



Economic Affairs Committee

Corrected oral evidence: UK energy supply and investment

Tuesday 22 February 2022

3 pm

[Watch the meeting](#)

Members present: Lord Bridges of Headley (The Chair); Viscount Chandos; Lord Fox; Lord Griffiths of Fforestfach; Baroness Kramer; Lord Livingston of Parkhead; Lord Monks; Lord Rooker; Lord Skidelsky; Lord Stern of Brentford.

Evidence Session No. 1

Heard in Public

Questions 1 - 15

Witness

I: Julian Critchlow, Former Director-General of Energy Transformation and Clean Growth, Department for Business, Energy and Industrial Strategy.

USE OF THE TRANSCRIPT

1. This is a corrected transcript of evidence taken in public and webcast on www.parliamentlive.tv.
2. Any public use of, or reference to, the contents should make clear that neither Members nor witnesses have had the opportunity to correct the record. If in doubt as to the propriety of using the transcript, please contact the Clerk of the Committee.
3. Members and witnesses are asked to send corrections to the Clerk of the Committee within 14 days of receipt.

Examination of witness

Julian Critchlow.

Q1 The Chair: Good afternoon and welcome to our first meeting of this new inquiry from the Economic Affairs Committee. Before I welcome Julian Critchlow, I need to declare my interest as an adviser to Banco Santander. Mr Critchlow, would you like to introduce yourself?

Julian Critchlow: Thank you. Good afternoon, everyone. I was the Director-General for Energy Transformation and Clean Growth at the Department for Business, Energy and Industrial Strategy from 2018 to 2021. That period, other than covering Brexit and Covid, covered the time when we legislated for net zero for 2050, we set the sixth Carbon Budget, we set up the Net Zero Strategy and all the sectoral plans, and we bid and prepared for COP26, which was held last year.

An additional factor that might help with my context is that prior to joining the Civil Service I spent 30 years in business working in the energy sector as a chemical engineer by training. I worked with some of the largest global investors in the energy system and for the last 10 of those years I ran the global Utilities practice at Bain & Company, the global consulting firm. I retired from the Civil Service in March last year and I am now advising, in a non-executive capacity, companies that are interested in the transition.

Q2 The Chair: Wonderful. That means that you are admirably experienced and set up to address the topics that we want to cover today. We are meeting at a time and on a day on which energy prices are very much in the news. My first question is trying to take a step back and ask you how we can disentangle what is happening now in the energy market from long-term trends and causes. To what extent do you, given your experience, see the recent and today's rises in energy prices as a feature of the global energy market—in other words, the long-term trends? What can you pick that is long term as opposed to short term?

Julian Critchlow: The first thing is probably context. The global energy markets, which have been based for a very long period on a set of fossil fuels, have always been volatile. They have been volatile because of two dynamics. One was the supply/demand balance and the capital investment cycles. The other was the geopolitical component to those through things like the exporting groups of OPEC and the gas equivalent.

Markets have always been turbulent. What is significantly different in this period is that as a global economy moving towards net zero we are moving away from a commodity-based system to one based on capital. We are investing a huge amount—I know we will come back to this later—but that ultimately disconnects effectively from the global commodity markets. Once we move towards net zero, a lot of our energy will be locally produced; it will have the benefit of being sustainable, secure, safe and hopefully low cost. Also, because it is capital, it will tend to be a fixed price. It will be dependent on how much capital we spend in the renewables.

Ultimately, in the long term, we will end up in a situation where our prices are much less volatile but we will have a transitional period. We can talk about the UK case, that is a pretty fast transition, but for the next 10 or 15 years we will still be using commodities like gas as a transitional fuel and oil in our cars as we move to electric vehicles. The faster we move, the faster we disconnect, but until we have disconnected, we will still be exposed to the volatility in the markets.

The current volatility in the gas market, which is quite exceptional, is a large element again due to two factors. One is the global recovery from Covid, but there is also the geopolitics of the gas market.

The Chair: Given your experience, over the last few years with the trilemma, have we focused more on renewables at the expense of affordability and reliability in our policy?

Julian Critchlow: If we go back over the long view, over 30 or 40 years we have moved around the trilemma with our priorities, depending on the nature of where we were. In the 1970s, when we had the oil crisis, we were very concerned about security of supply. With the liberalisation of the energy markets in the UK, we became very focused on the cost and trying to liberalise and use our natural resources, such as our gas off the continental shelf.

More recently, we have been getting very conscious of the environmental impact of those, so we have moved to balance the security of supply, the environment and the cost, but this is no longer necessarily a trade-off, because we are beginning to get to the point where the renewables are the cheapest source of generation in two-thirds of the world. For offshore wind, we have now reached a price of below £40 and heading south, when our wholesale price has been £50 or £60 per megawatt hour historic long-term average.

The Energy White Paper expresses very clearly that we are breaking that trade-off from the trilemma between security, sustainability and cost.

The Chair: I have in front of me a quote from Greg Clark when he was Secretary of State. He said, "The policy conundrum known as 'the trilemma' is, I think, coming to an end". Do you think that we have broken out of that and are free from that?

Julian Critchlow: We are coming towards the end, but we are still in part of the transition. It is all dependent on us installing the right renewables. For instance, we can still make it high cost by installing the wrong renewables.

If you look at the early experience of Europe when we moved in about 2009-10 there was quite an odd mix of renewables installed across Europe. Anybody who goes on holiday tends to see that the sun is in the south of Europe and the wind, for sailors, tends to be in the north, but we put about 600% more solar in Germany, which had 60% less irradiation than Spain, and we put a whole load of wind in Spain—23 gigawatts—

when there is more sun than wind. If you had done it more optimally you would have saved about \$100 billion during that period.

You can always get it wrong by picking the wrong technologies, but we have done a pretty good job. We are obviously a very windy place in northern Europe, particularly this week, and we have a lot of coastal properties. We have begun to exploit that.

The cost of the technology is not just what you deploy but what everybody else deploys, and if everybody else deploys wind that will also help to bring down the cost over time. It is very important to pick technologies that you have the natural resources for and which you can benefit from and hopefully export some of your capabilities to other people who will use the same technology.

The Chair: Very good. Thanks very much.

Q3 Lord Rooker: I have a very minor declaration to make. I am a director of the Ludlow Hydro Co-operative, which runs an Archimedes screw on the River Teme at Ludlow, which I suspect, given what the river is like today, has had to be switched off, because that is the reality. I think we supply enough electricity for about two lightbulbs in all the houses in Ludlow. Nevertheless, it is renewable.

I will ask about the energy mix over the next decade and the role of oil and gas. As we move to net zero, how do we ensure that we have sufficient investment in oil and gas? I saw the quote from the Minister a couple of days ago. If, as Greg Hands says, net zero is part of the solution rather than the problem, how do we square that with energy security? This is an issue that will not go away. We will need oil and gas. How do we ensure that there is sufficient investment while we are transitioning to net zero?

Julian Critchlow: It is a very important issue. If you ring-fence the issue of transport, today we are basically diesel or petrol cars, and we have 8,000 or 9,000 petrol stations, four refineries and a whole supply chain that supplies that. We have a lot of oil capacity from our continental shelf and our imports.

As we go through the transition to electric vehicles, if we are, say, half way through and have half electric vehicles and half petrol and diesel cars, we will still need to be able to supply those cars. An average car lasts 13 years, so it takes a while. We sell 3 million cars a year, but we have 13 years on average before the cars we sell today will be retired. Therefore, we will need to have a dual-running system for quite a while.

We will need to have a diverse set of supplies for oil and gas, and we can talk about gas later. We will need to continue to develop that as well as deploying the infrastructure for the electric vehicles, electric heating and all the ways in which we will decarbonise industry—hydrogen, carbon capture and storage and all these technologies. Effectively we will end up parallel running.

We have a long history and quite a lot of experience in attracting diverse sources of supply. In the case of gas, we used our UK continental shelf very extensively in the early days, and since then we have been diversifying away and importing more from pipelines from Norway and LNG sources from Qatar and other LNG shippers.

Diversity is the way to protect yourself against any one source of supply, but we will have to maintain diversity in the gas as a transitional fuel as we build up and hopefully transition more and more to the renewables.

Lord Rooker: What is the security aspect of this for the public?

Julian Critchlow: The more we move, the faster we move. The faster we are effectively domestically producing our own electricity that goes into our own electric vehicles or our own electric homes, the more secure and, as I say, disconnected we will be from the global markets. But it will take a reasonable period, even under our very aggressive Net Zero Strategy, it will take a while for us to be able to transition all those cars and all those homes across.

Lord Rooker: Is it conceivable that we will have to open up a new oilfield under the North Sea?

Julian Critchlow: This is always a question of whether there is already enough supply and sources of supply in the oil and the gas to supply us. One of the arguments used for domestic production is that we are a very high-quality provider of oil and we have low emissions. We can control the standards of those emissions if it is on our own continental shelf. Equally, that shelf has been depleted, so we have been diversifying across other sources of supply. It is a balancing act here. Diversity is obviously our friend in ensuring security.

Q4 **Lord Fox:** I have two related questions. You talked quite extensively about the electrification of transport, but the electrification of home heating or the removal of hydrocarbons from home heating seems to be an as yet unresolved issue. Do you feel that, in terms of time and driving a transition, that will be the determining step ahead of cars? Secondly, is there a role for natural gas in blue hydrogen as another transition between gas and green hydrogen?

Julian Critchlow: Taking both parts of the question, if you look at the Net Zero Strategy and the profiles of transport and homes, the overall UK plan is made up of all the different sectors moving at different rates—with the power sector going fastest—to be decarbonised by 2035. Transport and heating are very close behind. They are going at breakneck speeds to get there, because we are ambitious in making that transition.

Heating buildings is going at nearly the same rate as cars. People are quite used to changing cars regularly—as I say, after 13 years, which is the average lifetime for a car. Very soon, the electric car will be a better, cheaper and nicer experience for you, so as long as you can finance it - and 90% of cars are financed - to keep the monthly cost down. It is

relatively easy to make that transition because, if the infrastructure is there, it is a compelling product.

Homes are much more complicated, because people do not move as frequently. If you look at all the technologies that have gone into homes, they take a while to get into those homes. We need our housing stock to be more energy efficient first in order to reduce the amount of heat that we have to put into the homes before we decarbonise the heating system. The first priority is to push continuously on the energy efficiency of the housing stock.

But 85% of homes are on the gas system. It is the largest use of gas in the UK and gas is 43% of the energy that we use in the UK. This gas vector is very challenging for the UK, because we have become such a gas-dominant economy.

We have a number of choices. We have the choice of electrifying a lot of that. My home is mostly on air-source heat pumps now, so that is one option. Another option is to consider putting hydrogen through hydrogen boilers. We will need hydrogen for a lot of the other uses. That 43% is across the economy—industry, generation, homes. We will have a big hydrogen market, because we will not be able to replace all the uses of gas with electrification.

The home specifically is a big decision. We have still not got to the end of doing the safety case for the deployment of hydrogen in homes. That decision in the Heat and Building Strategy comes in around 2026, so it is quite soon; it is not that far off. We know that in the meantime we have to build up the air-source heat pumps, the electric element.

We transfer about 1.6 million boilers every year. If we were to transfer every boiler to a heat pump, we would have to do an equivalent of that in heat pumps, and at the moment we do 30,000 or 40,000 a year. At a minimum level, we would need to get up to 600,000 heat pumps even if we went to all hydrogen boilers for the switchover.

We have a very clear strategy in the near term, which is to build up the heat pump capacity that we are putting in, evaluate the safety case for hydrogen, and make a decision in about 2026. Then we will either continue to build the heat pump capacity or add the conversion to hydrogen boilers and do the conversion of all the upstream.

Q5 Lord Livingston of Parkhead: I should declare my interests. I am on the board and a shareholder of National Grid and Standard & Poor's.

Going back to your gas point, it is reasonably clear where the outturn is on gas if you go back 30 years from now. If you were still in your job in BEIS, what would be your recommendation to the Government on the question, which Shell has commented on today, of a new North Sea rig for gas, given global tensions and our shortage of gas relative to domestic and close domestic production? Would it be that they should support additional gas production in the UK?

Julian Critchlow: As I said, we will be using gas through this transitionary period. The question is where the gas will come from. At the moment it is coming from the continental shelf and from Norway and LNG suppliers. For the mix, if you want to have the lowest-carbon gas source, the standards that we would apply and it being very local would mean that we could have minimum methane emissions in the supply chain and therefore a low-cost, secure and lowest-carbon impact from greenhouse gases. It is perfectly viable for that to be part of the mix to help with the transition.

Lord Livingston of Parkhead: You would say to Government that we should seriously look at it.

Julian Critchlow: Clearly whether you want to support that in the current environment is a political consideration, and this is also a similar discussion about onshore gas reserves. As I said, the demand is there. The question is what are the lowest-cost, most secure and lowest methane-emitting sources of the gas that we can obtain during the transition. If that happens to be in the North Sea, that is a viable vector to go down. Globally there is no lack of gas, so with incremental investments we would have to substitute some gas use elsewhere. Our profile of gas usage is defined by our net zero strategy, so we will not be using more gas.

Q6 **Lord Stern of Brentford:** Forgive me, but neither would we have much impact on the world price of gas. I will declare interests. I chair the board of SYSTEMIQ and I advise NatWest and Citi in these areas of energy—renewables, climate and so on.

I will start by thanking you not just for coming here, of course—we thank you for that—but also for all the work at BEIS. I am not sure how much the committee knows about Julian’s very strong leadership in that place for a long time. One of the products shortly after he left was the Net Zero Strategy. Thank you for that.

I want to ask about the pace of cost reduction in renewables and how we can work to accelerate it still further. We all know, and you referred to, the £40 per megawatt hour for offshore wind and how fast that has come down. It is clearly in all our interests to bring those costs down as fast as we can.

Could you comment on the mechanisms by which we could work to accelerate that pace of cost reduction from the point of view of international action, because we know that that scale is way beyond what happens here; it is what happens in the world? Could you also look at it from the point of view of the cost of capital—as you said, we are substituting capital for commodities, so the cost of capital is a big part of that—and from the point of view of storage, because that is a big part of the renewables, including hydrogen of course, and technological advance?

Please take us through how those different elements in the cost of renewables combine, and particularly how we can work here and with

others to drive them down still faster.

Julian Critchlow: It is a very good question. A lot has been written about a very good case study in the UK offshore wind sector. The price has clearly come down very rapidly, from £115 a megawatt hour five years ago in the auctions to less than £40—£39.65—and it is heading very rapidly south. That same opportunity could happen in floating offshore wind. In the recent Scottish options auctions, a lot of the 25 gigawatts that was bid for was floating offshore, which looks like something that will scale globally because there are a lot of deep-water sites for floating offshore wind. The two technologies will potentially scale globally.

The UK had a very stable policy in the most recent years and has set out very clear scale objectives going forward, from the 10 gigawatts that we have achieved so far to 40 gigawatts. Having long-term stability of the direction is very helpful to the manufacturers, as it enables them to put up scale facilities, spread the costs over multiple wind farms and get the cost of capital down. It is expensive to bid for these projects. They have been able to invest in thinking about how to modularise the actual installation so that you can get a real-experience cost effect in the way you install as well as in the scale of the equipment you are installing.

Long-term, consistent policies are very important, which means not flipping between technologies too often. There are lots of technologies that we could talk about and that people are very passionate about, but unless they will scale, we will not get the full cost benefits. We need to look at the overseas markets as much as the UK; I gave the example of putting in the wrong technology, as Europe did, which can be very expensive.

We have some very well-established mechanisms in the CfD that have helped bring in private capital. We have put €43 billion into offshore since 2010, which is 48% of all the offshore. We are now a leader in deploying that, and that has been driven by having a clear mechanism that works and can provide good but not abnormal returns.

There is always a temptation to tweak, so holding the course and having some stability in the course is impactful. The danger is that you always want to make it more complicated. When I entered the market 30 years ago, it was the CEEB and the gas boards. We moved to a very liberalised market that was very market driven and driven by commodity prices, but now we have rowed back to some degree into a market that is now driven by these competitions for capital. That means that the size of our competitive market is declining. Only about 40% of the electricity generators are generating now with a commodity, and that will go down rapidly—even the wind farms are under construction now—by 13% in the next few years.

We are getting to a situation where our whole market is driven by the prices of the contracts that are given. It is moving towards a fixed price market, basically, which makes it very important that we pick the lowest

cost for our environment and the lowest-cost technology, so that it is secure, sustainable and low cost.

Lord Stern of Brentford: Thank you very much. Could you add a bit on the cost of capital? We are replacing commodity by capital. Clearly it is a matter of how good you are at doing it—the technical side, the economies of scale and so on that you referred to—but it is also the cost of capital itself. You mentioned the contracts for difference that give confidence in bringing down the cost of capital, but do you think there are other ways we could bring down the cost of capital?

Julian Critchlow: If you look at what has happened over the lifetime, the original capital that we put into wind was very much private equity. It was more like venture capital, because there was a lot of planning risk, technical risk, connection risk. There were lots of risks that you had to be willing to take advantage of. After that, it became much more certain and the cost of capital came down. That allowed the utilities to buy up a lot of the businesses.

Airtricity was one of the big original ones that was bought by SSE, which has allowed the utilities to invest, but it became even more a very modular and certain process. The more certain we make it, the more the cost of capital can come down. Infrastructure funds have come in now with an even lower cost of capital, which also contributes to the saving.

If you are doing a renewable facility versus a commodity, the cost structure might be 30% capital, 70% running costs. It is a pay-as-you-go type system. With wind farms it is very largely the capital that matters, so the cost of capital is critical to keeping the costs down.

Q7 **Lord Stern of Brentford:** My last question is about storage, particularly of hydrogen; I included storage in my questions and you have included it to some extent in your overall answers. We are in the early days of that. Do you see any ways in which we can accelerate that cost reduction? Will that happen in the world markets and the competition, or is there anything special that we can do here in the UK?

Julian Critchlow: When you think about security of supply issues—I know the irony here; I am in a near net zero home, I drive an electric vehicle, I use air-source heat pumps, and I have been cut off for 48 hours by the storms—storage is one vulnerability.

We can protect ourselves from that kind of resilience issue by having more wires, some redundancy in our system. We can put them underground; that is more expensive, but they do not get storm damaged as much.

There is a cost to that insurance policy, and for storage it is the same thing. We talked about this in 2018 when we had the “Beast from the East” and whether we had enough gas storage. The markets largely said yes, we had enough, because we have very diverse sources of supply. We can use more LNG, we can use swing on our pipelines to turn up the gas when we need it in events like the “Beast from the East”.

If you really want to be really secure, you could also have some more gas storage, but you would have to pay the insurance premium. You have to pay a bit more to have that extra level of security. From an industry point of view, if you have to call on some interruptible customers and say that they cannot have gas, that is one cost. To have a storage facility that you do not use very often is a cost to the system, and somebody has to pay for that.

If we will be reliant on gas and on hydrogen—going back to the question about blue hydrogen—in the early days. Either we will have the conversion of methane into hydrogen and then need to store it for our peaks, or we will have to have green hydrogen generated by renewable power when we have excess and, again, store it for when we need the storage. We will need more storage, because we will not have the same swing capacity that we have on natural gas at the moment.

Q8 Lord Griffiths of Fforestfach: Thank you very much. I declare, as an interest, that I am a member of the European board of the Environmental Defense Fund, which is an American organisation, a charity, but the largest pro-green, pro-business think tank and advocacy institution in the US.

I am a novice in this area, but you mentioned a number of factors that explain the reduction in the cost of wind. Am I right in thinking that economies of scale dominate?

Julian Critchlow: They are very, very important. As I said, if you are putting up a factory for blades and know that you will make a certain volume of blades, you can share the fixed costs over the larger volume, so clearly economies of scale are a very important component. Also, experience matters a lot, as does the ability to modularise how you construct the wind turbines; if you watch the offshore fields being put up now, it is a very factory-like process and they are put at a very rapid pace.

The components are built for installation. Because we have done so much now, we are gaining that experience, and you put back into the design of the wind farm to make sure that it is easy to install and maintain; the consideration would not have been the same when it was on land, because the land is easier to get to in that sense. So experience counts in both ways. The more scale you have, the more economies of scale you have; but your ability to redesign the processes and get the cost down in a "Model T" Ford-type way also brings the cost down very rapidly.

Q9 Baroness Kramer: Mr Critchlow, this may be the dumbest question that you will get today, because this is not an area with which I am familiar. It is a thought that came to me and a puzzle in my mind after I listened to one of your earlier responses when you were talking about the energy mix and the future role of oil and gas.

There seemed to be an implication that if we opened up a new field in the North Sea, new gas would come to the UK. My understanding is that only part of what is presently sourced from the continental shelf at that point

comes to the UK. It goes on to the open market, the global market. Your response seemed to suggest that if we open up a new field, we will be able to capture that and that then becomes our security of supply. That is not the way it is working today, unless I have it very wrong, which I could have.

Julian Critchlow: Clearly the usual source of a local field is to go into the pipeline connections that we have. We currently have a lot of connections with Norway, a lot of connections with the existing fields. So it is more likely to come to the UK, but it might substitute other gas that we would have otherwise imported in LNG. You are right in the sense that it is still a global market because we have a fixed amount that we will use in our energy mix. If we get that from the local continental shelf, we do not have to get it from international markets.

Baroness Kramer: But we have no particular mechanism, unless we write a specific contract, that would deliver it to us rather than to anybody else.

Julian Critchlow: As I am saying, there is no lack of gas in the world. To the extent of incremental investment in the gas system, there is no need for us to be spending more money on gas. Equally, we want to have the lowest greenhouse gas emissions from the gas process. To the extent that UK companies are also doing that and reducing the emissions, that is also a positive in the short term.

Baroness Kramer: To clarify, you are saying that it would reduce the brown, shall we say, of the overall global gas mix.

Julian Critchlow: There is no need for the additional gas globally.

Baroness Kramer: There is no need for additional gas and it does not particularly change the UK mix.

Julian Critchlow: It will not change the amount that the UK will use, because the UK will be on its envelope to get to net zero.

Lord Livingston of Parkhead: But the UK would source a greater proportion of its gas from its own continental shelf if you produced more, because they are attached to pipelines that go to the UK. I think that was the original question.

Julian Critchlow: Correct.

Baroness Kramer: I know that a lot of the gas does not come to the UK currently.

Julian Critchlow: It would also displace gas that we would otherwise import from elsewhere.

Lord Livingston of Parkhead: Yes, it will increase the proportion of domestic demand that comes from domestic production.

Julian Critchlow: Yes.

Lord Stern of Brentford: And have a negligible effect on world prices.

Julian Critchlow: It will have a negligible effect on the overall price.

Q10 **Lord Skidelsky:** I have no interests to declare. What are the most viable solutions to the renewables intermittency problem? You have touched on that and it overlaps with the problem of transition, obviously. However, security of supply is security of supply not just over a long period but from moment to moment. What approach do you favour? You talked about the need to choose the right technology. There are also many, many solutions to the problem of intermittency of supply. Which path would you follow and what would you concentrate on? Do you have a priority route to overcoming the problem of intermittency?

Julian Critchlow: I am glad that you framed it in terms of security of supply, because that is the element of the trilemma that we are focused on.

Security of supply is not just about intermittency, as you mentioned. There are all the technical aspects of voltage and frequency regulation; there is inertia; there is black-start capability. All these things contribute to security of our supply, but clearly having the right amount of capacity when you need it is very important when you have intermittent renewables.

In history, to ensure that we had a secure supply we had a diversity of sources. Diversity is still a strong element. We have a mixed system. When I started in the industry, the system was very much coal, nuclear and oil-based. They were the predominant three. Through the “Dash for Gas”, that moved to gas and we had to have diverse sources of gas to ensure that we had guaranteed supply.

More recently, we have substituted the coal and brought it down from 40% to under 2% by bringing on the renewables. As we continue to grow the amount of energy that we need in order to be carbon free in the electricity system, we have lots of choices, because we will be putting in twice as much generation capacity and four times as much renewables. So we have the ability to continue to make course changes based on the cost of the different technologies around the world.

What might the options be for the security of supply when we have lots—40 gigawatts—of offshore wind.

The first would be smart demand management. If you have all the transport moving on to the electricity system, obviously you do not want everybody charging their cars when they get into work or home from work. That will create a massive peak, and it will not necessarily be when the wind is available; there might be excess wind overnight and we could be smart-charging those cars and putting it into the storage in the batteries. Demand and supply can work together in a smart way, which has very low cost; deciding to have your car charged at a different time of day.

The second will be energy storage. Cars are being manufactured at such a scale globally that the battery costs are coming down very fast. That means that they are already becoming competitive with new capacity. Over time, as they come out of the vehicles, they might have a second life on the grid and bring the cost down. That would bring intraday storage—storage just within the day. You could be using energy storage to mitigate against the wind not being available.

A variety of storage technologies are being scaled globally and the costs are coming down such that you would look at those. It could be hydrogen, as we discussed earlier. It might be compressed air. There are lots of different technologies for different duration periods. Those could cover you for maybe the intraday or intraweek period.

The real problem will be what happens when you have a very quiet summer, like last summer. For that you will need some back-up capacity. At the moment, gas would be an obvious choice—the cost is a relatively low capital cost for it to sit there not operating for most of the time. Then, when you need it, you can operate it. That gas could be CCGT - a gas power station with capture of the carbon on the post-combustion - or it could be putting hydrogen in - pre-combustion, removing carbon from the gas before it goes into the power station.

Again, we will have to watch to see how those costs develop, because it will be very dependent on the cost of the hydrogen and the cost of the carbon capture. But because we have such a large amount of build over time, we have quite a lot of options to develop. As long as we are clever about our deployment, we can deploy the back-up that is the most cost effective.

Lord Stern of Brentford: So gas will be the default position for both problems of security.

Julian Critchlow: It could be green hydrogen rather than methane, and in the short term it could be blue hydrogen, because blue hydrogen will be very cost competitive in the short term, allowing us to build a hydrogen supply chain that then will switch over to green hydrogen. That is what the Hydrogen Strategy that we published last year laid out.

Q11 **Lord Fox:** I did not declare any interests earlier, because I do not have any.

I have two points. One is that, by the time you get to 2035, if you have decarbonised the power generation, if you are pointing to gas presumably it will have to be hydrogen. But you seem to be describing a series of options in a not very concrete way. That is not a criticism, it is an observation. Secondly, is there any plan for storage, or is it about waiting for something to turn up?

Julian Critchlow: No, absolutely we need to have both the creation of storage markets and the diversity of these options—smart demand management, storage and back-up gas capacity. In each of those cases, it is absolutely in the planning.

Lord Fox: Is there a timeline? There are timelines for some things, but is that on the timeline, and what needs to happen in order to keep to that timeline?

Julian Critchlow: Although 2035 seems very close, in generation terms it is quite a manageable timeframe. Putting up a gas plant takes 18 months. It is not a long process these days, because we know how to build gas plants and how to do the connections. All I am saying is that you can keep some optionality. It is the concept of being able to define in 13 years' time exactly what our energy mix is. If you looked back 15 years, you would not be doing wind. You need to keep some flexibility in order to watch what happens in the cost positions for the different technologies.

Lord Fox: You mentioned phase modulation, or whatever you call it, particularly in wind-generated electricity. Do we have sufficient storage now to be able to balance the sort of electricity that we are generating, given that so much is now coming through wind power?

Julian Critchlow: At the moment, we have a very reliable system, bar, as I said, the storm damage to the networks. We have a very reliable electricity system that is expertly managed by the system operator in terms of understanding how it should architect forward to solve all these technical issues. Obviously adding 40 gigawatts of renewables will create a whole new set of challenges for how the system runs. It will also create a whole set of new challenges for connections. At the moment, we have a whole set of connections to 10 gigawatts. We will be quadrupling that, so we will have to be intelligent about how we bring the power onshore.

Lord Fox: Is that the national grid you are talking about?

Julian Critchlow: That very much runs to what kind of offshore transmission system we want to have in the future, so that we do not have to have four times as many connections coming onshore. These are the technical complexities that you create in such a huge transition. Everything is very, very interrelated.

Q12 **Lord Monks:** I have no relevant interests to declare either on this subject.

The Climate Change Committee's report has been drawn to our attention and it has advised that investment levels will need to increase to around £50 billion annually by 2030. This is a big jump from where we are now, and we are a bit behind some other countries in our investment levels.

Now that you have retired from the Civil Service, what do you think the Government might be able to do to encourage more investment? We understand that most of the investment required will be from the private sector. The private sector needs the right incentives and encouragement if it is going to do that. Are the Government doing enough to get this kind of money into this area, or will we be in another situation, which we have been in before with other sectors, where British productivity is languishing a bit behind the best?

Julian Critchlow: There is definitely a different view being in the Civil Service versus being in business. In business, when you say that there is an investment opportunity, that means that your business can grow. As long as you can get a return on that investment, that is a very attractive option. The fact that we have estimated in the net-zero strategy that £700 billion to £800 billion worth of investment will be required by 2037 is very good news if you are one of the private sector investors, as long as you can get the return on that investment.

That requires government to help catalyse each of the markets. A lot of that investment will go into new vehicles, for instance, but there is a perfectly good financing mechanism for consumers to buy a vehicle through. As long as they are supplied and are attractive - the models come through - and we have enough in the supply chain to be able to satisfy consumer demand, consumers will buy that vehicle if it is a better and cheaper product and is better for the environment.

The assumption is that there will be a very rapid inflexion point. In the next five or seven years, we will move very rapidly from being early adopters of all these technologies. We are already seeing this in the car market. The demand goes up very rapidly as people begin to see the end of the 2030 and 2035 deadlines approaching. They will want to be in electric vehicles. That means that you need to have the vehicles, you need to have the infrastructure. If everybody rocks up on a Bank Holiday Monday and cannot charge on their long journey, they will lose confidence. But if they find that there are lots of chargers, they will have a very good experience, which will encourage the adoption.

There are lots of things that government can do to catalyse these markets. In some sectors they will have to create the market. We need to create a carbon price for carbon capture and storage to allow people to buy that service and be able to capture, transmit and store the carbon - to sequester it - in a field. That business model does not exist today. The Government has a very clear role and the consultation is out to develop that, and similarly for hydrogen; we will have to help to pump-prime those markets to some degree.

Assuming that you can create a market for low-carbon, low-cost hydrogen, there are lots of businesses that can invest behind the products and services around it—hydrogen boilers, conversion of industry, ultimately hydrogen generation. All of these can be financed from the private sector, but in the initial pump-priming, similar to offshore wind, the Government have a very important role.

Lord Monks: Reading between the lines, I get the impression that you are quite optimistic that this is under control, that we will be able to generate enough investment capital to take full advantage of the various plans that have been developed by the Government. Am I right to think that you are an optimist about that?

Julian Critchlow: I am an optimist; I went into this role with a vision that there was a way of getting the right level of investment. I am also

optimistic, because at COP 26 you saw two very strong, important messages in all the negotiations and agreements.

First, a lot of businesses turned up to talk about the business opportunities that are coming out of this transition. They are saying that we have reached the tipping point in the power sector and the automotive sector and that there are lots of opportunities. This is like a carbon bubble that is bursting very rapidly in different sectors and people are asking about the opportunities that come the other side of that.

Secondly, and importantly, was the finance. The GFANZ, the combination of all the banks with \$130 trillion worth of assets, was looking ahead and asking, "What will these businesses be worth if we do not transition them?" We have a lot of capital that can support the transition and be in the fast-growth, sustainable businesses, but equally we have to be able to transition away from the ones where you will be left holding the carbon when those legacy industries are closed down.

You saw this very much in the transition in the European utilities market. When we began to add those renewables, 55% of the value of European utilities was wiped out in only five or six years, because all those renewables came on and all the old carbon assets were left quiet. But out of that emerged some very strong businesses. Ørsted, formerly DONG Energy, is now worth around €40 billion. That put up a lot of wind farms. There are lots of opportunities coming out of this. There is a lot of connection. This is a massive industrial revolution, changing the energy mix like we did in the first Industrial Revolution. Out of that, if you invest early and you invest hard, you get better GDP growth and better factor productivity as an economy.

Lord Monks: You mentioned some British firms that are leaders on scale in this area.

Julian Critchlow: We are doing a lot. We are doing a lot in nuclear, with small modular reactors. A lot of the utilities have shifted their profile to invest in wind farms. There will be a lot of opportunities to service homes in the future. Most recently, in offshore wind, we have been very committed, but we had a bit of a slower start. A lot of the companies in wind generation were Nordic companies, because the Nordics went in early. That lesson is not lost. For the next 30 gigawatts, we are very committed to there being a lot of jobs in the UK around that. There will also be a lot of opportunities in the hydrogen strategy, in carbon capture—in all the opportunities that will come out of the transition. We have learned that lesson.

Lord Skidelsky: A quick question. You have just mentioned jobs. Do you think there will be a net loss of jobs in the transition to the new forms of energy, or do you think there will be sufficient job replacement?

Julian Critchlow: There were fewer farming jobs after the Industrial Revolution and a very different mix of jobs came out of that. I think it will be exactly the same through this transition; a very different mix of jobs

will come out. The UK learned this very strongly in the Industrial Revolution; we invested early and got the benefit from exporting all that capability for hundreds of years afterwards. Our GDP doubled, our factor productivity doubled, but our investment rate also doubled in order to be able to lead that. This will be the same picture; either we can wait until the costs come down and then be a buyer of all those services, or we can invest early and be an exporter of all those services.

Lord Monks: So you are not a Luddite.

Q13 **Lord Livingston of Parkhead:** You have talked about private sector investment, and I agree that there will be a lot, but particularly in the short to medium term there is probably an excess of investment or cost requirements over and above what is being supplied. It is being raised just now largely from consumers. Do you think that we should continue to have an energy levy, or would you put it into general taxation or into something else? How would you deal with the gap, as it were, between now and lower energy costs?

Julian Critchlow: Certainly one of the things that will have to change very much in this transition is the fiscal system that supports it. This has already been very amply demonstrated in markets that are ahead, like Norway in its transport transition. We make £27 billion from fuel duty and vehicle excise duty. My EVs do not pay most of that. Clearly if we get to 100% EVs we will have a big hole in the budget. On another issue, when I use my electric heating I am paying for the decarbonisation of the grid. When 85% of homes use their gas heating, they are not paying anything, or very little, for the carbon that they emit. These fiscal and tax systems will have to be levelled up so that the polluter pays as a general principle.

Equally, there are huge distributional effects from that. If you are making a trade-off between heating and eating, you have to have a transition plan that allows a just transition. It makes it a very complicated equation. It means that you know where the end state is and where the starting state is, and you have to feather in and make the transition nice and smooth so that people's behaviours can move away from the carbon-emitting products but they are not penalised because they do not have the capital or they are bearing all the costs of the transition because it is falling on energy bills.

Lord Livingston of Parkhead: So the general taxation acts as a regulator to specific taxable. I think that is what you are saying. What about a general carbon tax? It has been talked about. Is that feasible? Can it be done, given that the nature of world trade means that you end up importing carbon? Would you recommend that?

Julian Critchlow: Again, that is a very important issue. We already have a traded carbon price. As to whether we should do it as a tax versus a trading system, we have gone for a trading system. We do have to worry about products and services. When we export them, are we going to be competitive? When we import them, will carbon be embedded in those products? So we need to think about carbon border adjustments, which

might be regional rather than country-specific. Ideally, there would be a lot of like-minded countries that are willing to drive maybe linked traded systems to make sure that the carbon price is the same across markets and that there is a very clear border adjustment for products coming in and products going out.

Lord Livingston of Parkhead: Do you think that would be a better solution to where we are today?

Julian Critchlow: It is very important that you do that; otherwise, you will not have level playing fields. In exactly the same way as in the gas/electricity example I gave you, it would not be a level playing field on global competitive markets.

Q14 **Viscount Chandos:** What effect do you think financial services regulation is having on energy investment, and what effect is the commitment that financial institutions are making, whether because of regulation or their own decision-making, with regard to the availability of the capital that we have been discussing?

Julian Critchlow: I always think of this as a bit of the Trojan horse, although it was quite trumpeted at COP. If there is transparency about the climate financial risks in a financial institution or a corporate, if you can see how much that carbon bubble is worth in those accounts and how much you might lose if it bursts, that gives you very good motivation to transition.

If you also apply climate financial stress tests to financial institutions to make them test what happens when the bubble bursts, again you make them look ahead.

These two things, the accounting standards and the stress tests, are very important to motivating capital to do the right thing. One of the big outcomes at COP was GFANZ, the grouping of 450 financial institutions that put all their funds together and said, "We buy the answer". They have not done that yet, although we will hold them to account. The fact is that they are saying, "We see the risk, we see the transition, it is beyond the tipping point, we need to move". This will be an accelerating process, and we want them to engage with Governments and with other financial institutions to bring them into the fold.

Viscount Chandos: As a familiar theme in our various questions, does that regulation strike the right balance between the net-zero objective and the security of supply?

Julian Critchlow: The UK, with the Chancellor's announcement at COP26, has clearly set out its stall to be a leader in this. We are also very exposed. We have a large exposure to carbon in our markets. In many ways we have a very high need, but we also have a very high risk, so it is quite brave for us to be doing it. But the fact is that we are reaching the tipping point, and if we do not do it, we will be left holding a set of assets that are not worth as much as they were before.

Viscount Chandos: Do you think it has the right balance?

Julian Critchlow: I think it does, because we are accelerating so fast that we are now more at risk of being left standing if we do not move at the front. The opportunity is there for us to take, I would say take it.

Q15 **The Chair:** Finally, do you think there should be capital add-ons for banks that lend to fossil-fuel businesses?

Julian Critchlow: I am hoping that the transparency and the stress tests will bring quite a discount to people who do not move and will provide a premium for those who do move.

The Chair: Do you think that that could accelerate the move away? You are putting a great premium on gas exploration and areas where, in the transition, we need to keep affordability and reliability key?

Julian Critchlow: I do not think there will be any shortage of gas during the transition, so we will be able to source the gas that we need from the transition, and there is enough capital invested and enough supply.

The Chair: I saw that Bain put out a very interesting paper saying that it is private equities that are piling into gas. Does that bother you?

Julian Critchlow: Ideally, ultimately we will have as much transparency in the private capital as in the publicly quoted capital, but I come back to the message that it is a bubble, and if it bursts and a private owner holds it, they will have the same problem that a public owner will have, which is that it will not be as valuable as it was when they bought it.

The Chair: We have gone over time. It was a very useful session and we covered a vast amount of material. Thank you very much indeed.