



Science and Technology Committee

Corrected oral evidence: Long-duration energy storage

Tuesday 21 November 2023

11.20 am

Watch the meeting

Members present: Baroness Brown of Cambridge (The Chair); Lord Borwick; Baroness Neuberger; Baroness Neville-Jones; Baroness Northover; Lord Sharkey; Viscount Stansgate; Lord Wei; Lord Winston.

Evidence Session No. 11

Heard in Public

Questions 99 - 107

Witnesses

Dr David Joffe, Head of Net Zero, Climate Change Committee; Owen Bellamy, Head of Power Sector, Climate Change Committee; Rachel Hay, Head of Energy Supply Decarbonisation and Resilience, Climate Change Committee.

USE OF THE TRANSCRIPT

This is a corrected transcript of evidence taken in public and webcast on www.parliamentlive.tv.

Examination of witnesses

Dr David Joffe, Owen Bellamy and Rachel Hay.

Q99 **The Chair:** I welcome the witnesses to the committee's 11th evidence session in our inquiry into long-duration energy storage. We will now hear from the Climate Change Committee. We have with us Owen Bellamy, the head of power sector; Rachel Hay, the head of energy supply decarbonisation and resilience; and Dr David Joffe, the head of net zero. This session is being broadcast live on parliamentlive.tv and a full transcript will be produced; it will be sent to you shortly after the meeting for you to make any minor corrections. Should you think while answering the questions of any additional information that might be useful to us, we would be very happy to receive it as additional evidence.

At the start of this session I have to declare my interest as chair of the Adaptation Committee of the Climate Change Committee. I ask Viscount Stansgate to kick off with the first question.

Q100 **Viscount Stansgate:** In March this year the Climate Change Committee released a report, *Delivering a Reliable Decarbonised Power System*, which set out key recommendations for the Government to deliver net-zero electricity by 2035. We will come back to specific aspects of that later in the session but, first, could you briefly outline the key recommendations in that report?

Dr David Joffe: Sure; I am happy to do so. Thank you very much for the invitation to speak to you this morning.

There is a set of recommendations. I will run through them quickly; I am sure we will come back to each of them. The overarching one, I guess, is the recommendation to government to publish a long-term strategy for delivering the 2035 net-zero electricity system. We made the recommendation for that target in 2020. The Government committed to it two years ago but we still have not seen a plan for how they expect it to be delivered. Part of the idea for the report that we published in March was, "Well, the Government have left a gap here. Can we usefully fill it and at least set out what we see that system looking like?". It is clear that a plan is needed so that actors in the system understand their roles and roughly what the system will look like.

The Government have set out quite a lot of their ambition for large-scale electricity generation. What they have not set out is how the system will operate and how we will get the flexibility that we need within it. That is key, particularly with the lead times that we have heard about this morning; it is key to get that as soon as possible in order to provide the necessary clarity. Clearly, the Government have now committed to setting out a short overarching plan, but we will see whether that goes as far as it needs to. We think it needs to set out their approach to different technologies and the portfolio of technologies that will be required; how policies and regulations will deliver; what strategic decisions are required and how they are going to be made; what the decision points are in time;

and how the Government will handle delivery risks and governance. So there is quite a lot that we think needs to be in the plan; it remains to be seen whether that is what the Government will publish.

I will just run through the other recommendations. As we heard in the previous session, one was to formalise the institutional responsibilities of the future system operator, Ofgem and the Government in delivering this system. Another was to develop a long-term cross-sectoral infrastructure strategy covering liquid and gaseous fuels, electricity, CO₂ and heat networks. Another was to identify a set of "low-regret" investments for hydrogen and electricity that can proceed now rather than waiting for a perfect plan and waiting for 2026, when the Government have said they will make decisions on the balance between hydrogen and electricity for home heating. We just need to get on and build, really; that was the driver behind that recommendation.

There was also a recommendation for a Minister-led infrastructure delivery group to ensure that these things are moving forward. The reason why we recommended that it be Minister-led is that this needs to be across the GB system; this means that there are actions required in Scotland and Wales that are outside England's planning system. Planning responsibilities are devolved; therefore, in order to bring in the devolved Administrations, the idea was to bring devolved Ministers into that process.

We recommended a review of governance arrangements for resilience to climate hazards and recommended that, in the national adaptation plan 3, the Government set out a vision for what a well-adapted, climate-resilient energy system would look like.

Finally, we made two recommendations on hydrogen: fast-tracking the business models for transport and storage, and finalising the funding for low-carbon hydrogen. Within that, it was interesting to hear the clarification from the earlier witnesses; it was the first time we have heard the figure of 66 terawatt hours as a clarification of how much hydrogen 10 gigawatts gives us. That figure of 66 terawatt hours, which we heard from Paul Monks, is still below the number that was in our report for 2030; 76 to 121 terawatt hours was the range that we put in there. So the question of whether that is sufficient needs to be clarified.

We also think that more clarity is needed on the uses of hydrogen. We are concerned that the way in which hydrogen will be incentivised, for example in industry, may lead to a playing field that is not level and may in some areas incentivise the use of hydrogen over more cost-effective solutions, such as electrification, just because of the way that things are being incentivised. We think that needs clarifying as well.

Viscount Stansgate: Considering that it has been more than six months and many of the recommendations you made were marked as urgent, how do you think the Government have responded so far?

Owen Bellamy: We have looked at that. There were 10 priority recommendations in our March report. Seven of them were marked as urgent for this year. The Government have come back and published

their response to our annual progress report to Parliament; they published it in October, I think, and went through those recommendations one by one. We have looked at that response. We think that the majority of the recommendations have been partially accepted in one form but not wholly accepted, while one was specifically rejected.

Without going through the whole list again, I will give some examples. The Government have accepted in principle the need for a delivery plan or strategy plan for 2035 but they have not filled in the details of when it would come out or what it would look like, so that has been partly accepted. The Government have said that they do not think the Minister-led infrastructure delivery group mentioned by David is needed because it is covered by other processes that are already under way, including a Minister-led approach to electricity transmission infrastructure. Of course, that transmission infrastructure is only one part of the whole picture. It is a fairly mixed picture overall.

Q101 Lord Sharkey: It is quite clear to us that one of the key messages in the inquiry so far has been a sense of the real urgency involved in these discussions. We are talking about infrastructure that can take years and years to build but needs to be available in 2035, so decisions and funding need to be in place imminently.

I have three questions. First, can you set out what you would most like to see from the Government in the near term to speed these timelines up? Secondly, what do you think are the biggest risks that will lead to further delay on the current timelines and make targets such as decarbonisation by 2035 impossible? Thirdly, can you set out the scale of investment required for this transformation of the electricity system, giving some sense of how it compares with existing spending, and what we will need to do to leverage the kind of funding we are going to need? I can repeat the questions if you need me to.

Rachel Hay: Thank you for those questions; I will take the first two then pass over to Owen for the last one. You are absolutely right that the needs are urgent. We have a target for delivering a decarbonised electricity system by 2035. That is now broadly 11 years away. Gas currently makes up around 40% of our electricity generation by source and we have made a lot of progress to date in decarbonising. But while we have made good progress to date, removing the first 10 terawatt hours of gas from the system is a very different challenge from removing the final 10 terawatt hours and we have a long way to go.

As we have discussed, the lead times are long. We have heard from stakeholders around seven to 10 years for hydrogen storage and seven to 12 years for gas pipelines. The Electricity Networks Commissioner talked about 12 to 14 years for electricity transmission, although obviously he has ambitions to halve that to seven years. Even if we manage to reduce those timelines significantly, we still have a difficult challenge ahead. We have an awful lot to do in a very short amount of time. Ultimately, if we do not get the additional flexibility that we need built, we will remain

reliant on gas and we will fail on those ambitions to decarbonise the system.

What we most want to see from government in the near term is to speed those timelines up, David has touched on some of that and I will expand on a couple of bits. One is this comprehensive strategy for the delivery of a reliable decarbonised power system by 2035. We have mentioned that the Government have acknowledged the need for something here. They have talked about a commitment to a short plan setting out how policies form a coherent whole. Our worry is that it will not go far enough. This is a very significant challenge. In a way it is odd that we do not have a strategy for delivering on this, given that we have strategies in various other areas.

We set out in our progress report a number of elements that we think the strategy needs to include—a portfolio approach to delivery covering the full range of low-carbon flexibility options; demand flexibility, storage, hydrogen, gas and CCS interconnection; and setting out how these will be delivered, as well as clarifying the scale of any residual role for unabated gas, which I think an earlier question was getting at as well.

Critically, we need a demonstration of how the suite of relevant policies and regulatory levers will work together to deliver that objective. It is clear that there is a patchwork of a whole range of policies here. What we are missing is an understanding of how they will knit together to deliver that outcome. If we have a 2025 delivery date for business models for transport and storage of hydrogen, what does that mean, working back from 2035 and actually delivering this stuff?

There is also setting out what strategic decisions will be required to guide effective delivery; setting out a comprehensive timeline for delivery, with milestones and delivery points; an assessment of the key delivery risks and being very public about those and what the contingency plans are for managing them; and governance arrangements, the role of different parties in overseeing delivery.

We have also been concerned that resilience seems to have taken a bit of a back seat—climate resilience in particular. We will get on to this when we come to some of the roles of different parties, but it is not something that we feel we have heard enough about. Given that we are about to embark on a huge programme of build, it is not wise to be building things without climate resilience in mind. These assets have long lifetimes. We need to be building that resilience in now.

Getting the strategy right is one thing. The other angle there is concerted action to drive infrastructure delivery. In relation to transport and storage, David mentioned a range of recommendations—a Minister-led infrastructure delivery group; a cross-sectoral infrastructure strategy; identification of low-regret infrastructure that we can progress with now; and speeding up business models for delivery. In addition, we need to get the generation built, and the rest of the framework has to support it. We welcome the update to the administrative strike prices for offshore wind, which we hope will make a difference to the next auction. That is a positive development after some difficulties in that area.

On the biggest risks that will lead to further delay in timelines, there is the question about delivering in 2035 and the very pertinent question that if we are trying to do this by 2030, if that ends up being an ambition, what chance do we have of doing it? It is fair to say that we need to get moving extremely quickly on a lot of these areas. It cannot be just about working with current timelines. It needs to be about cutting down delivery timelines across infrastructure types, working out where the blockers are and starting straightaway. The scale of the challenge in removing those blockers should not be underestimated. It is very significant. These are complex frameworks with a range of elements in the pipeline that can cause delays, for which we need to work out solutions.

With the strategy, the main risk is insufficient strategic oversight and direction. While the FSO has been identified as a key body that can undertake strategic planning, we see a clear role for government in taking strategic decisions across a range of areas. It will be extremely difficult for the FSO to do an adequate job there unless it gets the strategic steers from government and is seen by industry as collectively having government backing.

There is definitely a need for pace over perfection. Our perception has been that part of the reason for not setting out some of these decisions to date is that there has been a lot of hesitation, which to some extent has been understandable, because it is not clear at any point in time what the precisely right answer is. The problem is that pursuing that precisely right answer is causing the problem.

Lord Sharkey: Is that not an inevitable feature of what we are doing? There is no precisely right answer.

Rachel Hay: Yes. We just need to make some decisions now, acknowledging that they may not be perfect. The worst decision that we can make is to not progress and not make those decisions. Also, when we made that recommendation that transport and storage business models be brought forward from 2025, the Government's minded-to response was that they would remain at 2025 because that was an ambitious timeframe. Changing the perspective to say, rather than "starting from now, what is deliverable going forward?" instead to work back from 2035 and to say, "If that's where we need to be in 2035, when must we have completed a number of stages before that?" i.e. working backwards from the target. We must also ensure that resilience is part of it. As I have mentioned, climate resilience has not been sufficiently considered to date.

I am aware that I am talking a fair amount, so I will try to move a bit more quickly. I will say two more things. On infrastructure, we think that there are material risks around the delivery of the electricity grid. The build needs are very significant. You are probably familiar with some of the statistics here. National Grid stated that to support the government target of 50 gigawatts of offshore wind by 2030, for the next seven years it would need to install more than five times the amount of transmission

infrastructure just in England and Wales, than has been built in the past 30 years.

This is a very significant challenge. There is a large amount of work in train. We welcome the statements that the Government have made acknowledging this issue and setting out an intention to address it. The Prime Minister committed to speeding up connections to the grid by committing to an energy spatial plan. We are also awaiting an action plan this year to respond to the Electricity Networks Commissioner's recommendations. We have yet to receive further detail about whether that will be enough. We understand that the plan will be electricity transmission focused but, as Owen mentioned, there is a whole range of infrastructure that needs to get built here, not just the grid.

It is important to note that we have to consider resilience, as I mentioned. The issues are also not just about connections but planning and consenting. A key part of the challenge will be co-ordinating effectively between the UK and the devolved administrations.

On the hydrogen side, again there are risks around the pace of infrastructure build. We know that hydrogen is a necessary part of the system. There are questions about the exact scale of its role on both the power side and the non-power side. It is really important that we identify strategic needs and start that process of investing now. We cannot wait until 2026 for decisions on the role of hydrogen in heating. Resilience remains an important angle here because one role that hydrogen can play in long-duration energy storage is helping to manage the system in times of wind droughts. We need to understand the reasonable worst-case scenarios for future weather and climate so that we can make sure we have enough back-up on the system of various kinds to deliver those outcomes. We have not seen enough on that to date. Our view remains that it looks very tricky, if we are just delivering business models in some of these areas by 2025, to be on track.

If it is not possible to bring those business models forward, we need to understand what pathway the Government see to delivering it. How will they bring those 2035 timeframes about if they are not bringing those business models forward? Those are the main things.

Lord Sharkey: Do you detect a guiding mind in government?

Dr David Joffe: In DESNZ there is a block of people who work on nuclear, a block of people who work on renewables and a block of people who work on carbon capture—that is the large majority of the people working on energy supply. There are people working on how the system fits together and the roles of these other technologies we have been talking about, but there are far fewer of them. Importantly, because it is a smaller group of people, it perhaps does not have the power within the department to say, "This is what the system needs to look like" and so on. So there is a challenge there. It is recognised within the department, but it is still a challenge because of the sheer imbalance between the number of people working on different things.

Lord Sharkey: Perhaps we can come back to this at the end.

Owen Bellamy: That also points to the need for a strategy or delivery plan for the 2035 objective, to give that overall structure and framework.

Lord Sharkey: And a commitment to actually doing things.

The Chair: I think you were going to make a quick comment about funding.

Owen Bellamy: Yes. In our advice to the Government on the sixth carbon budget, we said that the extra amount of low-carbon investment that would be needed in 2035 would be about £15 billion a year over and above what you would expect to happen anyway. When you add in what you would expect to happen anyway, it probably comes to an investment of about £20 billion a year in 2035, which is a fairly significant amount.

For context, over the last decade or so the average level of investment has been about £13 billion a year in the energy system, so a fairly large acceleration is needed. But, of course, in the context of total investment in the whole economy, it is relatively small because that is about £400 billion a year. So it is a significant acceleration of energy system investment, but it is not as significant in the context of total investment.

Q102 **Baroness Neville-Jones:** I asked the departmental witnesses about the issue of the strategic spatial energy plan, and I would like to pursue that with you as well. The idea is obviously that you have a plan that sets out in more detail the energy projects and infrastructure that the UK needs, and that has been presented to us as an essential requirement to get investment and a sense of strategic direction. My first question is: is that a correct analysis? Would you add to or subtract from that? If you agree, who should be responsible for delivering? We got a muddy answer from our departmental witnesses. What level of detail does it need to go into to be useful?

It emerged very clearly from the answers that who is responsible for delivery is a matter of debate inside government at the moment. How does whoever is responsible then get the various actors who are tasked with contributing to delivery to follow through? How do they ensure the correct level of co-ordination?

Nick Winser said to us that the plan needed to be endorsed, and he was probably thinking of somebody responsible for delivery who was not part of government—the implication being that government would need to endorse it. What do you think about that issue? Do you think it is absolutely essential that it has government backing? Do you think it ought to be statutory, or can it operate without so being?

Those are a number of questions about how one goes about creating an effective—if you think this is a good idea—delivery of the spatial energy plan.

Owen Bellamy: We definitely think that a strategic spatial plan would be useful and a worthwhile addition to the plan that is needed. That obviously needs to sit within the context of some of the other points we discussed about having an overarching strategy that tells you what you

need to do. So it is a worthwhile contribution to that. We do not have a strong view on who the right person to do that would be.

Baroness Neville-Jones: Is that because it does not matter or because you simply have not formed a view on that?

Owen Bellamy: It is more the latter. The FSO would be an obvious candidate, but there are other options—it is not necessarily the only candidate.

The important point is that it needs to be done in a sequenced and co-ordinated way because there is a range of issues that only the Government can take strategic decisions on, and whoever this planner is will not necessarily be able to. The process for coming up with that plan needs to go through a sequence of identifying what the Government's strategic priorities are for some of these investment needs—for example, are we taking a more hydrogen-focused or a more electrification-focused approach? That will determine what is needed in each area, and you cannot necessarily expect the planner to make those kinds of strategic decisions themselves.

They need to work in a co-ordinated way to deliver the plans. In a sense, the Government's strategic decisions about which directions to go in some of these areas also depend on what the planner thinks would be deliverable in the different local areas. So there needs to be a degree of co-ordination, and that is probably the most important aspect of that question.

On the level of detail, it clearly needs to be at least regional and possibly down to the local level as well. A range of work is ongoing on local area plans—Ofgem has done some work on that recently. It needs to go down to the level where you can make infrastructure decisions, because you need to know where those are going. So, at minimum, it has to be down to the regional level.

Baroness Neville-Jones: From what you are saying, it sounds as if you think that, if such a body were not government itself, it would need to work extremely closely with government, and that government would need to actively co-operate, for this to work.

Dr David Joffe: I think so. The way it probably has to work is that the Government give a strategic steer to whoever it is—let us assume it is the FSO—who is doing the work. They will then come up with some different options for how the plan might look, requiring further choices from the Government at a greater level of detail. The FSO would then come up with a plan, taking on board those steers, and this plan would then have to be endorsed by the Government in some way.

Baroness Neville-Jones: So it is an iterative process.

Dr David Joffe: It would have to be because ultimately it requires the Government to take the choices, but they need to be informed about what those choices are before they can make them. Importantly, it then has to have the Government's stamp of approval for it to have power within the planning process and to override some of the objections that

are otherwise made on a case-by-case basis in the planning process because no one knows what the plan is—that is important.

Baroness Neville-Jones: On the level of detail, you said it would go down to the regional level. Does that not imply that it would go quite a long way down the system?

Dr David Joffe: It does. Fundamentally, we need to work out where key assets will be. For example, we have a pretty good idea of where the hydrogen storage might be, because only certain geologies are suitable to host salt caverns. But in order to make the infrastructure investments, we need to know at a transmission level what we are joining up, what the capacities need to be and so on. So the regional level sounds about right.

Baroness Neville-Jones: Does that imply that it would have to have authority of a kind that enabled it to deal with devolved Administrations? This is a national issue.

Dr David Joffe: Yes. There are important questions about how we take a system-wide view across the GB system. One reason why we called for the Minister-led review was to involve devolved Ministers in the process. How we make that work in policy terms is an important question.

Baroness Neville-Jones: How soon do we need all this?

Dr David Joffe: The answer in general to all such questions is: ideally yesterday or the day before, particularly for making strategic decisions across the energy system for these long lead-time investments. We have heard different numbers for the lead times on hydrogen storage, for example, but ideally we would come to a final investment decision on some hydrogen stores this year. That is clearly not going to happen, but it is ideally what would be happening so that we could have confidence that they would be there by 2030.

Baroness Neville-Jones: So you would mark it urgent?

Dr David Joffe: Yes, but the problem is that if you mark everything urgent, it loses its value.

Baroness Neville-Jones: Absolutely. Perhaps later you can give us a list of priorities in terms of urgency.

Q103 **Lord Borwick:** Clearly, hydrogen is going to be one of the most important portions of this scenario. In your view, have the Government put sufficient incentives in place to reach their target of 10 gigawatts of green hydrogen generation by 2030?

Dr David Joffe: It is an ongoing process. They have set out the hydrogen business model for the use of hydrogen. That works by essentially subsidising the cost of hydrogen down to the cost of fossil gas. That incentive in itself is probably sufficient, but it is quite indiscriminate. All the work that we have done, and indeed the Government's hydrogen strategy, identifies an important role for government in taking a strategic approach to where in the energy system the hydrogen is used. Because we will have a finite amount of low-carbon hydrogen, we really need to prioritise it in the right places. Having an incentive scheme that allows

any industrial user, let us say, to use low-carbon hydrogen even if they could have electrified—that might even be cheaper—creates a distortion. The danger there is that we end up with too much hydrogen use, we are not strategic enough in how we use it, we do not have enough green hydrogen for other priority uses, et cetera. So there is an important strategic role for the Government to co-ordinate this, and that requires targeted incentives rather than something that is too broad, which is probably where we are at the moment.

Lord Borwick: But even then it is very detailed work for the department to say which form of energy somebody will use. As you say, incentives can influence that but they cannot control it.

Dr David Joffe: Yes. It appears that the Government's strategy here is to let the market do its work and for people to make the investment decisions on whether to electrify or to use hydrogen, et cetera. For that to work, you need a level playing field in terms of the incentives, but we just do not have the equivalent incentives for industrial electrification, for example, that we have for industrial hydrogen use, so you could easily end up with the wrong decisions being made simply because the incentive framework does not provide that level playing field.

Q104 **Lord Borwick:** I want to turn to gas with CCS. Is that really an alternative to hydrogen storage?

Dr David Joffe: It is in some roles within the electricity system. We have identified two potential roles for hydrogen generation in the power system. One is back-up, operating for relatively few hours a year, maybe 10%, as a last resort—not necessarily that efficient, but there to provide a back-up when the wind is blowing less. The other is what we call mid-merit, which is a load factor of more like 40% or 50%, where you are operating a fair bit across the year, although not the whole year. We think the latter role could be taken either by gas with carbon capture and storage or by hydrogen with combined-cycle gas turbines, whereas the former role is suited only to hydrogen generation.

For the mid-merit role, we think there are choices to be made. That is not necessarily a choice fully for the Government. They could set up a framework where the market could decide the relative mix, within bounds, but the Government also need to set out that they, for example, want both kinds of technologies and the ranges of gigawatts and so on that they want. So they are potentially competing for that mid-merit role but, even if you go for gas with carbon capture and storage for the mid-merit solution predominantly, you are still going to need something like hydrogen for that very low load-factor back-up role.

Lord Borwick: I understand that, but the capital cost is a whole lot less for carbon capture and storage because we already have the turbines, switching systems and control systems to get it in place—microsecond starting and things.

Dr David Joffe: It depends what one assumes. If we are talking about the existing gas plants that we have, clearly you could retrofit carbon capture to those, and that is a lower-cost solution than a new-build gas

CCS plant, but equally some of those plants could be converted to burn hydrogen instead such that you also have the benefit of being able to reuse that power plant. In order to make those decisions, either the operators and owners of those plants within a market framework or the Government would need to understand whether the plant could be retrofitted with carbon capture or converted to hydrogen. We have had a go at doing some analysis of that, but clearly we do not have the level of detailed information that the asset owners have. Our assessment was that gas with carbon capture has a slightly higher upfront cost than a hydrogen turbine, but that probably has higher efficiency so the running costs would be a bit lower. But it is pretty marginal, to be honest, and probably within the margin of error.

Q105 **Lord Wei:** One of the themes that we have heard is that there are a lot of actors involved in the energy system. Your report earlier this year said that the Government should clarify urgently and formalise the responsibilities of the FSO, Ofgem and Ministers for strategic planning and the delivery of the decarbonised resilient energy system. Has that been done? Do you have a sense of how the different actors in the energy system will work together and how they should work together?

I have a follow-up question. Another recommendation was for a Minister-led infrastructure delivery group. Do you know whether that is taking place? Is there much sign of cross-departmental working to identify infrastructure projects that should be enabled as a priority?

Rachel Hay: On formalising roles and responsibilities, it is important to note that some valuable progress has been made in a number of areas here. In October 2023, the Energy Act received Royal Assent. There were some steps forward there, in so far as there was an update to Ofgem's remit, which was hard fought for for a long time, to give it a legal mandate targeting net zero. There was also the establishment of the FSO and a duty on it to carry out its functions in a way that promotes net zero. Those are positive developments.

What we did not see, but had recommended, was resilience, particularly climate resilience, being explicitly acknowledged as part of their roles. That seems to us to be something that is persistently left behind but is fundamental to delivering a reliable decarbonised power system. That is why we framed the report that we wrote in March as an entirely combined report, where those two aspects of the aims have to go hand in hand; you really cannot consider them independently.

There was also the May 2023 consultation on the strategy and policy statement for energy policy in Great Britain. That is a really important vehicle for clarifying respective roles and responsibilities. We have yet to see the final version of that and we are not yet sure what the publication date will be. Again, there were helpful things in there and we would like it to go further and specify exactly how the actors will be expected to work together to deliver some of these outcomes and some of what we have talked about with regard to taking strategic decisions as part of that: exactly who is responsible, and what is the order of decision-making that we need to get this done?

Resilience comes out in a number of areas, but it is resilience in its broadest sense. It could include climate resilience but, unless we acknowledge that that is an increasingly important thing to consider explicitly, the risk is that it gets left behind.

We also had the August consultations on the FSO's roles and on the hydrogen transport and storage minded-to positions, which consulted on the specific roles of the FSO. For instance, in there was a proposed new role for the FSO to analyse and plan electricity system resilience, again defined in its broadest sense.

I have already touched on areas where more clarity is required, but I note the question about how those strategic decisions will be made and the sequencing there, as well as making sure that climate resilience is receiving enough prominence. If it is not explicitly part of Ofgem's and the FSO's roles in the Act, can that be clarified explicitly in the strategy and policy statement or through another route? We saw, for instance in the Electricity Networks Commissioner's report, that it was not a big feature. Equally, in NAP3 we did not see much on, for instance, security of supply considerations at a system level related to climate resilience, so we would want to see more on that. We know that there is a plan for the governance of resilience to be reviewed, which is positive. So further clarification is required there.

Lord Wei: On the point about resilience, why do you think there is reluctance to give it more priority in departments and the regulators? Is it just a case of playing catch-up, or is there a structural reason why it never gets the prominence that perhaps it needs to now, given what has happened?

Rachel Hay: My sense is that it is more the former. I do not think it is that people explicitly disagree with the need to consider it; it is just that it risks being more of an afterthought. There is the climate resilience that you have to build in at an asset level when you are building the stuff - you need the right standards in place and need to understand what the risks are. Part of the problem is that some of our standards are not fit for purpose and have not caught up with where the science is on how the climate is expected to change, so people feel a bit at sea with exactly what they need to do, and there is not a lot of clarity over the respective roles and responsibilities, which is why we have made recommendations around governance.

When you are thinking about energy system design, understanding how the climate is expected to change is fundamental to understanding how you need to dimension the system—you just cannot separate the two; you have to consider them together.

Baroness Neville-Jones: Does that mean that safety by design is not part of the picture?

Rachel Hay: I am not sure I fully understand what you mean by "safety by design".

Baroness Neville-Jones: These days, one of the things that we are adjured should be done in future planning is building in security and

safety from the outset, and it therefore has to be considered alongside other features of the system. It seems you are saying that is not happening.

Rachel Hay: It is probably that the understanding of what safety means has not kept pace with what is coming and the evolution of the understanding of what security of supply means. Preparing for a one-in-20 winter now does not mean the same thing historically as it will mean in the future, so we need standards fit for the changes that we are expecting in the system in the future.

The final question was on the Minister-led infrastructure delivery group. As Owen mentioned, there was agreement from the Government in their response to our recommendations on the importance of speeding up consenting and building network infrastructure. They announced the plan to create a new Minister-led governance process specifically focused on accelerating transmission infrastructure, but it stops short of our recommendation. They mentioned that they do not believe a wider Minister-led infrastructure delivery group is needed at this time.

In this session we have been trying to get across that the infrastructure challenges that we face are not limited to electricity transmission infrastructure; they are across a whole range of areas, and we need a plan to solve that challenge. We particularly need a plan that enables us to solve it, acknowledging that there is a whole range of actors here that have an important role, including across the devolved administrations, which is why we were coming back to the Minister-led process as the most appropriate one.

Q106 **Baroness Northover:** One of the concerns we have had is whether a purely market-based approach to storage is ensuring security of supply, particularly for very rare events such as wind droughts, which might require energy to be stored over multiple years. This might interline with the economic incentives for operating an energy storage facility. Can you expand on whether incentives can be designed to overcome this, or do we need a strategic reserve of generation, as advised by the National Infrastructure Commission?

A related policy concern is whether incentives should be technology neutral—we have addressed that to some extent—and how to design them so that they support the development of a range of different storage technologies that provide different services to the grid. How can this best be done, and does the review of electricity market arrangements play a role here?

Owen Bellamy: Security of supply is definitely something for the Government to consider, along with their tolerance of that level of risk. We would definitely expect the Government to make a judgment about what is appropriate now—there are some standards now—but also in the future.

A range of options is available for dealing with that. The Government currently have a capacity market for ensuring the security of electricity

supply but, as you mentioned, people have mentioned a strategic reserve as well. On our side, we do not have a specific view about which of those is the best approach in the future. The key thing is that the Government need to set out in their strategy which standards they expect to be needed in future, and to design a policy framework that enables that to be met. You would not expect the market by itself to deliver that, because security of supply is a property of everything that is happening and it is not within any one individual organisation's or company's ability to manage—so it needs to be managed by the Government.

On technology neutrality, we definitely agree that that is the right way to be aiming in the longer term, but we need to distinguish between the shorter term and the longer term. A useful frame there is thinking about the transition to a decarbonised electricity system in 2035. There will be a decarbonising phase over the next 10 or 15 years, and then we will have decarbonised the system. The challenge is that the approach to technology neutrality might be slightly different in those two phases.

In the decarbonising phase that we will go through over the next 10 or 15 years, the technologies that we need to deliver that decarbonised system are not commercially available in the marketplace, so there is a need for the Government to take strategic decisions about supporting those technologies, ensuring they become commercially viable and bringing them through. Once those technologies are there and able to compete in the market, having a technology-neutral approach to that competition is a sensible way of organising that, but it is important to distinguish that from the phase where you need to make those technologies available.

On the Government's review of electricity market arrangements, they are looking at some of these issues but it is a review of electricity market arrangements, not energy market arrangements. They are perhaps looking at some of these issues more from an electricity perspective. In some of the consultations that the earlier witnesses mentioned, they have some options for dealing with some of these issues, but it is important to make sure that they bring in the energy perspective as well and that it is joined up. Ultimately, that comes back to some of the points we have been making about the need for an overarching strategy to make sure that all these different parts are joined up.

The Chair: Thank you. We come to Baroness Neuberger, who will ask our last question.

Q107 **Baroness Neuberger:** As you know, we will be making recommendations to the Government in our final report and questioning the Minister over the next few weeks. Your report makes a number of recommendations that we may well echo. As of today, if you could have three or four recommendations for the Government, what would they be? We know there are far more, but what would your top "Come on, Government, get on with it" things looked like?

Dr David Joffe: It is hard for people from the CCC to be asked what our most important recommendations are. It is like asking a parent which is

their favourite child. I will have a go—thank you for the option to give three or four.

I think that the most important one is having the plan for what the system will look like in 2035, because that underpins so much of everything else. If we do not have that, we cannot really make progress.

Getting on and identifying the set of low-regret investments that can be made, in the sense that we need to get building some of this stuff and not just moving the process on one further step, is really important. Also, there are the institutional arrangements between the FSO, Ofgem and the Government, because until you have worked out who is responsible for what, it is very hard to move the system forward.

I also like all our other recommendations.

Baroness Neuberger: Of course.

Dr David Joffe: I like them as if they were my own children.

Baroness Neuberger: Obviously we will ask the Minister various questions as well as doing our own report. If you like, we are asking what is at the top of your tree.

Dr David Joffe: I have had a go.

Baroness Neuberger: Thank you. Do the other witnesses wish to say anything, given that this may be like identifying the favourite child?

Rachel Hay: Those sounded reasonable, but the devil is in the detail. It is not just about the high-level commitment. It is about what will be included in the plan that is published and whether it will cover the right range of things, for instance.

Baroness Neuberger: Thank you very much.

The Chair: What would be your figure for the amount of long-duration energy storage that we need in 2035?

Dr David Joffe: I thought we had got through this without having to come up with a number.

The Chair: What range, do you think?

Dr David Joffe: It is definitely double figures of terawatt hours; we can narrow it down to that. I do not think it is up at the 100 terawatt hours of hydrogen storage capacity that has been mooted. It is probably in the range of 10 to 30 terawatt hours. That would be my best guess of the range for hydrogen storage and those sorts of things. Rachel actually has numbers in front of her.

Rachel Hay: The needs are not specific only to hydrogen storage. Looking at long duration storage, we have talked about the fact that there are different options here. There is gas as well, for instance.¹ For

¹ Low-carbon dispatchable power could be provided for instance by hydrogen turbines (which will require hydrogen to be stored) or gas CCS plants (which will require gas to be stored).

hydrogen storage specifically, our modelling has around one to three terawatt hours by 2030. By 2050 the upper bound of the range that we have is 12 terawatt hours, but we acknowledge that some estimates are very much higher than that.

For the seventh carbon budget we are keen to make sure that we have considered appropriately the range of factors, including alternative solutions. There are also the resilience considerations about what we might be facing—wind droughts and other things—and making sure that the number is appropriate. That is the upper end of our range, acknowledging that this is only one of a wide range of technologies that perform important roles in the system to deliver in those kinds of events.

The Chair: If we wanted to suggest to them that there is a no-regrets investment that they should start now in hydrogen storage, how much should they kick off with?

Dr David Joffe: I think that 10 terawatt hours would be pretty low-regrets in terms of what we ultimately need. Whether we need that by 2035 or it starts being needed by 2040 or 2045 is a question, but if we are going to need it anyway then it is not much of a problem. Of course, if it turns out that we need 30 or 40 terawatt hours, it is better to have got going earlier on. The main thing is to get on and build it. We can work out as we go the precise figure that we are aiming for in the long term, but 10 terawatt hours seems perfectly reasonable. It is within the range that we set out for 2035 and, given other estimates that are out there, it seems to be at the bottom end of the range, so as a low-regrets number it seems perfectly reasonable.

Baroness Northover: It is less frightening than the Royal Society's estimate. Did you find Professor Monks's figure reasonable?

Dr David Joffe: The number that we heard from Professor Monks for the first time was about the amount of hydrogen production in 2030 rather than about the storage volume.

Clearly, it is a lot less than the Royal Society estimate. That modelling was done in a particular way that, as it set out, was quite extreme and probably a worst case in terms of how much we would need. We have considered lots of alternatives that can reduce the amount of hydrogen storage that you need. There are contributions from demand-side response, from interconnection and so on. It depends on the mix of generation in the system, the shape of demand, how much of it is weather dependent, et cetera.

The Royal Society said that you need hydrogen storage sized to be able to cope with multiple bad years in a row, in terms of the amount of wind generation and therefore the amount of hydrogen that you have, whereas we think that you can probably have a smaller store and, if you have a bad year, you can refill it with blue hydrogen: import the gas and refill the hydrogen store. So you do not need as big a store and the hydrogen staying there for 30 or 40 years. You can have a smaller store and refill it, even in a year when the wind is not blowing as much.

We think solutions like that mean that you probably do not need the 100 terawatt hours, but you clearly will need a fairly substantial store. I do not think this is the appropriate time to be saying that we know the exact number; we should just move forward and build some of this capacity. Once we have a clearer idea of the direction of the energy system, we can have a clearer idea of exactly how much storage we will need.

Baroness Northover: One of the things that was emphasised to us was that, because of the geology of the UK, this was something where we have the potential to export to the continent.

Dr David Joffe: Other countries using our hydrogen store? Interestingly, that is the reverse of what is happening at the moment on fossil gas; we do not really have that much storage for fossil gas and we are using the storage facilities in continental Europe.

To some extent, that is possible. And, of course, we should not be thinking too much in isolation about the GB system when we know we will be interconnected with other countries. But it becomes very hard to work out what the right level of capacity in the GB system is if you then have to work out what will happen in every country across Europe.

Baroness Northover: The argument was being made was that this was a potential for the UK. Obviously you are addressing, and we need to address, what the UK needs, but potentially, if there is an expansion of this storage, it is something that we could then export.

Dr David Joffe: Yes, and that means we could have relatively high ambitions and lower regrets about overbuilding because, even if we do not need it for our system, there is still a value to other energy systems to which we are interconnected. I see that point, and the industrial benefit of being able to export things is clearly there as well, but this is quite speculative at this point. It is important to recognise those opportunities, but we cannot be too definitive.

The Chair: It remains for me to thank our witnesses very much for an interesting evidence session and to say that the meeting is formally concluded.