HOUSE OF COMMONS

Science and Technology Committee

Oral evidence: The role of Hydrogen in achieving net zero, HC 97

Wednesday 21 July 2021

Ordered by the House of Commons to be published on Wednesday 21 July 2021.

Watch the meeting

Members present: Greg Clark (Chair); Aaron Bell; Dawn Butler; Chris Clarkson; Rebecca Long Bailey; Carol Monaghan; Graham Stringer.

Philip Dunne, Chair, Environmental Audit Committee, attended the Committee.

Alan Brown, Business, Energy and Industrial Strategy Committee, attended the Committee.

Questions 422 - 533

Witnesses

I: Guy Newey, Strategy and Performance Director, Energy Systems Catapult; and Mark Neller, Director, Energy Business Leader UKIMEA, Arup.

II: Rt Hon Kwasi Kwarteng MP, Secretary of State for Business, Energy and Industrial Strategy; Sir Patrick Vallance, Government Chief Scientific Adviser; and Professor Paul Monks, Chief Scientific Adviser, Department for Business, Energy and Industrial Strategy.

Examination of witnesses

Witnesses: Guy Newey and Mark Neller.

Q422 **Chair:** This is the final oral evidence session in our inquiry into the role of hydrogen in achieving net zero. I am pleased to be joined in this meeting by Philip Dunne MP, Chair of the Environmental Audit Select Committee, and Alan Brown MP, a member of the Business, Energy and Industrial Strategy Committee.

We have two panels of witnesses this morning. We are going to end up with the Secretary of State, the Government's chief scientific adviser and the Department for Business, Energy and Industrial Strategy's chief scientific adviser, but to start proceedings I am delighted to welcome our first pair of witnesses. Guy Newey is the director of strategy and performance at the Energy Systems Catapult, and Mark Neller leads the engineering consultancy Arup's energy work in the UK and beyond. Welcome to both witnesses. Thank you very much indeed for joining us.

Perhaps I may start with a question to Guy Newey. We have taken a lot of technical and engineering evidence on the role of hydrogen in attaining net zero. From a policy point of view, what is your assessment of how the Government's hydrogen strategy should fit with their overall decarbonisation strategy?

Guy Newey: Thanks, Chair. Good morning. That is a really tough, knotty question to grapple with, and it is absolutely the right one. In the medium term, the strategic choice for the Government when thinking about hydrogen—or, indeed, any technology, because there is nothing special about hydrogen versus electricity or other issues—is how you create genuine demand for the product and allow it to compete against other technologies and different alternatives. You will have heard lots of evidence on what those areas are.

In the medium term, you want to get to a framework where hydrogen as a vector is competing against electricity in the different applications, whether that is heating demand or heavy goods vehicles or public transportation and so on. You will have covered the evidence on the areas there.

Of course, we are not there yet because hydrogen is a relatively new challenge. In the shift from 80% target carbon reductions by 2050 to net zero, hydrogen is a huge winner, so lots of the bits of the economy that, if I was being unfair, we are hiding in the last 20% will be the ones where they are looking to hydrogen—lots of heavy industry, lots of areas like shipping and aviation.

The challenge in the medium term is how you get that industry going while keeping your eye on the long-term gain, which is trying not to get in a world where all these technologies are becoming, in the pejorative, subsidy junkies, as it were.

The way we tend to see it is: keep your eyes on that long-term prize and think about the wider policy frameworks that you want to get in the different sectors that are going to drive genuine demand for applications of hydrogen. In the short term, think very hard about the areas where the analysis said it is most likely that hydrogen will be most needed and most significant. Most of the modelling and analysis would say that it is in the harder-to-treat sectors—various elements of heavy industry, shipping, trains, buses, etc. You might need innovation support to get there along the way.

I will make a final point. There are some specific innovation challenges—and maybe we will come to this later—that are really important. It is quite easy to say you should use it in different industrial processes, but each one will have its own subtleties—whether there should be innovation support there, how you increase carbon capture rates on CCUS, which is important on blue hydrogen, and other areas like the potential of nuclear in hydrogen production.

Q423 **Chair:** Is it fair to say that you see hydrogen playing a supportive long-term role? You talked about 20%. Is it a 20% role rather than an 80% role? Is that where it is destined?

Guy Newey: The way I would characterise it from our analysis is that it will still be a huge part of your decarbonisation solution. Our modelling would suggest that by 2050 you will need 200 to 300 TWh of hydrogen use across your economy. Bear it in mind that at the moment low-carbon hydrogen use across the UK economy is basically zero. Entire hydrogen demand is about 30 TWh, and the vast majority of that is grey hydrogen. It will be a huge growth story, but it will not be everything. It will not solve all your problems across the economy. To call it a niche is wrong. It is a very big niche, but that means it is very competitive for how it will be used.

Chair: That is very helpful; thank you very much. "Big niche" is quite a good way to think about it perhaps as we conclude our deliberations.

Q424 **Dawn Butler:** Mr Newey, you talked about hydrogen being a huge part of our 2050 strategy. Professor Marcus Newborough told us that the UK should prioritise energy efficiency first, electrification second, and green hydrogen—he was very specific about green hydrogen—third. Do you agree? Will the future role of hydrogen be huge, or will it be marginal in the overall energy mix in the UK?

Guy Newey: I am always a bit nervous about simple characterisations like that because there is a big role for improving the efficiency of the way we use energy across the economy, and that has great benefits for consumers and for the environment.

The fundamental physics of electricity versus hydrogen means that, if it was just engineers in charge, absolutely, we would be doing as much

electrification as possible because it is fantastically efficient, and we know how to produce it in a clean way.

The modelling analysis will say that hydrogen will get sucked up by those areas where you do not have alternatives, where it is difficult to electrify or because of the characteristics of the technology. For example, with heavy goods vehicles, the current understanding is that the batteries are too big to give you the range you need to make long-distance deliveries. Some people have challenged that. Indeed, some people have given evidence to that.

I tend to think of it as the hard-to-treat bits of the economy as where it is most likely to end up in. That is still a massive part of your economy.

Q425 **Dawn Butler:** Mr Neller, do you agree?

Mark Neller: The first thing to do is to understand the size and scale of the challenge around decarbonising the energy system. On a cold winter's day, about a sixth of the energy that we use is moving around the system as electrons through the electricity network, about a third of the energy we use is moving around as liquid fuels, and about half of the energy that we use is coming through the gas grid.

We have looked at this problem of how you decarbonise that and how you shift it to a low-carbon solution. We think that there are four lenses that you need to look at the problem through. You need to look at the problem through an engineering or a technical lens. What are the technical challenges? How do we overcome those? Do we have a solution that works technically?

We then need to think about it from the delivery perspective. How are we going to go from where we are today to our low-carbon future?

We then need to think about it through an economic lens. What does it mean for UK plc in jobs, the economy and the cost to consumers?

Finally, we need to think about it from a people perspective. What does this mean to homeowners? What does this mean to people who are using the energy system, and how do we make this transition acceptable to them?

We think that you absolutely need to decarbonise the electricity network. We need to build out offshore wind, we need to replace our nuclear fleet and we need other sources of renewable electricity, but we also need a very strong second way of moving energy around our energy system, and in our view that way of doing it is hydrogen.

We see a very substantial role for hydrogen in the energy system, probably at the upper end of the National Grid future energy scenarios—the system transformation scenario that they have selected—because we think that, when you look at the problem in a rounded way through those

four lenses, that offers a more realistic and better way of achieving a net-zero energy system.

Q426 **Dawn Butler:** That makes sense. I can see it as you talk about it and visualise all the different lenses that have to be considered. But should we not be moving faster in that direction if we are going to achieve that target in the next 29 years? Are we not way behind where we should be with the infrastructure?

Mark Neller: I think there is a need to accelerate the pace of change and there are opportunities to do that. We have spent a lot of time thinking about the engineering challenges, and through work like the Hy4Heat programme that has looked at hydrogen safety and the development of hydrogen appliances we do understand an awful lot about the engineering challenges associated with transition, but we need to put a greater focus and accelerate the attention on issues such as what this means for people, how we enable consumer choice, how we put people in the middle of the transition, and how we start planning for an implementation, because those are the real areas we need to move on to of how we actually implement this transition and whether we have all the roles and responsibilities allocated to the right players in the market to make sure we can deliver on the transition.

Q427 **Dawn Butler:** Do you think that the Government have been doing that? If not, in what sectors and areas do you think there needs to be more investment or more clarity?

Mark Neller: I think that the Government have been doing a great job in collecting the evidence around the engineering side over the last few years, but there is now time to put more emphasis on planning what this transition might look like and how we can enable consumer choice through the transition.

I am hoping, in the hydrogen strategy, that we are seeing a more detailed timeline, we are seeing faster commitments, we are seeing opportunities for innovation and particularly opportunities for the UK's manufacturing base to benefit from a hydrogen economy.

We have some fantastic manufacturing opportunities to create jobs right across the UK if we can take advantage of a first-mover advantage from hydrogen.

Q428 **Dawn Butler:** How quickly do we have to act? What is our window? If we do nothing for the next five years, what would that mean in regard to reaching our net-zero target by 2050?

Guy Newey: We will not meet our net-zero target. The net-zero targets are incredibly ambitious and difficult, and that is across the board of the economy. The easy bit is electrification, which we have made loads of progress on. It is still a huge challenge to make your whole system work all the time on low carbon. That is before you get your very difficult

system, which is how you are going to decarbonise cement, as Mark said. We have no time to waste. We need to up the pace, for sure.

Mark Neller: I would go a little further than that. Not only will we have missed our carbon targets; we will also have missed a fantastic opportunity to be a leading economy in the hydrogen sector. We have a very short window in which to signal to the market and to the private sector to invest in all the hydrogen technologies that everybody will need in order to decarbonise. We have a brilliant opportunity in the UK—with boilers, buses, our car manufacturing, our fuel cell technology in the midlands, aviation, shipping, clean steel manufacturing—but there is a narrowing and rapidly closing window for us to seize that opportunity and to grow the economy and generate jobs in those places that need it most.

Q429 **Dawn Butler:** Can we not just do a technology transfer and take the technology from Germany? Should we just be focusing on green hydrogen and not grey or pink hydrogen, for instance?

Mark Neller: Maybe I could start with the hydrogen colours question and then come on to the second question about trade if that is okay.

Chair: Briefly, if you would. We have lots of questions, Mr Neller.

Mark Neller: We need blue hydrogen, in short. The alternative is to keep burning unabated methane. You cannot build out the renewables fast enough to decarbonise everything without a strong role for blue hydrogen.

That is a fantastic enabler to then getting the demand side going so that we can then move to green in the 2040s or 2050s, but we need a 25-year slog of lots of low-carbon, low-cost hydrogen through a blue-hydrogen process.

Q430 **Chair:** On technology transfer, can we just copy the technology that the Germans are developing?

Mark Neller: We will then lose all the competitive advantage. If we want to build a manufacturing base for the hydrogen technology in the UK, we need to move first.

Q431 **Alan Brown:** Mark, you spoke about the urgent need to create that market and that environment. What is your No. 1 thing that the UK Government need to do apart from publishing their hydrogen strategy? What is the No. 1 thing that needs to be in that?

Mark Neller: I think that there are some strong commitments needed on transport. We saw the transport policy published recently. There is much more that the public sector could be doing to generate demand for hydrogen applications in the public sector by looking at how we procure low-carbon, low-emissions vehicles, which can stimulate the demand side for hydrogen and start that manufacturing process. That is really

important for getting green hydrogen and transport going over the next few years.

We then need to make the commitments for the carbon capture and storage around the industrial clusters and we need to sort out the blending of hydrogen into the gas grid. It is an absolutely essential component of getting to a financial investment decision on the major blue hydrogen projects across our industrial clusters.

The role of blending into the gas grid is misunderstood, and that particular decision absolutely needs to be brought forward as early as possible. In fact, we have seen that done in Germany where they published their hydrogen strategy in June last year, and they have already enacted the legislation to enable hydrogen blending into their gas grid.

Q432 **Alan Brown:** How quickly should that legislation be enacted in the UK, because it is not allowed at the moment?

Mark Neller: I am expecting the hydrogen strategy potentially to target a date of 2023. I am hoping that it is much sooner than that.

Q433 **Alan Brown:** Thanks. Guy, in your opening answer you mentioned nuclear energy. Do you see a role for hydrogen being produced with nuclear energy in the UK economy? If so, why do you think so?

Guy Newey: I would say there is a potential role for it going forward. If you need to produce that quantity, 200 TWh to 300 TWh of low-carbon hydrogen by 2050, there are different technology options to do it, but that will require a huge build-out of renewables if you want to do it on top of what is already a likely doubling or tripling of your electricity system at this stage.

The alternative is a lot of CCUS or indeed biogasification with CCUS. There are lots of characteristics with some nuclear technologies, particularly some of the high-temperature reactors, which could really lend themselves to being ongoing churning out hydrogen production in that way.

That could provide flexibility for your wider system because, instead of nuclear power stations, which are not easy to turn on and off, as it were, you could switch between providing electricity to the grid and providing low-carbon hydrogen production, but you are also using some of the waste heat.

I do not underestimate how difficult it is and where nuclear policy in the UK is to get that forward, but it comes down to this. If you do not, you can rule out nuclear in that space, but you have to have a huge build-out of other technologies, which have their own constraints already. It would be very premature to stop it as a technology option.

Q434 **Alan Brown:** It is a bit premature. I am aware that Energy Systems

Catapult did a report along with Good Energy that said that we could do electrification without doing nuclear. Is that report valid in stating that new nuclear is not required?

Guy Newey: It is absolutely valid. The point of doing scenario modelling out to 2050 is identifying what you need to believe in order to achieve a particular outcome. You can have an electricity system that is renewables only, but what you need to believe about that is, if you look in the detail of that scenario, you have 40 GW to 50 GW of biomass renewable plant not being used very often because you need that amount to be used to fill in the gaps where the wind does not blow for two weeks at a time. That is a possible world to do it. Is it desirable? Is it realistic? The point about scenario work is not that you are saying that is the right answer; you are saying in order to believe that.

Our core scenarios would see an important role for nuclear across the economy, partly because it helps you with that key engineering challenge, which is the two weeks of no wind when your demand is likely to be high. There is definitely a world in which you can do it without nuclear, but then you have to do a lot of CCUS, which still has its challenges, and you probably have to do a lot of bioenergy. You have to do even more wind and solar on top of what is already likely to be a very high roll-out. The point of scenario analysis is, what do you need to believe in order to deliver the particular scenario?

Q435 **Chris Clarkson:** I want to turn briefly to the applications of hydrogen. In what areas do you think the Government need to work to give direction to industry on the application of hydrogen? Conversely, in what areas do you think that consumers will dictate the viability of hydrogen?

Guy Newey: Key areas where hydrogen is needed are all the scenarios where there do not seem to be any technological alternatives—refineries, ammonia production, methanol. They all seem important. There is some role in chemicals, although there are potentially alternatives.

Steel is a really interesting one because hydrogen is an obvious answer to some of those challenges, but electrification is an alternative.

Cement could be, although, again, you get into how you might come up with high-temperature heat pumps.

HGVs is an area, and I think most people see shipping as a really important side of that. Aviation is an interesting one. Mark might know more than me on that one.

Those are the areas where there do not seem to be many alternatives. Therefore, your focus should be, in a low-regrets world, getting on with those areas.

Mark Neller: I would agree; that is the place to start—where there are no alternatives. We are going to need lots of hydrogen. We can rapidly build up our hydrogen production capability.

The whole area around consumer choice on domestic heat is really important. Offering consumers that choice at the point of converting their gas network—either electrification or hydrogen—and understanding what is important to that choice so that we can plan for it is a really important thing to explore when considering how we implement decarbonisation of domestic heat.

Q436 **Chris Clarkson:** Thanks. Drilling down on that, domestic heating will be one of those sectors that they will have to develop. Are there any others that you would consider the Government should really be putting some focus on developing now? Particularly, I would like to know your thoughts on the decarbonisation of transport plan that came out last week.

Guy Newey: There are other areas that probably might need some focus but are probably not quite as urgent, although all of this is urgent, which goes back to the previous point.

One of the interesting questions is whether hydrogen can be used in the electricity system with low-carbon turbines sitting around not being used very often but helping when the wind is not blowing in a much windier system that we are heading for.

The heat issue is obviously the most controversial politically, as you will have seen from the evidence that you have had. From the pure physics point of view in electrification versus hydrogen, heat pumps win hands down. The key challenge is consumer acceptance.

It is worth saying that the hydrogen-for-heating world is not a slam dunk, either. Hydrogen is a tricky beast. You have to be thinking about where it fits in all the pipes and whether it will work through, as well as the cost of producing it.

It is a bit simplistic to say from a consumer point of view that it will be super-easy for hydrogen decarbonisation on the heating side; we just have to worry about the cost and the infrastructure. We absolutely should be putting money into the innovation. That is one area where the Government are doing great work in exploring the safety case and the applications. But it is not a slam dunk from a no-consumer-disturbance point of view. It would still be a huge engineering challenge to bring it forward for heating.

Mark Neller: The only other thing I would say on that would be that there is a model of having achieved that in the past. It is the only model of a major transformation of our energy system. It was successfully achieved in the 1960s. It was a conversion from town gas, which was 50% hydrogen, to natural gas. While we have a much more fragmented industry now with competition, it provides a really interesting case study of how we can transform our energy system very quickly in a way that is acceptable to consumers.

Q437 **Chair:** I have a couple of follow-ups to Guy Newey. If you have seen the

evidence that the Committee has heard, you will have seen that there has been a concern about smart meters and their ability to work with hydrogen in the future. Has the Energy Systems Catapult looked at that, and do you have an assessment of how big an obstacle it is?

Guy Newey: I confess I have not, Chair. Mark, from an engineering side, might have looked at it in more detail.

Mark Neller: The Hy4Heat programme that Arup has been running on behalf of BEIS has looked at smart hydrogen meters. We were responsible for advising BEIS on awarding two contracts for meter manufacturers to develop prototype smart hydrogen meters. Both of those contracts are successfully working their way through the prototype phase. We fully expect to have SMETS2-compliant hydrogen meters within the next six to 12 months.

Q438 **Chair:** But the implication is that the ones that are being rolled out will not work and that we will need these new ones. Is that correct?

Mark Neller: That is highly likely. One of the things that would be interesting to look at is whether it is possible to take those smart meters out and replace them with the hydrogen-ready ones and to recalibrate the instrumentation inside them, effectively, to change the computer programming in them to monitor for hydrogen rather than methane. That is a really interesting piece of work to be done. We know that, if we go through a conversion programme and convert the gas grid, there will be work to be done in consumers' homes, and an element of that will be replacing those meters.

Q439 **Chair:** Thank you. Guy Newey, you expressed some caution about the handling of hydrogen when used for domestic purposes and made the reasonable point that it is not altogether straightforward. What implications do you think that has for some of the calls that have been made, including to this Committee, that the Government should be mandating that any new future boilers installed have to be hydrogen-ready? Is the implication of what you have said about the handling concerns that we are not at the point at which it would be right to make that regulatory requirement?

Guy Newey: No, I do not think so because a hydrogen-ready boiler, from my understanding of the engineering, would still be working on the methane basis. Your moment of challenge would be when you switched your grid over to hydrogen. The boiler would be robust, although you would have to change some parts, which is a relatively straightforward process.

There is a key challenge when you are thinking about hydrogen, and it links to the smart meter point. The upgrade that is going on now will make the gas network largely hydrogen-ready. It is the piping between that network and the house that will be one of the challenges—the Hy4Heat and other programmes are looking at that—as well as how you

are going to produce enough hydrogen. That is one of the areas that needs work.

Q440 **Chair:** Unless you are confident that there is a viable economic solution to that—it may be outside the household—it would be a waste of money to have the extra cost that goes into a hydrogen-ready boiler, would it not?

Guy Newey: Yes, my sense is that the extra cost on hydrogen-ready boilers depending on the market size will not be that significant. They are basically the same thing. Once you get them mass produced, any difference will be marginal. That is my understanding. Mark probably knows better.

Mark Neller: We have published all the safety work that we have done on Hy4Heat that demonstrates that for the majority of domestic properties the existing pipework is fine. Our safety casework has been signed off and endorsed by the HSC. There is a letter from the HSC that recognises that, if we progress into hydrogen trials in domestic communities as planned, the work that we have done on the BEIS Hy4Heat programme is a solid foundation for the risk assessment; pipes are perfectly fine for hydrogen— if they do not leak with methane, they don't leak with hydrogen—and the insertion of a thing called an excess flow valve into the meter and into the gas pipe means that the risk to the consumer is no different from the risk to the consumer today.

That question is answered. Certainly, what Guy has just said about the cost of the appliances is correct. There is a marginal increased cost for the first couple of runs of production. Once you get into mass production, the costs of hydrogen-ready boilers are comparable to the costs of methane boilers today. It is a very low-regrets solution that unlocks a lot of opportunity downstream.

Q441 **Chair:** I see. Thank you very much. Going back to Guy Newey on some of the policy aspects, we have talked about the different colours of hydrogen—blue, green and grey. When we talk about blue hydrogen as if that is an option, what that means is hydrogen that is paired with CCS, carbon capture and storage, for which the technology is by no means at a point of commercial development. Are we eliding something that is wishful thinking, having available CCS? What is your perspective from the Energy Systems Catapult as to the reliance that we can credibly put on CCS being available to make blue hydrogen a dependable option?

Guy Newey: It underlines the point about lots of these questions; you have to think about the whole system together. You have to be thinking about the production as well as the end use.

I agree with Mark's analysis; there is a very important role for blue hydrogen going forward. The CCUS technology is relatively in its infancy, but it works elsewhere. It is, as much as anything, a commercial

question, and the Government have set out some thoughts on how they will think about leading forward.

One of the key innovation challenges—a really interesting one—is your capture rate. If you capture 90% of the carbon emissions through the blue hydrogen process, that makes it very difficult to see a world where blue can be a significant part of net zero when you are getting to 2050 levels of target. It should very much be part of the next 10 years.

If you could get that capture rate up to 98% or 99%—that is a fantastic innovation engineering challenge and is not straightforward—it suddenly becomes much more valuable to do it. You have to be seeing all parts of the system and how they are working together. You need to get the commercial models in line with the innovation programmes. That is one of the key challenges for the hydrogen strategy.

Q442 **Chair:** Looking at other countries and what they are doing, what lessons should we take from the practice of other countries? Germany has been particularly prominent. Mr Neller, as a global consultancy, do you look at other countries, and would you commend any of their work to us?

Mark Neller: The German hydrogen strategy has provided a really good foundation for the German economy—the amount of investment, the way that is signalled to the market and the level of commitment. They have very heavily focused on green, but I do not think, from having had a read through the summaries of it, they have completely excluded opportunities for blue. It is the pace at which they are moving that is particularly impressive—the fact that it was published over a year ago and they have already started enacting legislation to support it. That provides an interesting comparison.

We are certainly in conversations with gas networks right the way across the world that are equally interested in the work that is being done in the UK. We are definitely leading the way there. There is quite a lot of interest from that direction.

There are also some interesting things going on in Australia and Japan looking at exporting hydrogen from Australia to Japan. You can start to see a world in which there is an international trade in low-carbon hydrogen. That is some way off, but at least you can start to see how this might unfold over a period of time.

Guy Newey: The only point I would add is a general point. Often, when we look at Germany and others, we feel a slight inferiority complex. I do not think the numbers on successful decarbonisation in the UK hold up against that.

That said, the ability to partner the industrial base with some of these big engineering challenges is potentially more successful. Mark is right: we are in a race across all the fronts of net zero. Thinking very carefully where we have comparative advantage, and the various elements of the

hydrogen value chain that we definitely do, is part of the reason that we need to get on with it.

Q443 **Chair:** Thank you. Germany has made a big choice in favour of green hydrogen rather than blue hydrogen, but I think, in one way or another, you have both said that we should be looking at both. Why do you think the Germans, by implication, have got it wrong, and why should we be riding both horses?

Guy Newey: I am not super-close to the detail in Germany. I would expect there is quite a lot of politics going on in the favouring of green hydrogen versus others, although I note that they are still very keen to build a huge gas pipeline to Russia, so there is still overall in the economy quite a lot of gas that way.

The active debate in the blue and green hydrogen is at which point green will overtake blue in cost reduction. There is some great analysis that puts that point at, some say, 2030, some say mid-2040s. We would see it later than 2030. There is so much uncertainty.

This underlines the point I was trying to make at the start. You want to get some horses into the race, but then you want to design the race so that the two technologies are going to compete and there is an even playing field because, frankly, it is unknowable whether one technology will be cheaper at what point. You want the market to reveal which is the best way. You need support at the start, and I think the evidence suggests that it is worth supporting both of those horses depending on what you can afford, but, ultimately, you want a market framework to decide. That is what the players in the market want. If you chat to all the innovators, they do not want to be subsidy dependent. They want a regulatory framework where they can go out and say, "I am green hydrogen. I am ITM Power in Sheffield, and I am going to beat blue hydrogen and the projects going on." That is incredibly exciting.

Q444 **Carol Monaghan:** We have heard a good bit this morning about boilers, and we have had evidence on boilers and the policy decisions that have to be made. Boilers aside, are there other policy decisions that the UK Government should be making, and how quickly should these decisions be made?

Guy Newey: There is policy need across the board of the whole economy. Our incentives for decarbonisation in different sectors of the economy are pretty chaotic, and that is a mixture of regulation and taxation, etc. If I was thinking about the hydrogen question, one area that is particularly missing—we have touched on this a bit—is that your applications of hydrogen, your choices about hydrogen in different ways, are actually quite local. If you have an area that has a significant industrial base and big potential for hydrogen to be decarbonised, that strengthens in that particular area the case for thinking about it more in other applications such as heating. Right now, we do not have any mechanism either in the Ofgem price control process, or generally in

policy, of thinking about what the plan is for a particular area because it will be very different for different areas. Decarbonising Grangemouth is a totally different challenge from decarbonising Kent, for example. It will depend on the industrial ecology going on. One of the things that is missing—and this is across the piece on net zero but particularly for hydrogen—is that ability to think about what is needed in the local area.

Q445 **Carol Monaghan:** That is a really good point, but, beyond the local area, are we thinking widely enough about infrastructure required for a hydrogen transition?

Guy Newey: That is what you want to reveal with your plan. You want to get lots of decisions made through market processes and market signals, but some of this stuff is just monopoly infrastructure decisions. What are we going to do with the gas grid? What heat networks are we going to install? What electricity upgrades do we need? There is also energy efficiency, and there are installations and things like that. These are just monopoly decisions, the characteristics. You have to have a process to think about what the best process would be. Right now, that is a bit inconsistent, if I am being charitable.

Q446 **Carol Monaghan:** Thank you. Mr Neller, I saw you were nodding. Are there any points you want to add to that?

Mark Neller: Regionality is really important. There are definitely opportunities. An example would be that we could look at how you might prioritise some of the gas mains replacement in the industrial clusters so that you more rapidly replace the old cast-iron mains in areas that are more likely to see hydrogen blending or 100% conversion. That does not increase the overall cost of the programme; it just prioritises it first into the locations where you then unlock the opportunity for blending and conversion.

That more regional flavour is important, and Guy's point is that, at the moment, you do not see where that kind of strategic thinking and planning is happening across the various different parts of the energy business.

Q447 **Carol Monaghan:** Are we putting enough effort and resources into developing systems for the metrology surrounding hydrogen?

Mark Neller: That is not a particular area of expertise for me. My understanding is that there are grades of steel that have already been demonstrated as being perfectly suitable for carrying hydrogen at high pressures over long distances, but I think there is probably some more research to be done on our existing infrastructure. Certainly, if you were building new pipelines today for hydrogen, my understanding is that there are grades of steel that are perfectly adequate for that because, in fact, there are high-pressure hydrogen pipelines already in existence.

Q448 **Carol Monaghan:** Thanks for that. I was referring to the measurement of the gas itself. For example, we heard evidence a couple of weeks ago

about how there might be issues with smart meters in the metrology of hydrogen. Maybe you do not have any further information on that.

Mark Neller: I answered that question just a moment ago on the work that we are doing on the Hy4Heat programme. We have already awarded contracts on behalf of the Government for the development of hydrogen smart meters. We can tick that off as achievable given that we need to replace them and look at how we might be able to reuse the old ones.

Q449 **Carol Monaghan:** Thank you. The hydrogen boilers or the boilers that can work on natural gas, methane and hydrogen have been presented as a low-regrets option in hydrogen development. Are there other low-regrets technologies that we should be considering at the moment?

Mark Neller: It is those transport applications that it looks unlikely that electrification will be able to solve in the short term. There are lots of things that we should be moving on to the electricity grid. We should be looking to accelerate the uptake of hydrogen in shipping, aviation and industry as well as in the public sector fleet—bin lorries, gritters, buses and all the things that local government has within its control. Looking at those as a good way of getting demand for hydrogen up and running will then enable investment in the supply side. Those are the kinds of areas that would be really good to focus on early to build up the supply and demand that you need to grow the hydrogen industry.

Q450 **Carol Monaghan:** Thank you. Mr Newey, do you have any thoughts on that?

Guy Newey: I agree with that. It is about creating a genuine demand for hydrogen production so that there is something real to send to. Heavy goods vehicles of the various types that were described are really important.

The other one I would emphasise is thinking in detail about the different industrial applications and targeting where you think the UK has a potential advantage, but that could be very significant demand quite quickly.

You have to think about international competitiveness, because, if you are putting up the price of producing these technologies, as we are seeing—lots of the heavy industry is on pretty thin margins, to be frank—you have to think about the whole system. If you are taking the bet that the whole world is moving towards that place, there is absolutely a strong case in the medium term for Government support.

Q451 **Carol Monaghan:** Are the issues in the public sector's development of the use of hydrogen that Mr Neller has just spoken about the same areas that would be most in need of Government support to develop them and to develop the use of hydrogen in them?

Mark Neller: Some of these applications exist already. Some great UK-based technology allows you to convert diesel engines to run on blends of

hydrogen and 100% hydrogen. We need to do more to stimulate innovation and build on the fantastic work that is done in the midlands on fuel cell technology. There is definitely a need to stimulate innovation and provide some support. As long as we are looking at how we are comparing the cost of the carbon and the alternatives around diesel with the hydrogen, we can move to a position where that, over time, starts to attract it commercially.

Q452 **Carol Monaghan:** Thank you. Mr Newey, do you have anything to add?

Guy Newey: The public sector is, from memory, 4% or 5% of emissions across the economy. We should be using it as a test bed. We are involved in a brilliant programme with Government called Modern Energy Partners, which is looking at some of the challenges of decarbonising hospitals and prisons and all these areas, of which hydrogen is likely to be a potential part.

Q453 **Aaron Bell:** Thank you to both our witnesses for all their answers so far.

I want to pick up a few issues that we either heard earlier in the session or from earlier in our inquiry. First, we have talked a lot about use cases for hydrogen. It seems that in the longer term, when we get to a highly electrified future, one of the main use cases will be storage, particularly inter-seasonal storage. Do you see any alternatives to hydrogen as a long-term energy storage requirement in the UK, and does that imply that we need a strategic reserve of hydrogen to be set up at some point over the next couple of decades?

Guy Newey: It depends what bit of the energy system we are thinking about. Some people would argue that you could use hydrogen to provide 60 GW of back-up electricity capacity for those two weeks a year where the wind does not blow, for example. That is certainly a credible pathway to do it.

At that point, you have to think about the economics of a power plant that only gets turned on every three years—that power plant might be in some kind of strategic reserve—as well as the storage of hydrogen. I do not think the evidence is there that the market could not provide the hydrogen you want, ultimately, if people are willing to pay the price.

This is why you have to think about the whole system together. If you have more nuclear on the system you would not need as much of that back-up there, or if you have more CCUS on the system you would not need as much of that back-up in the electricity system.

But, in other sectors, we are going to need a huge variety of types of storage because it will be, as you say, a much more electrified system and a much windier system in almost all scenarios partly because of the success of offshore wind in cost reduction, which is a great success story.

We are going to need things like heat storage and very sexy new technologies like hot water tanks that do not need a lot of innovation spending but could be a really important part of your system.

There are other types of thermal heat storage going on. The point is, how do you design your market to allow different types of storage vectors and storage technologies to compete and provide real value to the system? That is about getting your whole energy system ready for a much more flexible world.

Q454 **Aaron Bell:** Thank you. Mr Neller, what are your thoughts about the future of energy storage in the UK in particular?

Mark Neller: Energy storage will be incredibly important. I agree with much of what Guy has already said. One of the key things to think about as we build out more and more offshore wind—rightly so, as we are moving more and more of our transport on to the electricity network—is that you are going to get imbalances between overproduction from the offshore wind and over-demand from the system. How do you balance that? How do you make best use of that available energy?

Hydrogen certainly looks like a good option as part of the overall long-term storage solution. The need for a long-term strategic store for hydrogen is probably some way off. If you think about how an implementation might work, we have our industrial clusters to get going—our main centres of production. We then need to start joining them up with a hydrogen transmission backbone. At some point, we need to start thinking about a strategic store to augment that, potentially connected to green hydrogen production from constrained offshore wind. That is probably a little way off yet in terms of the build-out and the development of a net-zero energy system. We could think about market mechanisms for delivering that.

Q455 **Aaron Bell:** Thank you. I go back to what you said earlier, Mr Neller, about first-mover advantage. Sometimes with new technologies, it is not an advantage to go first because you end up going down a dead end. Which particular applications do you think we might have a first-mover advantage in, and what will the benefit be to UK plc of getting there first?

Mark Neller: There are a number of areas. Electrolyser manufacturing is an obvious one. Guy has already mentioned ITM Power. There is definitely first-mover advantage there for us. Johnson Matthey has some great technology. It has a strong manufacturing base in the UK.

On the boilers, you have Worcester Bosch and Baxi, a strong UK manufacturing base. There are plenty of opportunities for Rolls-Royce, for example, in gas turbines that could be significantly exploited. There are marine-based applications for shipping. How do we think about shipbuilding and integration of hydrogen propulsion systems? Hydrogen storage fuel cell electric propulsion is a great way of decarbonising

maritime. There are some fantastic UK-based businesses that could be in the lead there.

There are lots of opportunities in those niche areas where pretty much everybody agrees we are going to need hydrogen. Looking at skills, looking at the supply chain, looking at the manufacturing base and how we can build out from our existing successful industries in this space is really important.

Q456 **Aaron Bell:** Thank you. Mr Newey, you have spoken very passionately about competition and how that can drive things forward. You said in the opening answer to the Chair that we did not want subsidy junkies. Is that a theoretical concern, or are you already worried that the existing infrastructure might be creating subsidy junkies?

Guy Newey: I am not worried about it in hydrogen yet because we have not started subsidising anyone, if I am absolutely frank. It may well be premature to do it. It is very easy to set up a system of subsidies to support particular technologies in terms of production or use. It is very hard to get out of it once people are used to it and the financing is used.

The point that I was trying to stress is that, in the medium term, you want to be creating that real demand. For example, if you regulated that all buses in cities had to be low carbon, if I was a hydrogen bus manufacturer or somebody producing hydrogen, that is a real market I can go and sell into—a significant prize to go after.

You would have to look in different sectors about the level of maturity and what support because you certainly need innovation support. I work for an innovation agency. There is absolutely need for support in those particular ways. What really drives innovation at the scale we need is proper market pull. That can be created by pricing. It can be created by regulation. The subsidy one would always be a bit wobbly for people.

That said, we are at such an early stage that it may be that we need to move on. I can just hear the lobbyist saying, "Just give us this subsidy to get going with this bit and we will move on."

Q457 **Aaron Bell:** Do you think we have seen too much subsidy in the renewable sector, whether in the UK or abroad? You say it is too early to say on hydrogen, but there has been a lot of subsidy to promote solar, wind and so on across the world. Has there been too much, or has it been about right, in your opinion?

Guy Newey: It is a massive success story of cost reduction. A lot of that is subsidy driven. In orders of magnitude, we have incredible cost reduction for a reasonable amount of money. I would say that it is quite hard to justify some of the subsidies we have paid to solar PV on people's roofs, where it is not really a UK comparative advantage. Offshore wind is a good success story, although in 2015 and 2016, when I was in government, that looked pretty pricey and quite politically dangerous. Guess what? Now it is cheap, and everyone is in favour of it.

As an aside, for the power sector, now the challenge is how you get into real demand for low-carbon power, which is ultimately what we want, and allow all these technologies to compete. That is quite a big market design question.

Q458 **Chair:** Mr Newey, you will know that one of the big policy choices is how to develop the market, short of simply leaving it alone. Professor Sir Dieter Helm, whose work we know, has been very critical of the use of subsidies for deployment to do what is, in effect, a research and development task, and thinks that if you are going to pay for R&D it should be done directly. We did not do that when it came to offshore wind. Now is the time in which we need to decide on the approach. Which approach would you recommend?

Guy Newey: There are a couple of points I would make. The first point is that you cannot invent a 10 MW offshore wind turbine at £39.50 or whatever the strike price is in a laboratory or in a garage. You get that cost reduction and that increased scale by deployment. The purist version of innovation would have you spend all your money on the R&D stage, but the deployment stage is where the engineers really get into the detail. How do we get the cabling right? How do we get the maintenance right? That is where the costs come down as well as the financing.

You need a proper market to go into. The challenge on what we have with electricity is that we did not quite recognise that what we were doing with CfDs is an innovation policy, so we are at this stage of how you get out of that innovation policy, which we do not call an innovation policy; we call it the market. I am a bit less purist on where exactly the division goes, but I probably agree strongly with Dieter; you want to get to real markets in the medium term.

Q459 **Chair:** Thank you. There have been quite a lot of sources of evidence in this inquiry that have disagreed with each other, as I am sure you both noticed. One is on the choice of technologies. Baroness Brown, in evidence to the Committee, steered us away from the approach of picking winners and thought that one should have a general encouragement of the various potential technologies. Michael Liebreich, whom I think you also know, said that at some point we have to choose some winners and stop the mantra of "all technology might improve" on the basis that we would end up spreading public resources too thinly, and if something is to be deployed at scale you need to get on with doing it. Where do you stand in this debate that the Committee has heard?

Guy Newey: Very briefly with what is an incredibly complex and contested space, I am probably more leaning towards the Liebreich view. You want to get markets as much as possible that are pulling all the different technologies so that they can compete.

From an innovation point of view, you have to choose some technologies to support. You should be really thinking about what the global scale potential of this particular technology is and whether the UK has definite

comparative advantage in that space. Then, to a certain extent, you have to roll the dice. You want to be constantly iterating and saying, "I am not sure this is actually turning out."

I would have thought that we could avoid some costs in some of the areas that we have done and probably made some better successes if we had been a bit more rigorous right at the start. That said, you are going to get things wrong with innovation policy. If you are not getting anything wrong, it is not working and it is not innovation policy. There will be mistakes made, and politicians have to be honest about that. The rigorous analysis of "you are going to pick winners but it will be based on clear criteria" is absolutely essential.

Chair: Thank you for that. You cannot see, but in the room are the Secretary of State and the Government's chief scientific adviser, who will no doubt have heard your endorsement that some things will go wrong and mistakes will have to be made as we develop the role of hydrogen. I thank our witnesses, Guy Newey and Mark Neller, for their evidence this morning.

Examination of witnesses

Witnesses: Kwasi Kwarteng, Sir Patrick Vallance and Professor Monks.

Q460 **Chair:** We are going to move on to our final panel of witnesses. I am very pleased to welcome back to the Committee—they have made several appearances—the Secretary of State for Business, Energy and Industrial Strategy, Kwasi Kwarteng; the Government's chief scientific adviser, Sir Patrick Vallance; and, for his first appearance before the Committee, the relatively new chief scientific adviser of the business Department, Professor Paul Monks. Thank you very much indeed for joining us. We are very pleased to have all of our witnesses. Sir Patrick, we are particularly grateful because we know how occupied you are with Covid matters, and you expressed positive enthusiasm to help us with our hydrogen inquiry with everything you have on. That is particularly appreciated.

Perhaps we can start in general on Government policy. Secretary of State, what view have you formed so far on the potential for hydrogen in attaining net zero?

Kwasi Kwarteng: Thank you very much, Mr Clark. I would like to say, from the start, that I am very pleased to be here, and I think it is an incredibly important session.

As far as I am concerned, hydrogen can play, potentially, a big factor in our drive to net zero. You will appreciate that, as Energy Minister for 18 months before I became Secretary of State, I have been thinking about the hydrogen economy and have been directly involved in the policy for two years now. I believe strongly that hydrogen has a part to play.

Between those who think it is essentially a panacea and will solve everything and those for whom it is overhyped, I steer a middle ground.

I was very interested to hear what Guy Newey said in his answer to your question about having a multiplicity of technologies or betting on specific ones. I tend to think that in 2021 it would be a foolhardy Minister who told you exactly what the energy mix would be in 2050. From my point of view, we have to keep an open mind about different technologies to get to net zero. That does not mean that we are not investing and supporting certain technologies, but we have to have an open mind. Hydrogen has a part to play.

Q461 **Chair:** Thank you. You are working and your team is working on a hydrogen strategy for the country.

Kwasi Kwarteng: Absolutely.

Q462 **Chair:** Can you update us on when we might expect that?

Kwasi Kwarteng: There was talk about it landing this week. We are going through the right-round process, which you are very familiar with—

Chair: Very familiar.

Kwasi Kwarteng: —and we are very hopeful that we can get the hydrogen strategy out in the next few weeks.

Q463 **Chair:** When Parliament is sitting, or could it be during the recess?

Kwasi Kwarteng: I was hopeful that it would come out before the recess. Given where we are, there is a case for publishing it just after the recess. I, as a parliamentarian, like yourself, would have wanted to wait until the House came back, but you will appreciate the urgency of this. There are investors. A whole community out there is waiting for the hydrogen strategy, and we will try to get it out as soon as possible.

Q464 **Chair:** Okay. As you say, there is great interest in Parliament, not least on this Committee, to be able to scrutinise it. You will give an opportunity, I hope, to Members of the House of Commons and the House of Lords to ask questions about it when it comes out—

Kwasi Kwarteng: Yes, I would be very happy to do that.

Chair: —at the first available opportunity.

Kwasi Kwarteng: Clearly, with the best will in the world, ideally, I would have wanted the strategy to come out when the House is sitting so that both Houses could scrutinise the document. I would be very happy to make a statement. I was very prepared to make a statement in the House on the strategy. However, it may not be possible to publish the strategy ahead of the recess tomorrow.

Q465 **Chair:** I understand that. You have been very open about it.

In terms of the point that you addressed and you picked out from what Guy Newey said about being technology neutral, the argument of those who say that you should choose the most likely ones is that, in terms of the confidence of investors and participants in the market to roll out at scale, if there is some ambiguity as to which technology will prevail, they will hold back. The argument is that it is better to choose one or another so that deployment can start rather than hedging bets. How do you counter that?

Kwasi Kwarteng: I think you are right. This is a nuanced picture. You are quite right to say that investors need strong signals from Government. That is absolutely the case. I understand Michael Liebreich's point about having certainty and being able to scale up capacity. The only issue I have with that is that in 2021 it is very difficult to know what the capacity of these different technologies will be. You will remember that 20 or 30 years ago the view was that diesel would be the great answer to pollution, and people were actively encouraged to take up diesel cars, but, of course, 20 years on, that was a mistake.

There needs to be a little bit more humility and a bit of a broader approach in technologies. Having said all that, we have supported technologies. We have supported offshore wind, we have supported other renewable technologies, and we are giving a signal. It is a balanced approach. I do not think you can bet on one or two. At the same time, we support certain technologies.

Q466 **Alan Brown:** In the 10-point plan it is stated that it is hoped that there will be 1 GW of hydrogen production by 2025. How much of that 1 GW is envisaged to be blue hydrogen?

Kwasi Kwarteng: In the first instance, you will appreciate, Mr Brown, that blue hydrogen today is much easier to produce and is much more cheaply produced than green hydrogen. Most of the modelling I have seen suggests that in the first instance, the next few years, blue hydrogen will be produced to a greater extent, and once you have created a market for hydrogen the cost curve of the production of green hydrogen will come down. That is the received opinion on that.

Q467 **Alan Brown:** Equally, in the 10-point plan, carbon capture and storage is not expected to be up and running until the mid-2020s. No go-ahead has been given for a CCUS cluster yet. Is it viable to get 1 GW mostly of blue hydrogen by 2025, or will the delay of CCUS impact on blue hydrogen production?

Kwasi Kwarteng: As far as I remember, the 10-point plan—I think the eighth point in the 10-point plan was all about CCUS—said that we would have two clusters up and running by 2025 and a further two clusters by 2030. Clearly, if we have two clusters up and running by 2025, there will be the ability to capture enough carbon dioxide to produce blue hydrogen in the quantity you have mentioned.

Q468 **Alan Brown:** When do you envisage a greener pricing mechanism for

storing CO_2 so that business models can be finalised and final investment decisions made by the various private companies?

Kwasi Kwarteng: In terms of the timescale—we are in July 2021 now—we have had a consultation on business models for CCUS. We have closed the application for the first round of CCUS installations or investment. I have said that we should have a business model by 2022 that will make it investable from then, and then we can produce the two clusters by 2025. It is an ambitious timescale, but it is something that we can achieve.

Q469 **Alan Brown:** That business model will include the Department agreeing the pricing mechanism for storage of CO_2.

Kwasi Kwarteng: Yes, that would be the route we would go down.

Q470 **Alan Brown:** Okay.

Can I change tack slightly? Also in the 10-point plan was an aspiration to do up to 20% blend of hydrogen within the gas networks. When do you see the gas management safety regulations being changed to allow that blend? Surely that is critical as a signal to the market.

Kwasi Kwarteng: You raise a really important question. We are having discussions about the standards. Clearly, they have to be amended if we are going to accommodate the blending of hydrogen, as you say. It is a Department of Health and Social Care competency. Ultimately, if there was an SI, that would come from the Department of Health and Social Care. I am speaking to my colleague, the Health Secretary, about this.

Q471 **Alan Brown:** I would not want to correct you, but, as far as I understand it, the Health and Safety Executive is looking at this, through the DWP, so are you talking to the DWP about how this is managed?

Kwasi Kwarteng: I will get back to you on that. I was pretty sure that there is a strong Health equity, but I might be wrong about that.

Q472 **Chair:** Perhaps Professor Monks might be able to help.

Professor Monks: For clarification, it is the Health and Safety Executive that is responsible for the use of hydrogen, but there is both a Health and a DWP angle to it.

Kwasi Kwarteng: Both Departments.

Q473 **Graham Stringer:** Hello, Secretary of State; it is good to see you at the Committee.

Professor Newborough has said that energy efficiency, then electrification, then green hydrogen should be the priorities in that order for the economy. That leaves a relatively marginal case for green hydrogen. But in your introductory remarks you said you were convinced that there was a major role for hydrogen. Can you comment on what Professor Newborough said and square that circle?

Kwasi Kwarteng: Mr Stringer, you will know that there are lots of experts who have different views. When I first became Energy Minister, I had very well-attested, well-respected scientists telling me that hydrogen was not in any way part of it, and people are still saying that. People of great authority say that hydrogen should not be part of the mix and is overhyped. There are others who say that hydrogen is the answer to all our problems, and I have always taken a middle view. I think it has a role.

The second thing I would say to what you say is that, even if you think green hydrogen will not play a big role but will play a role, you have to get the capacity up and running now. It is no good waking up in 2040 and saying, "Now we can develop green hydrogen," because it takes a long time to invest and build up capacity in these technologies. Even if you think the role of green hydrogen will be limited, it makes sense to encourage the production today in 2021.

Q474 **Graham Stringer:** Thanks. Most of our commercial witnesses have said that they want some kind of public support. They have given different dates on the when of it. It would be fair to say they are aiming for 2030 at least, and maybe it would be beyond that. The Prime Minister has said that he does not want the consumer, particularly the domestic consumer, to pay extra for the pathways of hitting net zero. What do you envisage to be the public subsidy over the next eight or nine years?

Kwasi Kwarteng: I think there is a degree of support. There is a wide acknowledgment that, in order to develop renewable technologies, we have to have some degree of Government support. It so happens that, over the past 10 years, when we have supported offshore wind, we have had a wholesale price of power, of energy, that has fallen considerably, so the additional costs on the consumer have actually been outweighed by the fall in the wholesale price. Today, a consumer pays a lot less for electricity than 10 years ago, even though we have supported renewables to an extent.

I think that the ultimate cost to the consumer will be a reflection of the wholesale price—I think there is some Government support—but I cannot tell you today, in 2021, what the effect of that will be on consumer prices in nine years' time.

Q475 **Graham Stringer:** Is the Department not making any assessment—it would be irresponsible not to make an assessment—of the public subsidy needed over that period, if you accept that there is a public subsidy?

Kwasi Kwarteng: In the initial phase you are quite right, but, of course, all these auctions, if that is the route we go down, are dynamic. Offshore wind is an obvious example. Nobody could have anticipated what the strike price would be. Of course, the strike price fell much faster than anyone anticipated. As a consequence, the level of public subsidy cannot be predicted. Of course, we model these things, but we cannot, with any

confidence, say exactly how much the auctions will cost, if they are auctions, over the next 10 years.

Q476 **Graham Stringer:** I accept that nobody knows what is going to happen tomorrow, let alone in two or three years' time, but you must have some ballpark figures that you can show the Committee.

Kwasi Kwarteng: I have various figures that are based on various assumptions. In the first instance, we have committed something like £1 billion to CCUS clusters, in the two and two, as I have described, and we have committed something like £240 million in a net zero hydrogen fund, which can be used to support the production of hydrogen. All of this is well attested.

Q477 **Graham Stringer:** That is over what period?

Kwasi Kwarteng: That should be over the period of a Parliament, I think. That was where we set the £240 million, and it is not fully invested. We have not even decided what the business model will be—what the investment model will be. We do not know whether it is going to be a RAB model or a CfD model in the context of green hydrogen. I cannot possibly tell you how much the support will be when we have not finalised the investment proposition.

Chair: Thank you very much indeed. We will go to Philip Dunne.

Q478 **Philip Dunne:** Thank you very much, Chairman, and thank you for allowing me to guest at this session with the Secretary of State and the chief scientific advisers.

Secretary of State, you know from the work that my Committee, the Environmental Audit Committee, has been doing into the energy efficiency of buildings that we are awaiting the heat and buildings strategy. You have just indicated that the hydrogen strategy might be published in the coming days, during the summer recess. Can you give any insights into when you expect to publish the heat and buildings strategy?

Kwasi Kwarteng: I would like to say very soon, but we are still in conversations about the exact timing of that publication.

Q479 **Philip Dunne:** So, that may not come out during the recess; it is more likely in the autumn.

Kwasi Kwarteng: You are reading into that; I am just saying I do not have a specific date. I wish I could tell you the exact hour and minute, but I cannot do that.

Q480 **Philip Dunne:** Okay. Are you able to give us any insights into where you would see the role of hydrogen as a source of future heat in domestic buildings?

Kwasi Kwarteng: You raise an important point. I always felt it made sense to publish the hydrogen strategy ahead of the heat and buildings

strategy, if possible. We already have pilots that are up and running. If it is used and it is demonstrated that it can be used safely in domestic heating, hydrogen can have a big part in decarbonising natural gas, essentially. Substituting natural gas with hydrogen has a great decarbonising effect. I think that it makes sense to have a hydrogen strategy published ahead of the heat and buildings strategy.

Q481 **Philip Dunne:** It sounds as though that is going to happen. Can you enlighten us on the prioritisation you see for hydrogen within heating domestic buildings? There is a very clear role for heat pumps, but a rather less clear role yet for hydrogen.

Kwasi Kwarteng: I understand. Having been a parliamentarian for a while and having sat on Committees, I understand the Committee's passion for certainty and precision. Unfortunately, I cannot give that guarantee. We already have pilots in places like Fife, in Levenmouth, that are trying to demonstrate the feasibility of hydrogen, exclusively hydrogen, powering homes. I cannot guarantee or prejudge the outcome of those trials. If the trials are successful, I think we can go ahead and view with confidence the role of hydrogen in domestic heating. If, for whatever reason, the trial is not successful, the role of hydrogen might be more limited. I cannot tell you at the moment what the outcome of those trials will be or what the conclusions will be, unfortunately.

Q482 **Philip Dunne:** Moving to another potential application for hydrogen, our Committee yesterday, as you may or may not have seen yet, launched an inquiry into net zero aviation and maritime, looking for low-carbon fuel sources for shipping, potentially hydrogen, ammonia or methanol fuels, or alternative low-carbon sources of fuels for shipping, which is a big emitter.

A couple of years ago, Lloyd's Register indicated that the challenge of introducing net zero fuels into shipping was "dwarfed by the challenges of getting the right fuel ready and the necessary supporting infrastructure on land" in order then to fuel the maritime world—but that would also apply to aviation. Are you looking at the land-based infrastructure that might be required for alternative fuels for aviation or shipping?

Kwasi Kwarteng: Yes; that is a question that you could direct to Grant Shapps in Transport. We talked extensively about the use of decarbonised sources of fuel in aviation. I was very pleased essentially to resuscitate the Jet Zero Council, which you may know of. We hired Emma Gilthorpe to be the CEO of that. It is something where we have applied a lot of energy in the past few months, and she is doing a great job at the Jet Zero Council.

It is not just about hydrogen. We are looking at electricity as well. I was in Norway a couple of weeks ago and I saw electricity-powered ships. They run lots of ships that are powered by electricity through the fjords. They are shorter distances, but there are other technologies that can be used in decarbonised transport and decarbonised shipping.

Q483 **Philip Dunne:** We will look forward to inviting you to appear before our Committee to talk about jet zero in particular.

Kwasi Kwarteng: I would be very happy.

Q484 **Chris Clarkson:** Secretary of State, some have advocated regional clusters for using hydrogen. Is the Government announcement in the transport decarbonisation strategy to develop "the UK's first multi-modal hydrogen transport hub" in the Tees Valley an indication that that is the approach that they will be taking?

Kwasi Kwarteng: That is an approach. I hate to say it is not my subject, but, clearly, the Department for Transport owns the decarbonisation of transport agenda. My understanding is that we do want to have a regional approach, and I think Teesside is an excellent place to have a hydrogen-powered, decarbonised transport system.

Q485 **Chris Clarkson:** What balance are you going to strike between keeping technology options open and making decisions? Are there any sectors you do—

Kwasi Kwarteng: This is the perennial question. I think there is a balance. I do not think it makes sense, in 2021, just to put all your eggs in a couple of baskets in terms of the decarbonisation agenda, but, at the same time, you have to make choices. I think we have struck the right balance and we have supported offshore wind very considerably, to the extent that we have the biggest offshore wind capacity in the world. I think we have made it very clear that we want to support CCUS and the production of hydrogen. At the same time, we are not privileging that over other forms of decarbonisation—for example, electrification.

Q486 **Chris Clarkson:** Are there any sectors you definitely do or do not see hydrogen playing a part in?

Kwasi Kwarteng: In terms of the demand—and I am sure the chief scientific adviser in BEIS will back me up on this—hydrogen has a range of applications that we can see. One is obviously in transport, particularly in heavy goods vehicles and trains. There is a real potential for use of hydrogen in domestic heating, which provides a decarbonised source of gas, which would be very useful. The third is in industrial processes.

There is already a demand for hydrogen. Our job is to make sure that it is produced at a cheap enough rate to be scaled up and used in the way that I have described.

Q487 **Chair:** Perhaps I could ask Professor Monks to come in, as the Secretary of State has teed him up.

Professor Monks: That is absolutely right. I think what you will end up doing is choosing where to use hydrogen. The question really is how much hydrogen is going to be available. Then you should choose to use it in the hardest to decarbonise sectors. The Secretary of State mentioned that there are certain industrial sectors where there are few other choices

than to use hydrogen. In the end, because of the way that we will generate hydrogen, there may be a regional pattern.

To refer to the earlier question around infrastructure, there will be an infrastructure cost to install hydrogen for transport. You might want to think of using heavy vehicles, for instance, just keeping it on the major routes and not rolling it out across the whole of the country.

There will be some choices to be made around that, but, as the Secretary of State says, those key sectors are the important ones that hydrogen can be used on. There will be a question, rather than which sectors can or cannot use it, of how to use a resource that will have some finite limit to it to drive the most decarbonisation that we can.

Q488 **Chair:** The prospective use in transport and addressing the need for a network concentrating on the trunk routes goes to what the Secretary of State has referred to as one of the essential questions—whether you back a particular technology and have a comprehensive roll-out or whether you try to do a bit of each.

The logistics firm Wincanton gave evidence to the Committee on the prospective use of hydrogen in its network. It said that a limited network on the trunk routes would be of no use to it, because the great majority of its refuelling is away from either the depot or those main routes, so it needs to be all or nothing; it needs to have confidence that there will be hydrogen available across the country, or not at all. Trying to ride two horses and not to commit to a full roll-out will not allow it to invest in hydrogen trucks. What assessment do you make of that argument?

Professor Monks: It is a fair argument. As the Secretary of State has said a number of times, at the moment it is difficult to predict where it will go. It is clear that hydrogen has a role to play in transportation, and it is clear that its greatest benefit seems to be in heavy transportation, rather than for light-duty passenger vehicles and the like. Therefore, the consideration that will be co-developed with the users will be how to get an effective network that allows, in some senses, the most miles to be covered for the fewest stations. That will have to be the optimisation. That is an optimisation that we often do in energy networks anyway. It seems to be a tractable problem.

Kwasi Kwarteng: The point that Professor Monks made in respect of the geographical spread is critically important. You are looking at the dispersal of the technology. It is not the case that all the hydrogen stations are going to appear evenly across the country at once. The hydrogen economy and the hydrogen production that we see will, in the first instance, probably be centred around the CCUS clusters. In the production of blue hydrogen, we need to have a carbon-capturing facility, and it makes sense, if we are going to produce blue hydrogen where carbon capture occurs, that the use of that hydrogen will probably be quite near where the hydrogen is produced. It so happens that, in the north-east, in Teesside and in the Humber estuary, there are facilities

and plans, and at HyNet and at Acorn in Scotland, too, to have carbon capture. It is very likely that the production of blue hydrogen will be centred around those industrial clusters, and it is very likely that the demand for that hydrogen will, in the first instance, be around those clusters.

Over time, that technology can be dispersed and investment can be made across the UK, but Professor Monks made a very good point about the way in which this technology is likely to be dispersed or diffused across the UK.

Q489 **Chair:** Before I turn to Rebecca Long Bailey, let me bring in Sir Patrick and ask for his reflections on this very important debate on the role of hydrogen. As the Government's chief scientific adviser, not tied to a particular Department, what is your outlook for hydrogen?

Sir Patrick Vallance: Thank you, and thanks for the invitation to come here. It is a very important topic, and one that is not straightforward, as witnessed by the strong opposing views you have heard, which normally means nobody knows the answer.

The issue as I see it is that, if we work back from 2050 and ask what the timescale is to get things deployed at total scale, we quickly get to somewhere in the 2020s to have to make our answer. Therefore, the immediate R&D question is: what are the unknowns that stop us being able to make the decision today, and how quickly can we answer them? That, I believe, is where most of the R&D effort needs to be at the moment, to try to answer how we make the decision.

I completely agree that there is no single obvious answer today and that it is very likely that hydrogen will have a place in this. The Royal Society report lays that out very clearly and describes where hydrogen may have a role, and in any situation making sure that we end up with life-cycle net zero hydrogen is a key need for current use, as well as future use.

If we work along where it is most likely to be needed, it is things like heavy-duty transport. Shipping has been mentioned, with either hydrogen or ammonia, and heavy goods vehicles, possibly last-stage train, but with the issues that you have raised as being important; and certain aspects of industry, particularly where high temperature is required, where this may be necessary.

Then you get to ones that are less obvious as places where you are likely to need it. Energy storage is one where it may be needed.

We get down to domestic heating. Perhaps it depends a bit on the efficiency of heat pumps and the ability to use them, both in cities and in rural areas, and the ability to look at hydrogen in the gas main for domestic heating, which is being looked at now. As the Secretary of State said, it is a matter of getting the answers to those questions: "Can I run hydrogen through the gas main? Is that going to work? Are there

problems with delivery? Are there going to be problems with the uptake in use in households?" There is also a societal area as to whether people are going to accept that.

Those are questions that we need to try to get answers to relatively quickly to be able to make long-term strategic decisions, which, as you have alluded to, Chair, will have big implications for industry.

That is a rather long answer to your question, but it also plays to our need for big demonstrator projects. The challenge is scale. On top of that, we need to recognise that, as things evolve over the next 30 years, this is an experimental process and there will be incremental improvements and advantages that come from scale that, as yet, cannot be fully understood, so we need to bear that in mind.

There will also be a need for R&D more in the development pull-through of new technologies, and indeed research for things such as new membranes, catalysers, electrolysers and things that could enhance the ability to produce green hydrogen.

A range of R&D activities is required, but the one that answers the question, "Can I make a definitive decision?", is this point of, "What don't I know today that, if I knew, I could make a decision on?", and concentrate the R&D to try to get an answer to that in the next few years—it's in the 2020s.

Q490 **Chair:** That is a very helpful and clear answer. We need to make that decision relatively quickly to be able to deploy in time for 2050, but we do not have the information, I think you are saying now, to be able to make that decision now.

Is there a point at which you think we can have made these big decisions, for example, on use in transport and on use in domestic homes? What is the timeframe, would you say, for that decision to be able to be made?

Sir Patrick Vallance: I think it is a few years, not decades. You literally have a few years to make those decisions, which means it is very important that the policy objectives are clearly understood; the unknowns, the things that are stopping people making firm decisions, are clearly articulated; and the R&D agenda, both public sector and private sector, can then be appointed towards trying to get answers to those questions.

Some of that is ongoing: things like hydrogen studies and so on in—

Kwasi Kwarteng: I am sorry to interject—forgive me—but I think there is a distinction, Sir Patrick, between certain types of technologies. For example, with heavy goods vehicles, we know now that hydrogen can power buses, and I think it does in Aberdeen, I am told, whereas, as Sir Patrick says, we still do not know to what extent it is acceptable or

possible to use hydrogen in domestic heating. Even within that, in the uses of hydrogen, there is a mixed picture.

Sir Patrick Vallance: We already know that we can get hydrogen in trains, and we can get hydrogen in heavy goods vehicles. We know that we can power boats. The question is not, "Can you do it?", but, as we scale, "Do you want to do it?" That is the R&D question: what stops us making a choice between heavy goods vehicle hydrogen and another choice? That is where the R&D comes in. For those technologies, it is no longer, "Can you do it?" It is about the scaling challenge and the price challenge that comes with that, which we need to try to articulate to get answers that allow firm decisions to be made.

Kwasi Kwarteng: I think you are right—absolutely.

Q491 **Chair:** Is it fair to say that, even in R&D, there are some choices? Let us take heavy goods vehicles. We could put a huge amount of resource into moving research and development of hydrogen and advance that or, for the same budget, apply it to electrification and overcome some of the challenges there. If we do both, given constraints, we are likely to be able to do both less intensively than if we chose one and put a wall of research money behind it.

Even in working out the choices, there are some choices now for you, as an adviser, and for Ministers in taking decisions, are there not?

Sir Patrick Vallance: There are in the sense that, if we take electrification of passenger vehicles, it is there, and you can see which direction that is going in. That is not one where a big choice now needs to be made, because it has got over the hump of that. If you ask the question about heavy goods vehicles, it is still not really clear which way to go. So the choices, from a policy perspective, which others will need to consider, are, at this stage, "Do I want to ride two horses on this, or am I prepared to go with one?", and, "If I am going to go with one, are there any things that are still unknown that would help me make that decision?" That is where the R&D comes in.

In other areas, for sure, there will definitely be situations where we would still want to say, "I just don't know and, therefore, I am definitely going to be backing several things."

If you take a hierarchy of where hydrogen is more likely or less likely to be needed—Paul may want to speak to this—there are some things where we say that it is more likely we will end up with hydrogen, such as high-heat-intensity industrial processes where it may be more likely to use hydrogen, and in others where it is less likely.

Q492 **Chair:** Absolutely. Will you say a bit about your role in that, in this context? Obviously, these commitments affect the nation's now legal requirement to get to net zero, whereas the Secretary of State said, in response to an earlier question, that Grant Shapps, the Transport Secretary, is responsible for some of the transport policy decisions and,

to a certain extent, R&D. Although the Secretary of State is also responsible, I think it is still the case you hold the responsibility for meeting the carbon budgets. There is a danger that the different parts of the government machine may not be in sync, whereas your role, as the Government's chief scientific adviser, can integrate these different components. Is that how it works in practice, and is that how you see your role in this?

Sir Patrick Vallance: I definitely do not see my role as integrating the whole of the Government energy and power agenda, no—it is not my role at all. There are two ministerial committees that bring together Ministers from across Whitehall, one chaired by the Prime Minister, and there is a group of civil servants underneath that that brings together people from multiple Departments to make cross-cutting decisions. In the letter that the Council for Science and Technology wrote about this, we made the point very clearly that this is a systems problem that needs a full systems integration, including a systems map, because there are trade-offs between all these different points.

There are both political and civil service structures that bring it together, and there is the Net Zero Innovation Board, which I chair, which brings together chief scientific advisers from across Departments and others from Ofgem and other places, and some external advice, to say, "Given what the policy objectives are, are we putting the research money in the right place to help address that?" That is where my role comes into it, and Paul is a member of that group.

Q493 **Chair:** Will your new office that has been established and was announced in recent days help with that, or is it not germane?

Sir Patrick Vallance: The national science and technology council, which has been announced, which will be prime-ministerially chaired, and a ministerial committee, will be a place to integrate science and technology decisions and strategy for the reasons you say, which is that it crosses multiple Departments. Underneath that is the office for science and technology strategy, which is the sort of civil service support to that, and I would be part of that as well. I definitely see net zero as the big challenge that we face for the next decades, for sure.

Q494 **Rebecca Long Bailey:** Professor Monks, we have heard that, in the energy options pursued, particularly for transport, an international approach is needed, given that travel is across borders. How are you working with international partners on developing co-ordinated plans? Which countries' hydrogen strategies are we seeking to learn from in the UK?

Professor Monks: I am contractually obliged by my Secretary of State to say that they are going to be learning from our strategy, which is going to be world leading, clearly. However, I will put that aside and move on to the question.

With respect to the international context, we are part of something called Mission Innovation 2.0. We are one of the global leaders, alongside the US and China, looking at hydrogen, and we lead one of the key columns for that. That has a headline, interestingly, of producing hydrogen at $2 a kilo, which is a very interesting and a very ambitious number. We are working through the Mission Innovation.

As part of the Horizon programme, which we have subscribed to, we are working across Europe with European partners.

It is worth noting, in the international context, that, at the recent G7, there were discussions around this, along with colleagues from Australia, who also have a very ambitious hydrogen strategy that is very much in line with ours. The 10-point plan goal of 5 GW by 2030 is very much in line with the EU and other national ambitions around that, so it would seem that, internationally, we are aligned with that.

In terms of R&D, we are on the front foot. The Royal Society recently put out some very strong steers on hydrogen and on the R&D landscape that support that.

I would absolutely agree with the comment that it has to be an international effort, because of the pace, as Professor Vallance has said, in what will be required to deliver the R&D to roll it out at scale.

Q495 **Rebecca Long Bailey:** Thank you. That is really helpful.

Secretary of State, refuelling infrastructure is certainly crucial for hydrogen's role in transport. The EU has made a commitment of hydrogen refuelling stations every 150 km along major highways. Will the UK hydrogen strategy contain such a commitment for the UK?

Kwasi Kwarteng: The hydrogen strategy will not have a target for littering or installing hydrogen refuelling stations right through the UK. The strategy is focused on what Paul Monks was referring to regarding hydrogen production and incentivising investment in hydrogen production. That is very much the focus. It does talk about demand, but, as far as I remember, there was no infrastructure offer in the strategy. The strategy is very much about trying to harness the private sector, just as we did in offshore wind very successfully.

Q496 **Rebecca Long Bailey:** Would you not agree that investment follows the creation of a market and that, to create the market, you have to incentivise manufacturers to manufacture hydrogen vehicles, which they will certainly not do if there is not a promise of refuelling stations across the UK?

Kwasi Kwarteng: As I said earlier, there are three main sources of demand for hydrogen. One is in heavy goods vehicles—and your question directly addresses that. There are other sources of demand, in domestic heating, for example, and particularly—I think this is where it will be used

in the first instance—in industrial processes, which Sir Patrick Vallance and Professor Monks referred to.

I think that there is demand. I have gone up to Grimsby and I have spoken to a range of companies in the Humber estuary that want to see hydrogen used in industrial processes. I think that, in the initial phase, much of the demand will come from there, not from having hydrogen refuelling stations 150 miles apart throughout the UK.

Q497 **Rebecca Long Bailey:** The Institute for Government has stated that, while the Government has "committed to securing a green recovery from Covid-19," the "package of policies it has announced so far has been modest compared with other countries, and some have been poorly designed and implemented." For example, the German green hydrogen strategy has been promised €9 billion, and the Japanese Government have allocated $20 billion for stimulating their national hydrogen economy, but the UK, as you have already set out, has promised £240 million for the net zero hydrogen fund, which pales in comparison.

Are there plans for the UK to commit to levels of investment in line with other countries in the near future?

Kwasi Kwarteng: This question always comes up, and I always give the same answer. The key to this is not simply Government spending. The principal reason why we have more offshore wind capacity than either Germany or Japan is that we incentivise private sector investment. We created an investible proposition that essentially ended up meaning that £100 billion of private sector money has already been deployed in the offshore wind sector.

The trick—the key to the hydrogen strategy—is to come up with an investible proposition that can incentivise private operators and private investment in the production of hydrogen.

The German strategy, which came out last summer, which I read with interest, as well as the EU strategy, differs in two significant respects from our proposed strategy. First, it is focused exclusively on the production of green hydrogen. At my insistence and that of others, we have a twin-track approach: we are investing in the production of blue hydrogen as well as green hydrogen.

The second key difference is that their spending commitments were all about Government or state spending, whereas we know from our experience in offshore wind that we get real success by creating a structure—an investible proposition—where the private sector supplies most of the capital and deploys most of the investment. That, I think, is the best way to proceed.

Q498 **Rebecca Long Bailey:** I certainly agree that public investment is often a catalyst for private investment. A recent report from Ballard and Deloitte found that "UK Government support for hydrogen and the fuel cell market was less consistent and co-ordinated compared with other European

countries." Would you agree that there needs to be a public-private partnership in investment?

Kwasi Kwarteng: Absolutely. This is what we have been talking about all session. We have mentioned contracts for difference rounds; we have mentioned the return on asset model; we have mentioned a number of models that are supported by public finance. Ultimately, the trick—the key—is to attract huge amounts of private investment. I completely agree with you that there does have to be some public investment.

Rebecca Long Bailey: Thank you very much.

Q499 **Chair:** One of the key differences between the emerging UK strategy and the German strategy is blue hydrogen, which requires CCS. We talked about the demonstrator plants. But we heard from the previous panel about the difficulties in getting from about 80% capture to the over 90% that would be required to be compatible with net zero. Clearly, the technology and the research has not cracked that yet.

Perhaps I may ask Sir Patrick and Professor Monks: is this a research programme that is being funded or contemplated, and do you have any assessment of how likely it is that CCS is going to get to the level of capture required to make that contribution? Perhaps we will start with Sir Patrick.

Sir Patrick Vallance: Paul may want to start on this.

Professor Monks: It is a good question, and it talks to the question around the R&D landscape. We have done an R&D landscape document for hydrogen, which informs both the hydrogen strategy and the Net Zero Innovation Board. These sorts of questions have been laid out.

On the question of blue hydrogen and what level of carbon residual or whatever you want to call it that you have left, you can reach up to 97%. The Department is funding R&D on absolutely this sort of topic. The Secretary of State was at Cranfield recently, looking at a new steam reformation project, which absolutely aims, by some very novel British technology, to drive that recapture up.

An interesting, science-led question sits at the bottom of what you are asking. It is clear, with blue hydrogen, that you do not end up with the same purity as you do with green hydrogen, and that has an effect on some of the usage cases, particularly around fuel cells. If you have a little bit of carbon monoxide or carbon dioxide in there, it poisons the metals in the fuel cells. Again, you will end up in different usage cases with the blue and green hydrogen, so there is a little bit of another rankle on the blue-green question.

Absolutely, on one of the R&D questions, as Sir Patrick Vallance was saying, this is one of the big areas. It is taking it from laboratory scale, where you can get not quite 100% but getting on for 100%, but if you try

to do it at scale like the Cranfield experiment, you will not be able to see that you can maintain that.

Q500 **Chair:** Sir Patrick, is this one of the areas where we need to do some research to be able to address the question of whether we should be relying on blue hydrogen and whether it is going to be pure enough?

Sir Patrick Vallance: It is an area, as Paul has said, where getting up at scale towards the levels you need to get to has not been cracked yet, and therefore there needs to be more work to crack it and more R&D to get there. It looks like a tractable problem; it does not look like one where you would say that it can't be cracked, but it is a difficult scaling problem.

Q501 **Chair:** Why do you think it has proved resistant to a scalable problem for so many years? I remember that, 20 years ago, the previous Government to the coalition, was pursuing experiments on CCS. That is quite a long time, given the pace of technological development. Why has it proved so elusive to you?

Sir Patrick Vallance: Paul may want to deal with the specifics. Scaling problems are always much more difficult than people think. There is a tendency—I can say this as an erstwhile academic—to think that you have discovered it, and therefore the only little thing to do is to get it implemented and scaled up. Of course, that is where a lot of the problems occur in all fields. You end up with a loss of efficiency, an increase in impurities and difficulty in actually making this operate efficiently at scale. I think there is an inherent problem.

Then I suspect there is a second problem, which is the focus of interest in this, and really getting it to work has increased only relatively recently. A lot of people have been trying to crack it, but it has not had that mass interest in trying to crack the problem. You could take, as a rather recent example of a different scaling thing, the scaling of vaccines, which is incredibly difficult. It just goes to show that, if you throw everything at it, you can do it, but if you do not throw everything at it, it takes a very long time.

Kwasi Kwarteng: I think Sir Patrick makes an excellent point. You and I were in the House when we proposed £1 billion for CCUS in 2015. You will remember that, as a consequence of budgetary debates, that investment was pulled. Sir Patrick is absolutely right to say that the commitment and focus on this question has intensified considerably in the past five years.

Q502 **Graham Stringer:** As I think you heard at the end of the previous session, Aaron asked the witnesses whether it was a good idea always to be first into the field. Sometimes it is better to pinch other people's ideas and let them make the mistakes, with those costs. That is a different kind of question, on the timing, from the question between different technologies to get us to net zero, is it not? I wondered whether you had thought about that in any particular areas. We often say it is good to be

first; then we can benefit from selling the technology. Sometimes, however, it is good to be second. Have you given that a thought?

Sir Patrick Vallance: Again, I would say that, as a general answer, that is true in almost every field. The first is not always the one that wins, and very often it is the so-called fast follower that turns out to be the way it gets there, because you have ironed out a few of the problems, you have seen some of the mistakes that people have made and you can leapfrog. That will be true in some areas here, for sure.

It goes back to the question that you can already see where hydrogen has been applied in a number of areas—heavy goods vehicles, trains, shipping and ammonia and so on—but it does not necessarily mean that what is currently there will win out or that you jump in with both feet and say, "I want to be first." Being first as a sort of mantra is not right; being there or thereabouts is pretty important. You do not want to be so far behind that you cannot be successful.

In some cases—I think this is important—where you have a UK innovation advantage in some way, why not be first if you can do it? You can win by being first, for sure, and where we have that advantage, we should go into it. There are advantages in some of the research areas as well that have come through, around things like membranes, solid oxide electrolysers, water-splitting technologies and so on. There are things going on in the UK that you could look at and say, "Actually they look pretty interesting," and you would not want to slow that down.

Q503 **Graham Stringer:** Are there any areas where you think we might be better slowing down and benefiting from other people's R&D?

Sir Patrick Vallance: Frankly, when I look at the scale of the problem with net zero, I do not think we should be slowing anything down. We have a very significant problem to get to net zero, and we should go as fast as we can go, but we do not do that with our eyes shut or in blinkered isolation; we do it as firmly as we can in an international context, with understanding of what others are up to. Paul alluded to that. Projects such as Mission Innovation, which brings together multiple countries, trying to crack part of the hydrogen cost issue with technology, are exactly the sorts of things that we need to keep very close to and be part of.

Q504 **Graham Stringer:** Both you and the Secretary of State have used the lowering costs of offshore wind as an analogy for the technology of hydrogen. Are there any particular areas where you expect those costs to come down in the introduction of a hydrogen economy or a partial hydrogen economy?

I would also say—and this is a comment, not a question—that a lot of the reduced costs for offshore wind come from whatever rate of depreciation you put on offshore wind, and I think that some of those assumptions are pretty heroic at the moment.

Sir Patrick Vallance: I think this may be for others to comment on in detail, but there is a very obvious issue with hydrogen, which is that the cost comes down when you have scale. Therefore, every time you look at one narrow section of the hydrogen question, it does not look very attractive. The cost is fundamentally a bit fixed, particularly when we look at green hydrogen, by the cost and availability of electricity. We have a series of things that knock on to provide some cost constraints around that. We start to look at hydrogen for transport and, on its own, the economics look worse than if we then say that we are also using it for industry, for heating and for something else. When we have scale, the costs come down quite rapidly. I think there is an interconnected problem here, which means, again, that there is a whole-systems thing.

However, this is much more the Secretary of State's—

Kwasi Kwarteng: I think Sir Patrick is absolutely right. The key, from my point of view, is getting the investment because, clearly, in driving the down the cost curve, we need an initial investment. That is why it resolved itself into a chicken-and-egg problem. If we were to look at offshore wind 10 years ago, for example, it cost something like £150 per megawatt-hour. Without some support, the costs would not have come down. This refers to what Guy Newey was saying at the end of his session. He said that we can have the best research in the world, but a lot of the innovation and cost reduction comes from actually doing the process. As he said, we could not build a 100-metre 10 MW wind turbine without actually trying to do it. You could not research your way to find that.

A lot of this is dependent on initial investment and support. Then, once the private capital is galvanised in the way I have described—through learning and through doing and refining manufacturing processes, getting more innovation in the manufacturing process itself—we can see a cost reduction.

We speak to companies such as ITM Power. It is already driving down the cost of electrolyser manufacturing, which is a component cost of the production of green hydrogen.

Q505 **Graham Stringer:** Are there any particular pieces of evidence that you need or are looking for to enable decisions to be made between the different green technologies?

Kwasi Kwarteng: That is a very good question. As I said, there is a chicken-and-egg problem here. People come to me about marine technology. Marine technologies and renewables are very expensive, but the only way that you can actually reduce the cost is by supporting them in the first instance.

If, for example, the costs in an auction process of—let us say—tidal power did not come down quickly enough, we would probably cease to support that. It is that sort of thing. As Guy said, people will make

mistakes. A lot of this is learning by doing, and we cannot simply theorise our way to the right answers.

Q506 **Graham Stringer:** I understand it is empirical and a scale issue, but I just wondered whether there were any particular areas that you were looking at to gather that evidence, beyond doing the large-scale experiments.

Professor Monks: Perhaps I could add something. The International Energy Agency has just put out a levelised hydrogen cost document, which goes from now to around 2050. That really helps with exactly the kinds of numbers around this. As Sir Patrick said, in some senses, with blue hydrogen, it is the cost of the gas at the end of the day: it is what you put in.

It is interesting, with green hydrogen, although it is currently more expensive than blue hydrogen, that it is the R&D that is going to drive down those costs.

Kwasi Kwarteng: Exactly.

Professor Monks: That is what it is.

Back to the blue-green mixture, we are going to have in our future energy system a large amount of wind, and we have intermittence there. It makes sense for us to have green hydrogen so that, when we are not using our electricity to produce directly, we change the energy vector into hydrogen.

I know that everybody sits on these sorts of things and, whenever we get to these and talk about energy, we say it is a systems problem, but it truly is a systems problem. Actually, net zero is a system of systems problem. It is a matter of making sure that we do not stop innovating and stop because we are trying to work out, in what is a complex system, with lots of cogs moving, what the right option is. We have to keep on pushing through there, or else we will get paralysis in that decision making. That is what the hydrogen strategy says, and that is what R&D says. We need to keep pushing this, because that is what will drive the cost down.

Kwasi Kwarteng: Exactly. My critical point on that is that the R&D is forthcoming only with some support initially, because we have to incentivise people to spend money on the R&D.

Q507 **Graham Stringer:** If I may just change the subject to smart meters or, in some cases, not-so-smart meters, the Committee was surprised to find that the current generations of smart meters do not work if we move to a completely full green hydrogen supply domestically. What will be the cost of changing the current generations of smart meters—there are two generations of smart meters out there, I think—to a new generation that will be able to deal with a pure hydrogen feed?

Kwasi Kwarteng: All I can say about that is that we are developing prototype meters—they have not actually been developed—which can be installed to be adapted to hydrogen. Again, you are asking me for a degree of precision where I cannot tell you to what extent hydrogen will be used in domestic heating. It may well be the case that all our houses that are currently on natural gas, which is about 85% of consumers, can switch to hydrogen, or it may be the case that it could be a much smaller proportion. It is also dependent on the take-up of heat pumps.

There are lots of variables. This is one of the constant themes of this session. There are lots of variables that will affect the answers that you are seeking.

Q508 **Graham Stringer:** Yes and no. I am sure there is at least one very clever person in your Department doing a back-of-an-envelope calculation on replacing all the smart meters now with smart meters that will work for pure hydrogen. It must be a relatively simple calculation.

Kwasi Kwarteng: All I am saying—

Graham Stringer: I guess a Secretary of State like yourself, who is very good at the detail, will want to know the answer to it.

Kwasi Kwarteng: As I said, there is a degree to which we are trying to seek false levels of precision. Yes, it is true that we could make a calculation on the basis that every single home in the UK adapts itself to a hydrogen gas supply within 10 years, but that is not likely to be the outcome. It is very unlikely to me, even if hydrogen is adopted widely, that 100% of homes in the UK adapt—not even 100% of homes today are on natural gas. These figures should be treated with a degree of scepticism.

Q509 **Graham Stringer:** I will leave it there, Secretary of State. I am sure that that information exists. If you were to do a regulatory impact assessment, which you would have to do for any change of the system, whether to a mixed system or to a pure hydrogen system, you would have to work out the different alternatives.

Kwasi Kwarteng: But, as you will appreciate, Mr Stringer, we do not even have the conclusions of the pilots for hydrogen, which Sir Patrick was referring to. It could well be that we do not have any hydrogen gas in the distribution system for domestic heat.

Q510 **Chair:** It is the case, is it not, that the currently installed smart meters will not work with hydrogen? As you say, we do not know whether hydrogen is going to be deployed, but were it to be deployed they would have to be replaced or, we did hear in the earlier evidence session, as you might have heard, they might need to be uninstalled, taken back and amended and then brought back again.

Professor Monks: May I comment on this? Mr Stringer said that the Committee were surprised. As a scientist, it is, I am sorry to say, slightly

obvious, because hydrogen is a very different gas from methane. When you meter gas, you look at the volume that goes through a meter, and that depends on the density and the thermal conductivity of that gas—I am sorry to get "science" on you. It comes to me as no surprise whatsoever that you have to change the meter because, physically, you are changing the property of the gas.

On one level, as a scientist, it is obvious. You are then talking about the policy implications, but, scientifically, you would not expect a meter that is made for methane to work for hydrogen.

Chair: That is very helpful.

Q511 **Graham Stringer:** I think the surprise was that a programme that is five years behind schedule and that is costing £2 billion could not move to the next phase. I understand that a hydrogen molecule is much smaller than a methane molecule, but the fact that that had not been thought of and dealt with—

Kwasi Kwarteng: To be fair, five years ago, nobody was talking about a hydrogen model. I have been involved in this from a policy point of view, as a Minister, for two years, and the accelerated rate at which people are talking about hydrogen and we are actually deploying hydrogen has been astonishing all round the world. Advanced economies are looking at hydrogen in a way that they were not four or five years ago. As Professor Monks says, methane and hydrogen are very different, and you would not expect the meter to be able to track both. At the same time, I think it was unrealistic to assume, five years ago, that we could envisage a world where the whole gas network would be reliant on hydrogen.

Q512 **Chair:** But not now, and it is the policy question that is the germane one.

Kwasi Kwarteng: That is right.

Q513 **Chair:** Given that we have established today, and we know, that there is a policy decision coming about whether hydrogen will be deployed in domestic homes, is it sensible, knowing that that decision is foreseen, to continue to be deploying, at a cost of several hundred pounds per smart meter, a technology that may need to be replaced within the next few years, whether that is on consumers' bills or on the public purse? Should there be a pause in the deployment of what will be redundant smart meters if a decision to deploy hydrogen goes ahead during the time when you make that decision?

Kwasi Kwarteng: My own view is that it is a difficult decision to make, but I would not have a pause, because you are not substituting anything else in its place. Of course, the hydrogen roll-out is dependent on two things that we do not know. It is dependent on the heat pump roll-out and the acceleration, and to what extent heat pumps are used. It is also dependent on the trials that I have alluded to in the course of these hearings: what are the conclusions of those trials? It is also dependent on hydrogen production.

As I always say, given the number of variable unknowns, I do not think it makes sense to stop the roll-out of smart meters.

Q514 **Chair:** They are replacing functional meters, albeit not smart meters. If they are coming to the end of their life, that makes sense, but, taking away a meter that could continue for the next five or six years while you make this decision—on the current understanding, you cannot make it yet—on the roll-out of hydrogen, has that been examined at least?

Kwasi Kwarteng: I think it has been examined, and I think that, for the five or six years, as you put it, the smart meter actually can drive costs down more than sticking with the existing meters. I think there are savings there that make it worth while continuing with the smart meter roll-out.

Q515 **Aaron Bell:** I thank all three of our witnesses.

Secretary of State, we have heard that there are a lot of difficult decisions ahead, with a lot of options, and that, as Sir Patrick said, we need some R&D fairly urgently to help us make those decisions. What are the low-regrets policies that the Government will be pursuing with regard to hydrogen—the things that we can basically do or commit to almost today?

Kwasi Kwarteng: We have committed to CCUS many times. In fact, we have raised the amount of money that we have committed to it. I remember going into the manifesto that you were elected on, and we committed £800 million to rolling out this technology. Today, as in the 10-point plan and the Budget this year, we have committed £1 billion. That is something that is going to happen.

Once you have carbon capture, the production of blue hydrogen, as we have discussed, fits very neatly with that. The representatives of the industrial clusters that I have spoken to, notably in the Humber estuary and on Teesside—have repeatedly said that the carbon capture that they want to see will be allied to the production of blue hydrogen. I think that, as a low-regrets minimum, we will be committed to CCUS and to the production of blue hydrogen.

The production of green hydrogen is already being driven by very strong UK companies. I mentioned ITM Power, and there are others that are already committed to it. The production of both forms of hydrogen and CCUS are things that are happening.

Q516 **Aaron Bell:** That is on the production side. On the use case, especially if it is geographically focused, as you said, that gives an option for testing hydrogen as a fuel for industrial processes. Is the testing of that something that we are definitely going to do in those settings, or could that hydrogen be used for something else, as we heard from Professor Monks?

Kwasi Kwarteng: We have the industrial decarbonisation strategy, and I would like to mention the fact that the hydrogen strategy itself was always going to be part of the industrial decarbonisation strategy. Initially—and the Chairman will perhaps back me up on this—hydrogen was always seen as part of the industrial decarbonisation strategy. It was only last year that I took the decision, along with the Secretary of State at the time, to split the hydrogen strategy from the industrial decarbonisation strategy. That is where the geographical focus was coming from in the first instance, in so far as heavy industry in the industrial clusters was very interested in looking at hydrogen to decarbonise. I think that will be a no-regrets first step in the use of hydrogen.

Q517 **Aaron Bell:** You referred earlier to the fact that domestic use trials are still ongoing, but they have gone pretty well. A blending trial at Keele University in my constituency has gone very well.

Kwasi Kwarteng: That is right.

Q518 **Aaron Bell:** Assuming that the further trials go well, are we looking at introducing that blending as soon as 2022 or 2023? In line with what the Climate Change Committee recommended, are we looking at mandating H_2-ready boilers by as early as 2025? Are those reasonable targets?

Kwasi Kwarteng: There are two things here. The experiments at Keele University—which I was due to go to, but of course the lockdown prevented that, so I am still looking forward to my visit—are blending up to 20% in terms of volume, as I understand it.

Aaron Bell: Yes.

Kwasi Kwarteng: But the trials in places such as Levenmouth are 100% hydrogen, so they are slightly different. If those trials go well, as you have suggested, we could enter a world where, within eight or nine years, we could have hydrogen in the gas distribution system. We could. That is the potential. However, that is as far as I can foresee and that is as much granularity as I can provide at the moment.

Q519 **Aaron Bell:** On the boilers mandate, is that likely to be—

Kwasi Kwarteng: I could say that the heat and buildings strategy will be coming out soon. I think that gas boilers will be here for the foreseeable future, but there is a world in 10 years' time, in the 2030s, when we could be seeing hydrogen boilers. There are discussions at the moment: manufacturers are looking at producing hydrogen boilers.

This is a really important point. The manufacturers' appetite to produce hydrogen boilers is very much determined by Government policy, and that is where we need clarity. That is why I am very interested in the heat and buildings strategy being published, as well as the net zero strategy.

Q520 **Aaron Bell:** In supporting the investment and innovation that we need to see, I completely agree with your answer earlier that getting the private sector involved, as we did in offshore wind, is absolutely key. Do you anticipate using the same sort of scheme—contracts for difference—to provide the incentive and the confidence to private investors?

Kwasi Kwarteng: Yes. It cannot be the case that the contracts for difference system, the auction system, is uniquely and exclusively relevant to offshore wind. If the mechanism works for offshore wind, there is reason to believe that it could work in other technologies. I can see the case, for example in the production of green hydrogen, for having a supported mechanism such as the CfD round. I can see that case. I am not going to pre-empt or prejudge that and say what route we are going down, but one can see a world in which one had an auction process for the production of green hydrogen. There are questions about what the offtake in demand is because, of course, with electricity generation, you are feeding straight into the grid, but the investible structure is something that we have looked at and that we are consulting on.

Q521 **Aaron Bell:** Thank you.

Finally, if I could turn to you, Sir Patrick, you gave a very comprehensive answer to the Chair earlier about where you see this fitting into the overall picture. Looking at an even wider picture, the science capability review a few years ago highlighted the need to strengthen science across Government. Just last week, you spoke about the need "to build an enduring science and engineering capability within government that is equipped to face the challenges of the future."

How ready would you say the Government is to implement the hydrogen strategy and a plan to get to net zero? What steps need to be taken so that policy makers and decision makers in Government who do not work in the science profession can get the advice and the help that they need?

Sir Patrick Vallance: The science capability review, which was published just over two years ago, outlined what we thought were the steps that needed to happen, including making sure that every Department has a chief scientific adviser. I am pleased to say that we are in that position, and we have a great group of people now in role—including making sure that they have the support they need, which is very important.

The last spending review explicitly asked for the chief scientific advisers to make sure that they had put in bids for the system they needed around them—and it will be the case again for this spending review that we will be doing that—including making sure that every Department has a science plan and every Department has a series of areas of research interest that can then be expressed for others to work on, as well as a developmental science objective. For example, the BEIS one and the DFT one both have hydrogen specifically in their areas of research interest. That system is getting there.

You asked a much broader question, which also speaks to the Government reform approach. It cannot possibly rest on the chief scientific advisers and the small offices they have. It is about upskilling science and technology right across the civil service. We have already doubled the intake of people on the science and engineering fast stream, and we are pushing to increase the general fast stream proportion of people with science and engineering degrees.

Also, learning from the past 18 months, we are increasing the ability to use data visualisation to help people make tools, which has been instrumental in what has happened in the Covid pandemic.

Then there will need to be a series of offerings right the way across for people who perhaps do not feel comfortable with science and technology but who need to be able to interact with and be good customers of it—and a series of programmes is being put in place.

That is a long answer to say that bits of it are in place and bits of it still need work to get to a fully science and technology-enabled civil service, which will, I think, be required for the challenges that we have, of which net zero and all the complexities of that are definitely one, and probably the major one.

Q522 **Aaron Bell:** That sounds very promising but, parsing your answer a little, I suggest that the culture is not fully there, and that people always think, "I need some scientific advice, I need some better data, and I need to ask somebody about this." We have not quite got there yet, but we are on the right track.

Sir Patrick Vallance: We are on the right track. I would like slightly to rephrase what you have said, because there is definitely an element of, "I need scientific advice. How do I go and get it? Is there enough of it?" That is definitely part of what needs to be fixed.

I would argue that there is a separate bit, which is, as I am having my discussion around policy, even though I do not think a science and technology person needs to be there, actually having them there brings a different dimension. That is the cultural bit, which I think is really important, because it brings a different way of looking at problems and a different set of potential solutions.

Q523 **Aaron Bell:** If I was to ask you the same question in 18 months' or two years' time, you would be confident that we would be much further along that path, and that it is happening quite rapidly.

Sir Patrick Vallance: I am confident that we are definitely on the right track, but I am not going to say that I know how far we are going to be. I would like to be very far along that track. I think it is urgent and important, and I think the Government recognise that. We need to push on it as hard as we can.

Chair: That concludes our questions on hydrogen, and I am very grateful

for witnesses' answers on that.

You are very generous in appearing before the Committee, but you do not come every week and there are some relevant questions that we would briefly like to touch on before we go. Rebecca Long Bailey has a question on the confirmation hearing that we had on Sir Andrew Mackenzie's appointment as the chair of UKRI.

Q524 **Rebecca Long Bailey:** As the Chair said, I would like to ask briefly about the appointment of the new chair of UKRI. As you know, the proposed applicant told this Committee that he did not think that his role as chair of Shell, a non-executive director role, was a conflict of interest. However, as I am sure you know very well, section 172 of the Companies Act 2006 states that directors have a duty to act in such a way as "to promote the success of the company" for the benefit of the shareholders. This is a very clear, overriding duty.

His role within UKRI will require him to work with the CEO of UKRI to advise you, the Secretary, on major strategic investment priorities. Are you concerned at his ability to comply with both duties while avoiding allegations that the work he carries out for UKRI or the advice he gives to you is biased towards the business interests of Shell?

One example I can think of is one that we have already been discussing: Shell's long-term plan in hydrogen overall.

Kwasi Kwarteng: I know that this question is a very serious one and I accept that, on the face of it, people might think there was a conflict of interests. His role as chair is not an executive role, and I think his interest as chairman of Shell is also well known.

It so happens that I co-chair the Hydrogen Advisory Council. The co-chair was Sinead Lynch, who was a Shell employee. There is always conversation with different companies about strategy, but I do not think that Sir Andrew Mackenzie's role as chair of UKRI would in any way influence executive decisions by the CEO and board of UKRI.

Q525 **Rebecca Long Bailey:** Certainly, situations will arise where he is advising you on major strategic investment decisions on a whole range of issues that would provide financial benefit to Shell overall. He might not be doing that consciously, and I am sure he never would, but those allegations will follow, which unfortunately will undermine the role and standing of UKRI. Are you going to do anything to set out in detail how such conflicts of interest will be avoided, and preferably before his appointment?

Kwasi Kwarteng: I have tried to make it very clear that he does not have an executive function. The advice he gives, even as chair of UKRI, will not be specifically directional in terms of where UKRI puts its funds or which research projects it chooses to back. I do not see the conflict of interest that you envisage.

Q526 **Rebecca Long Bailey:** Even though the Companies Act sets out a clear legal obligation on his part in his role with Shell to act in the interests of his shareholders.

Kwasi Kwarteng: He is chairman of Shell and he is also chair of UKRI. I do not believe his role as chair of UKRI is an executive one—in fact, it is not an executive one—nor do I believe that he has any influence or mandate to invest in specific research projects.

His job as chair of UKRI is to provide advice to the CEO. He is not directing funds to particular research projects. He provides advice to me, and he is simply there to provide strategic direction. He is not there to arbitrate or comment on specific investment choices.

Q527 **Rebecca Long Bailey:** As you have said, he is there to provide strategic direction. Just so we can be clear, you are not going to set out in any detail how conflicts of interest can be avoided, if they should arise, which they inevitably will.

Chair: I think it is the case that an agreed conflicts of interest policy has been concluded, you wrote to me to say—

Kwasi Kwarteng: Yes, we are looking at this. We have written to you to say that we feel that there is not actually a conflict of interests, but there is a process, where his management is overseeing his performance in the job of chair in the usual way.

Q528 **Chair:** Obviously, the Committee will continue, I hope, to hear from you and Sir Andrew. It is worth putting it on the record that there was nothing personal in the questions that we had; it was more the structural aspects.

Kwasi Kwarteng: I hate to make the obvious point, but your Committee, as I understand it, endorses the appointment, so it seems odd to me that we are revisiting an issue that I thought had been resolved.

Q529 **Chair:** No—it is not just a question of endorsing the appointment. The question that the Committee put was that it recommended that you should put a clear framework in place to manage any reality—but probably, as Rebecca says, more the perception—of any conflict of interest policy. All members of the Committee felt that was important.

Kwasi Kwarteng: Sure; we can revert to you in terms of the structure—and I think we have.

Q530 **Chair:** Finally, to Sir Patrick, this is a session on hydrogen, and we do not have the time to be going into a session on Covid, but, as we go into the summer recess, there are a couple of questions on Members' minds, which they were keen for me to ask you, of current relevance.

The first is looking to the autumn and winter. As Government chief scientific adviser, you commissioned a report from the Academy of

Medical Sciences, which was published just a couple of weeks ago and which has made some recommendations about the winter, including preparing for the possibility of a booster vaccine campaign.

The Committee heard just a few weeks ago from Sir Andrew Pollard, who thought that, happily, the level of protection of the current vaccines may not require that. Perhaps you might give your initial response to the report that you commissioned and on any other aspects of the winter handling that the Committee should be updated about.

Sir Patrick Vallance: I commissioned a report last year from it for last winter, which was very helpful, and I did the same for this winter, asking it to look again. I also asked the Royal Academy of Engineering to look at a report that came out at about the same time on buildings infrastructure and infection risk. Both of those reports have come in, with very helpful suggestions.

As before, the academies' reports have been evidence based, taking real expert advice, and they have laid things out very clearly. I have sent those reports, and they have sent those reports, to the relevant Departments and Secretaries of State, who are looking at them carefully.

One of the key features is that they clearly indicate that there is going to be a wave of infections this winter: not just Covid, but flu, RSV and other infections that we are aware of. That needs to be factored into NHS planning. They make a series of observations and recommendations around co-infection, backlog in the NHS, wider health implications, vaccines, test and trace, isolation, communication and the sorts of things that encourage spreading. All of those are very important.

On the booster question in particular, it is a very difficult area. There is some evidence from Israel that there is some decrease in antibody levels occurring after six to eight months or so, particularly in the elderly. There is other evidence that the T-cell response—the other part of the immune system—may be much longer lasting, so the question of exactly when boosters come in is a very technical and important one, which is being looked at now. My own view is that it is likely that we will need boosters in certain populations, particularly the elderly and the most vulnerable, and we may need them sooner than we do in other populations.

It is also my view that, as this turns to being an endemic infection that we see every year, it is likely that there will be proportions of the population who get an annual booster every two years or so, which is what happens with flu as well.

The Academy of Medical Sciences report lays out those options quite clearly.

Q531 **Chair:** Thank you very much. The second area is the pilot study that has been conducted into test and release. We have heard evidence that compliance with requirements to isolate would be higher if people who were required, because they were a contact of someone with Covid, could

test daily and go about their business if they were testing negative. That pilot scheme was announced on 29 April. It has not reported yet. There was a point of order in the Chamber of the House of Commons this week expressing concern that it would now not report while Parliament is sitting. Can you update us on the timing of this pilot? Under whose auspices is it being conducted? As the Government's chief scientific adviser, does it ultimately report to you?

Sir Patrick Vallance: No, these studies report to Departments.

There are two studies that I think are particularly important. One is the trial being run by Public Health England, the so-called stock trial, which is on daily testing versus isolation in the general public. That, I understand, has enrolled 46,000 people. It is a randomised study. The protocol is published, as it should be, in advance, so that people can see what the trial design is. I believe that they are expecting answers from that trial over the next few weeks, with an aim to potentially having something at the end of August.

I cannot be precise about that, as it depends on when they get to a certain level of enrolment versus incidence of disease that you can make that cut. They have an independent data monitoring committee. That is a very important study.

The second very important one is the one that is going on in schools, which is due to report imminently and which was a cluster randomisation study of, I think, over 200 schools, looking at the same question of daily testing versus isolation. As I say, I think that is due to report imminently. That is under the Department of Health and Social Care, which sponsored that. Again, there are published protocols so that people can see what it is. That is due to report imminently. Those, I think, are the two really key studies.

The pilot studies on workplace testing are much more about the operational aspects, rather than the true test of "Does this work?" and "What is the difference between two different approaches?"

I would concentrate on the two randomised studies as giving that information; the workplace pilots are much more about operational aspects, and I believe they are under the auspices of one of the deputy chief medical officers.

Q532 **Chair:** Thank you. That means that they will report after 19 August, when there will no longer be a requirement for contacts to isolate, so their conclusions, frustratingly, will come at a time when they are redundant rather than useful.

Sir Patrick Vallance: I do not know. I think the first one—the schools one—will report soon. I think it will be days. On the second one, I do not know exactly when it is going to report. I am sure they are working very hard to get it out before that date, because they would be very important pieces of information, but they have to respect the trial integrity and

make sure that they do not stop prematurely or end up with a result that is partial.

Q533 **Chair:** Indeed. Finally, before we let you go, we are going to spend the summer—our Committee and the Health and Social Care Committee—writing up our report into the joint lessons learnt inquiry, to which you have been generous in giving evidence. Is there anything since you appeared before us, any further reflections, that you would like to draw to our attention as we make our conclusions?

Sir Patrick Vallance: If you look around the world, it is becoming increasingly evident that zero Covid is not sustainable and that this becomes an endemic question. How do you get to the endemicity of this, and how do you manage that? It is increasingly obvious that there is going to be continued variation and there will be mutations coming through, which will cause a challenge to vaccine systems; so the vaccine infrastructure is absolutely critical to success here.

It is obvious that the preparation—to some extent, this was behind the "100 Days Mission" report that we put together for the G7—has to be done beforehand. Entering into a pandemic with a system where public health has not been properly funded for several years, or the NHS is not able to flex capacity, or we have not invested in maxing infrastructure, puts you at a very big disadvantage. It is the preparation beforehand. That is why we need to do that now, for future pandemics, and to make sure that we are able to respond with the appropriate reactions within a very short period of time.

Chair: Thank you very much indeed. I thank our witnesses—Secretary of State, Sir Patrick and Professor Monks—for your evidence today. That concludes this session of the Committee.