HOUSE OF COMMONS

Business, Energy and Industrial Strategy Committee

Oral evidence: Decarbonisation of the power sector, HC 283

Tuesday 24 January 2023

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Watch the meeting

Members present: Darren Jones (Chair); Alan Brown; Ruth Edwards; Jane Hunt; Mark Jenkinson; Andy McDonald; Charlotte Nichols; Mark Pawsey.

Questions 228 to 270

Witnesses

II: Dr Paul Dorfman, Chair, Nuclear Consulting Group (NCG) and Associate Fellow, Science Policy Research Unit (SPRU), Sussex Energy Group, University of Sussex; Nick Lawson, Chief Executive, Ocean Wall; Dame Sue Ion; Lincoln Hill, Director of Policy and Public Affairs, Nuclear Industry Association.

Examination of witnesses

Witnesses: Dr Paul Dorfman, Nick Lawson, Dame Sue Ion and Lincoln Hill.

Chair: We are now going to move on to the second panel, having a look at the role of nuclear energy in the energy mix. In the room, we will be welcoming Lincoln Hill, who is the director of policy and public affairs at the Nuclear Industry Association; Dame Sue Ion, an engineer and expert adviser on the nuclear power industry; and Nick Lawson, who is chief executive of Ocean Wall. On the screen, we are welcoming Dr Paul Dorfman, who is the chair of the Nuclear Consulting Group and a fellow at the University of Sussex. Thank you all for being with us.

Q228 **Andy McDonald:** In the British energy security strategy, the Government set an ambition to deliver up to 24 gigawatts of civil nuclear capacity by 2050. Is this realistic, deliverable and a desirable ambition?

Lincoln Hill: It is realistic, ambitious, desirable and, in fact, absolutely necessary. We will not hit net zero unless we build 24 gigawatts of new nuclear. We have six gigawatts of nuclear today. We need four times as much clean electricity to hit net zero in 2050—that is according to the CCC—on a grid that is going to double in size. We need nuclear to provide that base of clean, firm power to make that system work.

If you look at all the credible modelling that has been done by OECD, MIT, BEIS and a range of others, it shows that you need nuclear working alongside renewables. Those are the facts, also, of which countries have had the most success in decarbonising their grids. The 24 gigawatt target, if it is followed through, gives some crucial confidence to the supply chain to make the long-term investments in skills and capabilities to deliver that programme efficiently and the confidence to developers that there are going to be fleets of new reactors.

The best way to deliver nuclear is in fleets. You keep replicating designs. You keep your supply chains active. You get your financing right and bring those costs down. You will cut the overall cost. You will cut your times to deployment. If we do that, we will deliver the target and get what we need.

Dame Sue Ion: The policy of 24 gigawatts by 2050 and the proposed set-up of Great British Nuclear was certainly welcomed by the sector and, as Lincoln has said, is the right thing to do. Failure to act on it in any meaningful way, especially in the light of the issues of energy security brought about by the situation in Ukraine, is meaning that we are being left behind and it calls our intent into question.

Other countries are already making clear statements of intent and following them up with clear actions. There is the French Bill on accelerating new build in France, changes to Swedish law, Canada

moving to deploy SMRs and eastern Europe committing to both multi-unit build of gigawatts and SMR technologies. Our own Rolls-Royce had a lead on the SMR front, but it is losing potential export opportunities as well as the ability to deliver here because of our Government's failure to move forward. People are questioning the UK's intent.

Nick Lawson: From my perspective, here as an expert on uranium, 24 gigawatts requires 12 million pounds of mined uranium. The point that Dame Sue mentioned about the Russian invasion has meant that there is now a genuine issue that we will be unable to get mined uranium from the principal producer of uranium, which is Kazakhstan, in the quantity that we want.

The other big issue is the issue of financial sequestration, which is the buying of uranium by financial institutions to sequester it away from the utilities. This is not just being done by financial players. This is being done by Governments as well, as we have seen with the US strategic uranium reserve fund, what the Chinese are doing and, more recently, the announcement from the Kazakhs themselves that they are looking to buy, store and hoard uranium. For me, that is the biggest issue in terms of our growth ambitions for nuclear.

Q229 **Andy McDonald:** I will come to Paul on screen. Perhaps you might be able to make a comment about whether there is a viable alternative to produce that amount of power.

Dr Dorfman: In 2021, solar and wind made up three-quarters of all new electricity generation capacity installed worldwide. Including other renewables, the proportion was 84%, with nuclear nowhere. In 2022, the number is about to be better for renewables and the same for nuclear. A recent Government Investment Minister said that North Sea wind power would be more valuable to the UK than the oil and gas industry. There is nobody left to dispute the fact that UK net zero heavy lifting will be done by renewable power.

The Parliamentary Office of Science and Technology recent report stated, "The UK's future electricity system will include large amounts of variable wind and solar, with a less certain capacity of nuclear". In terms of GBN, apparently Simon Bowen is not impressed with what he has seen so far. At a recent POST meeting, Government Departments had their day in court, but there were no lessons learnt. There was no real information, no real data, largely just rhetoric.

Q230 **Andy McDonald:** Do people want to come back on the viable alternative?

Lincoln Hill: We are saying, "Build a lot more renewables. Build a lot more nuclear". If you have two things that work, why not let them work together? I am advocating for the France and Sweden model. France has quite a lot of nuclear. It also has a lot of hydro and wind, and it is building out solar in a big way. Sweden has a lot of hydro, a lot of wind

and a lot of nuclear. Between them, they have the most consistently clean grids in Europe and a stronger base of sovereign power as well to reduce their gas imports.

Paul is suggesting more the Germany model, where you do a lot of renewables. You do not do nuclear. You turn off your nuclear plant. That does not work. The Germans now burn more coal than anybody else in Europe. Yesterday, they were burning 30 gigawatts of coal to make up their power supplies. There is no future in that. We are saying, "Build a robust mix". Do the fleet build, as they have done with wind, and they have made great progress on it. Let us do that on nuclear too and then we can have a robust and diverse source of sovereign power in this country. That has to be the way forward.

Dame Sue Ion: The other thing to remember is that almost all the wind power that exists today will be replaced by 2050 because of the lifetime of the assets of a 20 to 25-year asset base. The new nuclear stations, and indeed Sizewell B, which we have here today, have lifetimes of up to 80 years and possibly longer. The asset base and the certainty of the power that you obtain from the nuclear power stations is lasting decades.

Q231 **Andy McDonald:** All of our power stations, with the exception of Sizewell B, are going to come offline this decade. How is that going to affect our ability to decarbonise power?

Dame Sue Ion: It is not going to be as good as it was because, currently, the nuclear power stations provide 50% of the low-carbon power that we have when wind and solar are running.

Lincoln Hill: This is one of the reasons why we—Sue for longer and more eloquently than I—have been advocating that we needed to get on with a new fleet of nuclear reactors quite a bit sooner than we have. We have known for decades when these stations would retire and that the impact has been more gas burning and flat-lining progress on emissions. We are certainly late to it but procrastinating will not make the situation any better. This is the time to get on with that fleet. The sooner we commit to it, the faster it will be online and the cheaper it will be.

Dame Sue Ion: Even the Government's own recent review by Chris Skidmore has said that mobilising the investment that is needed towards the 24 gigawatts is a "no-regrets" decision that the Government could take.

Nick Lawson: I do not mean "arms race" as a pun but, if China is trying to build 150 1.2 gigawatt power stations by 2035, there is going to be a natural shortage of skills and a natural shortage of the equipment that is needed to build these. The work that is being done with Rolls-Royce in particular in the north-east of England at the moment is admirable but, to my fellow panellists, we need to accelerate that.

Back in 2007, when we had the biggest move in uranium in its history, half the world was against nuclear. Now we have a nuclear renaissance.

We have bipartisan support in the Senate. We have Greta Thunberg saying that she approves of nuclear. It is now universally accepted. We have to understand that nuclear is now the way forward, and we have to get on and build these sites. A lot of that is also coming through the SMR programme.

Dr Dorfman: It is interesting that there are misconceptions being touted here. Greta Thunberg says that you can potentially allow the current stock to puff along but she certainly does not support nuclear with all that that implies for these kinds of statements. For the Government to meet their targets, we need to get there by about 2030 to 2035. By BEIS's own account, nuclear takes 13 to 17 years, which puts Sizewell C at late 2030. That is far too late for our climate and far too late for our energy issues.

POST itself—the Parliamentary Office of Science and Technology—said, "Globally, EPRs [mooted for Sizewell C] built in China and Finland [and France] have incurred significant cost overruns and time delays of up to 12 years". What is interesting is that Henri Proglio, former chief executive of EDF, said, to the National Assembly last week, that it is urgent to review the design of the EPR. We are really talking about Sizewell C here, which is really what is on the cards.

What is absolutely fascinating about this is that the French will not touch EPR 1, that being built in Hinkley and mooted for Sizewell C, with a bargepole. They will not touch the EPR 1 with a bargepole. All of their new plans are for the EPR 2, which is a stripped-down version. Now, that is something really to consider.

Dame Sue Ion: The EPR is not the only large gigawatt system in the global market. Westinghouse, with their AP1000, are achieving significant success internationally. The Koreans are achieving significant success internationally with their alternative unit. The EPR is not the only choice for large gigawatt systems that could enter the UK.

Q232 **Ruth Edwards:** Lincoln Hill, globally, nuclear power station builds have some of the largest increases in cost and time overruns. In your experience, why is that? What is behind that?

Lincoln Hill: The reason for that is that we have often been building reactors in ones and twos, tinkering with designs and not fully committing to the programme. There are a lot of reactors that have been suspended midway through because there was a change of political support. If we get rid of that, and we go with a programme of committing unequivocally to fleets, you can get really good results out of these reactors. The French built the cheapest reactors of any of the big western and G7 countries. They are building them in five and a half years. In 1980, they had 34 reactors on the go at once, and they are finishing them in five to five and a half years.

The Koreans, likewise, made a firm commitment to continuing to build nuclear in fleets of two, three, four, five or six of the same units of the same design on a site. They have built the cheapest units probably over the last 25 years. If you have the commitment, and you keep your supply chain active and you do not let your expertise fade, you can really deliver this in quite good time at reasonable cost. If you stop and start, as we have in our experience in the UK, then you really get cost overruns.

That is not to say that there are no challenges. These are major infrastructure projects with the challenges that come with those, and we certainly, as the industry, have to look and learn lessons about our project management and about the maturation of design work. The basic principle is the bolder you are and the bigger the scale of your ambition, the cheaper and faster it is to deliver. That is what we have to take going forward.

Q233 **Ruth Edwards:** Dame Sue, SMRs have been touted as a potential way to mitigate some of these challenges. What is your view on that? Do you think that is accurate?

Dame Sue Ion: The benefit of the SMRs is the smaller capital outlay at the outset, so the reduction in financing costs that would otherwise be heavily loaded on the system. Also, the industry has not stood still. The opportunity for modular work, not just on the nuclear steam supply system but in the whole construction of the power station itself, means that we are talking about nothing like the build that was taking place in the 1970s, 1980s and 1990s. It is about modularising most of what goes out to site so that you can build it in the factory before it goes. You can have all the quality systems and the inspection systems and be ready to construct, and hopefully do that 24 hours a day, seven days a week.

It revolutionises the financing and the capital outlay that you have to make at the outset. That is why SMRs offer an economically viable alternative.

Q234 **Ruth Edwards:** I took from your opening comments that progress on SMRs is quite advanced in other countries and that the UK Government were too slow. Please correct me if I am wrong. If that is the case, what do you think the Government should be doing, and by when, in order to make sure we do not get left behind?

Dame Sue Ion: We are already being left behind. We have lost time that we could have had. The American design, the GE Hitachi design, is now marketing globally and receiving potential orders globally. Rolls-Royce's design is ahead in the system here in the UK but we need to get moving now to actually start to look at deploying that—and I do not mean in singles. Like Lincoln has said, we need commitment to a fleet, even if it is a small fleet, to give investors the opportunity to have confidence in Government policy.

Early commitments to both site, so that they have sites to build, and to a small number to get them going as soon as possible means that you could have a Rolls-Royce system on the grid close to 2030, but it needs to be done now, i.e. this year.

Q235 **Ruth Edwards:** It needs to be done this year, not in the next Parliament.

Dame Sue Ion: Going to the next Parliament is ludicrous. It means that we have lost the plot in terms of what you need to run a viable, vibrant nuclear energy system in the 21st century. One design for each Parliament is just a crazy way to do things.

Q236 **Alan Brown:** Dame Sue, you have already touched on the EPR design. Is it not the case that there has not yet been a successful EPR project delivered anywhere in the world?

Dame Sue Ion: The most successful EPR projects are probably the ones that have been built in China where the speed of delivery was—

Alan Brown: The China EPR also went offline for over a year so it has not been that successful.

Dame Sue Ion: Yes, that is true. I could not disagree. The EPR has not been the most successful of the large designs that have been marketed globally.

Q237 **Alan Brown:** Hinkley is something like almost 50% over budget and is clearly running behind in programme. At the moment, EDF is saying 2027 for Reactor 1 but a potential 15-month delay on top of that. Does it make any sense to try to sign off on another EPR project when we know the problems that there have been and where Hinkley is still to be proven?

Dame Sue Ion: That is a matter for the Government and EDF in terms of where they are with respect to the negotiations with respect to Sizewell C. The benefit in sticking with the EPR for Sizewell C is that all the lessons that have been picked up on Hinkley Point will be taken forward. As I indicated in my earlier answer, in terms of other sites in the UK, there are other potentially good designs that could be deployed with better international experience, like the Westinghouse AP1000.

Q238 **Alan Brown:** Given that seven out of the existing nuclear power stations will effectively be offline by the time Hinkley comes on, if nuclear is so important, how come the system will be able to operate with seven of the existing stations closed down?

Dame Sue Ion: As the stable nuclear stations close down, currently the only firm power that we have that is available to us is coal and gas. In times where there is low wind and low solar, it will be the fossil fuels that make up that gap because that is what the alternative is. Hopefully, there will be some life extensions granted to one or more of the existing AGR stations that might buy a little more time. EDF may well enter negotiations with the Office for Nuclear Regulation to look at potential life

extension, but only small life extension, of those AGR units. That will only be granted provided there is appropriate justification for their safety.

Q239 **Alan Brown:** Lincoln, if the future is nuclear, why do your members find it so hard to raise finance? EDF is practically begging for Government support for Sizewell.

Lincoln Hill: The finance sector wants to see a couple of things. They want to see a nuclear green label. They want to see us follow the science, as other markets in which they invest have done, and say nuclear is green and sustainable. We are falling behind on that. If we want to raise finance, we have to catch up with the other markets.

It is also because there has been a lack of clarity on the commitment from the Government. This is a highly regulated industry. People want to see that the Government are certainly committed to it, that they are not going to interrupt the process and that they are going to commit to a set of fleets. If investors see that, along with the green label for nuclear, which is absolutely in line with the science, then there is the capital out there to finance these projects.

The Government cornerstone stake, if you will, in the Sizewell model is good for driving market confidence, and it is absolutely possible that we can finance these stations competitively. We have to show the commitment. We cannot ask people in the financial sector to show commitment that the UK Government are unwilling to stand behind, and that has been the real mismatch.

Q240 **Alan Brown:** Is it not the case that the cost overruns and the risk involved in building a nuclear station are what make it hard to attract finance?

Lincoln Hill: Yes, especially if you are building one at a time. If you build in fleets, that risk is much reduced, and that is the international experience in Korea and France, delivering the cheapest reactors the world has seen by building in fleets. We can really reduce that risk. There is no infrastructure project that is without risk but we can really clamp down on the risk by committing to building the fleets, keeping our supply chains active and making sure that we are certain about where we are going, and that we are co-ordinating the way the projects are being done across the sites and in what order they are done.

I just want to come back to what you said about the retirement of the existing fleet. With the retirement of the existing fleet, our current grid system is not operating well. We have record power prices at an average of £200 per megawatt hour just this past year.

Q241 **Alan Brown:** Are you saying that this rise in prices is because a couple of nuclear stations have shut down? Is that your argument?

Lincoln Hill: That is part of the reason for it. I can send a report to the Committee, if you like, from Cornwall Insight that says that the

retirement of stations in 2024 would also have an effect on that. If you take the nuclear production off the system, that firm power, it ends up getting replaced by gas, which is the most expensive form of power that we have. We have record balancing costs of £4 billion per year. We have had more notices and warnings about grid capacity in the last eight months than we have had in the previous five years. To me, that is not a system that is operating well, and it is a clear warning sign that we have to build more nuclear to complement renewables if the system is going to work going forward.

Q242 **Alan Brown:** Can I put that to Dr Paul Dorfman? Lincoln Hill says that the electricity prices have spiked because we have lost some nuclear capacity and that the firm power needs to be replaced by gas. Do you have a view on that? Also, how good is nuclear at complementing renewables when renewables can be a bit variable?

Dr Dorfman: There has been what could be described as a little bit of misinformation here in terms of the replicability of fleets. The French fleet and the Korean design are largely cheap and cheerful, and they could not be built here now with current standards, with all that that implies for this form of rhetoric.

In terms of cost, there is little interest from the investment market. The City has said "no", largely because Lazard states that utility-scale solar and onshore wind costs less than a quarter of new nuclear. In that sense, maybe the Treasury's concern should be taken more seriously.

BEIS itself has stated that nuclear construction is 40% higher than expected in Europe and 90% higher than expected in terms of the delays from data for all nuclear power plants. Despite the expectations that private finance would replace state ownership, investors have largely said no, and that is largely because of the construction risks.

Again, a quote from POST is that, "Globally, but particularly in Europe and North America, construction of new nuclear has faced considerable overruns of time and budget". This is the Parliamentary Office of Science and Technology just a couple of weeks ago. To quote POST, "There are concerns that over-emphasis on nuclear could divert investment and resources from other low-carbon technologies".

By the way, just the other week the French Minister for energy transition said that renewable energies cost €60 to €80 per megawatt hour, and that this is the price level that should be had for new nuclear. Good luck with that yet.

The problem is this. There is a significant amount of rhetoric from nuclear, especially in terms of SMRs. Again, POST has a lot to say about SMRs, and not all are full of admiration. The reality is potentially otherwise. There is a distinction between rhetoric and reality here. There is a distinction between the evidence base and magical thinking. The former head of the National Grid says that the baseload is an obsolete

concept. This is because modern grids are base cost with renewables cheapest to dispatch and everything else following the net load that is over.

Utilities worldwide are moving from a world where we forecast demand and schedule supply to one where we forecast supply and schedule demand. US wholesale power prices are briskly retiring uneconomic and inflexible fossil and fissile fuel power as cheaper and more agile resources take their place. Substituting the word "firm" does not make the concept any better. Nuclear is slow and expensive, and it is far too inflexible to go up and down with the swings of demand.

Then we turn to the last gasp of nuclear, which is this business that nuclear can back up the variability, which can be dealt with, of renewables. As POST said just the other week, "Nuclear stakeholders claim existing reactor types—"

Chair: Dr Dorfman, sorry to interrupt. Can you not take time reading out the POST note? We can read that. What we are keen to hear from is your answer, and we are a bit tight for time today.

Dr Dorfman: Okay. Basically, nuclear is very bad at load-follow. Nuclear does not ramp up and ramp down well. If you are going to go for the renewable evolution, there is no discussion about this. This is exactly what is happening in the world today. There is no energy professor who will not say that the heavy lifting will be done by renewables. If you are going to do that, which is going to happen, the last thing that you want to back up renewables are nuclear because nuclear does not load-follow well, as POST has said.

Dame Sue Ion: It is just incorrect to say that nuclear cannot load-follow. France manages very significant load-following on its system. To say that nuclear cannot load-follow, particularly with modern systems, just is not true. It can.

I agree with Dr Dorfman from the point of view of the renewables doing the heavy lifting, but what we are saying is that you need a sensible balance mix in order to have a stable grid in the 21st century; and nuclear complementing the significant amount of renewables that we expect to see is the way forward.

Lincoln Hill: I can send the Committee a graph of the French nuclear fleet going from 32 gigawatts to 52 gigawatts and 52 gigawatts back to 35 gigawatts in a 48-hour period, if you want to see nuclear load-follow.

Chair: That would be lovely. Thank you very much.

Q243 **Mark Jenkinson:** Dr Dorfman, is it not possible at the most rudimentary level, regardless of any ability for a particular reactor to ramp up or down, that we can divert electricity very simply, at the flick of a switch, should frequency reach the point that tells us that the supply is in excess

of what we require so that we can divert it to an electrolyser, a battery storage bank or whatever that might be?

Dr Dorfman: Yes, exactly. It is true that the French fleet does, to a certain extent, load-follow, but this is actually quite limited, and you certainly do not want old, clamped-out reactors powering up and powering down. As we have seen, half of the French nuclear fleet has been offline last year for safety reasons. To turn to your question, yes, we can do it. We can back up renewables. New modern grid operators emphasise diversity and flexibility over so-called baseloads.

The short and sweet answer is that the renewable evolution is here. Yes, we can back it up. You talk to any energy professor worth their salt, and that is what they will say.[1]

Q244 **Mark Jenkinson:** I want to move on to technologies. Beyond Hinkley C and Sizewell C, to what extent is there consensus on technologies for the remaining 16 to 18 gigawatts?

Lincoln Hill: There are a clear set of options but there is no consensus. Because I represent all my members and vendors, I do not want to pick winners between them. For large-scale, beyond the EPR, you basically have two options: the AP1000 from Westinghouse; and the APR1400 from KEPCO, which is the Korea Electric Power Corporation. Both have worked internationally. Both of them are interested in deploying in the UK. Both of them want to see if we are serious about it, and both of them want to see Great British Nuclear set up as an organisation with real teeth to be able to drive forward future deployment.

I view us as a great nuclear nation. We pioneered this industry in the 1950s. We have a great track record and it contributes a lot to this economy, but we are the only great nuclear nation without a UK-flagged or an own-flagged reactor design to export, and that is a market that could be worth £250 billion, especially in the countries with smaller grids that want to replace coal and gas with nuclear. I would like to see us be serious about the Rolls-Royce design.

To take a step back, there is a broad consensus that you need a mix. You will need a new fleet of large and a new fleet of small to get to the remaining 16 to 18 gigawatts, and to give the certainty to achieve the cost reductions and the time-to-deployment cuts. There is plenty of room and, after 24, we may well need quite a bit more than that. We have to preserve the options and show the market very quickly that we are serious about it.

Q245 **Mark Jenkinson:** What about the extent to which the Government's choices on SMRs and AMRs are or are not the right ones to date? For example, the Government signalled a preference for a high-temperature gas reactor with a demonstrator in the early 2030s. Is that the right

[1] The witness subsequently wishes to clarify that the 'back-up' referred to here exclusively involves non-nuclear back-up.

decision or should we be open to other AMRs? Do we have the balance right between that large SMR and AMR?

Lincoln Hill: Sue knows more about the gas-cooled engineering so I will very quickly answer and then maybe Sue wants to come in. I would want to look at AMRs not so much exclusively in terms of grid decarbonisation but in terms of what they can do for industry; industrial decarbonisation, co-location with industry supplying high-temperature steam at 500 to 600 degrees Celsius. That is the best one. The high-temperature gas-cooled design is the best because we have the most years of gas-cooled reactor engineering experience of any country in the world. We can put that to use. We have thousands of people who worked on it and we could be a real leader in that.

I do not know nearly as much about this as Sue. I do not mean to step in front of you, Mark, but, if you want to hear from Sue, I would recommend it.

Dame Sue Ion: Certainly in the short-term gigawatt size, light-water reactor and small modular reactors of a light-water type are the way forward. For AMRs, certainly the most sensible system of choice would be the high-temperature gas-cooled reactor, of which there are more than one design. They give the added advantage of the ability to have heat as well as electricity, so they have dual mission. You can make hydrogen more easily with a high-temperature reactor. The heat output is better from a high-temperature reactor.

For the UK, we have the indigenous resource in a very detailed understanding of gas-cooled reactors where a lot of the science and technology is common and read-across. We had experience of supporting the South African programme in high-temperature reactor back in the early 2000s. A lot of the expertise that went into it was UK expertise. Originally we had the Dragon Reactor down at Winfrith in Dorset, which was the world's first and only, at the time, operating high-temperature reactor.

We have the technology. We also have the part of the fuel cycle that goes with it in terms of Urenco. We have a design from Urenco for a small off-grid type reactor called U-Battery, which has been pushed mainly with Urenco's own money. We have the ability to lead the world in the production of high-assay, low-enriched fuel, which will be needed for the high-temperature reactor fleet globally. There are a lot of indicators that say to us that high-temperature reactors ought to be next in line after the gigawatts and small-light water reactors.

Q246 **Mark Jenkinson:** Lincoln earlier touched on the benefits of fleet building. What does that mean for our future mix of technologies? Particularly on the large scale, we have heard of two or three different reactors but we have chosen one so far. How do we get that mix right going forward for scalability alongside?

Dame Sue Ion: The choice so far is pairs being built very slowly in sequence. What we actually need is what the global world normally does, which is to build the same design in short order one after the other. Any choice of large ones you would probably want to look at somewhere between six and eight to get you going. That would constitute fleet in that sense.

Q247 **Mark Jenkinson:** That is three to four pairs.

Dame Sue Ion: Yes, or triples. Small ones could get going with five or six, and then build out from there. As soon as you get to numbers five and six in a line, you have started to get the economics of fleet-build as well as the commonality and the understanding of the reactor systems.

Q248 **Mark Jenkinson:** How far away are we from having fusion commercially viable? It has always been 25 years away.

Nick Lawson: We are looking at what First Light are doing in Oxford at the moment. Commercial is probably 2032, so we are probably 10 years away.

Q249 **Mark Jenkinson:** Do we think the Government are taking the right steps to support fusion?

Nick Lawson: I do not know the answer to that.

Lincoln Hill: I could not speak too much to what First Light are doing. The Government have to sustain the R&D funding that has been put into the STEP programme. It was good that a site has been chosen up at West Burton. It is a good example of what we can do, with an old gas plant going over to nuclear. We probably have to step up our research and development funding into fusion. We have to be very conscious that, at the moment, our science is some of the best in the world and we have to make sure that we keep up the funding and start looking at the commercial models and put those regulations into place.

What happens with a number of things is that our science is really good but then the Americans beat us to the commercialisation of it. We do not want that to happen again. We need to get our regulations in order. We need to get a long-term target of not just every spending review but a 25 to 30-year research and development funding programme for fusion, as well as seeing what the steps of commercialisation are so that we do not lose out on yet another race where we got to the science but they got to the business model before we did.

Nick Lawson: First Light is actually under the wing of Oxford Science Enterprises, which was Oxford Science Investments, which is a co-invest between Oxford and the private sector, of which I am disclosed as an investor in. There is good private sector support for that.

Dame Sue Ion: I gave evidence to the Science and Technology Committee last year, along with experts from First Light and from the UK

AEA. Nick may be a little optimistic with respect to the 2032 commercialisation date. That is different from demonstrated delivery of a viable technology. Certainly in terms of the alternatives offered by the UK AEA, the STEP programme, I do not think there is any chance of commercial serious production of the units before the mid to late 2040s. There is a lot of engineering development still to go and a lot of materials work still to go before you get to a commercially viable product.

Q250 **Mark Jenkinson:** We have heard how the world is pivoting towards nuclear to meet net zero. How confident are you on the UK's ability to secure—I think you did touch on it before—enough supply of the nuclear fuel it needs?

Nick Lawson: That is a big issue. At the moment, the world produces 135 million pounds of uranium, and the Chinese themselves require pretty much that for their 2035 ambitions. Then there is the issue of overfeeding in the conversion process as well as the amount that is being sequestered out of the market and the strategic reserves. I am genuinely worried that there will not be enough uranium to satisfy any ambitions for the existing fleet let alone a future fleet.

It is not like with coal where you add the coal to the power station. We go through a process of milling, conversion, enrichment and then fabrication, and that takes two years. That happens around the world. There are lots of issues now that are mitigating that such as the bifurcation of the world between China, Russia and Kazakhstan and the rest of the world.

In the US, because of the post-Fukushima event, which has been la secular bear market in the price of uranium, mines have shuttered. Not one pound has been mined in the US for the last three years. The US are now paying a premium for North American sourced uranium. It currently trades at $50 a pound. They will pay between $60 and $70 a pound. There is now a premium being paid to get provenance from North America, which does not actually exist.

Then you have the other issue that, post Fukushima, there was a surplus of inventory that hit the market when the Japanese decommissioned their nuclear fleet and there was the volte-face that took place by the Germans. That has disappeared. There is no inventory in the market.

I genuinely worry about lots of mitigating factors, and probably the biggest one at the moment is the fact that the majority of uranium gets exported from two mines in Kazakhstan via St Petersburg out through the Baltic, and that route is very likely to shutter.

What does that mean? It means it has to go through the Transcaspian route, which does not work, or it goes out through China to Shanghai, and not one pound of uranium has ever left China.

Q251 **Mark Jenkinson:** What can we do here to mitigate those risks?

Nick Lawson: We should start sequestering uranium for ourselves.

Q252 **Mark Jenkinson:** Will it lead to a resurgence in reprocessing, for example?

Nick Lawson: The British Nuclear Fuel Fund is already looking at the fuel cycle. We have the Capenhurst site. We have Springfields in Preston. It does not really matter. You can sequester the front end of the curve, which is the U308, the yellowcake, but you need to have the enriched uranium product. You need to have the stuff that goes into the pellets that goes into the reactors. We have to be through the entire fuel cycle and we have to own that part of the cycle.

"Atom Nuclear Energy", which is the Kazakh sequestering vehicle, is raising money in the UK to buy and store uranium. You couldn't make it up. They are raising western capital to store it, and it is going to be stored in Port Hope, Ontario, which is the commingled facility run by Cameco. Nonetheless, everyone gets it: the Americans get it; the Chinese get it; the Kazakhs get it. There is a fund that was launched by Sprott Physical Uranium Trust. It was launched in August 2021 and it now has $3 billion of uranium sitting in a commingled storage facility. We have our own listed company on the London Stock Exchange, Yellow Cake, which has a $1 billion stored in Port Hope.

I genuinely worry that whatever we talk about here will be meaningless if we do not have the fuel to power it.

Lincoln Hill: There are three steps in addition to what Nick is saying. We should be asking our allies, Canada and Australia, to re-open their mines. Cigar Lake is one of the easiest ones to re-start. They have thousands of tonnes of capacity per year. Cameco has some other mines as well.

Nick Lawson: The breakeven does not work. The breakeven price for a mine 10 years ago was $50 a pound. That is the price now. The inflationary cost of restarting a mine is $85. A greenfield site is $100. That is because sulphuric acid costs have doubled in the last two years. You have the rig costs, the labour costs, the geologists, the scientists. You cannot just restart a mine. All these mines shuttered when the price after Fukushima dipped. You cannot just simply turn it back on. There is no mothball capacity here. You have go back through the WNA. You have to hire the people in. Kazatomprom, which still operates its mines, has actually cut its production forecast next year, not because it does not want to produce more but because it physically cannot. That is one of the big issues as well.

It is easy to say, "Let's restart the mines". Economically, you cannot restart a mine until we get to $85 a pound, and we are at $50 at the moment.

Lincoln Hill: The Australians are having similar issues to what Nick is discussing, and they have quite a lot of reserves. The Kazakhs, to date, have not shown that they want to go along with Russia's strategic

approach. They want to continue exporting. There are the difficulties that Nick has talked about.

We are one of the few countries that has world-class facilities in both uranium conversion and uranium enrichment. We have given Westinghouse a direct award on uranium conversion. I would like to see one go to Urenco to up its enrichment capability. Treat these as strategic assets as well as just commercial assets. Put the investment into them to scale up our own capacity so we have more capacity for ourselves and for our allies so that we get jobs and investment and they get energy security while trying to drive the Russians out of this sector of the nuclear fuel market. That is what we need to do.

Nick Lawson: The Russians have been very clever here. They own 38% of the enrichment market and more of the conversion market. The Megatons to Megawatts Program after Perestroika saw them de-enrich their uranium from fissile strength to energy strength. As a consequence, Rosatom, the Russian utility, has roughly 40% of the enrichment market. It is genius by Putin and so dangerous for the world.

Dame Sue Ion: While some of the points that Nick has made are true, I would just like to not correct but change the emphasis on some of what has been said. First of all, on the price of uranium, fuel cost in a nuclear supply system is small in the overall scheme of things. The fuel bit is very low compared with the capital assets of the station and what it takes to build it. Even with the price increase that Nick is indicating, it is not going to—

Nick Lawson: No, but it is the actual ability to get it.

Dame Sue Ion: If the price goes up enough, people will invest. The other point is the availability of recycled material, which historically Russia has played a large part in. This is not reprocessed material; this is recycled uranium from the system. There are facilities like ConverDyn in the United States and Orano in France, which are also players in this. Our site in the UK had a mothball conversion facility that is now going to be restarted as an additional investment so that we can continue, or begin once again, to process recycled uranium as part of the international fuel supply system.

At Capenhurst, where the enrichment takes place, they can refurbish their oldest line in order to stay in production. It already has enough room to actually close some of the gap that will be caused by cutting Russia out of the enrichment.

Nick Lawson: I reckon it is 3 million pounds at Capenhurst. I do not know if you have a different number to that.

Dame Sue Ion: I would not like to put a figure on the number but it is small in the overall scheme of things.

Nick Lawson: It is small. We need 12 million to fulfil our ambitions. We reckon we can reprocess and we still have to secure the U308 to be able to reprocess that, to process that uranium.

Dr Dorfman: Russia-dominated and Russia-controlled Kazakhstan supplies 42% of all uranium feedstock worldwide.

Nick Lawson: It is not Russian-controlled. President Tokayev is not Russian-controlled. The Kazakhs are doing everything they can to lean to the West. There is Kazakhmys, Kazatomprom and the fact that "Atom Nuclear Energy" is raising money in the West. The first visit President Xi did post Covid was to see President Tokayev. There is a guaranteed economic security around Kazakhstan away from Russia.

Dr Dorfman: We can debate this. The fact is that it is going through Russia. In a sense, we are taking a lot of time over this issue, which is an important issue. I would like to draw the Committee's attention to the issue of climate and the fact that Greenland glaciers are melting 100 times faster than expected.

Q253 **Mark Jenkinson:** The question was specifically about the UK's ability to secure enough nuclear fuel for a nuclear fleet. Let us not diverge too far.

Dr Dorfman: I did not realise that you were not that interested in climate change.

Chair: Hang on a second. Procedurally, you have to go via the Chair if you want to make a contribution. I think Mark Jenkinson has finished asking his questions. If it is really pertinent, you can be very brief.

Dame Sue Ion: It was a comment with respect to the ability to secure nuclear fuel. There is a risk here in the UK, unless we pay significant attention to the Springfields site and the business load on it. Springfields will make the last AGR fuel some time in the next two to three years as the AGRs retire. Currently, the fuel for Hinkley Point, and potentially for Sizewell C, will go to France, not to the UK. We should be thinking about doing something about that because, otherwise, we will lose the UK's domestic ability to manufacture 21st century normal light-water reactor fuel.

Nick Lawson: That is a great point.

Chair: Thank you. Right, let us all take a breather. Just to let everybody know, I will have to draw the session to an end at 12.30, and there are still quite a few questions to go.

Q254 **Mark Pawsey:** We have heard a great deal about the need for more nuclear, but one thing I want to understand is what the impacts are going to be on consumer and business bills. Can we get some agreement on how much additional nuclear we need?

The Government's British energy security strategy set an ambition of 24

gigawatts. I have just read here that we have eight gigawatts at the moment, so that is three times as much as we currently have. The Committee for Climate Change gave an estimate of a need for between six to 10 gigawatts. First of all, can we agree how much we need? Is there any agreement? I suspect Dr Dorfman may be an outlier here. From that, how much is it going to cost to develop it all? Dr Dorfman, I assume that you do not want any at all.

Dr Dorfman: I am not sure about "outlier" in this context, given the fact that there is a worldwide consensus that renewable will do the heavy lifting for net zero.

Mark Pawsey: I really want to ask you how much you think we need by 2050. How much nuclear power do we need to produce? From your earlier remarks, I am assuming nothing at all.

Dr Dorfman: It is generally understood by everyone that 24 gigawatts is illusory.

Q255 **Mark Pawsey:** Lincoln, is 24 ridiculously ambitious and rather more than we need? Is the Climate Change Committee's figure more sensible?

Lincoln Hill: I do not think 24 is too ambitious. It is probably around the mark of what we need; it may be a bit on the low side. A lot of what you get out of the different models depends on the assumptions you make about the cost of capital of financing the stations.

For those people who have kept their cost of capital assumptions at the Hinkley rate of 9.2%, we should have less nuclear. When we implement the regulated asset base model, which we have done and are doing and hope to implement, you bring it down to more like 6%. Then you see more nuclear in the 20 to 25 range. If you build fleets, you could easily be competitive in the early 30s. The French have 62.

Q256 **Mark Pawsey:** Do they have 62 now?

Lincoln Hill: Yes, they have 62 now. They want to keep what they have and build eight to 14 more at least. The Koreans have 25 already and they want to build more and export. It is not unachievable but it has to be done through fleets. It will certainly cost tens of billions. I would not want to give you a figure more precise than that but, if Great British Nuclear was empowered to set the strategic direction, the order in which we do them, the way we co-ordinate the sites, how efficiently we move the supply chain and prep it, then that is a big impact on cost. That is why the sooner they are set up and say what the next two projects are going to be and what the roadmap is, as Chris Skidmore said, the more you will have a very clear idea. It is a big figure but the benefits are there.

Q257 **Mark Pawsey:** Where do you see the need?

Dame Sue Ion: Twenty-four gigawatts at the moment looks about right. Back in 2010, the Royal Academy of Engineering did a study that looked

at building the maximum amount of renewables of every single type in order to meet an 80% reduction in carbon by 2050. It estimated that it still would need 40 gigawatts of nuclear in the mix even after building everything—

Q258 **Mark Pawsey:** It is massively larger quantities than we have done historically, and even more than we are doing now because of the amount that has come offline.

Dame Sue Ion: That is true, but we did have more nuclear capacity in the system until our Magnox fleet started to retire.

Q259 **Mark Pawsey:** We were doing 13 in 1999. That is a far way away from the ambition.

Dame Sue Ion: That is true, but the grid demand is expected to increase significantly as we decarbonise heat and as we decarbonise transport. 24 gigawatts looks about right.

Q260 **Mark Pawsey:** Lincoln, I get your argument about economies of scale—the more we do, the lower the cost per unit—but what assessment would you have of the impact that this huge investment that the country has to make, which has to be paid for one way or another, is going to have on consumer bills?

Lincoln Hill: The regulated asset base model put an estimate that, for a station the size of Sizewell—3.2 gigawatts at peak of construction—the impact on consumer bills would be about £1 per month. If you multiply that out, you see where that could work out to. The other thing we have to look at is the cost of not doing nuclear. As I briefly mentioned earlier, the cost of balancing the grid every year is currently running at £4.2 billion. That works out at £135 per household every year. If you take that to just the domestic users, that is probably about £50 per year, so four times as much as what the Sizewell C RAB payments would amount to.

Then, as the nuclear base shrinks and as the variable generation grows, that balancing amount is projected to increase quite a bit. It would be in the single digits per month for this big programme on consumer bills, and potentially save a huge amount off the balancing costs, which do not get assigned to any technology but still show up on our bills at the end. That is the way we have to approach looking at it.

Q261 **Mark Pawsey:** Is the regulated asset base the best way of us doing these things?

Dame Sue Ion: It is one way. There are others. I am not a financial expert. There are other ways. There are contracts for difference, which we no longer seem to be using. I am not the right person to answer that one.

Q262 **Jane Hunt:** We have talked about the resources needed and we have talked about the resource barriers that Nick mentioned earlier on. Let us talk about regulatory and policy barriers. If we are going to hit the 24

gigawatts ambition, what is it that the British Government need to do in terms of releasing from barriers for regulatory and policy? Do you have any good examples of other countries that have great ideas in this area?

Dame Sue Ion: In terms of what the Government can do policy-wise, it is to be clearer than they currently are with respect to what exactly they want in the mix. Are they prepared to back that by various means? Just articulating that 24 gigawatts is a nice aspiration is not good enough. They have to be firmer than that, otherwise the investors have no confidence that they are serious and that they mean it. In terms of that as a policy statement, it would help if there was something a bit more firm than nice words on a document.

In terms of regulation, we already have an internationally very highly regarded regulator. The regulator is geared to both regulate the current asset base and review applications as they come in for a future reactor fleet. You could ask whether the regulator is sufficiently well financed and whether they have enough resources to do that. In a Select Committee appearance last week, Mark Foy, the Chief Nuclear Inspector of the ONR, said that he did have enough resources to do that. It is about statements of policy that say, "We want 24 gigawatts and we want a mix of large and small, and here are the sites". Siting is one of the most important things that the Government could make decisions on in terms of allocation of the sites to potential developers.

Q263 **Jane Hunt:** I am going to ask you about that in a second. Lincoln, what is it that is holding your clients back?

Lincoln Hill: A lot of it is the barriers that Sue has referenced. In terms of regulation policy, there is an issue around planning. It does not just affect us in the nuclear industry; it affects our friends in the renewable industry as well. The development consent order process is massively detailed, time-consuming and uncertain. I and they would like that the regulators, the planning inspectors and others have a net zero duty imposed upon them, so that they consider the great national need to reach this target when they are looking at the applications for low-carbon generation.

To give you another example, a nuclear project will have to do a development consent order, a generic design assessment, a nuclear site licence and then 90 additional construction permits, consents and licences. A lot of those are duplicated. Streamlining those would be a great place to start.

Q264 **Jane Hunt:** Do you see that happening in other countries? Are there any good examples?

Lincoln Hill: Yes. Places such as France and Poland are much better at just pointing at a spot in the ground and saying, "We are going to license this reactor and we are going to build six of them and get started in two years' time. This is an overriding national priority, so just do it". To Mark Pawsey's earlier point, we had the same amount of nuclear in 1975 as

France did—about five to six gigawatts. 20 years later, we had 12 and they had 60 because they said, "We are just going to do this; let's get on with it".

Nick Lawson: Without sounding like Cassandra on the walls of Troy, we should, with urgency, have a UK uranium reserve fund. It should be stored at Port Hope at a commingled facility with our Canadian partners, and it should be made up of UF6 and U308. We need to do that with an element of urgency now. It should be a public-private endeavour.

Dr Dorfman: Regulation involves a number of things such as finance regulation and a regulated asset base. It was tried before in America. It was called ECR—early cost recovery—and it lost the US millions. Only one reactor is coming online associated with that, leaving billions in its wake.

In terms of regulation, you need to talk about the environment as well. Surprisingly, Sir David King, the UK's former Chief Scientific Advisor and longstanding nuclear supporter, says new nuclear at Sizewell C would be "very difficult to protect from flooding" due to rising sea levels on the Suffolk coast.

There are some very key issues here that we need to think about in terms of nuclear and climate. The US Nuclear Regulatory Commission says 55 of the US nuclear sites are already experiencing flooding hazards beyond their design base. What we know about the regulation of planning, which involves climate, is that our coastline is going to retreat. The problem with nuclear is that it needs significant amounts of cooling water, which is by the coast. Increasingly, we are understanding what will happen to our coast. Sir David King says this and we should take notice.

Q265 **Jane Hunt:** I want to go back to what Dame Sue talked about before. We have this 24 gigawatt ambition. We have eight sites in a planning policy that was set in place in 2011. Are we on the right track? Is it the right number? Are they in the right places?

Dame Sue Ion: It is always easier to look at new nuclear build on existing licensed sites, so that is certainly where we should start. Until there is significantly more confidence in the sector and in the ability to build and construct, I cannot see that other sites would be licensed, except for where we look at high-temperature reactors that are much smaller and where you look at co-location on an industrial site with the appropriate creation of the licences that would go with that such as with high energy-using sites like aluminium production, glass production, cement production and that sort of thing. I cannot see that happening in a short time. It is something that we would need to plan for going forward.

Q266 **Jane Hunt:** In terms of your clients, Lincoln, are these the right places and the right number?

Lincoln Hill: Yes, we have to start on the existing licence sites. They are the ones with communities that support them and want new nuclear, as

well as existing grid connections that can be upgraded rather than purely fresh connections. There is still quite a lot of room on the sites for a significant amount.

Going forward, there are a lot of coal and gas sites that will be decommissioned that have grid connections of about what SMRs do. For the second or third wave of building, you would want to bring those in. You have to start with the ones we already have and then see how we go.

Q267 **Alan Brown:** Dame Sue, how confident are you that the UK is going to have the capacity in place to safely manage and store nuclear waste from the existing reactors as well as if the 24 gigawatt ambition comes to pass? How will the Government be able to deal with storing that waste?

Dame Sue Ion: A lot of the waste that exists is what one would call legacy waste from the early development programme in the UK and from the early reactor types that we chose. If you look internationally with the modern light-water reactor type, the waste inventory is much lower in terms of volume and the ease of dealing with it. Countries such as Sweden and Finland, for instance, have had no problem in looking at how they would dispose of their light-water nuclear waste.

Alan Brown: Finland has just had to build a big geological disposal facility.

Dame Sue Ion: We do not yet have a site for the geological disposal. There is a process in play that is being run by the Government through the NDA and subsidiary, which is in charge of that. The journey towards the selection of a site is in progress. The additional volume that would be created by a new fleet of light-water reactors is not significant in the overall scheme of things, given the legacy that we have to manage safely and ultimately dispose of.

Q268 **Alan Brown:** How much progress has really been made in finding a geological disposable facility?

Dame Sue Ion: The process is under way in terms of communities that have indicated that they are willing to enter into the process to look at geological disposal, both in Cumbria and at other sites in the UK. There is a process in play where communities have said they are willing to engage and take the process forward.

Q269 **Alan Brown:** If this process is ongoing, how can EDF guarantee that, in the strike price that they have agreed for Hinkley and for the contract they are trying to negotiate for the RAB model for Sizewell C, they have included all the costs for end disposal when they are actually still trying to find a geological disposable facility?

Dame Sue Ion: That is true but, in terms of the engineering required and the anticipated cost of such a facility, there is provision in the strike

price that has been agreed for the final decommissioning and the disposal cost that would be accrued all those years ahead.

Dr Dorfman: Let me quote the recent chair of the UK Nuclear Decommissioning Authority. This is a direct quote. Nuclear disposal costs are "enormous" and there is "no certainty that they will perform the long-term task required of them…These are considerations that sadly receive little attention in current debates about the need for new nuclear-generation capacity".

Q270 **Alan Brown:** How is it that new nuclear has so much less waste compared to existing?

Dr Dorfman: That is almost mendacious in terms of the idea that the volume will be less. It is not the volume that we worry about; it is the heat. It is the radioactivity. It is the toxicity that is important. We must remember that these new generation three are high burnup reactors, which means the waste comes out hotter, more toxic and much more difficult to deal with. There are some real questions to answer about that.

Chair: Thank you, everybody. We have timed out for today. We are grateful to all of you for your contributions. We will now bring the session to an end.