind of medium range European flight aircraft, so the kind of Airbus A320, Boeing 737-type aeroplane, and then from those experiences looking at the long-haul solution.

It is about timing. All are important and each of those solutions will need differing levels of support between industry and Government between now and when they come online. I don't think we are overly focusing on zero-emission flight. I think we are looking at doing some very exciting work through the Aerospace Technology Institute at the moment. The FlyZero project is ground-breaking in how we take the learning from Rolls and others on these hydrogen electric aircraft. At the same time, we are progressing sustainable aviation fuels. As we said earlier, we have made this step change in both Government support and industry commitment over the last couple of years. There is more work we need to do to that to get it fully commercialised.

Interestingly, the carbon removal space and how we join up with the broader work that is happening across the UK strategy and society on creating carbon removal is going to be very important because if we need to bring net zero earlier, carbon removal, in my mind, is going to be a key part of ensuring that we do that or aviation does that. Again, it feels to me a little bit at the moment with carbon removal that we are in a space where we were maybe five years ago with sustainable aviation fuels, where we understand its potential and we have kind of demonstrated its capability, but we don't have production-scale facilities available and we are not doing it right now. I think there is quite an urgent need to develop that area.

Q29 **Duncan Baker:** A final question to you, Dr Miyoshi. How effective and useful is the Jet Zero Council and its FlyZero scheme? Is it particularly useful at driving this whole initiative forward?

***Dr Miyoshi:*** Yes, certainly. Working together with industry draws investment. Together with academia and industry, it has been pushing that very much. In Cranfield we have the electrified aeroplane project as well as hydrogen. These are really pushing forward. Meanwhile, as Andy said, we need to have several options. Now we have APD and also a UK ETS and an EU ETS and therefore the sustainable aviation fuel industry might want to have an incentive for the specific route or market. We need to assess those impacts. Also I hope the revenue will be invested in the Jet Zero Council net zero project to push this technology further.

**Duncan Baker:** I am grateful. That was fascinating. I could ask so many questions, but it was very interesting, so thank you very much indeed.

Q30 **Helen Hayes:** My questions are about residual emissions and offsetting. You touched on the UK and EU ETS there, so my first question is to Dr Miyoshi. Can you tell us about the relative benefits of cap and trade schemes such as the UK ETS, the EU ETS and CORSIA and which do you think are more effective at reducing emissions?

***Dr Miyoshi:*** Thank you very much. Firstly, market-based mechanisms and tax are different. For example, the Kyoto Protocol established there are three types of market-based mechanisms that the emissions trading scheme added to the project-based scheme. The difference between tax and the emissions trading scheme is the emissions trading scheme is a framework by setting the level of emission and then using the market power to try to reduce the total amount of emissions. The tax system is to put tax on a ticket or whatever and then try to reduce the demand for traffic.

The positive point of the emissions trading scheme is that an emitter can have a choice to reduce emissions to invest in the new efficient airplane or not, so we need to assess which tools are the best option. Particularly, as the Chair said, the Covid situation totally changed the market reaction. Before Covid, 2019 was a kind of peak time for aviation. At that time, for example London Heathrow, 6,000 kilometre miles, passengers in

economy class emit 570 kilograms per passenger. If we charge US$30 per tonne, the passenger needs to pay US$17 if we pass on everything.

In 2019 if we put the total charge on the passenger, maybe we would expect around a 5% drop in traffic. We need to compare which tool is better. Also, now we have many tools, so we need to assess which has the impact of the tools as a one whole air transport system. It is difficult to say which is best or not.

Q31 **Helen Hayes:** That is very helpful. Thank you very much. Can I ask Dr Jefferson, sticking with that theme of what is effective and what isn't from the tools that are available, should travel providers be obligated to provide offsets? Can you say a little bit about the transparency and assurance in some of those offsets? How do we ensure that they provide permanent and sufficient carbon reduction?

***Dr Jefferson:*** That is a very good question. Thank you. I think on the market base measure issue, there are a couple of points to make. First, the industry accepts the polluter pays principle, so we need to address this and it will be addressed.

At the moment, the challenge aviation faces is that it is a global competitive market. As we are in the UK, I think, an enlightened country that is striving to move forward this debate on tackling emissions from aviation. If we just do it in the UK the risk is we almost penalise our goodwill and our enlightened position at the expense of other countries. A passenger may choose, for instance, to say, "Okay, if we increase tax on aviation in the UK, I will fly to Amsterdam and I will get a flight from Amsterdam to New York, for instance, because it is going to work out cheaper".

The work we did in the carbon road map indicated that a carbon price that is effective in the market, so through emissions trading and obviously internationally you have the Carbon Offsetting and Reduction Scheme for International Aviation—CORSIA, as it is called. I think the emissions trading scheme is a good scheme because, as Dr Miyoshi set out, it sets a clear framework and effectively an emissions cap that we all have to work in. That drives a carbon price for the units that people will trade in the emissions trading scheme.

Internationally, we have a carbon offset reduction scheme. That works slightly differently with a slightly different set of rules. There is a risk that the stringency of the carbon removal options that are available through CORSIA will not meet what we would want to see here in the UK or what may be happening across emissions trading schemes in Europe. What we have to do in that case is clearly articulate, from both a UK and hopefully a European perspective, what we expect we would like to see CORSIA moving towards.

The other issue with CORSIA at the moment is that it purely talks about dealing with emission levels above where things were in 2020. That will

not deal with things below the emission levels in 2020. That is missing a trick in my view. Certainly, with the global industry now making commitments to net zero by 2050, I think CORSIA now stands out as a mechanism that needs change. We as the industry are calling on ICAO, the UN body for aviation, to make that change, to make the commitment to net zero and also to then re-evaluate CORSIA and its role going forwards.

The other thing we have said in our work is that we need to move away from carbon offsetting towards carbon removal to improve the stringency and certainty for society that the carbon is being permanently removed and not dealt with in other mechanisms. I think there is lots of work to do. The challenge for us in the UK is how quickly do we implement policies that impact UK aviation activity, and what does that mean for aviation and emissions globally? Do we create unintended consequences where somebody says, "I am going to fly through Amsterdam or Paris or somewhere else because it is cheaper" and, therefore, you are almost creating carbon leakage. I think that is the thing we have to be very careful about.

Q32 **Helen Hayes:** Can I ask specifically about the assurance around tree planting as an offsetting measure? If that is being offered and that is what consumers are being told, where is the monitoring and assurance about the scale of the tree planting, the equivalence and the longevity of the impact on that, just from a consumer point of view?

***Dr Jefferson:*** A very good question. I spoke about the emissions trading scheme and I have spoken about CORSIA. The other thing is voluntary airline offset schemes that they offer people when they book flights. easyJet, for instance, offsets all emissions for its flights and it chooses mechanisms that then provide carbon removal.

All I would say at the moment is that there is a risk that consumers choose not to purchase or buy into that. I think that has been an historical issue. I think easyJet's move was encouraging, because that is the airline saying, "We are going to do this for you rather than ask you do you want to do it". We have seen reciprocal measures by British Airways offsetting its flights domestically in the UK, so we have some pioneering airlines trying to do the right thing.

On the schemes and how robust they are, if it is a voluntary measure by an airline it is more in control of, "What kind of scheme do I invest in and how does that work?" It reports that back through its own governance. Within that there are checks and balances, so its shareholders are challenging them as a company to say, "You guys have to be carbon neutral. We need to see robust evidence to say that what you are doing is taking carbon out".

There is a risk with tree planting that if we are planting trees and then having forest fires, because of climate change and global warming, we are obviously undoing the good work that was done in the first place. I

am not close enough to the detail of those voluntary schemes to be able to say if that is all covered or not but we can definitely find out for you.

With things like CORSIA, there are more checks and balances in those kinds of processes because they have to evidence that it is long-term carbon removal. That is done through the UN process of auditing verification, so probably not perfect but in a stronger position.

Q33 **Helen Hayes:** Thank you. My final question is to Dr Jefferson and Chris Young. Sticking with the negative emissions technologies theme, what investment is currently taking place by the aviation industry into negative emissions technologies? How on target is that to ensure that those technologies are able to play the role that is probably needed to reduce our emissions?

***Chris Young:*** I will start. It is reasonably early days on the negative emissions technologies. We are working on direct air capture, as I talked about earlier. We are hoping to have a pilot scale direct air capture plant by 2023, but there is a lot to do to scale that up as a negative emissions technology. Feasibly, as part of aviation, you could position some of them at airports. As we talked about earlier, there is the potential of using that as part of a Sustainable Aviation fuels plant as well. It becomes very encouraging.

It is early days. We are in support of a grant from BEIS to help fund some of the activity into that direct air capture. It has great potential and it is something we should continue with and get the pilot scale plants up and running.

Q34 **Helen Hayes:** What does "early days" mean, for example, in targets for 2030?

***Chris Young:*** It is early for us to say how much. The plants that we are looking at, at the moment, at a pilot scale would not make a material difference. The question is how scalable those plants could be. I think that is something that needs more research and more investigation further.

***Dr Jefferson:*** It is early stages. Carbon Engineering, a Canadian-based company that is heavily invested in direct air capture, joined Sustainable Aviation last year. It has been really helpful for us starting to get into this space, understand what the challenges are, what we think the opportunities are. I know it is also involved in some projects on the north-east coast of Scotland and is looking at an early stage carbon capture storage, a direct air capture unit facility.

I think we are on the cusp of that kind of large first scale demonstration plant. The challenge will be a little bit like what we were saying with sustainable aviation fuels. Once we have done the demonstration at the large scale, we need to rapidly scale up and commercialise. I think that is where between what is happening in the energy sector—because they are also very interested in this as part of their residual emission challenge, as

will be some industrial processing industries, the cement industry and others. We have an important time where we need to bring these industries together and say, "We are all interested in it. We want to see it happen. The Government want to see it happen. Let's join those forces and accelerate the progress." It is probably not where you would feel it should be at this point but on the cusp of doing some really exciting stuff.

Q35 **Helen Hayes:** Thank you. Dr Miyoshi, do you want to add anything on that?

***Dr Miyoshi:*** Yes, at Cranfield we are looking for any kind of opportunity and also like a nature-based solution to carbon capture by soil or plant, and not only for $CO_2$ but also the contrail assists total reduction and has much more impact. I hope the UK Government put in the investment for research in those areas.

**Chair:** Thank you. The last set of questions to the aviation panel is from James Gray.

Q36 **James Gray:** It has been a long afternoon, and I have been very impressed by all you have had to say so far about all of the efforts that the aviation industry is making to achieve zero carbon. It is very encouraging.

One last set of questions. Of the four strands broadly, which you talked about earlier, all of which have to work together, apart from very much in passing you did not mention demand management at all. Surely there is an argument that says we must reduce the demand for air travel if we are to achieve anything like the targets we are setting ourselves. What do you think?

***Chris Young:*** We firmly believe in the benefits of aviation and air travel for society and we think we have a path that gets there through technological means. We will clearly have to review that path and I think the consultation says every five years there will be a review looking at how well we are doing along that path. We have a route and a strategy through the deployment of technology.

Q37 **James Gray:** Therefore, no limits and no limit to demand you say?

***Chris Young:*** Some of the carbon offsetting schemes and things like that and pricing mechanisms may inevitably have an impact on demand, but I don't think there is any need for additional means.

Q38 **James Gray:** The CCC indicated it thought growth should be 25% on 2018 levels and it looks like being about three times that high.

***Dr Jefferson:*** Certainly, I think this is an important part of the debate and, clearly, I have a lot of sympathy from the mindset of climate change is a really big issue and we need to solve it. We need to do that right and on time so that we don't see the worst effects.

The issue within industry is, as Chris articulated—and we have a plan. We have made a commitment to net zero and we believe that that is

achievable through technology innovation and, therefore, would not require demand management. I think the Committee on Climate Change has taken a different view, as you rightly articulated, and said that it thinks that demand should be constrained and aviation growth should not be permitted until such a point as they can do that without increasing emissions or remaining on a pathway to net zero.

I think the Government in their jet zero strategy set out a view that there is a net zero pathway between now and net zero 2050, and that there will be regular checks and reviews on progress of the industry against that pathway every five years. I think the view within Sustainable Aviation is that if we are not on track with that emission pathway to net zero by 2050 in those reviews, as a measure of last resort clearly demand management is an area that is important to consider.

Coming back to this issue of making a move in the UK around that without the rest of the world making it, the risk is are we solving the problem of taking aviation carbon emissions out of the global equation or not by making that move in the UK? I think we need to be careful because we might stifle desire and investment in innovation. We might also obviously restrict people's ability to fly in the UK, which might force them to do strange things, like get a ferry across the Channel and get on a plane in France. Those are the things we need to be careful about but, certainly, we do need to guarantee that we get to net zero in 2050.

Q39 **James Gray:** You say you are reluctant. Therefore, if the other strands don't work, you might have to consider demand management at some stage down the road between here and 2050. We would be reluctant to do so but we would consider it?

***Dr Jefferson:*** That is where the conversation of Sustainable Aviation is, absolutely, yes. We would not take that as a measure of first choice. We would say—

Q40 **James Gray:** Let us talk about it in theory. Given that you say you hope you will not have to do it, let's talk about it in principle. Would increasing the cost of flying, either by air passenger duty or by tax on fuel, have an effect?

***Dr Jefferson:*** The work we have done in our road map assumed a carbon price of £220 per tonne by 2050, which effectively would be put on to a ticket price. That reduced carbon emissions and demand for flying by a small amount but not significantly. If you look at the UK's demand to travel, it is relatively in economic terms an elastic price, so you have to put price up quite a bit before people stop flying. That is one way of looking at it.

Another way of looking at it is you set a cap on the number of flights or a cap on the number of people that are allowed to fly, or you think of things like frequent flyer levies and other ways in which you restrict

flying. As I say, I am not averse to having those conversations or exploring them. I just think we need to do that intelligently.

Q41 **James Gray:** Of course. A cap would be very difficult to do because you might end up hitting your cap and then people that urgently need to fly for one reason or another would not be allowed to fly. That would be completely inequitable in a free society.

You think, therefore, it would not work unless it is a pretty harsh increase in price. If that were to be the case, let's imagine that airlines prices were doubled, for the sake of the argument, might that not be said to be a regressive form of taxation because people who are least able to pay that extra money will be the wrong ones? We would not be discouraging the right people. Is that a reasonable way of putting it?

***Dr Jefferson:*** Yes. That to me is not fair and equitable. It is not solving the problem and it is probably not helping industry invest in innovation, so it is a triple negative in some regards. The other proposal I have heard from a number of NGOs is the idea of a frequent flyer levy, so those that fly more pay more.

Q42 **James Gray:** Would they mind? Perhaps they would not mind if they have lots of money, frequent flyers. Would they change their behaviour because of that?

***Dr Jefferson:*** Maybe not but I would also suggest that if there is a strong desire to do that we understand the consequences: is that affecting business and trade that the UK is trying to do globally and what does that cost us? Is it stifling innovation in the technology opportunities we have discussed and is it achieving what we want to achieve in reducing global aviation emissions or not? Are other countries joining that same mindset because if they are not, again we are in a place where we are constraining UK aviation and people's ability to travel in the UK but that is not happening elsewhere. I think those are the things we need to think about carefully.

Q43 **James Gray:** Finally, because I think we want to move on to the shipping panel quite shortly, the Chancellor perhaps an hour ago now in the Chamber announced a reduction in air passenger duty effectively. For domestic flights there will be a 50% cut to £13 and for long haul there will be a new band that will cost more for the very long haul, up to £91. Will that work? What effect will that have for the environment and for net zero? Presumably you will welcome that from the point of view of increasing passenger numbers and making it easier to fly, but surely that has a contrary effect in achieving net zero.

***Dr Jefferson:*** It is important to say that Sustainable Aviation does not take strong views on tax matters regarding APD, but from experience APD at the moment is money raised by the Government against aviation and the Government choose to spend that money how they see fit. What is not happening is that money is not in any way hypothecated to manage the impacts around environment, net zero or anything else.

Increasing APD for long-haul flying will make it more expensive to do long-haul flying, whether you are a leisure passenger or a business passenger. If you have cut it domestically it will encourage domestic flying. That is probably as much as I could say on that one at this point.

**Chair:** Thank you. I think Caroline Lucas has one very quick question.

Q44 **Caroline Lucas:** Thank you and apologies if you have already covered this before I came in. Sorry, I was in the Budget debate.

Given that just 15% of people take 70% of the flights in the UK, that is quite an issue when it comes to equity. Have you considered the whole issue of tax on aviation fuel? As you know, aviation does not pay any tax on fuel. I appreciate that internationally that becomes an international thing to be agreed but domestically we could choose, if we wanted to, to put tax on the fuel domestically. For equity, the little old lady who doesn't fly at all is paying tax on the fuel that heats her home perhaps but not when it comes to flying. How is that fair and would you support putting a tax on domestic fuel for flying?

***Dr Miyoshi:*** I did analysis and published a paper based on the US aviation fuel tax, how it affected demand and other aspects. The impact on demand was limited. In general, our conclusion was the combination with EU emission trading schemes and with tax could be very useful because the impact is very limited. That was our analysis. Again, travel behaviour change is very important I might say, particularly for the short-haul sector. If we have electric vehicles or high speed rail, maybe we might choose that, especially as after the Covid pandemic our perception is totally different. People might pay the carbon offset more willingly. For that we need transparent information and choice. For example, from my place to go to Luton or Stansted what sort of emissions, if we use a taxi or a car? Also, for the flight the carbon emission by airlines is very different. Transfer of reliable information is required to change travel behaviour.

Q45 **Chair:** Thank you very much. If you have written a paper about the US experience of pricing aviation, we would be very interested to read that if you are able to submit it to the inquiry. Thank you.

***Dr Miyoshi:*** Very well.

**Chair:** I would like to conclude the panel by thanking our panellists, Chika Miyoshi, Andy Jefferson and Chris Young, for joining us today to talk about aviation. We are now going to move onto the maritime panel. We will do that quickly if we can. Thank you very much.

## Examination of witnesses

Witnesses: Simon Bullock, Sarah Kenny and Anna Ziou.

[*This evidence was taken by video conference*]

Q46 **Chair:** We now turn to shipping and we are joined by our panellists, who

include Anna Ziou from the UK Chamber of Shipping, who I believe has given up her holiday to join us today, which is why she is present on screen. I am not going to ask you where you are calling from, Anna, but you are very welcome. Could you just indicate your role at the UK Chamber?

***Anna Ziou:*** Hello, everyone, and thank you very much for the invite. I am a policy director at the UK Chamber of Shipping, dealing with environmental policy issues. The UK Chamber of Shipping is the trade association of the UK shipping industry and represents more than 200 members, associate members, across the maritime industry. My background is shipping. I have 15 years' experience and have been working very closely with the UK Government and I also attend IMO meetings on energy efficiency issues.

**Chair:** Thank you very much. We are joined in the room by Sarah Kenny. Sarah, you are chair of Maritime UK. Could you explain to the Committee what it does?

***Sarah Kenny:*** Good afternoon, everyone. Maritime UK is the overarching trade association that pulls together all the marine and maritime sector. As Anna has just said, Chamber of Shipping is a member of Maritime UK, so we span the entirety of the shipping sector and the rest of all of the maritime industries that support it, so everything from maritime services insurance underwriting to science and technology and ship building.

**Chair:** Thank you. We are also joined by Simon Bullock from the Tyndall Centre, which organisation usually manages a regular witness before this Committee. Can you explain your role within the Tyndall Centre in relation to this inquiry?

***Simon Bullock:*** Yes, of course. I work on international shipping. I also have a focus on the issue of electrification of shipping, for example, or shore power connecting ports and ships. I cover the whole shipping brief and there are other colleagues at Tyndall who work on other aspects of it, for example biofuels and wind assisted technologies.

Q47 **Chair:** Thank you. I am going to start off with some questions about the context of where shipping sits in the desire to get to net zero Britain. The Government published their Transport Decarbonisation Plan in the summer and announced, as part of that, a net zero for shipping and consultation to be undertaken, I think, next year or to report by the end of next year. Anna, I would like you to start, please. Could you explain the significance of the shipping industry for trade globally and for the UK? We have had some evidence from the Suez Canal incident on how dependent we all are on global trade. Could you put that into context for us.

***Anna Ziou:*** Yes, of course. The maritime industry makes a significant contribution to all nations and regions of the UK. Maritime is responsible for keeping the country supplied: 95% of British import and export goods are moved by sea. Also, it contributes around £46 billion to the UK

economy, which is more than air and rail combined. It has a very important role for the UK overall.

Q48 **Chair:** Sarah, in the context of net zero emissions, shipping hitherto has been on a declining trend but could you explain that? Is that because things that have been happening within the industry are deliberately to reduce emissions or is it more reflective of relative proportion compared to other emitters?

***Sarah Kenny:*** I think it is a little of both. If you look at $CO_2$ emissions globally from the marine and maritime sector, across the period 2009 to 2020 there was a reduction of 0.8% overall. What is interesting there is that at the same time volume demand on the sector went up by 30%. In real terms, that is telling you that the sector is indeed doing something to achieve a level of decarbonisation. Much investment has happened within the sector in the past 10 years, predominantly looking at what might look like quite quick wins. Most of them are technological developments, such as looking at the use of hydrofoils, reduced friction, hull form designs, progressively moving into different forms of fuel so the progress into LNG and subsequently ammonia.

There has been technological advancement at the same time as quite a significant volume demand. That has resulted in a reduction but, as you say, there is also an increase in other emissions in other sectors as well, which has contributed to that offset.

If I could briefly put into context our role versus aviation. Tonne for tonne the sector is by far the cleanest form of transport of goods and services, so just to put some flavour on to that. Comparatively, if you look at $CO_2$ emissions per kilometre per tonne, the maritime sector only just scrapes in with about 0.1 kilograms whereas for aviation short haul is about 2.5 and long haul is about 1.5. That is the scale of the difference on a tonne-for-tonne basis of the sector.

Q49 **Chair:** I hear what you are saying. Is it also the case that vessels have been getting much larger and, therefore, the average emissions per tonne have been coming down as a result of concentration on much larger vessels? Could you put that into context for us?

***Sarah Kenny:*** It is certainly true that scale plays a big factor in that. When you look at the average tanker size—and Anna will be very well able to comment on this from her Chamber of Shipping background—you only have to look out at sea to see the difference in the size of tankers that you would have seen 10 years ago versus today. There is a significant difference in scale, but that is a real-terms environmental contribution.

Q50 **Chair:** Anna, perhaps you might refer to the significance of tankers. As the world decarbonises and has less reliance on fossil fuels, which tend to be a massive source of transport around the world, will you anticipate that that in itself will lead to a significant reduction in emissions by the

shipping sector? Obviously it depends on what is replacing them, but on the assumption that the replacement fuels are distributed and more locally generated, will we have less demand for tanker fleets?

***Anna Ziou:*** This is a very interesting question and it is one of the questions that is raised very often during discussions on decarbonising the industry. The International Maritime Organisation has carried out a study on GHG emissions and a prediction of those emissions for 2030. It predicts that despite the reduced amount on certain sectors, emissions from shipping are estimated to increase by 90% to 120% by 2050. There is going to be an increased demand from other sectors due to the increase of global trade and also new sectors will probably emerge, noting the need for transport of hydrogen and other renewable sources.

Q51 **Chair:** Thank you. Simon, in light of your work at the Tyndall Centre, what role do you think there is for shipping emissions being reduced in volume and how significant is this to the overall achievement of net zero Britain?

***Simon Bullock:*** Sarah is exactly right that shipping is more efficient per tonne mile than other transport forms, but it is still a very large contributor to global warming. If it was a country, it would be the sixth highest emitter, around about the same level as Germany and around double the size of the UK. It is an important sector. Sarah also mentioned that emissions have been essentially flatlined over the last decade at 0.8%. It depends on the baselines you take, but it is essentially flat.

If we want shipping to play a fair contribution to meeting the Paris climate change goals, we have research coming out tomorrow showing that you need to be at zero emission before 2050, and at least one-third of the way there by 2030. At present, although there are efficiencies, demand is growing as well, so we predict that emissions from the shipping sector will be roughly the same as they are today by 2030. It is pretty urgent that we see a changed trajectory for the shipping sector. There is a lot of momentum, which I am sure we will we come on to, but at present the shipping sector needs to do far more to do its part in meeting the Paris goals.

**Chair:** We are very interested to see that report, if you would send us a copy of it when it is published. Thank you. James Gray has a quick follow up.

Q52 **James Gray:** Leaving aside tankers, which is a slight diversion, demand seems unlikely to go down for dry cargo and container shipping, which is likely to go up. Changes in diet in the Far East, for example, will mean vastly increased quantities of grain, and ore and coal as well. Leaving the demand part to one side for the moment, the only way you are going to achieve the kind of reduction you are talking about is if you change the fuel. What percentage of long-haul routes still use bulk carriers or container ships that still use heavy fuel? To what degree is heavy fuel oil being removed, obliterated, or stopped? If it is, what consequence does

that have for freight rates and the cost of moving cargo?

***Anna Ziou:*** I can address this question. Since 2020 the industry has a new regulation that limits sulphur emissions. That regulation had an impact on the type of fuels the industry is considering with regard to air pollution emissions. The industry is still heavily dependent on fuel oils. Obviously, they are low in sulphur emissions now but effectively we are almost completely dependent on heavy fuel or distillate fuels. We have seen recently some increasing demand for new-build vessels to be fuelled with LNG, and we see that also taking a proportion of those new-build vessels in the future until the zero-emission fuels are available and ready for commercialisation by 2030.

Q53 **James Gray:** Yes, but of the several thousand ships there are in the world at this moment, that is a tiny proportion over the last 20 years or longer. The new ships will not have any effect at all within the timeframe they are talking about. Heavy fuel oil runs at about $175 a tonne, or something, and diesel oil and LNG is two or three times more than that. The likelihood of a shipowner voluntarily switching from HFO to a more environmentally friendly type of fuel strikes me as being a bit unlikely.

***Anna Ziou:*** If we are we talking about heavy fuel distillate, they are approximately the same at the moment. The difference is between LNG and the rest of the fossil fuels. However, when considering zero-emission fuels or neutral-carbon fuels, the difference in price is around two times to eight times more expensive.

**Chair:** We are coming on to a whole section of questions on fuels. You can follow that up if we do not pick it up. I will move on now to Caroline Lucas.

Q54 **Caroline Lucas:** My first question is to Simon. What operational changes could reduce shipping emissions and what kind of savings could we expect them to deliver?

***Simon Bullock:*** Of course. There are literally dozens of operational measures you could use and I will just focus on two of the larger ones. The first is reducing speed or speed optimisation. That can drastically reduce the amount of fuel consumption of a ship. The literature tends to talk about a range of 15% to 35% savings, depending on the route and depending on the ship type and the age. Another major opportunity is through wind-assist technology, so big kites, sails, and Flettner rotors. Again, it varies by ship type and route, but that is about 10%. If you combine that with route optimisation, using weather data and GIS data to find the best and optimal routes for ships to take—my colleague James Mason works on this—that can ramp up the savings to around 20%. Again, some ocean routes are better than others and bulk carriers are probably better than container ships. That is a major saving.

On the broader point about operational measures, and I know we will come on to alternative fuels later, but the point about alternative fuels is that although they are essential, it will be the 2030s before they are

scaled up to a point where they make a difference. That is definitely an essential part of the jigsaw, but we need emission reductions in this decade as well. That is where operational measures on speed optimisation, on wind assist and shore power—all these operational measures—will be the big drivers of emissions reductions this coming decade.

Q55 **Caroline Lucas:** Can you envisage wind-assisted shipping being the norm sometime in the future, albeit alongside some of the other changes that you described? What would the impact of that be? Does it mean that people have to wait an awful lot longer before they get the things they order from Amazon, or is it more fundamental than that?

***Simon Bullock:*** It depends on the level of change you want. If you really wanted to ramp up the savings from optimisation beyond the 20% level, that would need greater changes to supply chains and routes and the whole supply chain. At the level we are talking about here, 20%, that sort of change would not have a drastic impact on it.

Q56 **Caroline Lucas:** Interesting. Thank you. You have already touched on this, Simon, so maybe I will see if Anna has anything to add. It was about whether the growth in the overall volume of trade is effectively cancelling out any carbon savings from these operational efficiencies. Simon, I know you said you have a report coming out tomorrow showing that, as a result of growth, emissions would stay much the same as they are now.

***Simon Bullock:*** Go to Anna in a minute. Demand issues are often neglected in discussions around shipping compared with operational measures and fuels. There is a report out by DNV this year, their maritime forecast to 2050, on the sheer scale of the infrastructure we will need to go zero carbon. Zero carbon is heavily determined by the level of demand growth that we have. If we have 25% demand growth, that is one scenario, or 180% demand growth in their other scenario, that doubles the amount of solar and wind infrastructure you would need to provide the electro fuels we will need. Choices around demand are absolutely critical in the level of infrastructure we will need to decarbonise and, therefore, the cost.

**Caroline Lucas:** What is the report you mentioned, sorry?

***Simon Bullock:*** It is the maritime forecast to 2050 by DNV, the Norwegian classification society.

Q57 **Caroline Lucas:** Thank you very much. Anna, do you want to add anything on that?

***Anna Ziou:*** Yes. To add a bit of context on the regulatory requirements that the industry currently has, the shipping industry has one of the most robust frameworks that address operational efficiency of ships. Since 2013 new-built vessels are required to meet certain efficiency design performances, and that is currently in phase 3, which requires up to 50% more efficient vessels to be delivered in 2022. Also, in June this year the

IMO agreed a very comprehensive framework to address issues from shipping in the short term and to meet the IMO's target of reducing and improving efficiency of the industry by at least 40% by 2030. That includes a benchmarking operation efficiency measure, as well as extension of the design efficiency to existing vessels. We believe that this framework is very robust to deliver those short-term efficiency gains. However, I agree with what Simon said, in the long term there is need for a complete systematic change in the industry, and we need zero-emission fuels and infrastructure to support the net zero by 2050 target.

Q58 **Caroline Lucas:** Thank you. Finally, Simon, you touched on the issue of shore power. What more do the Government need to do to support the development of shore power and is it something that should be mandated in the UK?

***Simon Bullock:*** First of all, shore power is an excellent measure. It does not just cut carbon emissions, it cuts air pollution in ports, where people live, compared with emissions out at sea. It is a double benefit. The UK has been slow in deploying shore power compared with other countries like the USA, China, Germany and Norway. There is a couple of reasons for that. Research we did with the shipping port associations last year found that, first, the UK Government do not give as much capital grant support to ports in particular to put in place the shore power facilities as they do in other countries that give bigger grants. The second issue is that shore power electricity obviously has to compete with the ship just being able to burn oil from its normal engines. The UK's industrial electricity prices are some of the highest in Europe. Not only that, some of these other countries specifically exempt shore power from paying environmental taxes because it is a clean form of power compared to dirty fuel burning in an engine. The UK does not do that.

In my view, two of the measures the UK should do are increase the grant support to ports in particular but also to ships to install shore power, because it is a social good, and to deal with the electricity taxation point, mandating regulation. As a package of measures, it is important. It will take a while to do it. California and the EU are doing it; the UK should probably do that as well but alongside and with earlier action on those fiscal measures I mentioned. One last thing is keep it technology neutral. It does not have to be regulation for shore power, just a regulation for zero-emission technologies in the port, and then maybe shore power is the best, maybe not.

Q59 **Caroline Lucas:** Sarah, would you like to add anything to that?

***Sarah Kenny:*** I think Simon has produced an excellent answer there. The principle of zero emissions while alongside is absolutely sound. What must not be forgotten is that the UK needs to make some strategic decisions and to an extent, although Simon has mentioned investment in electric ports in other countries, we have just commissioned our first one in Southampton. That is great progress and we must not forget that. But the generation of electricity domestically also needs to be factored into

this. We must not just push the problem somewhere else. I am not saying that lets shipping off the hook, but we need ships that have infrastructure that can accept electric charging. The benefits in coastal community air quality would be phenomenal. This is a really good thing to do but we must not push the problem of energy generation somewhere inshore, on land, and just transfer the problem somewhere else. It is understanding that this is a wider infrastructure point. It is not just about ships and shipping; it is a very broad infrastructure point.

***Anna Ziou:*** To provide a bit of statistical information, the UK Chamber of Shipping carried out a survey with its members last year to identify what percentage of those ship owners had shore power capabilities onboard vessels, and what the main barriers were. We identified that a large portion of our members had within their fleet shore power capabilities that they were not using due to the lack of infrastructure. That is a missed opportunity of reducing emissions because of the infrastructure. 80% of our members said that infrastructure is the key barrier and 40% of those said that retrofitting existing vessels with shore power was also a barrier, due to the high cost.

However, I fully agree with what Simon said, that any regulatory intervention needs to be coupled with funding, otherwise it will not be workable, and that is the only way that has worked globally. Also, we should see shore power not only as a short-term measure that improves air quality in ports and coastal areas but also as a long-term pathway. Full electrification of vessels is one of the pathways that the industry is considering, especially for short voyages. It is very important, in considering a holistic, strategic view of the port infrastructure, to facilitate this technology.

Q60 **Jerome Mayhew:** We have talked about making routes more efficient with wind, speed, and route optimisation, but the game changer is going to be zero-carbon fuel, isn't it? I am assuming that is right. Correct me, please, if I am wrong. Ms Kenny, I will start with you. Where are we currently on the state of technology for zero-carbon fuels?

***Sarah Kenny:*** Bottom line, up front, we are nowhere near as advanced as we should be in this space. It would be easy to say that that is a function of investment, but in actual fact I think it is also a function of economics and return on investment. We had a brief discussion earlier about fuels, so here we are. Anna mentioned the infrastructure investment on ships that is required to switch fuels or to achieve some level of switch from one to another or have the ability to run with several or make the transition completely from a fossil fuel to a more novel fuel and know that you have the shore-based infrastructure to support it no matter where your ship goes. There is a domestic and international context to this that is to do with shore-based infrastructure and competitive advantage and ship owners and operators knowing they can confidently invest in a particular type of fuel, or retrofitting their ships to accommodate a particular type of fuel, and knowing they will be able to

operate competitively internationally and domestically, as well as make the technology investment for that transition.

This is tricky in the marine and maritime sector because the average life cycle of a ship, if we just take a freight tanker, is 25 to 30 years. That would be quite normal with a several year design life cycle in front of that. We are talking about a very long-term business life cycle with, relatively speaking, low returns. There is a very low margin gain.

Q61 **Jerome Mayhew:** I will just butt in there. I do not know if you were sitting in for the first panel. We were talking about aviation. It was confirmed that the life cycle of an aeroplane is about 25 years. It is very similar and yet the degree of seriousness of ambition, investment and determination in the aviation sector dwarfs what we have heard so far about the shipping sector, where it feels like—in comparison, anyway—there is a hefty degree of complacence. Why do you think that is? What is different about the maritime sector that allows it to be left behind by the aviation sector? What is it doing right that you are doing wrong, or is there an explanation as to why you cannot travel at the same pace?

***Sarah Kenny:*** That is a really good question, and I do not think there is a simple answer, but I will give you some reflections. My reflections are that there is probably less of a direct connection between fuel price and competitive advantage instantly in the same way there is in the aviation sector. There is much more technical reticence around adoption of different or novel technologies in the marine environment. I wish there was not, but I am a marine technologist by background, and I have been doing it for a long time, and there is. There is very much a desire for someone to lead and others to follow, and because of the reliance on infrastructure globally to sustain competitive advantage, which choice do you make?

On the conversation about electric charging points in ports, knowing that you will have an electric hook-up wherever you are in the world, or wherever you need to go with your particular assets, makes a big difference to the investment you will make in which fuel or technology you decide to deploy on your fleet. It rapidly becomes very circular, but the margins in the maritime sector are really low. You are talking about 3% or 4%, sometimes 6% if you are lucky. It is of that order. You are making very long-term investments and you are making, therefore, long-term bets on which technologies are going to be desirable, affordable, available, and where you are going to get your competitive advantage from.

Q62 **Jerome Mayhew:** Do you think another difference between aviation and shipping is the degree of political pressure that has been exerted on the aviation industry, which for some reason shipping has managed, until now, to avoid? Do you think that might be an explanation?

***Sarah Kenny:*** That is a great question and I think in part it relates to our sea blindness. Anna mentioned earlier, and she is absolutely right,

that 95% of all of the goods and services that we either import or export in the UK arrive by sea. Interestingly, the fact that that has happened, up until Covid and some of the early disruption with Brexit, was relatively invisible to people. We just arrived; things arrived. For the public and, therefore, the political context, there is much more awareness now than there probably has been in many decades of the role of the marine and maritime sector, and the visibility of it. The transparency of it, therefore, is much more prominent than it has been for a very long time. I see that as a very positive thing and a huge opportunity to transform the sector. Technology, fuels and the route to net zero are key opportunities to engage in that transformation.

To your point about aviation, I think there is huge opportunity in seeing transport as an asset in its own right, as an industry in its own right, not just trying to package up the sectors, and learning properly, particularly between maritime and automotive where there is a huge amount of common ground. There is less so, but some, common ground between maritime and aviation, but maritime to automotive, there is a huge amount of common ground. I think we should be looking much more proactively at co-investment and collaboration. The point was made earlier in the aviation debate about the role of industrial and R&D collaboration. I think that is essential if we are going to move this on for the sector and for the rest of the transport infrastructure.

Q63 **Jerome Mayhew:** Thank you. Mr Bullock, going back on to the question I am meant to ask, how do we get around the challenges of getting new technologies and new fuels available at scale and predictably around the globe?

***Simon Bullock:*** The biggest challenge for the sector right now is that marine fuel oils are untaxed globally, although there is a lot of R&D going on. I feel it was a bit harsh to the shipping sector before to say that they are way behind the aviation sector. I do not believe that. I think there is a lot of good work going on there around methanol and other fuels, lot of innovation going on, and proposals to scale up R&D and the rest of it. But the issue is that it will not be deployed if it is much more expensive than fossil fuels. If you do not have a carbon price for the sector it is going to be very difficult to see those fuels scaled up at the level we need to see. That has been very difficult to achieve at the IMO level, where these things tend to be discussed and determined. The IMO started talking about market-based measures in 2010 and 11 years on we still do not have one. That is the biggest barrier for the sector.

Q64 **Jerome Mayhew:** Would a carbon border adjustment mechanism go some way to applying the pressure that you are seeking?

***Simon Bullock:*** That is an area I do not particularly work on. The EU is starting to take unilateral action. It said a few years ago that if it did not see progress from the IMO it would act. It was not just that it would do it unilaterally; it put conditions on. We now see it wanting to bring maritime into the EU ETS. It would be preferable to have a global solution, but we

do not live in that ideal world. We cannot wait any longer for the IMO to get its act together. I strongly suggest the EU's ETS approach is not perfect but pragmatic and realistic, it will drive some change and hopefully galvanise the IMO to take the action it needs to as well.

Q65 **Jerome Mayhew:** You will have noticed that the European Union published a draft Bill for CBAM on 15 July this year. It will be interesting to see how that develops. How can we make sure that zero-carbon fuels are genuinely zero carbon and not reliant on fossil-fuel feedstocks? Is there a simple solution to that challenge?

***Simon Bullock:*** You have to have really strong accounting principles, which are best done at the IMO level, with help from the classification societies and other technology experts. You are absolutely right that the way you produce these fuels is critical. When you burn methanol it produces carbon dioxide, so when you produce the methanol you have to be able to suck carbon dioxide out. Blue hydrogen through methane—methane slip is a big problem. Hydrogen through electrolysis is probably the best bet and then using it either as hydrogen or ammonia. Traditionally that has been seen as an expensive way of doing things, but the plummeting cost of renewables, offshore wind in particular, makes it seem to me as if green hydrogen is likely to be the strongest candidate for these fuels.

Battery power has a role to play as well. The UK is particularly good here, because we have a very low carbon intensity grid compared with other countries. Short sea shipping battery power would be a good one.

Q66 **Jerome Mayhew:** Ms Ziou, you put your hand up. Would you like to add something to that?

***Anna Ziou:*** Thank you very much. Yes, I would like to comment on the carbon pricing. I fully support what Simon said. Carbon pricing is needed to incentivise the industry to change, and that is needed urgently and through the IMO. In our call to the IMO to commit to a net zero carbon by 2050 target we have also asked the IMO to agree a carbon price mechanism as soon as possible, because it is needed to transition to the net zero but also to ensure that we do not have unilateral regional requirements, such as the EU's recent proposals. The industry does not support regional measures because they do not tend to work and they lead to carbon leakage.

On the question of how to ensure that the fuels are truly sustainable, the IMO has already started work on a life cycle analysis of fuels and is developing guidelines that will determine how these fuels will be calculated to ensure that they are truly sustainable and zero emission. There are a lot of discussions at the IMO at this point and we anticipate within the next two years having those guidelines ready and to provide a clear pathway on shipping's future to net zero.

Q67 **Jerome Mayhew:** My final question is back to you. We see where the

future is, whether it is green hydrogen, ammonia, one or two other zero carbon alternatives, but there is a degree of debate as to whether we should take advantage of some transitional fuels on the way. What are the risks of doing so or do you think perhaps using liquid natural gas is a good idea?

***Anna Ziou:*** As I mentioned before, LNG has gained some traction due to its emission content and benefits. However, its long-term sustainability in that transition will depend on the available R&D. We have seen that there are countries that are looking at bioenergy as a solution to ensure that there is locking of some emissions in the long term.

***Simon Bullock:*** My view is that LNG is not a good solution as a transitional fuel for two reasons. First, it is still a fossil fuel and it is very high carbon. If you include methane slip, it might not be any better, so there is that problem. The second one is simply of locking. If we build a large LNG infrastructure people will want to use it. It will last for decades but the talk of transition we have now is very short. If we had had this conversation 15 years ago there would have been a bigger role for LNG perhaps, but we do not have a long time for that transition. It feels to me that LNG will either be a high carbon stranded asset or a liability and it is best not to go down that route.

There are parallels with the discussion on biofuels you had in the previous session with the aviation people. There will be a lot of demand for biofuels and land generally. It is hard to say if biofuels are genuinely low carbon. It would be pragmatic not to assume that the shipping sector would be using a lot of biofuels because is it really low carbon and are there other sectors going to be more in need of it?

Q68 **Ian Levy:** I have a few questions on government strategy and support for the maritime industry. If we could go round the room, starting with Simon. The Transport Secretary has signalled that he would like shipping to meet absolute zero by 2050, so I have two questions on that one. Do you support this target and do you think it is achievable?

***Simon Bullock:*** Absolutely I support it. It is necessary. The Paris goal is 1.5 degrees. To get there we have to be zero emissions before 2050 and a long way along that path by 2030 as well. Can it be done? It is a big challenge. We are at the limit now because of the delays in the last decade. The transition is so fast and, as we have heard before, the ships have a long lifetime, the infrastructure lasts a long time, ships do not get replaced very often. We have to go for this now. Economically and technically it is totally possible. The issue is whether there is the political will.

***Sarah Kenny:*** When the IMO announced a 50% reduction by 2050 based on 2008 emissions the whole sector took a deep breath in because back then it felt very progressive. That target was announced in 2018. In 2019, when the Department for Transport published *Maritime 2050* and subsequently in 2019 the clean maritime plan, the aim to achieve net

zero by 2050 was announced. We remain one of the only nations that has made that level of commitment. That remains a very progressive target per the conversation that we have just had.

With the background that I have, my view is it is commendable to seek absolute zero by 2050. To get there from here without a significant investment—government and industry collectively—is not going to be possible. Without significant investment it will not happen. Measuring it would be tricky, particularly given the international context of the industry, where we operate, how we operate, and the fact that we have ships in shipping and ports and land-based infrastructure and seeing this as a multimodal transport network. Where do you start and where do you stop?

I would not want to get too far into the analytics of that, but we need to be clear. Ambition: great, absolutely 10 out of 10. Practical reality measures, making it real and the reality of what we would need to do for infrastructure broadly and ships in shipping technology—it is a hard thing to see how we can get there from here.

***Anna Ziou:*** The UK Chamber of Shipping has publicly called for the IMO to double its ambition. We support the IMO to commit to net zero carbon by 2050. We are working with the UK Government for the emissions to align international shipping with the Paris Agreement 1.5 degrees temperature goal. On the domestic aspect, shipping is the UK's next target. Internationally we are looking to level up international shipping with the UK's national targets.

Q69 **Ian Levy:** Simon, how ambitious do you feel the Government's transport decarbonisation plan is for maritime emissions or do you think it is too ambitious?

***Simon Bullock:*** There are lots of positive things in it, particularly the role that the UK says it will play at the IMO and has started to do with the paper it put in last month to the IMO calling for a stronger target. I think there are three things that should be updated domestically. First, the UK has now included international shipping in its carbon budgets so that the targets and the TDP should reflect international shipping as well as domestic.

Secondly, the modelling that the TDP and the clean maritime plan is based on does not have a lot of emission reduction in the next decade. One thing that has changed since then is the Government's guidance on carbon price that came out last month, which puts a far higher price that should be used in policy appraisal. That has a direct link through to the policies and the measures that are cost effective in this decade. It should reflect that.

The third is to get some actual policies on the ground. There is a lot of talk of consultations in there but there is an urgency thing here. People talk about the clean maritime demonstration competition—£23 million. It

was an excellent competition and superb entries that went into it, but it is £23 million. High speed 2 costs 6,000 times that. A road from Cambridge to Huntingdon gets £1.4 billion, that is just for one road, and the shipping sector gets £23 million. I am not proselytising for the shipping sector but it does seem that there is a disconnect in UK transport policy where the shipping sector is a poor cousin at the moment.

Q70 **Ian Levy:** Sarah, where do you feel Government support is needed that would help the shipping industry to achieve that net zero?

***Sarah Kenny:*** First, and Simon may or may not be aware of this, we welcome the £300 million announcement in the Chancellor's Budget statement today around decarbonisation for the transport sector. We do not know how much of that will come to the marine and maritime sector. Simon has just said about the clean maritime demonstration competition. In the bids that we had for that competition, we could have spent the money four or five times over. What that tells you is that the sector and the technologists, scientists and engineers who operate within it, and the ship owners and operators, have an appetite for change and have ideas. There is no shortage of innovative ideas on the table, many of which are realisable—to Simon's point—but only with investment to get to that 2050 goal, preferably earlier.

The trite answer is to invest. The clean maritime plan, the transport decarbonisation plan, the Government's 10-point plan, all of them signpost the right strategy. There is a need to make some strategic judgment calls, particularly on domestic infrastructure around the marine and maritime sector. Simon I think mentions short-sea shipping; that would need a significant investment in smaller ports around the UK to take haulage off the roads and put it into ships.

We could think harder and faster about which technology, particularly fuels—is it electricity, LNG, ammonia or something else—that we want in our major ports around the UK. Making those strategic decisions will act as signposts for the industry to make its own investment, but co-investment is the real key. It needs to be substantial. Our estimate that we pushed into the recent work on the spending review to advise the Budget was that just in the UK it would take at least £1 billion to get ready to decarbonise the sector.

Q71 **Ian Levy:** Anna, do you have any views on Government support to net zero?

***Anna Ziou:*** Yes, definitely. Ambitious targets should be supplemented with also ambitious public funding to enable the early transition. The earlier we start the cost of decarbonisation will be cheaper in the long term. To add to what Sarah said, in addition to R&D and also infrastructure, there is also a need for funding to be available for deployment. Early deployment is necessary to start the transition and we have seen other countries in Europe that are providing to the shipping industry a substantial amount of money to make that early transition and

to build zero emission of vessels. That funding will be key to enable the UK to transition to net zero but also to give the UK shipping industry a competitive advantage.

Q72 **Dr Offord:** Mr Bullock, I want to ask some questions about the IMO and there seems to be some reticence on its part about emissions. What actions do you believe need to be taken to ensure that the IMO starts to push for reductions in emissions?

***Simon Bullock:*** There are three. It has said that it will revise its initial climate change strategy in 2023 and the work for that needs to start now. There is a meeting this month. In that strategy revision there needs to be a 2050 zero-emission target but most critically a much tougher target for 2030 than there is at the present. At present it is an intensity target, which means the emissions can be roughly flat. They have to come down this decade.

With the stronger targets you need to increase the energy efficiency policies, which are currently just designed to meet the existing weaker targets, but the big new policy we need to see is a carbon price so market-based mechanisms are back on the agenda. The Marshall Islands have a proposal for $100 a tonne tax. That sort of thing is essential to get the alternative fuels. You can spend the money dealing with any distributional problems that you might have. For example, it is particularly important to support the Pacific Island nations who have very old inefficient passenger ships plying very long routes. A carbon tax would affect them greatly. You spend the revenues to make sure that those sectors are not badly affected. You do that for the other sectors where there are problems with it. Tougher targets in the carbon price.

Q73 **Dr Offord:** Ms Kenny and Ms Ziou, what would you like to see the UK undertake in action? The IMO is a UN internationally-based organisation. How do the UK Government push to ensure that there are reductions in emissions?

***Sarah Kenny:*** There is a fairly obvious geographic point that the IMO sits in London and the UK has a valuable role in thought leadership and showing the way here, given that we are still and remain a global maritime centre. We hosted the most successful London international shipping week a few weeks ago and we had the head of the IMO in attendance for much of the week, which was fantastic—a real signpost at that level of the collaboration and listening that is required. We must not ignore the fact that it is sitting in our capital city and use it as an opportunity to engage more proactively and progressively and to use our position to thought lead in that space.

Simon has mentioned pushing on the door of progress and pushing for more progress sooner. That is absolutely right. Ambition for 2050: fine. It is starting to look as if it is not progressive compared to what other nations are doing. To make progress it has to be pulled forward and we

should be lobbying for that, but we have to demonstrate some leadership in this to be credible at it.

It comes back again to pushing hard on showing what we can achieve here as a global maritime centre with a rich heritage and reputation for being leaders. We need to show that leadership, demonstrate what can be achieved, and use the fact that IMO sits on our doorstep as a route to demonstrate that.

***Anna Ziou:*** I fully agree with what Sarah said. The UK, as an island nation, is heavily dependent on shipping so obviously it has an interest for the international community to reduce its emissions. The importance of that is because through international actions is the only way that those emissions can be reduced cost effectively. It will also have a cost-effective result to the UK's transition.

I agree with what Sarah said and what Simon mentioned. Two key areas there are the 2050 target and the IMO to be revised in line with the Paris Agreement. The second one is carbon pricing. The industry currently is looking at different carbon pricing mechanisms. We would like the UK industry to come forward with proposals that will enable agreement at the IMO. Unfortunately 10 years ago we had the same discussions and those discussions about carbon pricing are very politically sensitive. I would like the UK to be seen as a bridging nation that will bridge those differences and enable the IMO to agree a workable carbon pricing mechanism. The industry is very keen to help in that aspect.

There is another proposal at the IMO for an R&D fund. We would like the UK to support that and to enable for a centralised R&D fund at the IMO to facilitate and to speed up the decarbonisation of the industry and the level of research that the industry has currently.

Q74 **Dr Offord:** One of the dichotomies of including shipping within the emissions trading schemes is that it does not entirely incentivise the industry to reduce its own emissions. Do you believe, Mr Bullock, there needs to be an international scheme rather than one where each country takes its own place but is unlikely to ensure a greater degree of engagement within emissions reductions in the shipping industry?

***Anna Ziou:*** Sorry, did I hear my name?

**Dr Offord:** I was just giving you a few minutes respite but please go ahead.

***Anna Ziou:*** I fully agree international measures are much more efficient. Shipping is an international industry and vessels are mobile. Through regional measures, the only thing that you are doing is shifting the problem to other areas and usually those areas are poor and developing countries that are already paying the price of climate change. Also regional measures account for only a small portion of those emissions and there is high carbon leakage there. The cost of decarbonisation also will usually be much higher.

Having multiple regional requirements will end up with a conflict of multiple regulatory compliance with the industry and that will be conflicting also regulations globally and will lead to trade inefficiencies. It could have the potential of undermining the IMO and also slowing down the transition of the industry.

***Simon Bullock:*** I agree with a lot of that. A global system would be better but practically will we get that in the timescale that we require? In that regard, the EU bringing in the maritime EU ETS is a good thing. It should galvanise the IMO and it is easily possible to integrate schemes at a later date when there is more of a global agreement than there is at present.

On the issue of carbon leakage, there were the EU's proposals this summer, a 500-page impact assessment on this. To my reading of it, it is very complicated, but I think they felt that the carbon leakage issue will not be that great. It was manageable, so ships are not necessarily going to add an extra stop just to avoid the EU ETS because that adds costs to them as well. Carbon leakage is something we should certainly be concerned about but it should not be a reason to say outright, "No, this will not work".

Q75 **Dr Offord:** I see the logic in that argument but one of the problems is identifying a sovereign nation's national inventory globally. How do you take into account global emissions and align it to a specific country?

***Simon Bullock:*** It is an exceptionally complicated issue about how you would divide international shipping emissions by country. The current way the UK does it around bunker fuel sales is not great because lots of ships bunker in Rotterdam so it gives an underestimate on the UK's emissions, but all the alternatives have problems as well.

What the EU have done is quite pragmatic. The EU MRV reporting system that we put in place a couple of years ago is the basis for the EU ETS. It simply says that we all measure the emissions for every journey and then divide those emissions 50:50 by the countries for the destination port and the arrival port. For technical reasons there are problems with that.

**Dr Offord:** Because it might be delivering to more than one port.

***Simon Bullock:*** Exactly. There are ways you can adjust for that but that is more complicated again. For now it comes back to urgency. We have to get something going here, even if it is not perfect. The EU's approach seems to be pragmatic, it can be seen to be fair. It is worth persevering with. Over time we will overcome these accounting methodology problems, which are some of the most boring things in the world.

Q76 **Dr Offord:** Does anyone else have any further comments on that last question?

***Anna Ziou:*** I do not quite agree with what Simon said. From an accounting point of view, the EU is double counting emissions from

shipping. Also carbon leakage is quite high because if you are an expert on EU MRV you will see that there are quite a lot of areas where a ship can avoid paying the full price of the voyage.

Also there is an issue of what you do when a container is coming from the US, it stops in the EU but is carrying cargo that goes into Africa. Are you taxing also cargoes that are going to double up in countries and other areas? From a carbon point of view, it is not workable including international emissions and domestic emissions. This is why the IMO is there, and from an environmental point of view as well.

We are aware that the UK has included international emissions from shipping in international targets and we welcome to work together with the Government to see how will we account for those. But it is very important to see, when we consider accounting methods, whether they are able to be implemented, they are able to be enforced because we need to ensure a level playing field, whether they are also able to ensure that there is no carbon leakage. There is also the administrative burden that you introduce to the industry, because the industry is very diverse and it has a high number of different types of sizes and ship types and trading areas. It is not as simple as it looks. When you get into the details of that it is a minefield. The Department for Transport will introduce some work on that and we are very keen to contribute constructively to that.

Q77 **James Gray:** Very briefly, to put all this into context, what we have done this afternoon is very interesting and useful. Can you tell me off the top of your head—it will be a difficult statistic to ask you for—what is the total number of British flagged vessels of 10,000 tonnes dead weight and above in the world today?

***Sarah Kenny:*** I do not know the answer to that question. Anna may have an idea of British flag.

Q78 **James Gray:** There are many thousands of ships globally of which a tiny number are British. The second question in context: when one talks about things like electrical power supply in UK ports, of the world's trade of trillions of tonnes a tiny proportion comes into the UK; it is a very small amount. It tends to be America, Japan. From those two lines of argument, even supposing we in Britain were to abolish heavy fuel, for example, it would not make a bit of difference unless the rest of the world did too.

***Simon Bullock:*** My view on those, and you hear it in other contexts as well, is why should the UK do anything? We are already 1% of emissions. If every country who was 1%, 2%, 3% of emissions said there is no point doing anything as we are tiny that would mean that you would be not including over 45% of the world's emissions because most countries are in that 0.5%, 1%, 2%, 3%. Climate change is a collective problem, which requires all countries and sectors to—

Q79 **James Gray:** True, but it does not apply to ships because they move around the world. That is perfectly true what you are talking about, generation of power, for example, but a ship can go from anywhere to anywhere. If a tiny British fleet were to be made the most environmentally friendly ships in the world the Liberian fleets would not necessarily follow suit.

***Simon Bullock:*** That is why we have all talked this afternoon about the importance of the IMO taking greater action but also national governments do. The UK has a leadership role, as Sarah says. Every nation will need to put in place its own measures to help its own industry and sectors alongside global agreements of the sort that the IMO and the ICAO can do.

Q80 **Chair:** There is a final question to follow that up. The Government have today in the Budget announced reform of a tonnage tax with a view to try to attract more ships registered in the UK. Do you have any views as to whether that will be successful and be helpful in having more influence over reducing emissions from shipping?

***Sarah Kenny:*** I know Anna will wish to comment also, but certainly that is a very important step. It has, anecdotally at least, acted as a blocker for UK flag registrations from the feedback that we have had across the sector. With that has to come the further conversation we have just had, that international pressure, so being a UK flag needs to mean something. We can all agree that it needs to mean something quite good in leadership, taking a position, being genuine leaders in this domain. The sector wants to get behind that.

That cannot be a reason to allow targets to slip and allow the route to net zero to not be met. It is great, it is a very positive step, and that announcement, along with the £300 million of investment into transport decarbonisation—provided maritime gets preferably more than its fair share—I see as very positive announcements. We need to get the IMO, it absolutely needs to be an internationally-led debate. There needs to be international regulation to avoid the challenges to competitive advantage of UK-flagged vessels operating around the world. Also to make sure that we take a stand when non-UK flagged vessels, who are not meeting those standards, arrive here, accepting that that has national implications for logistics and supply chains and companies here in the United Kingdom.

All routes lead back to a strong IMO and providing that leadership through the IMO as the UK, and having a strong marine and maritime sector is the best way of going about that, of having strength in thought leadership and being able to challenge those perceptions and flagging.

**Chair:** That is an upbeat note on which to conclude the panel. I will have to stop there as we have well run out of time. I will conclude by thanking Anna Ziou from the UK Chamber, Sarah Kenny from Maritime UK, and Simon Bullock, thank you for joining us again from the Tyndall Centre.

Thank you, colleagues, for bearing with us—we have run on a bit—and to Laura Grant who has prepared our brief from the Committee.