

Transport Committee

Oral evidence: [Fuelling the future: motive power and connectivity](#), HC 973

Wednesday 9 February 2022

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[Watch the meeting](#)

Members present: Huw Merriman (Chair); Mr Ben Bradshaw; Ruth Cadbury; Simon Jupp; Chris Loder; Karl McCartney; Grahame Morris; Gavin Newlands; Greg Smith.

Questions 1–63

Witnesses

[I](#): Paddy Lowe, Founder and Chief Executive Officer, Zero Petroleum; Louise Kingham, Head of Country (UK) and SVP for Europe, BP; Dr Neville Hargreaves, Vice President for Waste to Fuels, Velocys; and Dr Andy Roberts, Director of Downstream Policy, UK Petroleum Industry Association.

Written evidence from witnesses:

- [UK Petroleum Industries Association](#)
- [Velocys](#)
- [Zero Petroleum Limited](#)

Examination of witnesses

Witnesses: Paddy Lowe, Louise Kingham, Dr Hargreaves and Dr Roberts.

Q1 Chair: This is the Transport Committee's first evidence session in our new inquiry "Fuelling the future". We are looking at alternative fuels and what they can bring to our modes of transport.

We are delighted to have two panels this morning. Our second panel will be comprised of some policy experts, but we have the industry before us for our first panel. I ask the witnesses to introduce themselves for the record.

Paddy Lowe: I am Paddy Lowe from Zero Petroleum.

Dr Roberts: I am Andy Roberts from the UK Petroleum Industry Association.

Louise Kingham: I am Louise Kingham from BP.

Dr Hargreaves: I am Neville Hargreaves from Velocys.

Q2 Chair: Good morning to all four of you. We are really excited about this inquiry. It is a real glimpse into the future, looking at science and innovation. We are keen to get all your brainpower for this first hour.

I will start with an opener, which I will put to all four of you. We will start with Paddy and then go all the way down the line. It relates to what we call the Government's technology-agnostic position. They are not really looking to pick winners or losers. They have set the target—net zero by 2050—and are open as to how it is achieved. Do you think that is actually deliverable, or will the Government have to start picking winners and losers to get to that position? Perhaps you can tell us what you think the winner will actually be.

Paddy Lowe: We need a wide range of solutions. That is very clear. There is no single key. Electrification, which has been very successful so far in the renewables sector, will not cover all modes of energy consumption—certainly not in the transport sector—so we will need a wide range of solutions, in the same way as we have a wide range of solutions based on fossil fuel energy sources.

On the other hand, I think that some focus is required. I see quite a range—perhaps too wide a range—of possible liquid fuels. Perhaps some focus is needed around that.

Q3 Chair: What would your winner be, in what you want to see delivered?

Paddy Lowe: In liquid fuels, we have a massive set of assets out there already running on the known petroleum fuels. A good example—I have nothing in particular against it—is the debate around creating ammonia as a liquid energy source. There are lots of examples, but they are quite undeveloped and maybe not fully realistic. I see a general mood that we



have to do everything differently, rather than building the right solutions around our current methodologies and assets.

Q4 **Chair:** Thanks, Paddy. Andy, over to you with the same question.

Dr Roberts: My first point is that I am not sure that the Government are technology agnostic at present. They are focused heavily on tailpipe emissions in the road transport sector. There is no specific technology that will solve our problem. We need all of them, and some of them more quickly than others.

Q5 **Chair:** Can I drill in there? We make the point that the Government are open-minded—technology agnostic, as I called it. You feel that, in reality, they are not, because their policies are geared towards electric, for example. Is that what you are presenting to us?

Dr Roberts: Yes, certainly for the light vehicle fleet. The opinion seems to be that the same technologies can be applied in the heavy goods vehicle fleet, but I am not sure that that is right.

Q6 **Chair:** Thank you. Louise, as far as BP is concerned, what do you see as the future winners?

Louise Kingham: We are interested and involved in a range of those. Building on the comments you have heard, the thing that we observe is that there are different winners, potentially, for the near and the mid-term in different applications. I am thinking of different modes of transport. While there is a focus at the moment, as has been explained, on EVs for light vehicles—passenger transport—we can also see coming down the tracks an emphasis on sustainable aviation fuel for the aviation world, which will be incredibly important. While there are incentives in play at different stages at the moment, there are different applications that will benefit if we can pick up the pace of some of these things.

For example, one of the things that we can see is hydrogen having its place with heavy transport and big fleets. Obviously, there is also a place for biofuels, to make the best use of blending and the transport infrastructure that we have today, recognising that we will have ICE vehicles on the road for quite some time to come and it will be a transition in itself.

Having all our eggs in one basket does not feel like a good solution. We need multiple modes and multiple technologies in different applications. The way to try to pull that together, potentially, is to think about the obligation, or whatever the policy mechanism for decarbonisation of transport is, and to focus on absolute GHG emissions reduction, as opposed maybe to the volume of renewable fuel in the system or some other such methodology. That may be a way of thinking about driving investment in accelerating progress in some of these areas. As Paddy and Andy have said, it is multimodal and multi-fuel.

Q7 **Chair:** Thanks, Louise. Neville, can I put the same question to you?



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Dr Hargreaves: I will focus my answers on aviation because Velocys is about providing the technology to make sustainable aviation fuel. The aviation sector faces a particular challenge, in that for long-haul flight, which is responsible for three quarters of the carbon emissions of the whole global sector, SAF—sustainable aviation fuel—is really the only game in town. Hydrogen and electric propulsion cannot deliver the energy density that is required. In particular, following the comments that Paddy made, they would need wholesale changes to fleet and infrastructure, whereas sustainable aviation fuel can go straight into today's planes and be used immediately. We think that is extremely important. Yes, we should consider all solutions, but think really hard about what those solutions can deliver over what timeframe.

Chair: Thank you very much for the opener. We will move on to all the various modes of transport, some of which you have touched on. I will ask Greg to finish off on the transport decarbonisation plan and the Government's approach.

Greg Smith: Before we begin, for transparency, I put on the record that I have met Paddy Lowe a number of times to discuss this subject and have received briefings on it.

Chair: Greg, you have done what I should have done. Does anyone else wish to declare an interest?

Karl McCartney: I have met Paddy Lowe on a number of occasions, but none of the rest of the panel.

Chair: Great. I always forget that. Greg, thank you very much.

Q8 **Greg Smith:** For an opener, before we dig into some of the detail on the various transport sectors and the impact that different fuels can have on the decarbonisation plan, can I get briefly from each of you a sense of where responsibility for decarbonisation lies? Is it down to the Government to dictate and come up with a winner, or are we more likely to get decarbonised transport by whatever means is the right answer for whichever mode more quickly by leaving it to the industry to come up with the solution through private sector innovation?

Paddy Lowe: I suspect that it is a bit of both. The paper that Rolls-Royce put in was very interesting. It talks about the struggle with first-of-a-kind processes. We are bang in the centre of that right now as a company. There is a role for state assistance and support to get industries going that the state understands are strategically necessary. We see that happening in other countries. I think support is needed there. On the other hand, the market is very good at finding the right path and being the most efficient. In a sense, you set a framework and then let companies and engineers find the right answer and the most efficient solutions within that.

Q9 **Greg Smith:** Thank you. Andy?



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Dr Roberts: I think the Government have a crucial role to play in creating the right business conditions for companies to invest in different technologies. I do not think that Government should pick winners, but clearly for some technologies, such as carbon capture and major hydrogen production projects, the level of investment required is very high. Other countries are competing for that investment, too, so the business conditions have to be right in the UK to deliver those projects.

Q10 **Greg Smith:** Louise?

Louise Kingham: I would just be building on that, Greg, to be honest.

Greg Smith: Fair enough.

Louise Kingham: There are a couple of things. Paddy mentioned nascent markets, which is right. Take the ambition for 5 GW of hydrogen that is part of the 10-point plan. We have some real opportunities, which link to other Government strategies around people and place, regional development, levelling up and so on, where we can bring technologies that support decarbonisation of fuel. As Andy says, with the right mandates from Government in terms of regulation and standards to determine the pace of that progress, and the co-investment and financial mechanisms that support that nascent market development, we could be in a very strong position in the UK not only to supply decarbonised fuels in the UK but also, potentially, to export them.

Q11 **Greg Smith:** Thank you. Neville?

Dr Hargreaves: I will build on Louise's point as well. The link with industrial strategy is absolutely critical. For example, if we say that we want a certain amount of sustainable aviation fuel, or, as Louise put it, a certain level of decarbonisation through the use of sustainable aviation fuel, which is a better way of doing it, we can set a mandate, but how does that mandate get fulfilled? We actually need supply. We need investment in production to happen in order for that supply to be delivered.

It is fine to ask the market to do the investment, the technology and all the building work, but we must have the right market conditions for that investment to take place. If we do not make those conditions here in the UK, we will be at the mercy of other countries. We will be in a vulnerable and importing situation, as opposed to creating a great opportunity for exporting our technology and creating jobs here.

Q12 **Greg Smith:** Let me build on that. Whenever the Government look at anything, there will be an element of cost to benefit. Before we start digging into the individual transport sectors and the impact that alternative fuels can have, is there a correlation between the alternative fuels available and the cost of development and production, bang for buck, in terms of the level of reduction in carbon emissions? Are there easier, cheaper wins that will get us closer to net zero by 2050, or is there a point at which there has to be a massive injection of funding, be



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it taxpayer subsidy or private sector investment, in order to get to a point where we are as decarbonised as it is possible to get in various transport sectors?

Dr Hargreaves: That is a really good question. The task is huge. We have a massive decarbonisation to do. Again, I will focus on aviation as an example. The project we are involved in, with British Airways, to build a waste-to-fuel plant in Immingham, in north-east Lincolnshire, might be the first waste-to-fuel plant in the UK, and one of the very first in the world, but it will supply less than 1% of the UK's aviation fuel demand. We need a lot of investment to create that supply in the UK.

It has to be a portfolio approach. We cannot simply say, "We'll do all the easy things." If we do only the easy things, we will run up against feedstock constraints and will not have made the necessary investment to allow other technologies to come forward, and to reduce cost. The first of each kind will be quite expensive, but they will get a lot cheaper. You have seen that happen in the electricity industry. We need to get on with it. I think that we can pull in the industry as well. It does not all have to be funded by the taxpayer.

Chair: Greg, can I ask you to pick one more witness to answer that question, rather than all of them? We will then have time for the modes.

Q13 **Greg Smith:** We will find a happy medium. I would really like to hear from both BP and Zero Petroleum on this point, given that Paddy is very much at the start of developing a new technology, whereas BP has been in this space forever.

Louise Kingham: Yes, a lot longer than I have. I will answer very quickly, as I am conscious of time. What Neville says is right. There are some easier wins that are lower-cost and near-term answers. That is about using the current infrastructure and the facilities that we have, doing more on biofuels and blending, and taking a look at the standards around all of that. Earlier, a point was made about the pace at which we move these things up, such as advanced lubricants. It is all to make engines and fuels more efficient. Ultimately, our BP scenarios for the future show that that will be what dampens the demand for oil.

The incentivisation, if you like, or the larger-scale investment, which I agree should be co-investment between industry and Government, is around where you want to move from supplying SAF, as we do today, into producing SAF, which we would love to do here in the UK, as Neville said. It is similar for hydrogen. There are some choices about whether we want to go first and fastest and at what point we want to make those investments.

Q14 **Greg Smith:** Thank you very much. Paddy, within this cost question, I would be fascinated to get your take both on the main question and on the level to which we have to factor in cost where you do not have to reinvent the wheel when it comes to the aircraft engine, the plant or



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whatever it might be, as opposed to just the development of the new technology.

Paddy Lowe: To be specific on that, I am always asked, "How much will this fuel cost?" People expect an answer comparing it with fossil fuels. For me, that is the wrong comparison, because fossil fuels have fossils in them. What we need are fossil-free solutions. The comparators should look at the total investment across not just the fuel, but all of the assets that are necessary—not only the vehicle, but the storage, the distribution and all the logistics. Then you come to very different numbers, obviously.

Greg Smith: Okay. I am mindful of time. We need to plough on.

Chair: We will come back to you very shortly, Greg. We will now start to go through all of the modes of transport. We will go through road, aviation, rail and maritime. We will start with road because 55% of the UK's transport emissions come from cars. I will hand over to Ruth Cadbury.

Q15 **Ruth Cadbury:** Chair, I know that you want to start with roads. I will get on to that question, but I want to pick up something that some of you, particularly Paddy, mentioned about the Government's role in investing in or kick-starting decarbonisation at the early point. You said that other countries are doing it better. Can you give one or two specific examples?

Paddy Lowe: In our sector, we see a lot more activity in Germany and Scandinavia. It is starting to emerge in the United States. As Neville said, the opportunity is there to take a lead in investing in relevant technologies, and not only for the UK's programme of defossilisation. There is an opportunity for massive exports if we become one of the lead providers of the relevant services. As a planet, we need to end up running everything from renewable energy and not from fossil energy.

Q16 **Ruth Cadbury:** You are saying that to do that you need active Government intervention at the initial stages.

Paddy Lowe: You need investment in whatever form that can take. It could be direct investment. It could be providing frameworks and incentives, as has been mentioned. It could be procurement. The Government themselves are a big consumer of fossil carbon products. That is another very useful route by which Government can support the programme.

Q17 **Ruth Cadbury:** Is that being done in other equivalent economies?

Paddy Lowe: I won't answer because I do not know the facts and figures, to be honest.

Dr Hargreaves: The United States is doing a pretty good job, particularly in California, in certain aspects on rewarding decarbonisation. A negative-carbon fuel can get twice as much support per litre in California as it can in the UK today.



Q18 Ruth Cadbury: That is a useful example. I am sure that there are more. Thank you very much.

Andy, are the Government's plans to decarbonise the UK's roads too reliant on battery-powered vehicles?

Dr Roberts: I am not sure. For light vehicles, the answer is probably not. Enormous investment is required in charging infrastructure and decarbonisation of the grid. Of course, at the moment we still have a significant carbon footprint for the grid.

For other road transport—HGVs and public passenger transport such as buses and coaches—clearly a mix of technology is required, as Louise mentioned earlier. The Government need to put in place mechanisms that can bring forward those technologies. Low-carbon fuels have a very important role to play there, too, especially in short-term decarbonisation of both the light vehicle fleet and heavier vehicles. At the moment the RTFO does not altogether provide the support that is required for technologies such as hydrogenated vegetable oil—HVO—and other forms of low-carbon fuel.

When we look at heavier forms of transport, additional support may be required for high-blend biofuels. At the moment, we are limited by something called the blend wall—the specifications that ensure that the fuels are fit for purpose. They need to be in place, and we need to move to slightly different technologies to increase the bio-content of petrol and diesel.

Ruth Cadbury: Thank you very much. I think Karl had a supplementary.

Chair: Karl will come in for the rest of the section on road transport. Other Members may come in as well.

Q19 Karl McCartney: My first question is to both Paddy and Andy, if that is okay, although Louise might have something to say as well. To what extent will fossil-free or synthetic fuels be able to displace or replace the use of leaded petrol or diesel in cars, heavy goods vehicles and classic cars by 2050?

Paddy Lowe: Do you mean to substitute for what they use now?

Q20 Karl McCartney: Yes, displace or replace it completely by 2050.

Paddy Lowe: As Neville mentioned, the scale-up is an enormous challenge. There is huge capitalisation required to do that, not least to find the necessary energy to do it. That may come up in your next session, around capability. It requires an enormous amount of renewable generation, as well as the capital around processing. I have not done the work to look at a trajectory to 2050 for all of those markets. We are starting nearer term, so I cannot answer that specific point.

Q21 Karl McCartney: Specifically, do you think that vehicles that add the equivalent of an internal combustion engine but were designed for



synthetic fuels will have even greater benefits than just replacing fossil fuel in our current engines with synthetic fuel?

Paddy Lowe: Synthetic fuels, which is the name we give them—they are often called electrofuels—are fuels that come from, effectively, water and carbon dioxide in the air, rather than any other feedstock. The exciting point about that is that you can make fuels that will drop straight into existing engines, without modification. That is replacing the status quo with a fossil-free equivalent.

The exciting point that we see is in the long term. While combustion today has unwanted side effects, quite aside from global warming, those aspects can be improved dramatically because combustion can be improved with new fuels. The fact that they are synthesised opens up whole new avenues for new types of fuels that are far superior in combustion properties and things like contrails. I see that in 100 years we will have far superior fuels around us in a synthetic world than we have today in a fossil-based petroleum world.

Dr Roberts: Paddy is right. Lead has been removed from UK gasoline blends. We have lead replacement additives available for classic car vehicles. They should work equally well in gasoline produced from biomass, which is perhaps a bit further away than the synfuels for diesel and gasoil.

Some of those technologies have been well known over a period of 10 or even 20 years. The final stages of production for the technologies Paddy talks about are very similar to the coal-to-liquids technology that is found in South Africa with Sasol and the gas-to-liquids technology at the Shell plant in the middle east.

Some of those fuels offer real advantages over crude-derived jet fuel diesel. Cleaner burning, lower NOx emissions and lower particulates have been documented in trials. Low-carbon liquid fuels offer some real potential, right down.

Q22 **Karl McCartney:** Louise, do you have anything to add?

Louise Kingham: I would just reinforce what has been said. With synthetic fuels, it is about the cost and how we get it to a level that is something that can bring scale. That is the challenge we have. That is not to say, "Don't do it," but it needs to happen in parallel to the quick wins we talked about when Greg asked his earlier question. As Andy said, it is what can you do on biofuels blending, to have that running in parallel to support ICE vehicles alongside the ramp-up of EVs and, ultimately, the slightly different solutions that were mentioned earlier for heavy-duty transport and aviation.

Q23 **Karl McCartney:** I have another question for you and Andy. How carbon intensive is the process of producing alternative fuels for the car industry, be they biofuels or batteries for electric vehicles?



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Louise Kingham: That is a great question. You get a variety of answers. One of the challenges in moving the policies and frameworks from where they are today to where they need to be is to look at lifecycle greenhouse gas emissions—absolute emissions—as the driver for measuring best in class, as I think you would get a variety of responses to that question. We can certainly supply you with some data from BP.

Q24 **Karl McCartney:** What would your response be? That is what I am after.

Louise Kingham: I can certainly get you that. I do not have the BP numbers in front of me. We look at a variety of things that are happening externally as well. We can follow up with some of that.

Q25 **Karl McCartney:** Is it fair to say “very”?

Louise Kingham: Yes. I think that would be fair. As Paddy said, it depends on your inputs as much as on the outputs when you are designing these numbers and looking at the models.

Dr Roberts: I agree that some synthetic fuels are electricity intensive. They tend to be more hydrogen intensive than conventional petroleum products, so there are additional costs involved in producing some of the fuels.

Q26 **Karl McCartney:** I am going to have some quick-fire questions, and answers maybe, because I will go to all four of you.

You have mentioned blended fuels already, and I hope that you do not mind me maybe cutting across what you were telling me earlier. Knowing what we know about the power output of the blended fuels, if you were at a petrol station today and were faced with E5 or E10 fuel, what would you put into your car?

Dr Hargreaves: I would put in E10. Actually, I have an electric car, so—

Q27 **Karl McCartney:** If you had a choice between those two fuels, knowing what we know now and looking at what some of the Formula 1 companies are saying about the power output of E10 versus E5, what would you put into your car, even with the price differential?

Dr Hargreaves: I would put E10 into my car.

Louise Kingham: E10, but we make sure that E5 is available.

Dr Roberts: I usually use E10, but sometimes I put in E5.

Paddy Lowe: I don't mind.

Q28 **Karl McCartney:** That is interesting. I always put in E5, even though it costs more, because I think that you get more miles to the gallon, but that's my economics.

Andy, which are more environmentally friendly to produce: hydrogen-powered vehicles or battery-powered electric vehicles?



Dr Roberts: I can't answer that question.

Q29 **Karl McCartney:** Anybody else on the panel?

Louise Kingham: We would recommend them for different uses. There are some things that we would like to do with our projects in Teesside and Aberdeen, where we have blue hydrogen and green hydrogen. There are multiple uses and off-takes for that. There is heavy-duty transport. There is heating, potentially. There is decarbonising industry, using hydrogen as a feedstock. That changes the economics and makes them look more favourable from our point of view, as a business.

Q30 **Karl McCartney:** Are you looking at vehicles, perhaps to keep some of the vehicles that we have today on the road as internal combustion engine vehicles with synthetic fuels? Would that be an environmentally friendly way through?

Louise Kingham: To Paddy's earlier point, it depends on where you can get the cost of synthetic fuels to. It is potentially a question of when. It is not right now.

Q31 **Chair:** Louise, can I come back to you before we move on to aviation with Simon? BP must be looking at designing its forecourt of the future. We have heard some really interesting points about the alternative fuels that are available.

We have done an inquiry on electric vehicles. We looked at the challenges involved: range anxiety; getting the charging infrastructure in place; pressure on the grid, and whether that will actually blow the grid in parts of the country; and the fact that, as I think Andy made clear, electricity generation is not 100% green in any event. Given all those problems with the electric side of things, why are you not betting the house on alternative fuels? I suppose the point I am trying to get at is that there must be a problem with alternative fuels. If not, why are we dancing to the electric tune?

Louise Kingham: I do not think there is a problem. As I said when I was introduced, it is just that as a company we look at a whole range of solutions for different applications.

For light vehicles, the Government currently support moving in the direction of EVs. That is part of what BP wants to be responsive to. You are right in that the challenge with that, from our point of view as a company, is not so much about the demand, which we see grow quite quickly, but about whether or not the infrastructure can keep pace with the demand, and whether or not there is enough open competition to get the right type of charger, in the right location, for the right use for the end customer.

Obviously, there is ultra-fast charging and the slower charging that you do at home or when the vehicle is stationary while you are at work. If you are at a motorway service station, for example, you do not want to



linger too long. After a quick cup of coffee, you want to be back on the road. That is ultra-fast charging. I am aware that the CMA is looking at opening that up, as a bit of a challenge to the infrastructure development at pace. We welcome that, but it probably needs to come sooner. I do not know whether that came up in your inquiry.

To get quick wins early with ICE vehicles, biofuels, advances in lubricants and all the things we have already talked about are really important. While it might feel like EVs are the big push for light vehicles, we recognise that there will still be an awful lot of ICE vehicles on the road for quite some time to come, even after the ban comes in and new vehicles are not being produced. We recognise that it is important to be able to do that and to provide the E10s and E5s for those who need them. For as long as the demand is there, we will keep doing that. You will see forecourts and service areas developing with both EV and fuel provision to address the demand that is going to be there.

Chair: Thank you. I will not put that to anyone else because we should move on to another mode of transport, aviation.

Q32 **Simon Jupp:** Good morning, panel. Thanks very much for coming along this morning.

We are clearly going to talk about aviation fuel. Before we do that and delve into the Government's priorities, what you perceive them to be and what they should be, in your view, I want to ask Neville to explain to us exactly how sustainable aviation fuels are made. I understand that it is quite intriguing, and it is not particularly clear to many members of the public.

Dr Hargreaves: There are three main feedstocks that you can turn into sustainable aviation fuels. By a sustainable aviation fuel, we mean a carbon-based fuel. It is a hydrocarbon, like ordinary jet fuel, but without some of the bits that cause the soot and harmful emissions. You can make them from vegetable oils, with hydrogenation. That is the route being used for almost all sustainable aviation fuel production in the world today. You can make them from solid materials—solid wastes. That is what we are about—converting a wide range of solid feedstocks, particularly ordinary black-bag household waste, so that the carbon in it can be released and synthesised into fuels. The third way is to take CO₂ from the atmosphere and use renewable energy to convert it into a liquid fuel.

There are three different feedstocks. We need all of them. We need the vegetable oils because they are there today and it is the lowest-cost and lowest-energy transformation. We need the solid waste because that can access a much bigger volume of feedstock and therefore deliver a much deeper decarbonisation. We need the access to e-fuels because that releases the feedstock constraints completely, provided that you have sufficient supply of renewable energy. That is an important condition.



Q33 Simon Jupp: That is really clear and much appreciated, and a good context for the questions that I am about to ask. Some would say, and it has been touched on already this morning, that the Government are technology neutral when it comes to fuel in aviation. Whether you agree with that statement or not, when we look at sustainable aviation fuels, hydrogen power or electric flight, what is the preference among you? What should the Government really double-down and focus on, or should they spread equally the funding that they have available? Louise, I will come to you first.

Louise Kingham: For me, it is quite clear. It is SAF—absolutely SAF. There is an opportunity. At BP, we already supply that today. We would like to produce it, too.

There are a couple of things around that. We are very proud to be part of the Jet Zero Council, which offers us advice and guidance. In that room we hear quite a lot of consistency of view around this. There is a place for electrification of planes and for hydrogen, but it is some way away. What we can do today to give the UK competitive advantage at the same time as decarbonising aviation is SAF.

To do that, there are two things that we need. One is the mandate, which should be by 2025 at the latest. Ideally, it should be something between 2% and 5% from our point of view, if we are going to target a 10% mandate by 2030, because that is quite a ramp-up in a short time. Secondly, going back to the earlier question of what we spend and when with Government funding, if we are going to produce, co-investing around production and production facilities could look something like a contract for difference-type mechanism, which has worked successfully in other aspects of decarbonisation, would facilitate investment quickly in the UK and get competitive advantage. When you think about the hub that we are for aviation transport, it makes a lot of sense. We can also link the development of production facilities to people and place and some of the other Government strategies that are in play at the moment.

Q34 Simon Jupp: Thank you. Andy?

Dr Hargreaves: I agree with Louise. Most types of SAF are drop-in fuels, and they offer a very early means of decarbonising aviation. I think that will remain the case for the next 10, 15 or even 20 years. For hydrogen technology, the technology still has to be proven. It is easy to see that it will not be suitable for long-haul flights. Electric flight, yes, is further developed than hydrogen at this stage, but that will be limited to very short flights, island-hopping in the Highlands and Islands and so on.

Q35 Simon Jupp: Paddy?

Paddy Lowe: I generally agree with the previous two answers. For me, liquid fuels are the only answer for any flight of significant range. On a very short range, electric and hydrogen can work, but it is all about payload. An aeroplane is probably the vehicle, of all the vehicles in the transport sector, that is most critical on performance. With a plane, the



amount of energy it consumes to fly is a function of its weight. When you have low energy density, as you have in a battery—the number we use is 50 times relative to jet fuel for a current battery—suddenly you have a plane and it uses more energy just to be in the air, not to mention turnaround times, which is another factor. Charging is already a problem with personal transport cars. Imagine that with aeroplanes. The amount of energy they need is colossal. For us, liquid fuel is the only answer for scale commercial aircraft as opposed to niche applications.

- Q36 **Simon Jupp:** Taking sustainable fuels out of it for a second, when we look at hydrogen and electric, the Government have funded and helped to support various trials. There was one at Exeter airport in my constituency a couple of months ago, which was an electric flight.

Paddy, is there a preference from your point of view as to whether hydrogen or electric is a better option? People have mentioned on the panel this morning that perhaps electric is better for the Highlands and Islands and domestic aviation, for example. Do you have a preference?

Paddy Lowe: No. My preference would be for liquid fuel.

- Q37 **Simon Jupp:** That was not an option, but fair enough. Point taken.

Paddy Lowe: As I said at the beginning, there is a lot of excitement around us doing everything differently. Petroleum is a dirty word in current parlance. One of our missions is to bring back the credit to petroleum. The problem is the fossil bit on the front end with our current sources.

The jet engine is currently a product with 70 years of intensive development. A lot of that came originally from the UK. It is not only about performance efficiency but safety as well. It is very difficult to replace, particularly when you look at the weight factor that I was talking about.

I also read, "Well, batteries will get better." I have witnessed that in Formula 1. We first introduced batteries in 2009 in what was called the KER system. At that time, we thought that battery would never cut it for the opportunity that was made for a new system. Actually, the lithium-ion technology came through with very dramatic improvements in energy and power density in the course of just two years. That is already plateauing because it is an electro-chemical process. It will not significantly close the 50 factor gap that I talked about.

- Q38 **Simon Jupp:** I am conscious of time, but I will quickly come to Andy and Louise on this. Taking away sustainable aviation fuels for a second, I am going to persist on this point. If we are looking at hydrogen or electric, which do you think gives a better bang for your buck and should be invested in by Government?

Dr Roberts: Again, I think it is horses for courses. For short flights, electric offers potential. At this stage, the focus of Government should be



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on support of the OEMs developing those technologies. Hydrogen perhaps offers some potential for medium-range flights. Again, support probably needs to be targeted at the OEMs, the aircraft manufacturers. The oil industry stands by with early hydrogen projects to provide hydrogen for trials. As we stand, the six refineries in the UK produce about 800 tonnes of hydrogen a day, which they use internally in their processes. We are looking with BEIS at how some of that could be made available for trials.

Q39 Simon Jupp: Thank you. Finally, Louise.

Louise Kingham: From a production point of view, I probably favour hydrogen, but I think we are going to need SAF for a very long time to come. I do not think that is ever going to be knocked out of the equation by either of the other two, in reality.

Simon Jupp: Thank you; that is very interesting.

Q40 Chair: What is the point, Andy, of faffing around with electric and hydrogen when it comes to aviation? SAF already works. It is known to work. It is just a question of creating a market for it. I know we are keeping options open, but it strikes me as slightly bizarre that we would be talking about other technologies when there is already going to be pressure on electric, as we have mentioned, and there is something that actually works. At some point, don't we need to put our eggs into a basket on aviation?

Dr Roberts: The scale of SAF production required is very significant. The SAF needs to be available both at the departure airport and the destination. For long haul, clearly that is a challenge. Some of the long-haul destinations are remote from places that might produce SAFs early on. Tankering, where you carry sufficient fuel for the return journey, is not viable for long haul. That is perhaps not a direct answer to your question—

Chair: It is. That is great evidence, actually, so I will stop it there on that basis. Thank you.

Q41 Ruth Cadbury: Neville, you said that the key sources for SAF are vegetable oil and residual waste. Local authorities are reducing the amount of residual waste by diverting waste to recycling, although actually we should all be reducing the amount of waste we produce in the first place. What waste that is increasingly not going to landfill is going to energy and producing electricity. Will we have enough waste to produce sufficient SAF? Is the production of vegetable oils not going to be diverting limited resources, such as land, away from food production?

Dr Hargreaves: Let me take the second question first. It is exactly the right question, by the way. "Do we have enough sustainable feedstock?" is the fundamental question. The answer is that we do not have enough sustainable feedstock to do it all with vegetable oils. That is why it is a short-term part of the solution, but it does not deliver the medium and long term.



Having said that, there are very stringent rules about what feedstocks can be used. People can be confident that today, when someone says they have produced SAF from an oil, it has an honourable supply chain that you can trace back and show that it is not taking land away from food. To come to waste, which is where we are focusing, there is a lot of waste. Despite everyone's efforts to reduce and recycle, there is always going to be residual waste because eventually the cost of separating out all those bits becomes prohibitive, even the energy cost as well.

Is there enough municipal waste on its own to supply all the SAF required in the UK? No, I do not think there is. But if you take into account all the carbon sources, not just municipal solid waste but agricultural waste and forestry waste—the branches, the thinnings and the bits and pieces that are left on the forest floor—it can make a big difference. The UK is not the richest country in the world in that carbon resource, but we can make a big difference to the demand for aviation fuel. The rest has to be done with the third option I mentioned, which is atmospheric CO₂.

Q42 Gavin Newlands: Good morning, panel. I hesitated at the start, but I should probably declare that I have also met Neville, and bumped into Paddy at COP26, to discuss these issues.

It is pretty clear this morning that cost and energy is a big issue in production and development of this sector. Speaking with various people, contracts for difference have come up as an absolute must. Neville, if I could start with you, could you perhaps explain what a contract for difference model would look like for SAFs, and what benefits it would bring for SAFs and indeed potentially the wider synthetic fuel market?

Dr Hargreaves: As we try to get finance into building SAF production, the biggest single challenge we face is uncertainty about the price of the product. The price of the product is defined by Government policy. Mandates create a market, but they do not set a price. When we talk to banks and investors, that is the biggest thing they come back with: "How can you tell me what the price of the product is going to be?"

If we think back to the electricity market, that is exactly what CfDs did. They set a price. A producer knows at the time of investing in the plant, which is several years before it comes into production, that they will get a certain revenue from that plant, provided they produce the fuel. The beauty of it is that the funder is not paying more than they have to. There is no question of excessive profits because it is a fixed price. All they are doing is making up the gap versus the market. We envisage that the mandate will set the market price, and then the contract for difference is a mechanism for smoothing out the gap between the market price and the strike price—the price the producer receives.

It could be funded in a number of ways. In the electricity market Ofgem puts it on to our consumer bills. We need a slightly different mechanism in the aviation market. It is a well tried and proven mechanism, and we



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believe it is the single biggest thing the Government could do to create the opportunity for investment in production facilities in the UK.

Q43 Gavin Newlands: What discussions have you had with the Government on this? What is their current thinking, if any?

Dr Hargreaves: It has been an intensive area of discussion in the Jet Zero Council and in the meetings that we and other industry players have had with Ministers in the Department for Transport, BEIS and elsewhere. It would be fair to say that they have been receptive. I know that the DFT has a small team working on this very topic right now. We appreciate that, and we think they are trying to get there. Our biggest issue is pace.

We have a climate emergency. We also, as the UK, have an opportunity, as several people said earlier, to seize a moment and become a competitive nation as far as SAF production is concerned. Currently, our pace of delivery of policy on that is not consistent with the ambitions that Ministers have set out for SAF production.

Q44 Gavin Newlands: Louise, you are on the Jet Zero Council. You mentioned contracts for difference earlier. Do you have anything to add to what Neville has already said?

Louise Kingham: Just a very small point, Gavin, because he summarised it really well. You are quite right that we have had these discussions in depth in the Jet Zero Council. We have had a number of consultations published, to which the industry has responded. We are keenly awaiting the Government's response, should I say, and ideally what we would prefer is not yet more consultation but some decisions made so that we can take the advantage that Neville has described for the UK and get on with the job. That is what we are keen to do.

If we could get an answer within the next few months through that work with the Jet Zero Council, which I think has been an effective mechanism for bringing industry and Government together to discuss these things, that is what we would like to see next from industry, so that we can get on.

Q45 Gavin Newlands: Paddy, from Zero Petroleum's point of view, how necessary are contracts for difference? How big an impact would it have if the Government did not come forward with CfDs?

Paddy Lowe: We fully support the idea. It is always good to look at things that have been very successful and do more of them. The CfD in the case of wind and solar power has been a great success for the UK. It is a fantastic model. We have seen the prices come down with every round, and that trajectory is something we will see in the other sectors if we deploy it there. It drives all the right behaviours and outcomes. We would even suggest considering it in other aspects.

Should it apply for generation of hydrogen, which is an important precursor for synthetic fuels as well as for its own applications? I would



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add to the list storage or grid balancing, which is currently not really supported in any way in the market. That is something where, if we want to make a holistic system that works synergistically across all the energy media, and in fact get to fully de-fossilised grid power, storage is the final link that has to be solved. That could be solved by driving a market with CfD.

Q46 Gavin Newlands: Andy, do you want to come in to make a point on this? Also, does anyone have any suggestions for other mechanisms or interventions the Government can make in this area?

Dr Roberts: It is important to recognise that the CfD for renewable electricity production is a relatively short time period; four-year contract periods and so on. The models being developed by BEIS for industrial carbon capture, utilisation and storage are different, and have a longer time period.

The ICCUS and related models are further developed than the hydrogen model, but we expect a consultation on the carbon capture models later this year. Hydrogen may be this year or it may spread into the next. The development of the CfD model for sustainable aviation fuel only began just before Christmas, so it will be some time before that is developed.

The design of these models is very important. They are likely to be slightly different from the electricity model. The counterfactuals are sometimes different. For example, hydrogen has a different value in different sectors and the models need to accommodate those differences.

Q47 Gavin Newlands: I am conscious of the time. Does anybody have any suggestions as to what other interventions can be made? Speak now, or forever hold your piece.

Chair: Very briefly. It is 25 past and we have not covered maritime or rail yet, and I still have Greg to bring in on this.

Dr Hargreaves: I think the UK Infrastructure Bank can play a very important role by supporting patient capital, but that also depends on price stability being there.

Q48 Greg Smith: This question is very much to Paddy. This inquiry is about helping the Committee understand the alternative fuels that are out there and come to some conclusions to make recommendations to Government. Can you help us to understand how you actually went so quickly from establishing Zero Petroleum to putting a flight in the air, which is now in the public domain, entirely on your fuel, which, I understand, had no power drop-outs compared with if it had a fossil fuel in it? What were the barriers to you getting there and what will be the barriers to scaling up?

Paddy Lowe: For those not aware, the project was simply a demonstration of the ability to create synthetic fuel, to drop that into an engine without any modification and to deliver the same performance,



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which is exactly what we did. It was conducted very fast because the nature of it was to arrive at the outcome of a demonstration and not to have all the right detail in the process to get there. A lot of engineering is still required to get the process commercially ready, but through the demonstration we showed exactly that.

A lot of the problems that we see at the moment are about communication. I mentioned earlier the image of petroleum. We see a lot of sectors where people do not even know about synthetic fuels. They think that everything has to be electrified, so their mindset is already hardwired, through the media largely, that what you have to do to move forward with the right environmental credentials is electrify everything you have. As we have discussed at length, that is not the right answer in many applications. Communication is a big factor, and one of the great successes of the flight, we hope, was to get that message out there.

Greg Smith: This is quite a long-winded question—

Chair: No, it can't be.

Greg Smith: It needs a short answer.

Paddy Lowe: I'll be really quick.

Q49 **Greg Smith:** For the process of developing the fuel and actually producing enough of it to do that demonstration, what will the barriers be to scaling that up so that your fuels could be commercially viable?

Paddy Lowe: We need to fund that development. There is technological development, but then there is the build-out of it, which is a capital cost. Like the conventional oil industry, it is capital intensive. It is much more difficult to fund because you need it all up front. One of the reasons that biofuels, for instance, are attractive short term is that you do not have to recapitalise the farm. The farmer has his tractors, so you just plant different seeds or whatever. Sorry for the model, but capital is the challenge.

Greg Smith: Thank you.

Chair: It is 10.30 and we still have not covered maritime or rail. It's a good job we don't run the trains. Let's have one question to one witness only. If we can make them short and snappy, that will be super. Over to Gavin, first of all.

Q50 **Gavin Newlands:** Thanks, Chair. On aviation, most of the panel spoke about horses for courses in terms of the best fuel source for the aircraft. What alternative fuels are the most promising for decarbonising the maritime sector? I'll start with Louise. No, I'll go to Louise.

Louise Kingham: I think that was the instruction, in the interests of time.

You are quite right, Gavin, that we have some choices in maritime and possibly, as Paddy was saying in his world, more choices than we realise



in the wider public. The IMO is obviously doing a lot to regulate and drive progress. BP has about 300 ships in the water at any one time. There is a lot of work going on around engine efficiency, as much as there is with ICE vehicles and the contributions we can make there. We are doing the same in shipping. We are also looking at methane equipment going into ships, measuring the methane and making sure we ramp down on that too. It is not just about CO₂.

In fuel options, again there is diversity. There is hydrogen potentially, either as ammonia or in liquid form. There is LNG and biofuels, increasing the option for blending. We have a number of partnerships with others like Maersk and NYK, where we have run some pilots. We went up to B30, I think, in one of those projects to see if it had any impact on either the kit or the operation and what it did for emissions. There are some really positive results in those pilots. I think it is quite a good story, just to be really quick.

Q51 Gavin Newlands: As one brief follow-up to that, how expensive do you think it might be to produce enough fuel to meet demand? What potential upgrades to the shipping fleet might we have to make?

Louise Kingham: There is ongoing investment in the shipping fleet. I mentioned the 300 ships we have in the water. We do not own them all. I think the last vessels we purchased were in 2019. I do not have the numbers for what was spent, but we spent a lot on upgrading the internal workings of the ships and the energy efficiency and technology that we could introduce for the protection of the hull in terms of contamination, swapping different blends in and out, and so on.

The answer to the question is that it does not come cheap. It is expensive to do, but if we are driven by a mandate we will have to find a way to make it effective. As I mentioned, we have choices that give us different cost profiles.

Gavin Newlands: If it is not commercially sensitive, could you find that information and pass it on to us? We have a maritime inquiry coming up soon so it would be quite useful for us to find out how much it might cost to upgrade a fleet.

Chair: Thank you, Gavin. I want to give enough time to Grahame, who has not come in at all yet.

Q52 Grahame Morris: Very quickly, and related to my colleague's earlier question, Andy said there is an understandable emphasis on tailpipe emissions from motor cars. Specifically here, we are looking at maritime. Is there scope for bridging technologies to achieve the desired target of zero emissions, even if we are still waiting for the development of truly alternative fuels? I do not know who is best placed to answer that? Andy or Louise?

Louise Kingham: Very quickly—Andy might want to comment—I think we have these fuels today. We have the capability to boost the hydrogen.



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We have the capability to do that as ammonia or in liquid form. We have the ability in the pilot, as I mentioned, to ramp up the biofuel blend to do that.

Q53 **Grahame Morris:** To meet demand.

Louise Kingham: Yes. I think a lot of the options exist today.

Q54 **Grahame Morris:** The target date of 2050 for zero emissions is completely achievable for the maritime sector.

Louise Kingham: Yes, they have dates out. For GHG emissions they have dates out of 50% by 2050, and then for CO₂ intensity to reduce by at least 40% by 2030 and 70% by 2050. They have targets that push out a little bit further than that.

Q55 **Grahame Morris:** But they are completely feasible in terms of realising those targets and the demand that you are projecting for the alternative fuel.

Louise Kingham: From what we know today, and from the range of options that we have. Andy, is there anything you want to add?

Dr Roberts: The technology is there and within reach. The investment required and the ship replacement for some technologies is another matter.

Q56 **Grahame Morris:** Shipping, by its very nature, is international. What can the UK Government do to influence a global move to zero emissions? Is there something specific? Are we leading by example?

Louise Kingham: I think we show leadership through our engagement in the IMO. In BP, for example, we have very high standards around the quality of the operation, the safety and the environmental performance of the fleets, and we are ever improving that. I think it is incumbent on us as responsible businesses to take action. I am not so convinced that we have particular asks of Government around this issue. Some of the things we talked about earlier are more pressing.

Q57 **Grahame Morris:** As an aside, you said that BP has a fleet of 300 ships, presumably mostly tankers. Are they all British registered and flagged vessels?

Louise Kingham: I would need to check that for you because they are not all owned by us, but they may well all be registered in these waters. I would need to check because I am not sure.

Q58 **Chair:** That is something else you could put in writing.

Louise Kingham: Yes. Absolutely.

Chair: Moving on to rail, we did an inquiry on decarbonising rail. We found that it is going to be incredibly tough for the Government to get there by 2040, but we should finish with a question or two and I will hand



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over to Greg for this section.

Greg Smith: To condense the whole rail section into one question—

Chair: You are the master, Greg.

- Q59 **Greg Smith:** Electrification is probably further ahead in rail than it is in any other transport sector, not least because of the infrastructure that has been installed through overhead power cabling or third rail. Can that alone deliver decarbonisation in rail, particularly when it comes to freight and the weight that needs to be moved around on a freight train as opposed to a passenger train? Where can alternative fuels help rail meet their decarbonisation goal? Where shall we start? I suspect we are going to get a liquid fuels answer, so we will start with Paddy.

Paddy Lowe: If you start with freight, that is the easiest case in which you can say that you cannot fully electrify freight until you have fully electrified all the railways. That is the last application and it will take a long time. In freight, you are going to need mixed mode almost indefinitely. You then come back to whether it is going to be hydrogen, electric battery or liquid fuel. That may be dependent on a case-by-case basis, but battery and hydrogen all consume payload. In the operation there is a commercial cost to that if you are consuming payload with your energy store relative to liquid fuel. Then you have to look at the wider economics around those three possibilities. In some of the cases we have looked at there is a very strong commercial case for making synthetic liquid fuel when you look at the investment in the round.

- Q60 **Greg Smith:** Do you think there is a tipping point coming when spending more and more on installing electric infrastructure to the railways by whatever, overhead or third rail, is just throwing good money after bad, and dropping in a synthetic fuel would deliver greater economic efficiency as well as decarbonisation?

Paddy Lowe: I think we need an open-minded approach, and I know that is the nature of this exact inquiry. The system should be open-minded to the technology and not religious about electrification. All these solutions can work, and it should be assessed on economics, as well as time to market. We know that many lines have taken decades to initiate programmes to be electrified. If you move to a liquid fuel, it can be done in a matter of a few years rather than decades.

- Q61 **Greg Smith:** Thank you. Does anyone else have a particular point on rail?

Louise Kingham: Very briefly. I think your question is really astute. When we think about all sectors of the economy decarbonising, one of the ways that some will do that is by shifting their freight to rail. It is not just the pressure on the system today. It is what might be coming through. There are things like renewable diesel and HVO that could be used as drop-ins, as Andy mentioned in another context earlier, to help with that on the journey. At the moment, less than a fifth of freight rail is



electrified. As Paddy said, that will take time to do, so it is a really astute bit of questioning to do for the inquiry.

Q62 **Greg Smith:** Thank you very much. Andy, you look as if you have something to add.

Dr Roberts: No. I think hydrogen offers some potential for local routes, where the cost of electrification is not really viable. We have seen successful trials, both in the UK and perhaps a bit more than trials in Germany. The technology is there and it is ready to go.

Louise Kingham: One other thing I would add very quickly is a consideration for the Committee as to whether you think it is appropriate for DFT to look at blue and green hydrogen in the same way that BEIS is. We have projects that are moving ahead on both, so we are agnostic on it. We can see a place for both. You are likely to get blue to scale more quickly and at least at less cost than you will with green. It is just a consideration maybe for the inquiry to look at, relative to the twin track that BEIS, for example, as another Department is pushing in respect of hydrogen.

Q63 **Greg Smith:** That is a very fair point and a whole new debate that we could open up, particularly in terms of the creation of synthetic fuels. You use a lot of hydrogen in the creation of your fuel, don't you, but if it is blue going in there, it is not decarbonised?

Paddy Lowe: It does not make sense to make synthetic fuel from blue hydrogen, no. That would be nonsense.

Chair: Thank you. Paddy, Andy, Louise and Neville, thank you so much. You have given us such interesting evidence, which is why we have run over time—that, and the fact that I cannot keep to time. I hope you will continue to watch with interest the inquiry and the recommendations we make. It will be very much based on the evidence you have given us today. Thank you again.