HOUSE OF COMMONS

Science and Technology Committee

Oral evidence: Delivering Nuclear Power, HC 626

Wednesday 2 November 2022

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Watch the meeting

Members present: Greg Clark (Chair); Aaron Bell; Chris Clarkson; Tracey Crouch; Stephen Metcalfe; Carol Monaghan; Iain Stewart; Graham Stringer.

Questions 1-95

Witnesses

I: Professor Michael Grubb, Professor of Energy and Climate Change at University College London; and Professor Paul Norman, Professor of Nuclear Physics and Nuclear Energy Director at Birmingham Centre for Nuclear Education and Research.

II: Professor Francis Livens, Director at Dalton Institute; Dr Paul Dorfman, Chair at Nuclear Consulting Group; and Professor Laurence Williams OBE, Emeritus Professor of Nuclear Regulation and Safety at Imperial College London.

III: Julia Pyke, Sizewell C Director of Finance at EDF; and Paul Spence, Director of Strategy and Corporate Affairs at EDF.

Examination of witnesses

Witnesses: Professor Michael Grubb and Professor Paul Norman.

Q1 **Chair:** Order. The Science and Technology Committee is in session. I am pleased to begin our new inquiry into delivering nuclear power in the United Kingdom. During this inquiry we will hear from both proponents and critics of new nuclear power. We will hear from academics, policymakers and people in the various associated commercial bodies.

To start our session this morning, I am pleased to welcome Professor Michael Grubb, professor of energy and climate change at University College London, and Professor Paul Norman, professor of nuclear physics and nuclear energy director at the Birmingham Centre for Nuclear Education and Research. Thank you both very much indeed for coming.

I should say at the beginning of the inquiry that, as colleagues and some people watching will know, in September 2016 I was the Secretary of State who approved the Hinkley Point C new nuclear reactor that will be the subject of questions later on.

Let me start with a question to Professor Grubb. Would you talk us through nuclear fission, and how, at the most basic level, it supplies energy to the grid, and what advantages it has over other energy sources?

Professor Grubb: Well, the principles of nuclear fission, which have obviously been well known for well over half a century, are that you sustain a nuclear reaction by bringing together fissile material under carefully controlled conditions. Rods are inserted to help to manage the fission process and you bring it to a point where it can self-sustain. Those reactions generate heat and, in almost all the nuclear reactors built or conceived, you have tubes carrying liquid that carry the heat to a thermal generator. It has been described as a big boiler. It tends to become an extremely big boiler; the scale of Hinkley Point is around 3 GW, which is a huge power station by any standards.

The rest of the technology is fairly straightforward in terms of the basic mechanics of thermal generation. In that process, the nuclear fuel gradually burns up and eventually has to be stored somewhere as nuclear waste and replaced by new uranium, principally. I am not quite sure what level you wanted, but those are the basics.

Q2 **Chair:** That is fine to kick us off. We will talk about things such as small modular reactors and advanced small nuclear later.

Professor Grubb: In terms of the characteristics, it has the advantage, certainly as viewed today, of not being dependent on fossil fuels, because uranium is much more dense in terms of the energy it carries. It is potentially not hard to store reasonable volumes—I am not an expert on how much—and in principle it can operate as baseload. We could refer to its capacity to flex up and down.

I would like to say that when I was asked to testify, particularly on the opening of this, I said, "I am an energy and electricity systems expert; I am not a nuclear specialist," but they strongly asked me to come because they wanted the wider system expertise. I do have a basic background in the physics of nuclear, if that helps.

Q3 **Chair:** My colleagues have some questions on that for you.

In the spirit of an introductory overture question, let me ask Professor Norman a question. Given the rise in prominence and reduction in cost of renewables sources of electricity, especially in the last two decades, how important should nuclear fission be for the UK in future?

Professor Norman: It is complicated question. There are a lot of aspects to it, one of which is the economic aspect. We are aware, of course, that economic pricing can change drastically, particularly for certain types of energy sources, as we see at the moment with electricity bills and so on. Nuclear is fairly consistent in terms of its costings and pricings. The reason for that is that a significant amount of the cost is not associated with the nuclear fuel, whereas with fossil fuels, a lot of the economics are associated with the fuel itself, so if you change the prices of those fuels, it massively—and very quickly and directly, as we are seeing—affects the prices.

With nuclear, though, the fuel is something like 10% of your costings. A fair amount of it is the construction of the power plant in the first place: the investment in building this big system. That has some of its own challenges, because that up-front investment is quite significant, of course. You then have the portion that is associated with the running costs—the workers and other running costs—and about 10% or so on the decommissioning and waste side, if you budget for it up front. So it is about 10% or so on the fuel and 10% or so on the waste and decommissioning side. That means it is very insensitive to changes in uranium prices, for example.

Other aspects are, as we know, to do with climate change. Nuclear is a big, large-scale energy source that is very low carbon. Sustainability of supply is another aspect that we need to feed in. As you know, there are various aspects, and economics is one of them. One could argue that, with some of the changing prices at the moment, the economics of nuclear are not quite as bad as they used to be—it appears to be changing.

There are also a number of novel upcoming reactor designs that purport to be rather cheaper in terms of their electricity costs. Probably most of our association at the moment is to do with Hinkley Point C and Sizewell C, for obvious reasons, but there are some other reactor designs, such as the small modular reactors from Rolls-Royce, which purport to bring the cost down, and some molten salt reactors, which claim to bring the cost down even further. We have to be careful not to tie in a particular set of value for nuclear costs.

Q4 **Chair:** Looking forward, do you think there is still an arguable value-for-money case for nuclear, as well as the strategic-resilience case?

Professor Norman: That probably ties in with the last point I made about some of the small modular reactors and advanced modular reactors that are purporting to have rather lower costs. We are talking about something like a half to a third of the Hinkley C pricing. That obviously puts us in a slightly new ballpark and compares rather more favourably, even with cheaper renewables. There are still opportunities there, even purely in terms of the economics, but as I say I think it is broader than just economics.

Chair: During this inquiry we will be going into some detail on each of those components.

Let me turn to my colleagues. Before we start with Carol Monaghan, Stephen Metcalfe had a question on what you just said.

Q5 **Stephen Metcalfe:** Briefly, you said that 10% of the operating cost is for the fuel; is that right? Or was it 10% of the commissioning cost?

Professor Norman: That is roughly the overall cost proportion that feeds into your electricity prices.

Q6 **Stephen Metcalfe:** How much of that is based on the uranium price, which fluctuates, and how much is about the disposal and storage of it afterwards?

Professor Norman: The disposal and storage bit is the waste bit that I mentioned, which is the other 10%. You are absolutely right that a part of the fuel cost is not just getting the uranium but manufacturing it and making the fuel casings and things like that. I suppose that brings it down a little bit. Not all of that 10% is specifically the uranium.

Q7 **Stephen Metcalfe:** You mentioned in your final statement that small modular reactors were 50% to 33% of the cost.

Professor Norman: Yes, that is what they are claiming.

Q8 **Stephen Metcalfe:** That is to generate the exact same amount of power.

Professor Norman: Yes. It is normalised per amount of power, which is what you have to do for all sources.

Stephen Metcalfe: Thank you.

Q9 **Carol Monaghan:** Professor Grubb, can nuclear make a meaningful contribution to net zero?

Professor Grubb: It can in principle, yes. Obviously, the issues are all the usual issues and debates around nuclear power and cost. Any low-carbon source can potentially make a contribution to net zero, yes.

Q10 **Carol Monaghan:** What additional infrastructure would be needed to support the increase in energy capacity from nuclear?

Professor Grubb: First of all, if you have a very large power station in one place, it requires a very large transmission capacity. On the construction of the transmission capacity and feed-on through the grid for

Hinkley Point C, I do not know the numbers but I was a part-time adviser at Ofgem at the time and it was a pretty major undertaking, to put it mildly.

Q11 Carol Monaghan: Sorry—are we talking about rows and rows of pylons coming out from a power station like Hinkley Point C?

Professor Grubb: I don't think there would be a massive expansion of the number of pylons, but they would have to be the biggest pylons and have the thickest cables rated for capacity. I am sorry, but I do not know how many lines are required. I don't think you are talking about dozens of lines across the country. Obviously, you also need all the infrastructure associated with building the operation and the shipment of the nuclear fuel. That has some implications for the scale of roads and transport and, I guess, the volume of nuclear coming through on some of the train lines.

Q12 Carol Monaghan: In Scotland we are not going to build new nuclear power stations, but if new nuclear power stations were to be built in England to provide for energy needs, removing fossil fuel from that picture, how many would be required to provide the energy demand?

Professor Grubb: It depends on the scale of the individual stations.

Carol Monaghan: Hinkley Point C-size?

Professor Grubb: To give a sense, very roughly speaking the peak electricity demand in the country is around 60 GW. The average electricity consumption—averaged over the year—is about half that at about 30 GW. Hinkley Point C's maximum capacity output is 3 GW. Obviously, its average is somewhat less because it has maintenance and some other factors. Maybe for other reasons it does not operate all the time, as indeed we have seen with the French nuclear fleet. My ballpark would be in the order of 15 nuclear power stations on the scale of Hinkley Point—maybe a bit less if they all operated reliably and demand did not go up. That is the order of magnitude.

Carol Monaghan: So 60 GW.

Professor Grubb: I don't think anybody is really thinking of supplying all our power from nuclear power, though, so bear that in mind as well.

Q13 Carol Monaghan: Why not 20 GW, if we are talking about peak demand? Are you considering things like the storage of electricity? What are the other parts going to be?

Professor Grubb: To be honest, I don't think anyone in their right mind would try to build nuclear power to be able to meet the occasional winter peak. It is just far too capital intensive. We can come back to the system issues, but the main potential selling point of nuclear is the fact that it at least used to be classed as baseload power. Demand very rarely goes below about 20 GW, so in principle nuclear can just sit there churning it out. Obviously, life gets a lot more complicated with the renewable energy input, which I trust we will come to.

Q14 **Carol Monaghan:** How well will nuclear power be able to play a role in decarbonising other energy producers?

Professor Grubb: If you are referring to non-electricity uses, I think small to minuscule, to be honest. There are some suggestions, I think on Sizewell C—that maybe it could be connected to agricultural uses of heat or other uses of waste heat—but the heat coming out of a power station is fairly low grade. It has low-grade heating applications but they are mostly in cities, and obviously a nuclear station near a city is difficult.

In principle, you could also generate hydrogen from any electricity source—splitting water is the simplest way. Absolutely, some people talk about producing hydrogen from nuclear power, and the hydrogen can then be used in various applications—probably by far the highest-value one being various petrochemicals displacement.

Q15 **Carol Monaghan:** I have a couple of other quick questions. We are talking about current energy demands, but we know we are moving towards far greater reliance on electricity. If we look at electric cars and hydrogen-powered vehicles, all those things will require electricity. Also, there is the move towards electricity rather than gas for heating homes. All that will require a much larger amount of energy. You talked about 60 GW; do you have any estimate of what it could be?

Professor Grubb: The main scenarios from the CCC and BEIS are that, if you look right out to—

Chair: CCC being?

Professor Grubb: Sorry, the Climate Change Committee, which does the analytic work advising on carbon budget trajectories under the Climate Change Act. Their scenarios for net zero by 2050 absolutely involve strong electrification of transport and a lot of electric heating.

There are a couple of points to make about that. In general, those projections are for in the order of a doubling of electricity total demand—maybe somewhat more. Heating obviously is very much a winter demand, and the peak energy need for heating in the country from gas is in the order of four times electricity requirements in winter, so you would end up with a much more seasonally peaking electricity demand as well.

Electric vehicles obviously have the pros and cons of additional demand, but they are also batteries on wheels, so if you have smart interfaces, that can increase flexibility. Those are roughly the parameters we are looking at.

Q16 **Carol Monaghan:** So if we are talking about going down the nuclear route, we have gone from 60 GW potentially to double that, and from 15 stations potentially to double that. What role does renewable energy play in that?

Professor Grubb: Like I say, I am not sure anybody is seriously contemplating trying to provide all or even the majority of power from nuclear. Under those scenarios, if you want a major contribution from nuclear, you are talking about a lot of power stations.

Q17 Carol Monaghan: I have a final question. In Scotland, we are producing nearly 100% of our electricity with renewables, and there is potential for far more electricity to be generated in that way. Should England be more ambitious with its renewable production?

Professor Grubb: In my view, yes. Well, I suppose it depends. The Government had laid out an ambition for 50 GW of offshore wind by 2030. Obviously, the headline of 50 GW is in some sense a bit misleading, because the wind fluctuates, so the average power output is probably a third to 40% of that. That is a huge expansion of renewables, primarily concentrated in offshore wind. Personally, I think the Government should be substantially more ambitious about some of the contributions from onshore renewables as well. We could come back to that. Of course, that has implications for nuclear.

Carol Monaghan: Thank you very much.

Q18 Chris Clarkson: Thank you for coming in today, gentlemen. Picking up on that theme, what is your reaction to the Government's energy security strategy? Specifically, I want you to think about whether they have been ambitious enough with nuclear. I will start with you, Professor Grubb, because you are an expert in the system.

Professor Grubb: Yes, I did actually publish in the *Financial Times* a somewhat acerbic assessment, if I may put it that way, of the energy security strategy, primarily because I thought it was incredibly unclear what problem it was actually trying to solve. It seemed to mingle a response to the energy crisis and security associated with the current situation with very little substantively on energy efficiency—they shoved in some words at the front to make it look good, but there was really very little substance on energy efficiency. There was a fairly ambitious renewables target, and then on nuclear power they said, "We want more. We have an ambition of delivering definitely one new plant this year, and then rolling out more out to 2050."

I must admit that I and several colleagues looked at that and thought, "Yes, we've read this before. We've read these ambitions on nuclear power several times before." There is nothing in it really about whether or how it could credibly deliver and overcome the problems encountered in the past. It was just the wish list that we had seen before, as far as I could tell. The fact of saying, "The Government believe there should be new nuclear," was not really anything new; that has been the position for 15 years. Obviously, it was that push that led to Hinkley Point, and the issues around Hinkley Point should inform what we do now.

To my mind—maybe I didn't read the detail sufficiently—it was a bit of a wish statement without any clarity about how it would deliver in ways that we had not managed before.

Q19 Chris Clarkson: So more of a statement of intent than a strategy.

Professor Grubb: I felt so, yes.

Q20 **Chris Clarkson:** To your mind, what sort of detail should have been in there? Focusing on nuclear, because that is what the inquiry is about, if we were to reasonably and practically deliver that as part of the energy mix, what sort of detail needed to be in there?

Professor Grubb: Maybe two things. One is whether the stated commitment is definitively to more big nuclear stations à la Hinkley Point, or to put our effort and muscle into some new forms of nuclear, whether it is SMR or something else. And if it is to try to do both at the same time, you have another set of questions to answer.

The other big issue to my mind is, whether the expectation is that it would be financed in the same way as Hinkley Point, or that it would be returned to a purely state model, or that it would be some kind of regulated asset base financed by the Treasury. Hinkley Point had both the virtues and the drawbacks of fully private funding, and we basically learned the hard way what level of price and guarantee was required in order to persuade EDF to take the huge financial input. We could argue about the station itself, but the Hinkley Point contract was described as making it the most expensive object on the planet. I have heard that disputed with one other example, but it was still a fairly grand statement that says, "If nuclear power is that expensive, do we want to do it, or can we find smarter ways of financing it?" The security strategy, to my knowledge, did not really say it had landed on an answer to that question.

Q21 **Chris Clarkson:** Do you have thoughts on what the correct answer is?

Professor Grubb: I have a few thoughts. I may be running ahead, but I am happy to jump forward to what I think is the single most important thing to say in relation to that question.

My understanding of the Hinkley Point contract is that it is basically a 35-year contract at 9p-and-a-bit per unit, inflation linked, for all output from Hinkley Point. The problem is that if you are being paid that much for every kilowatt-hour you generate, you really want to generate, and that means that in the electricity market, you will actually bid down the price to something like -9p per kWh if you have to, so that you still get some output. That is probably an exaggeration, because you have the fuel costs and so on, but the point is—and I have not seen the contract, but nobody has contradicted me on this—that the design of the contract means it would throw other stuff off the system, including renewables, in order to be able to get its subsidy.

That seems to me a fundamental problem in a world in which clearly we are going to increasingly have periods when we have enough power from the combination of renewables and nuclear together that we need to sort out which we would want to generate. To me, that means we want a contract that sends appropriate signals to back off the nuclear generation when we really do not need it. As far as I know, that is not in the contract structure. Obviously, that does increase the risks to the investors, because they do not know that they will be able to generate at full power all the time.

Q22 **Chris Clarkson:** But by virtue of that contract, it is effectively un-diversifying our energy mix and therefore making it slightly less secure. Is that a fair statement?

Professor Grubb: I am not sure I would say that it makes it less secure. It would start to deter renewables investment—you could see a risk that Hinkley Point might throw them off the system when they came into contract, because renewables are now cheaper, so even under contracts for difference they would not bid down to -9p, because they would end up throwing money away if their CfD strike price is 5p; they would back out before the nuclear. It would deter some renewables if you had a lot of nuclear on the same structure. Does that increase or reduce our security? It depends on what your security problem is. If it is a huge, long winter wind drought—no wind for ages and you have not built enough storage—then Hinkley Point would improve the security of the system. Under other circumstances, it may do the opposite.

Chris Clarkson: Thank you. Professor Norman, what are your thoughts?

Professor Norman: I think that is right. There is only going to be a potential issue with nuclear if you have a huge amount of it and it is taking up the lion's share. I do not see it being a factor with the sort of percentages that we are talking about at the moment.

In terms of the new build rate, what I read into "one reactor per year" is that you are not going to get that with the Hinkley Point C-type reactors. Given the timescales for building them and the scale of the project—it was Europe's largest construction project—you are not going to manage that, but you might manage it with some of the smaller small modular reactors or advanced modular reactors. For example, the Rolls-Royce design is one that they are talking about and, it being an SMR—it is sort of factory production—it might be something that you could get to that sort of level of production.

For some of the advanced modular reactors, they are talking about very quick production. They still need to demonstrate that capability—I am slightly sceptical of some of the short timescales they suggest—but certainly you will be able to deploy that scale of reactor more quickly. In spirit, that sort of level of new build could be reproduced, but we have to bear in mind that the big-scale Hinkley Point-type reactors will not be delivered with that sort of rapidity; that will just not be possible.

My feeling is that it will be a question of the right mix. Generally, within nuclear itself but also outside nuclear, we often have a debate—we said a little bit about it just now—about whether to use wind or nuclear, but we need both in the right sort of proportions. It is about the right balance between nuclear and other sources. Nuclear has to be part of the mix if we are to go for the low-carbon future that we talked about. I do not readily see how we can do that without at least some nuclear in the mix, and within nuclear itself, there probably has to be a balance between large-scale and smaller stations.

In nuclear, we have previously fallen into the problem of throwing everything into—well, not quite one thing. Obviously, Hinkley Point has gone ahead, but you probably know of the Horizon Nuclear Power project, which was owned by Hitachi and aimed to deliver a similar sort of thing to EDF. That project had gone through quite a number of years of work and had 400 or so employees, but it was of course suspended because Hitachi opted not to continue. That is a case of putting all your eggs in one basket that does not then come to anything in the end.

I think we need to look more broadly. Yes, we are to some degree already committed to large-scale nuclear such as Hinkley and Sizewell, and although I do not object to that, I think we also need to look at smaller-scale nuclear and at where it couples with renewables and other types of sources. It is a complicated argument in that sense; there are lots of dynamics to it.

Q23 Chris Clarkson: Given that Rolls-Royce says that it will probably take about three years to onboard the first SMR because it will first have to build the factory that builds them, do you think that the Government need to focus on that now as part of the energy strategy? There is a perception that SMRs are sat on a shelf in a warehouse somewhere, ready to go, and could simply be taken out and stuck at the end of a road.

Professor Norman: Absolutely. If anything, a key point generally is that we should have been doing a lot of this years ago. We have delayed and delayed and delayed, and we need to get on with things as quickly and fully as we can.

Q24 Chris Clarkson: So it is time to stop talking and start doing.

Professor Norman: Yes.

Q25 Chris Clarkson: What sort of role do you see for Great British Nuclear?

Professor Norman: Nuclear in the UK has quite a long pedigree and history. It depends on who you ask, but in many ways, we had the world's first commercial nuclear power station—Calder Hall—back in 1956. In a sense, we started civil nuclear to some degree; the Americans followed the year after. Of course, we went down our own route on reactors—that was to do with the history at the time—and the Americans went down their own route of technology, which they tried to tie in with submarines. That links in eventually with Rolls-Royce, as we are dealing with today. We went down the gas-cooled graphite-moderated reactor route, which was rather unique. We have now branched out more towards looking at the water reactor designs that other countries are using. There is very much a change of emphasis. Does that answer your question? Could you remind me of it?

Chris Clarkson: It was basically about what role you see for Great British Nuclear.

Professor Norman: That's right. We had a leading role in the early days, and we have continued and evolved that expertise towards different reactor designs. Some of the leading aspects are to do with what designs have been produced by the UK. Those are, of course, the Rolls-Royce SMR—the Netherlands are already interested in units from there—and the Moltex design, which is fundamentally a UK design. I think there are possibilities for us to export some our designs. We have expertise in different aspects of nuclear and, as we have said, a host of different types of designs are being considered by different countries. Some of them are considering that flavour of gas-cooled graphite systems that we used in the UK—even the Americans are looking again at that. There are a lot of good options based on the long-running history that we have.

Chris Clarkson: Professor Grubb, is there anything you would like to add to that?

Professor Grubb: I am tempted to ask, what is Great British Nuclear?

Chris Clarkson: I can read you the definition, but I had to check.

Professor Grubb: If you would, I'd be grateful.

Q26 **Chris Clarkson:** Helpfully, the Government website says, "Great British Nuclear is an executive non-departmental public body, sponsored by the Department for Business, Energy & Industrial Strategy." Make of that what you will.

Professor Grubb: Right, so that's unfortunately not answered my question as to what it is intended to do. To me, there is a fundamental difference between a non-departmental body that is trying to help us to organise and analyse and maybe arrange contractual structures for nuclear, as compared with some body that is actually fostering British engineering or other industrial capacity in trying to build stuff. Those are very different things, and I don't know which of those GBN is supposed to be. Is it trying to take us back to the precursor Central Electricity Generating Board and the original nuclear construction bodies of the 1960s, or what, in the modern world?

Clearly, anything that involved engineering would have to have some kind of international reach because these big, complicated industries are international, but I genuinely do not know what GBN is supposed to do. It is a name at the moment, and I know now that it is a non-departmental body—thank you very much.

Chris Clarkson: I was hoping you would know.

Professor Norman: That was what I took from the question—what are the opportunities?

Chris Clarkson: It was a very good answer. You did better than I could, so thank you very much.

Q27 **Tracey Crouch:** I shall be brief because you have answered some of my questions and I know Graham wants to come in on this section. It might have been more helpful to ask this question at the beginning of the session, but, for those on the outside who are watching, what do you think is the current status of the nuclear fleet? What does it consist of? What is its output? How is it going to change?

Professor Norman: It is changing fairly rapidly. All of our earliest fleet of UK reactors, which were called Magnox reactors, are decommissioning. Most of the current fleet are advanced gas-cooled reactors, which were the successors to Magnox, but they are starting to decommission, which is a key thing to bear in mind. There are seven stations of that type, each of which is a twin reactor station, with output of the order of 1 GWe each. The last of those seven stations will stop around the end of this decade, so the train is running down the track and we are running out of track.

We do have Sizewell B, which is a water reactor. Again, it is about 1 GWe, so about the same as one of the other stations that I mentioned. It will keep going for some time. It is due to finish about 2035, but my suspicion is that it will get life extension, probably for at least 10 years, so I think it will keep going for a fair bit longer—maybe another 15 years or so, perhaps 20.

The AGRs—the ones that are closing—have already had their life extensions and will not be further extended, so as we said the problem is pressing. We need to start. If we are going to try to replace these systems, we need to be bringing Hinkley C online and we need to think about the other projects, such as the Rolls SMRs, Sizewell C and, potentially, some of the molten salt or other advanced modular reactors; otherwise, we just won't replace that capacity. Of course, that's low-carbon capacity we are losing, so if we are going to meet these net zero targets, we have to be replacing it with low carbon such as nuclear.

Q28 **Tracey Crouch:** Do you think we could have done this differently? I say that as someone who grew up in the shadow of Dungeness. There has always been a lot of controversy over that. Were mistakes made? Obviously, the decisions that were taken—

Professor Norman: I can mirror that history. I grew up in the shadow of Hinkley Point. My father worked there. We were, at one stage, going to be following Sizewell B with a further fleet of reactors. You will probably know that we had a Hinkley Point C inquiry way back, decades ago. That was approved, but the reactor was never built at that stage. So, yes, we did have plans to carry on that nuclear fleet, but, about 25 years ago, we stopped that. Of course, those reactors have still been there. They have continued to run, up to their completion lives, and we have seen a number of them retire. We are about to see more of them retire within this next decade.

Yes, we certainly could have done it differently quite some time ago by keeping the throughput of nuclear. As I said, even more recently, going back just five, 10 or 15 years, when things were starting to spring up regarding Hinkley C and the Horizon reactors at Oldbury and Wylfa, there could have been a bit more of a push to get that through.

Everything has been very slow, and there are, of course, reasons for that, which have to do with the design assessment approvals. That is a process that typically takes several years. When you propose your reactor design, it has to be approved; you cannot just build it, of course, so you have several years there. Then, typically, you have the decisions for the financing. That took EDF quite a while for Hinkley C, so I would still expect, possibly, a bit of delay for Sizewell C. All of that takes time.

You then have the building of the reactors, which, as we said for the big reactors such as Hinkley C and Sizewell C, takes a significant time. However, we might be able to get shorter timescales of build—in fact, we will—with the small modular reactors, such as the Rolls-Royce, or the advanced modular reactors, some of which claim very short build times. That allows you to potentially respond quicker. That is why I think we need a mix of large-scale nuclear—because we are already partly committed there anyway, we cannot really pull back from that—and some smaller-scale nuclear combined with that.

With those combined, and then mixed with renewables, we might be able to meet, with low carbon, the large expansion targets for power output, which we mentioned. Once you start to charge electric cars as well, as Professor Grubb said, what we produce at the moment may be only half of what we will need.

Q29 **Tracey Crouch:** You were asked about whether or not the energy security strategy was ambitious enough. Do you think that the aims within that strategy are achievable?

Professor Norman: Gosh. It is very difficult, because I do not think we have fully sorted out what the proper mix will be, and, particularly within nuclear, as I said, what the balance will be between the different types of reactors. Part of that is of course because, yes, we are no longer in that old CEGB philosophy, where everything was decided fairly centrally, in a joined up way, as to what the balance of everything was going to be. When we needed certain types of stations online, there was, essentially, a sort of Government-based planning of that sort of structure.

Now, everything is really down to the energy companies, as to what they want to build and when. You can try to coerce those companies into committing, and so on, but, at the moment, certainly for some of the nuclear options, we do not have that guaranteed investment of, "Yes, we will be building our type of reactors". Even Sizewell C appears to be slightly up in the air at the moment. I gather you will hear more about that later this morning.

Rolls-Royce are a well-known and well-respected UK company, and I think one would expect delivery from them, but with some of the other companies, things are rather more up in the air. You have the likes of NuScale, which I think is interested, Moltex, and Copenhagen Atomics, which also has a small-scale molten salt reactor and says it can build very quickly.

I do not think that the buy-in from those companies is assured, and that means it is very difficult to make anything fit with a strategy. As I say, they have all of those complications. They have to go through the design assessment process, which requires investment from them up front. These are complicated decisions, even for the companies planning smaller-scale investment.

Chair: Thank you very much indeed. We will go to Graham Stringer, but could you keep your answers brief, because we will need to move on to the next panel?

Q30 **Graham Stringer:** Professor Norman, going right back to the beginning, you were—I think surprisingly—rather precise about the decommissioning costs of nuclear power; I think you said 10%. What is the basis of that 10%?

Professor Norman: I certainly said, "roughly 10%". I would not want to be quoted as saying "exactly", but yes, that is right; it is of that sort of order.

The basis of it is the assumption that you invest as you are going along. You invest upfront and you keep the money in a pot that continues forward. Bear in mind that you have a process that involves build for several years and operation for 60 years. Then you start your decommissioning. There are different options for decommissioning: you can do it straight away—prompt decommissioning—or you can wait for things to radioactively decay away. That is the basis for it: continued investment as you are going along at that sort of level, and that the money does not get taken or pinched for other purposes.

Q31 **Graham Stringer:** But you are left with a very long-term storage problem of radioactive material, and it is difficult to assess the costs over a very long time.

Professor Norman: You have the same amount of material, so there is a possibility of changes in things such as rules and regulation that alter what you have to do. That potentially can change the costs that you have. My feeling is that the waste problem is barely changed by new reactor build. Virtually all our wastes are historical. We will only add in the order of a few percent to that waste problem by building new reactors. It is not a problem that you want, but it is a problem that we have, mostly from our historical use of nuclear power and our testing of nuclear weapons and so forth. That problem is already there, unfortunately. New build will barely affect it at all.

Q32 **Graham Stringer:** That is interesting. In answer to Tracey's question about the difficulties of assessing how quickly nuclear power stations are to come online, you talked about different ownerships and different kinds of building problems. Is there also a problem with how quickly you can connect those nuclear power stations into the full network? There is a time lag there, isn't there? Some of these stations are remote and it takes time. Has anybody done that rather complicated sum to say what order things need to be done in, with all the differences?

Professor Norman: Yes. As we said, it depends on exactly what you build and where. Professor Grubb alluded to the case of Hinkley Point. At Hinkley Point you are building a larger output than you previously had. You have the existing power lines and so on and, as he said, you need the full-whack cables and so forth.

The plan for new nuclear at the moment is that there are no plans to build on new sites. All the plans are to build on existing nuclear sites. To some degree, as long as you were to try and fit it appropriately, you have that matching capacity: you have the power lines and so on in order to provide the underpinning logistics.

Some ideas are, for example, that at Trawsfynydd there is a lake for cooling and they could fit smaller scale reactors like a small modular reactor—perhaps one of the Rolls-Royce ones. To some degree you would have to try and match up and align with the sites that we currently have. That can be done. Where necessary, such as with Hinkley Point, you might need to do some upgrades, but all the plans are for using existing nuclear sites because they have to be licensed sites, otherwise you would have to go through all that process for somewhere completely new.

Q33 **Graham Stringer:** That is very helpful. Finally, our history with nuclear power has been expensive and difficult. The decision to go for advanced gas reactors is described as one of the biggest public expenditure mistakes ever made—designing our own reactors and then procuring them in a very strange way. Both professors have been through the complications with the private sector provision of nuclear power. As we move into what looks like our next stage of nuclear power stations, what lessons are to be learned? What should we do and what should we not do so that we do not repeat those pretty dreadful public expenditure mistakes?

Professor Norman: One of the things that the UK did relatively poorly was to try to mostly iterate and change our reactor designs all the time. Virtually all the Magnox stations—11 of them—were different. Out of the seven AGR stations we have, there are essentially four variations. From a science and engineering point of view, that sounds clever: you make some slight improvements on the next one. The problem is that when that comes to just replicating the same process, having people who are used to the same systems and having replacement components and so forth, that does not work very well because you are changing it each time. The French, in contrast, have 50-something reactors. They are all water reactors and they only come in three different varieties. The French really took advantage of that replication, and it is that replication that allows you to build quicker and build cheaper.

My understanding from a PhD student—a former student of mine who was doing some of the costings on AGRs, who came up with the costings on the Rolls-Royce SMRs that you might hear about another time—was that the AGRs were starting to get more economically viable as we built that particular number, but we stopped before it became really good, so, as you say, there is unfortunately a lesson learned there. You do not perhaps want to have too many different things. There is a bonus to be gained by replication.

On the lessons learned, the final thing to add—I appreciate this comes from my own expertise and teaching of students and so on—is that of course nuclear is not very basic technology. There is quite a lot to know about in terms of the reactor physics and the safety and so on of these systems. These are more complicated than some other technologies. In my view, one of the lessons for going forward is that if we are going to have this expansion of nuclear, we have to make sure we have the people—the trained experts and the people who have got appropriate education and experience—to operate these facilities. Most of the companies are telling us that they are not getting enough graduates through with the appropriate nuclear expertise. That is also a key thing. We need to support nuclear students more and encourage them to go into the field. If you have not got the people to run all of these plants, you have got another problem.

Graham Stringer: Professor Grubb?

Professor Grubb: I guess we are winding up, so two remarks. On lessons learned, I would echo that. I would have said it more broadly as well. There is now substantial literature on the economics of innovation learning by doing, and it basically says that a lot of technological advance does come from learning by doing, and by the feedbacks and improvements. One of the reasons we have seen big advances in renewables is because they were quick enough to construct that you could learn pretty quickly and improve, and then expand and get better materials.

There is a difficulty with 3 GW nuclear power stations. The evidence so far is that it takes about 15 years before you have built anything, and then you can start learning for the next one. I think, instinctively, the smaller-scale ones have more capacity for learning as well as replication and economies of scale, but it does require a significant up-front commitment.

The other remark that I would like to make is about not so much learning from our past experience, but the need to think about the system. This is a really critical thing now for any nuclear strategy. People are used to thinking, "What we really need something like nuclear for is baseload power." It feels like common sense: the wind varies and we need baseload power. If you think about the system, the last thing we want is baseload power if it is interpreted as something that will sit there and run flat out every day of the year. That would mean you were trying to throw wind energy off on a windy day when you had more than a combination of too much.

What we want is flexible power. What we want is, at one extreme, peaking power. Nobody would build a nuclear power station. We have got lots of ways of providing occasional high-power needs. Currently, that is fossil fuels. We have the capacity market as a structure. The top 10%, maybe even 20% of the time, you are going to do something else. It is now clear, if the Government delivers on anything like its 50 GW wind target, and given what has happened in renewables, we will have at least 10% to 20% of the time when we have got more renewable than electricity demand. So what we need is stuff that can fill the middle. It is between 20% and 80% and can be flexible and can support. If we get really good on storage, you might be able to expand that and have a little more that looks a bit more like baseload. But I think our challenge is that it is not clear what the best options are for operating at 20% when you've got very low demand, up to 80%.

One other remark I really should make, which I hope will be of interest to the Committee—I certainly should for my colleagues—is that UCL is a large institution, and just last week, it was drawn to my attention that my colleagues published a paper called "The role of new nuclear power in the UK's net-zero emissions energy system", led by a researcher, James Price. What that did was take a projection of our every-hour demand, put in renewables and other stuff, and allow the model to optimise. In a nutshell, it came out with pretty pessimistic conclusions about the economic attractiveness of nuclear power under most of the scenarios.

That said—I am not an author, I am not responsible for it—that report also said it was broadly assuming the kind of economic characteristics of Hinkley Point C. It basically said, "If we can't do better than Hinkley Point C, there is very little economic rationale for nuclear power. Other things could be better for filling the needs of a reliable system." Like I said, I do not want to say more than that—it was not my paper and I do not know all of the assumptions—but it did look across a range of sensitivities. To me, the challenge for nuclear power is, in part, what its economic role is in this more complicated and variable system that we are going to have in the future.

Chair: Thank you very much indeed, Graham. I thank our two witnesses for kicking off our inquiry; we will have many sessions over the weeks ahead, and we will be going into greater detail on some of the points that have been raised today, but it was a very helpful start. Thank you very much indeed, Professor Norman and Professor Grubb.

Examination of witnesses

Witnesses: Professor Francis Livens, Dr Paul Dorfman and Professor Laurence Williams.

Chair: I am pleased to welcome Professor Laurence Williams, who is director of strategy and corporate affairs at the Henry Royce Institute; Professor Francis Livens, who is director of the Dalton Institute; and Dr Paul Dorfman, who is chair of the Nuclear Consulting Group. We have different views represented in this panel as to the attractiveness of nuclear power, and we want to start with some questions about the lifespan of existing nuclear reactors. I am going to go straight to my colleague Iain Stewart to ask some questions about that.

Q34 Iain Stewart: Good morning to you all. I am not sure whether you were able to hear the previous session, but we touched on the fact that many of our existing reactors will come to the end of their working life and be decommissioned by 2028. Just to put everything in context, could you give me an idea as to whether it is primarily safety reasons, economic reasons, or a mix of the two that determine the lifespan of a reactor? Can I put that to all three of you, please? Professor Livens, perhaps you could start.

Professor Livens: It is a mix of the two. Inevitably, any plant will deteriorate during its working life. You maintain it—you fix bits and you replace bits—and that costs you money, but it keeps it going. No operator would ever operate an unsafe plant, and I think it is simply a cost-benefit analysis: "How much money would I have to spend to keep this plant satisfactorily safe?" It becomes harder and harder as the plant gets older, so in answer to your question, a mixture, in my view.

Professor Williams: I agree with Francis. It is a mixture. We have a rolling 10-year system to review the safety of our reactors, but at the end of the day, if the regulator determines or deems that there is a significant safety issue, they have the power to order the reactor to be shut down. I know it was a long time ago, but in the case of Trawsfynydd, that reactor was shut down because of concerns over the structural integrity of the pressure vessel. But in general, as Francis has said, it will be a decision for the operator—the licensee—to decide how much money they want to spend to keep the reactor going.

Dr Dorfman: It is clearly the two. But the most important, as both the ONR and EDF have said, are the substantive questions of graphite depletion and keyway root cracking. I think those are acknowledged to be the key problem with the ageing fleet. They are life-ending conditions for this form of reactor.

Q35 **Iain Stewart:** Could any or all of the seven AGRs that are due to come offline realistically have their lifespan extended, which would give us more time to determine what new nuclear capacity, or indeed other energy source, would be built? Is that feasible, or is 2028 the endpoint for safety reasons?

Dr Dorfman: As discussed, graphite depletion and keyway root cracking are a life-ending condition. That is what the ONR and EDF say. EDF has significant modelling associated with this problem, and there are significant uncertainties associated with it, because it is very difficult to find out—to actually get in and do the engineering. Unfortunately, perhaps it is not feasible. Presumably your next question will be, "What then?"

Iain Stewart: Do the other panellists concur?

Professor Williams: In theory, it is right. Eventually something will say, "We cannot take the risk anymore about this particular factor." When you look at reactors, you have to say it is up to the operator to decide whether they can make a safety case for their continued operation. To date, there has been some information in the public domain, which would suggest that there have been inspections and that there are cracks. I think that the

ONR said there were cracks in a relatively small number of bricks in the core. EDF found no cracks in any of the control rods.

When you are looking at the effects of graphite on the safety of the reactor, there are a number of factors that you need to consider. There is the depletion of the graphite density over time, which can affect the neutronics of the reactor, and whether you can understand it and control it properly. There is the ability of the control rods to control the reactor, and the ability of the shutdown rods to terminate the nuclear fission as and when required. If the graphite core is being distorted and impinges on the ability to do that, that is clearly a factor that you would take into account.

This is maybe something you could ask EDF in the next session, but I do not think there has been any evidence so far to suggest that decisions to shut down the reactors are to do with safety concerns about the graphite. I have seen nothing in the public domain to say that. There may be other factors, such as the cost of maintaining or operating them. If you look at the fleet of AGRs that we have, Hinkley Point B and Hunterston B ran for 46 or 47 years. The projections for Torness and Heysham 2, which are the most modern of the AGRs, are that they will only run for 40 years, so what is happening in those reactors that is different from what was happening in Hinkley Point and Hunterston?

In principle, there is no reason why you cannot extend the lives, but of course there are a lot of practicalities when you consider the infrastructure that you need. It's not just about making a reactor operate. It is about whether you can get the fuel supplied. Of course AGR fuel is specific to the UK, so it is about whether or not the Springfields fuel manufacturing plant is capable of supplying the fuel for any additional life extension.

In the case of Magnox reactors, the fuel fabrication facility was shut down early. That is why Oldbury and Wylfa, the last two of the Magnox reactors, had to shut down—because there was not enough fuel to keep them going. We need to think about the long-term decisions. Also, you then have to look at whether Sellafield can take the additional fuel that would result from life extensions.

Iain Stewart: Professor Livens, do you have any additional comments?

Professor Livens: Only that there is clearly a debate to be had about life-extending the AGRs, but realistically we are not going to be extending them for many, many years into the future. It will be a fairly limited short-term extension, I would think.

Q36 **Iain Stewart:** But it might give us a little more time to determine what part nuclear has in the mix, and within that whether it is the larger-scale stations or smaller ones. Do you think that would be a useful addition of time?

Professor Livens: Yes, I think a breathing space would be very helpful.

Q37 **Iain Stewart:** I have one final question, if I may. We have seven AGRs, I think, coming offline, which is around 7 GW of capacity potentially coming out of the system over a short period of time. What mistakes were made and what can we learn about the commissioning of new nuclear in having such a big component of our generating capacity being commissioned at the same time and then coming offline at the same time? What lessons should we learn from that for whatever decisions are made at this point? That question is to Professor Williams, please.

Professor Williams: That is a very good question. I guess that the lesson is to plan ahead and make sure it does not happen. As was referred to earlier by Professor Norman, a series of things have happened—it has been stop, start, stop, start—in terms of the progression of the nuclear industry. Going forward, you need to have a long-term strategic plan as to how you are going to use nuclear energy, so that you do not get in the situation where you will shut them all down at one time over a very short period without having something else to take over from them.

The UK built 26 Magnox reactors in the period from 1956 to 1971. We built 14 AGRs in about another 10-year period after that. If you have the strategic planning, so that you understand when reactors will come to the end of their lives and when they will need to be replaced, that's the lesson that I would learn going forward. If we are going to deliver 24 GW of nuclear power between now and 2050, we have got to have a strategic plan to make sure that we do not have any gaps in the system.

Stephen Metcalfe: Professor Livens, did you want to answer the previous question or make a comment on that?

Professor Livens: *indicated dissent.*

Q38 **Stephen Metcalfe:** Okay, if you are sure. You are right that we needed a long-term plan, but we needed a long-term plan 40 years ago, so it's a bit late. We have a gap in our power and our demand is rising, so I think it's pretty clear that we've got to bridge that gap. We can bridge some of it with renewables, but there are the vagaries of the sun and the wind. Assuming we have to extend the life of the reactors, how do we do it? What are the practical steps?

I hear what you are saying about the operator deciding first, but what can we collectively do to ensure we do not have this quite significant gap in the amount of power available? Professor Livens, would you like to go first?

Professor Livens: It really is a case of, "I wouldn't start from here." The UK recognised this, because the new build nuclear White Paper was from 2008. The issue was that two of the three projects that paper stimulated did not make it over the line. I think we are in a very difficult place. Clearly it is possible to try to squeeze more life out of the existing fleet. I think the tone of the previous discussion tells us that the issues will always be based around, primarily, safety. It will eventually become uneconomic for an operator to continue to invest. As Paul Dorfman says, there may well be a life-ending issue that emerges. This is not a good long-term strategy. I don't know just how far we want to or can try to squeeze additional life out of the current fleet.

Professor Williams: I agree with Francis. I think three of the AGRs have already been shut down. I am not certain about the extent to which the amount of decommissioning will prevent recommissioning. Certainly, if the plants had not been significantly affected, in principle you could restart them, but I think you would have to ask EDF what they would want if the Government asked them to restart. It would obviously come at a price. The thing we can do practically now is recognise that, okay, you may be able to squeeze a little more out of Heysham 2 and Torness beyond 2028, but as Francis has said, we cannot expect them to go on for another five, 10 or 15 years. We have to recognise that if we are going to deliver a nuclear component to the electricity strategy then we have to get on with it.

We have to start addressing the issue. How can we start delivering new nuclear build? There are a number of things. There are reactors; we have mature reactor designs available now. There are SMRs coming along. Some are more mature than others, but they will shortly be available. What is the infrastructure that will allow that to happen? In the United Kingdom, no one is allowed to construct or operate a nuclear installation without a nuclear site licence. We need licensees. We need organisations that are prepared to take on the responsibility for constructing and operating a nuclear facility.

At the moment we have EDF for the UK, which operates the 14 AGRs and Sizewell B. We have a separate licensee being developed for Hinkley Point C and Sizewell C, but that is not yet approved. They are all in the EDF family. Who else is going to step forward and say, "I want to build a reactor on such and such site"? There are just no other licensees on the horizon. A practical thing we can do is look at how we are going to encourage organisations to come forward to be licensees. Professor Norman mentioned Hitachi at Wylfa and Horizon. Hitachi realised that, as a manufacturer of reactors, they needed an operator, so they created Horizon Nuclear Power. When Hitachi pulled out, that licensee—or potential licensee—disappeared.

Practically speaking, yes, we have to make sure we have people and organisations to operate these new power stations. We have to have a supply chain to deliver them. Again, as Professor Norman mentioned, we need to ensure we have sufficient people at all levels—from the technicians who will maintain the valves, pumps and electronics to the desk operators, reactor physicists and chemists.

Chair: Professor Williams, I think we have got the point on that. We need to be quite brisk, as we have a lot to get through, but you made your point clearly about skills.

Q39 **Stephen Metcalfe:** Thank you, Chair. I have one final question. Professor Williams, you mentioned potentially bringing back online or recommissioning those that have been decommissioned, to bridge the gap. Would Dungeness B be one of the potential candidates, and what would the challenges there be? Perhaps we could have a brief overview.

Professor Williams: There are three: Dungeness B, Hinkley Point B and Hunterston. The challenge will be how far down the line of decommissioning EDF has got.

Q40 Stephen Metcalfe: Do we know that? Do we know how far they have got?

Professor Williams: I certainly do not, but I am sure EDF do.

Chair: There are lots of questions piling up for our EDF witness, whom I see in the Public Gallery.

Stephen Metcalfe: So the answer is that it depends.

Professor Williams: Yes.

Q41 Aaron Bell: Thank you, gentlemen. I will not ask all of you all the questions, because we are a bit short of time, but I want to ask about delivering new nuclear—the third-generation reactors currently in construction, and the fourth generation coming after that. There is a bewildering array of reactor technologies in the UK alone, let alone globally. How is the choice of a reactor usually made, and what are the advantages and disadvantages of some of the third-generation reactors? I will start with Professor Livens.

Professor Livens: The thing you need to be confident of is that the design is mature, so that it is well understood that it can pass regulatory scrutiny. The point that Laurence has just made about a competent operator is really important. The UK regulatory system is a little unusual, and sometimes overseas developers perhaps do not understand its requirements, which can be a bit of a surprise to them. Those are really the two things you need: you need a good design that is well understood and well underpinned, and you need somebody who can hold a nuclear site licence. Those are the basics.

The supply chain has already been mentioned. Realistically, that has to be a global supply chain these days. There are certainly things that the UK can offer in the supply chain, but we cannot do the whole system. However, we should be very careful to promote what we can do. I will stop there.

Q42 Aaron Bell: You are not the first witness to mention the different UK regulatory environment. Could you set out what the differences are, and do you think they are justifiable?

Professor Livens: With Professor Williams on the call, I am slightly—

Aaron Bell: Maybe we should defer to him in a minute.

Professor Livens: It is essentially goal-based. It is the duty of the operator—the proposer—to present arguments that their system is safe. It is not a prescriptive tick-list-based system. It is often seen as the gold standard for that reason, and there are many strengths to it. For example, it allows much more flexibility than more prescriptive systems.

Q43 **Aaron Bell:** Professor Williams, is it the gold standard, or is it gold plating?

Professor Williams: No, it is not gold plating at all, because it is very flexible. It is goal setting. The goals are fairly straightforward, and it is up to the operator and its vendor to demonstrate how they are met. We are not unique; France has a goal-setting regulatory system, as does Canada. The US, which dominates, has a prescriptive system for its existing light water reactors, although it is looking at a new regulatory system to cover the non-light water reactor designs for future reactors. The UK's nuclear licensing system is probably the most efficient of all nuclear licensing systems, but it relies on us having competent operators who understand the technology that they are operating, and it requires a competent regulator to understand the safety case that has been put forward by the operator.

Q44 **Aaron Bell:** I completely understand what you have just said, but we are adapting the EPR design for Hinkley Point C. As we heard from Professor Norman, throughout our history there have been multiple new designs. Is there not a real delivery problem in that we keep having first-of-a-kind models being introduced in the UK, which makes it more expensive for us to deliver nuclear projects? Is there a question of economies of scale, which France obviously benefits from?

Professor Williams: Hindsight is a wonderful thing, isn't it? Britain was at the forefront of commercial nuclear power. The difference in the design from Calder Hall through to Bradwell and Berkeley—our understanding of the technology was developing all the time. By the time we got to the 1970s, we had a fairly stable understanding of the advanced gas cooled reactors. The basic core of the reactor has stayed exactly the same. It is not so much first of a kind; it is what the utilities choose to operate.

When it was the CEGB, it had a long-term strategic approach. Now we are in the free market, it is up to the market. EDF chose the EPR. Would I have chosen the EPR? Probably not, but that is a personal view. It is up to each utility to decide what it wants to do.

The regulatory system will cope with any proposal put forward, so it is equally capable of dealing with any change. It can deal with the EPRs. It can deal with the AP1000s. It can deal with the SMRs and it can deal with the advanced modular reactors that are coming down the line. There is no need to change the regulatory system. It is more, have you got a mature design and can you demonstrate that it will work?

Q45 **Aaron Bell:** Thank you Professor Williams. Dr Dorfman, if I could turn to you on some of the technical challenges facing the third-generation reactors under construction. What technical challenges are industry happy to work with? How do the recent problems that EDF has had with its EPRs in China, Finland and France potentially affect the construction status of Hinkley Point and Sizewell C here in the UK?

Dr Dorfman: Gosh. Thanks so much for letting me have my say on this. When one is talking about reactor design, in a sense, what we are really talking about is power—electricity. At the base, more pounds per MWh means less MWh per pounds. As BEIS published in its evidence to the Nuclear Energy (Financing) Bill, nuclear costs between 20% and 100% over budget, with one EPR station ranging from £26 billion to £42 billion and taking between 13 and 17 years to build, which puts Sizewell C at 2040 before first generation. We know that the EPR has had historic problems at Olkiluoto, Flamanville and Taishan, where it was shut down for one year. Even now, there are huge problems at Olkiluoto. Even in 2021, three quarters of total new electricity capacity installed worldwide was renewables. All this because utility-scale renewables are built on time and on cost.

More recently, renewables met all the rise in electricity demand in the first half of 2022, preventing £40 billion worth of fuel costs and 230 megatonnes of CO2. We don't exactly need to turn the argument on its head, but we do need slightly more discussion.

The evidence base says that renewables are comfortably—I can provide you with all the references on this—the cheapest form of new power. A very recent Oxford University report says switching directly from fossil to renewables would save the world £10 trillion, which only leaves the baseload argument, really, at the end of the day.

McKinsey—we all understand McKinsey, leading global energy contractors and consultants—say that renewables will become the new baseload, supported by flexible capacity, as early as 2030. Nuclear will be far too late. They also say that renewables are on track for 50% of world power by 2030 and 85% by 2050.

So I would like to bring the discussion back to a more evidence-based keel. One understands that there is this untoward, as it were, push for nuclear in the UK, but it has to be said that the UK is a bit of an outlier here. Nuclear can only be built with vast public subsidy, so the big builds are going on in command and control states such as China and Russia. At the end of the day, if your question is, "Will the EPR work?", well, it will kind of work, but it will work very late and at a huge cost.

Q46 **Aaron Bell:** To echo how Professor Grubb concluded, you do not think that there is necessarily a place for much nuclear in the future energy mix 20 years hence?

Dr Dorfman: Well, I am just going through the facts. A UK investment Minister says that North sea wind will be more valuable than oil and gas. There is no question that any energy professor worth their salt—I am not talking about a nuclear engineer or proponent—would say that the vast majority of the heavy lifting will be done by renewable energy. It is not a question; it is simply a fact that which only leaves the baseload, or the so-called back-up idea—the variability idea. The problem is, of course, that nuclear is also hugely variable. Twenty-eight of France's nuclear reactors are now offline.

Perhaps more important is that nuclear is too inflexible to ramp up and down with the swings of demand, in contrast to renewables. The point about nuclear is that it starts and then it runs. In other words, it does not load follow when there is variability. In terms of variability, there is no such thing as a free lunch, but there is no question that storage energy efficiency and demand-side management can and will cover this, and at base, counter the pace. In a lot of the discussion we have heard so far, if you were to turn towards the real evidence base, the future is clearly renewables. That is not a rosy-toned discussion; that is a simple, evidence-based discussion.

Q47 **Aaron Bell:** Thank you, Dr Dorfman. Professor Williams, can I ask you to briefly comment on the technical challenges, and the recent problems with the EPRs elsewhere? What are the implications for us?

Professor Williams: I think the technical problems have been quite clear, in terms of this reactor is quite complex. It uses the same pressurised water technology, but the actual reactor design is different. It is longer—the fuel has been stretched. That moves away from the traditional database of knowing how pressurised water reactors work. The evidence is quite clear; the EPRs have proven to be difficult reactors to build to date, and to operate. Whether we should judge the future of nuclear power on the EPR is probably not fair. There are reactors such as Sizewell B, which is the same pressurised water reactor, that has proven to be extremely successful, and there are other reactor designs out there that could do the same.

Q48 **Aaron Bell:** If I could just turn to those—sorry, we are short of time. With the fourth generation—the AMRs and the SMRs—we heard earlier that they should be considerably lower cost. How do they differ from the current fleet? Do you think that the timescale that people are looking for—the early 30s—are realistic for those technologies?

Professor Williams: Certainly, the Rolls-Royce SMR, which is basically a light water reactor, is proven technology. As Professor Norman said, the cost reduction is going to come from the fact that a lot of it can be manufactured in factories in modules, then shipped and plugged together. With the big reactors, most of the cost is in the pre-stressed concrete and the infrastructure. I think for Sizewell B the design costs were £1.5 billion and the actual pressure vessel was about £10 million. It is the civils that take up a lot of the construction costs.

Turning to SMRs, if we stick to proven technology, as Professor Livens said, that is the easiest way—mature designs to get the process going. With the more exotic designs, like molten salt reactors and others, there is a higher risk, but they may well come through at a later stage. We start off by delivering our programme with reactors of proven technology. I would say that we need a mix of gigawatt-size reactors and some of the more flexible, smaller ones. To come back on what Dr Dorfman said, the French fleet can load follow to a certain extent, but load following is not the only thing. You need to look at demand, and by choosing a selection of large reactors and small reactors, and when you can take them off for refuelling, you can match the nuclear capacity with the predicted load depending on how the year goes by.

Q49 Aaron Bell: Professor Livens, just briefly, any thoughts about the fourth generation? What are the potential benefits over the tried and tested designs that we currently have?

Professor Livens: If I could focus particularly on the advanced reactors, BEIS has expressed a preference for high-temperature gas-cooled reactor technologies. NIRAB—the Nuclear Innovation and Research Advisory Board—is looking at how you might use that heat to get at the difficult-to-decarbonise parts of the energy system. There is a debate to be had. We are thinking about it. There are certainly some things that would be very difficult to decarbonise without high-temperature heat. It is debatable at this point whether the HTGR is the right answer—how many of them, how big, and those sorts of questions—but at the moment it looks like there is an extra part of the system they could play in.

Q50 Aaron Bell: Dr Dorfman, did you want to come back on the previous comments from Professor Williams and Professor Livens?

Dr Dorfman: Yes, I think perhaps Professor Williams and Professor Norman may have misspoken, insofar as the Rolls-Royce SMR is not an SMR. An SMR is about 300 MW or less. It is a relatively small piece of kit. The Rolls-Royce effort is listed at 470 MW, which means that it is about half the size of the larger workhorse of the French fleet. The problem with SMRs is that the whole of the history of nuclear has been economies of scale. Build large to get economies of scale, which is similar for wind. SMRs hope to replace economies of scale with economies of modulisation, but there are huge potential problems associated with that in terms of proliferating a generic problem within the whole system. Also, the cost of tooling up to do this is very great. That leads to further issues. If they need to be built, they need to be sold, and where will they be sold? Potentially to other states that may have less stringent regulation.

Perhaps one of the key things about SMR is that a recent publication, co-authored by the former head of US nuclear regulation, states that SMRs produce significantly more waste per megawatt-hour than conventional reactors. Add the fact that SMRs are still in development, and recall that the Rolls-Royce SMR is not an SMR. That is simply a plain fact, and anybody who says that has misspoken, and all that implies. Given the fact that we really do not have that much time for the climate and we have limited resources, the problem is how we justify throwing significant resources into technologies that may well come too late for the climate and will certainly come too late for our energy dilemma when there are other technologies that are here and now, that work, and that are between four and five times cheaper.

Aaron Bell: Thank you, Dr Dorfman. That is a question for our Committee to wrestle with.

Q51 Carol Monaghan: Professor Livens, what is your response to the energy security strategy?

Professor Livens: If I look at it specifically from a nuclear perspective, the UK has assets that it could make an awful lot more of, which would contribute greatly to the security of its future energy supply. I have been doing a lot in the high-temperature gas-cooled reactor area. Fuel enrichment and fuel manufacture are both UK strengths, and they are things that not many other nations have. We are very good at graphite, because of our graphite reactor history. We are good at things such as materials qualification. There are a number of assets that we can and should invest in and support, to make sure that we get best value out of them.

Q52 **Carol Monaghan:** Dr Dorfman, do you have any comments on that question?

Dr Dorfman: A previous speaker discussed uranium. Although we do not get uranium from Russia and Russian-dominated Kazakhstan, they provide 42% of all uranium for all reactors worldwide, and 20% for all reactors in Europe. There is some idea that it will help us with our energy security, but although we do not get our uranium from those resources, there are presumably others, including China, and there may be a drag on certain aspects of availability. We have seen what has happened in Ukraine, with the weaponisation of civil nuclear risk. It is an issue that needs to be contemplated, especially given the UK national security strategy. Mostly all UK nuclear infrastructure is a tier 1 hazard.

Q53 **Carol Monaghan:** Surely that would still be the case with renewables. Or do you feel that the fact of being more widely spread would make a difference?

Dr Dorfman: It would not necessarily have the consequences. I was secretary to the Government's standing advisory committee examining radiation risk from internal emitters. I ran a Whitehall office for a number of years. The discussion was on radiation risk. There is a difference between a problem with a nuclear reactor, or some form of pollution associated with a nuclear reactor, and any form of pollution associated with a wind or solar plant.

Q54 **Carol Monaghan:** Professor Williams, what should the role of Great British Nuclear be?

Professor Williams: I wish I knew.

Chair: That seems to be a theme.

Professor Williams: I obviously tried to look at what is available in the public domain about Great British Nuclear, and there is not a lot. I do not know what it will do or what it is for. It cannot be a developer. If it is a developer, it would need to become a licensee, and it would need to become an electricity utility. I really do wonder what it is. I think it was Professor Grubb who made some quite interesting comments on his understanding of what Great British Nuclear could possibly do.

Q55 **Carol Monaghan:** Thank you, Professor Williams. Perhaps we could try Professor Livens.

Professor Livens: I know about as much as Laurence does, I am afraid. I would say that, if there were an organisation that took leadership and gave direction, as for example the UK Atomic Energy Authority has over decades with the fusion programme, that might be very useful. But that is a personal view.

Q56 **Carol Monaghan:** Thank you. Dr Dorfman, do you have any thoughts on the question?

Dr Dorfman: Again, it is the question of opportunity costs and opportunity costs lost. Why not Great British Renewables? The IEA just published its "World Energy Outlook 2022", which stated that renewables are the most important way to reduce emissions in the electricity sector. I would heartily recommend a Great British Renewables organisation.

Q57 **Chair:** I have a final couple of questions for you, Dr Dorfman, following up on a couple of things you said. You said that the so-called small modular reactors are not small in definitional terms. Does that matter? Does it have implications other than for the accuracy of the label?

Dr Dorfman: Certainly, yes. The Rolls-Royce effort is not an SMR—it cannot in any way be defined as an SMR.

Chair: I understand that, but what are the implications? If it is not small, do we need to be concerned? Does that have any consequences?

Dr Dorfman: I suppose Rolls understood the economics of nuclear in so far as nuclear has always been based on the economies of scale: you build big because it is cheaper to build one 1,000 MW reactor than 10 100 MW reactors. The same is true for wind. Then one comes down to, "How much does the large one cost in any case?", and the large one clearly costs too much. Lazard, I think, talks about the large reactor being four or five times more expensive than the equivalent plant for renewables. Clearly, Rolls has said, "Well, look, small modular reactors probably won't do the job, so what we'll do is scale it down a bit, call it an SMR or hope that certain other people will call it an SMR, and give the appearance that it is a little piece of kit to have."

Q58 **Chair:** So it would be more accurate to describe it as a smaller modular reactor.

Dr Dorfman: It is largely the same size as the first Magnox reactors and about the half the size of the 900 MW workhorse of the French fleet, so no, not an SMR.

Q59 **Chair:** That is helpful. You made a point about the countries engaged in commissioning new nuclear power stations. You described them as command-and-control countries—China and Russia—but they do include, recently, Finland, France and Korea, so it is not a uniform picture of the type of country, is it?

Dr Dorfman: Certainly not. Finland and the UK seem to be relative outliers. France is France, it has not commissioned yet and it has its own problems with 28 reactors offline and going on for about a £43 billion debt for EDF, with about £100 billion coming for its reactor upgrades—the so-called Grand Carénage. Basically, Macron has been inveigled into fully nationalising EDF. Again, that has significant implications for how much EDF may or may not be invested in the UK.

In terms of the reality, no, the market has fled nuclear—there is no question about that—so largely we see it in command-and-control countries. In terms of South Korea and UAE, their reactors are largely cheap and cheerful and they would not necessarily pass UK regulation. The UK has clearly gone for some form of subsidy—regulated asset base—but it must be understood that this has been tried before in the US. The US tried it as an advanced cost recovery system, which is exactly like the RAB system. Of the 31 applications, two are still in construction, hugely over cost and over time, with US electricity consumers left with—*[Inaudible.]*—$10 billion—*[Inaudible.]*—for the cancellation—*[Inaudible.]*

Chair: Dr Dorfman, we have lost your sound. I think the signal is giving up. Actually, we are coming to the end of the session, and you have been very clear in your evidence, as have all the witnesses in the panel. Professor Williams, Professor Livens and Dr Dorfman, thank you for your evidence today. It has been very helpful to expose some of the debates and disagreements. It is the purpose of the Committee to examine them and to come up with recommendations for the Government. Thank you very much indeed.

Examination of witnesses

Witnesses: Julia Pyke and Paul Spence.

Q60 **Chair:** Our final panel of witnesses today have joined us in person. I am pleased to welcome Julia Pyke, Director of Finance for Sizewell C at EDF, and Paul Spence, Director of Strategy and Corporate Affairs at EDF.

Your attendance at the session so far has given you notice of some burning questions that other witnesses had for you. If I may, I will start with those, perhaps directing them to Paul Spence, but Julia Pyke may wish to come in as well.

On life extensions, you obviously run a significant fleet of nuclear power stations. Are the proposed decommissioning timetables driven by safety concerns around graphite or, as was suggested, by rising maintenance costs?

Paul Spence: As you say, Mr Clark, we operate a current capacity of 5.5 GW. I will perhaps start with one of the earlier questions. In the last 12 months, we have closed three of the gas-cooled reactors. For the first of those, Hunterston, we have been on with the programme of taking the fuel out of the stations and moving it to Sellafield. We are well advanced in the planning to do the same thing at Hinkley Point, and for Dungeness we are still in the planning phase for the de-fuelling stage.

It is unlikely to be possible to bring those stations back online. We took the decisions about the closure of those stations very carefully, and in doing that we took a judgment about the safety of the operation across all the parts of the system, the economics of the operation and the ability of our team to do the work that we know is needed to support safety cases. Our judgment was that in the case of those three stations, it was the right time, with the planning we had done, to move into the de-fuelling phase and end generation.

Q61 **Chair:** To be clear, you said it was unlikely to be possible. That possibility implies safety compliance—is that what you mean?

Paul Spence: It is a mix. There are the requirements of what it would take to create a safety case that we were content to present to the regulator—we are the licensee and we have to be satisfied about the safety of ongoing operation—and in that we also need to look at the practicality and economics of what it would take to do it.

Q62 **Chair:** To probe that, obviously electricity prices have increased and, with the conflict in Ukraine, we want to secure more electricity supplies. Were the economics to be improved one way or the other, and were you given the money to engage in the work required for life extensions, would it be possible, or are there technical safety aspects that trump any injection of cash?

Paul Spence: The easiest way to describe it is that, for those stations we have closed down, the gap between what we believe is possible economically to achieve safe continuation of operation and the potential reward, is too big even at today's power prices,.

Q63 **Chair:** Are you still in discussions with the UK Government about that, or have both sides accepted that?

Paul Spence: On those stations, no, we are not.

Chair: Okay, thank you.

Paul Spence: Some of the previous speakers talked about the need to have the expertise of the people who are involved in developing those safety cases and understanding the operations. Those people are looking at what might be possible to extend the lifetimes of the stations that are still running. We are going through an exercise at the moment, first looking at Hartlepool and Heysham 1, which at the moment are due to close in March 2024. We hope in the coming few months to be in a position to take a decision on whether it is possible to get a bit more lifetime out of those stations. We are also looking at what might be possible for Heysham 2 and Torness, which at the moment are due to close in 2028. That means doing the work on assessing the state on all of the parts of the plant, not just the graphite.

We are looking carefully, as Professor Williams described, at whether or not we can assure ourselves that we can safely shut down in both normal circumstances and the extreme, one-in-10,000-years circumstance—perhaps where an earthquake is shaking the plant at the point that we wish to do the shutdown. We are going through that work.

Q64 **Chair:** When do you expect to conclude it to the point of being able to make a decision?

Paul Spence: We are looking to do that and to take decisions over the coming year. We know the urgency of that decision-making work, but we need to do the detailed modelling analysis.

Q65 **Chair:** Do you think that will be in autumn next year?

Paul Spence: We are working as fast as we can on that. I'll confirm a precise date to the Committee in writing, if I can.

Q66 **Chair:** Do you expect to make decisions on the way for different stations, or will you announce them all together?

Paul Spence: We will give our best view. The first two stations for which we expect to form that view are going to be Heysham 1 and Hartlepool. We expect to do that sooner than we can give the full view for all the fleet.

We are also looking at the longer term question whether it is possible to extend the life of Sizewell B, which at the moment is due to run until 2035. We are hopeful that we will take a decision on maybe up to 20 further years of life out of that station, which would take us to 2055.

Q67 **Chair:** Would you make that decision during the next year?

Paul Spence: A bit longer for that. There is a lot of technical work to do, not just to assemble the safety cases but to identify investments that we may need to make.

Q68 **Chair:** So beyond a year, but are we talking five years or two years? Within two years?

Paul Spence: I think we have said publicly that we would look to make that decision before 2024. Again, I will confirm that to the Committee, if I may.

Chair: Thank you. That is extremely helpful. We don't have much time because colleagues have to go to Prime Minister's questions, so I am going to turn to my colleagues now. Please keep your answers as crisp as possible, consistent with that.

Q69 **Graham Stringer:** I suppose the question that everybody wants to know is: why were the estimates for the cost of Hinkley Point C so far out?

Paul Spence: When we took the final investment decision in 2016, as Mr Clark said, we made our best estimate of the time it would take and the cost of the station. We have updated that since then, most recently to an estimate of between £25 billion and £26 billion for the 3.3 GW. We have also updated the point at which we expect the station to begin operating to 2027—an 18-month delay on the timetable we set at FID.

The first cause of the cost and schedule increase has been the global pandemic. We have said that we think somewhere over 12 months of the 18 months of delay are attributable to the pandemic and the impacts it had in terms of the reduction in the number of people able to work on the site during that phase.

Graham Stringer: Work continued through the pandemic on the site.

Paul Spence: Before the pandemic, we had about 5,500 people working on the site. At the lowest point, we reduced that to about 2,200 people working on the site. We are now at a stage where we have somewhere between 8,000 and 9,000 people working on the site every day, and probably twice that number in this country working on supplying material to the station. All of that slowed down, but the costs did not reduce proportionately with that effect.

The second big impact was to do with the fact that when we made our first estimate, we assessed what we thought was the requirement to take an international design but make it suitable for UK regulations. To do that has actually required more material, more time and more engineering. That is the second big component in the cost increase.

There were also some areas where the work has honestly been harder than we expected. In a first-of-a-kind project for 25 years, as we heard from some of the earlier speakers, it has taken a big effort to restart the UK's nuclear new build industry. I hope that we will see that benefit if Sizewell and future projects go ahead.

Q70 Graham Stringer: What are your expectations now of the continuation of the project?

Paul Spence: Six years after the final investment decision, we are 58%, nearly 60%, of the way through the project. We are progressing well. We have over 8,000 people on the site; we are looking to increase that to 9,000. We are moving from the civil engineering phase to what we call mechanical, electrical and HVAC, so the installation of equipment in the building. The project is a huge undertaking, but it is progressing well.

Julia Pyke: The vast majority of the equipment has already been produced for Hinkley, which means that it has been quality-checked. As a result, some of the problems that have emerged late in the build programmes of Olkiluoto and Flamanville will not emerge in Hinkley because the equipment is made early and is super quality-checked.

Q71 Graham Stringer: There have been problems with similar reactor designs in China, Finland and elsewhere. Is that a fundamental flaw? Was going with this kind of reactor a mistake?

Julia Pyke: Let me try to answer that in the way we describe it to investors.

Think about a pressurised water reactor. There are more than 300 around the world. It is like a car engine: they are basically the same. They might be a little bit different between Mercedes and Audi, but they are basically the same; what changes in each country is the car body. When you bring a reactor design to the UK, you need to think about it as changing the side that the steering wheel is on and changing the braking system. It is in making the UK-national adaptations to the body around the car engine—the essential core of PWR technology—where we have incurred these unexpected costs, as Paul described.

In 2015, the cost of the UK adaptations was not sufficiently well understood because not enough detailed design had been done. This is essentially the case for Sizewell. We have the detailed design before we start, which means that we know the quantities of steel, concrete and cabling, and we know the productivity hours required to install all of that. We can take that from Hinkley, so we have a much higher degree of confidence in our cost estimate than we had for Hinkley and certainly than those other reactor projects had.

In China, Finland, France and the UK, the essential core of the PWR engine to the EPR has been nationalised and that is why, in each project, you have seen first-of-a-kind issues emerging. Sizewell, for the first time, is going to be the third and fourth builds of the same reactor design. There have been two at Hinkley. In the journey between unit one and two at Hinkley, you can see the increase in speed and decrease in cost that you would expect when you are doing something for the second time. We are very much planning to build Sizewell as, effectively, Hinkley unit 3, taking the same trajectory of learning to build the exact same above-ground design.

Q72 **Graham Stringer:** We have moved into a period of inflation, partly caused by the Ukraine war and partly caused by increased demand after covid. What are your projected increased costs because of the change in the inflation scenario?

Paul Spence: Because we have not yet seen the full impact through the project, we have not said anything publicly and we have not estimated the full impact of what we are seeing at the moment. We are seeing cost pressure from our suppliers, who are coming to us and saying, "Have you seen these energy costs? What can you do to help?" But we have not added all that together at this stage.

Q73 **Graham Stringer:** The other side of the problem is the supply chain. Are you having problems with the supply chain?

Paul Spence: As I said, we have worked hard to build the UK supply chain. We estimate that we have spent nearly two and a half times what we thought we would have done by this stage—over £4 billion—with UK suppliers. We have spent £20-something million training people up. We have 1,000 apprentices. All that is about strengthening and creating a resilient supply chain. We are still facing challenges getting enough people on site, and in our suppliers, and having our suppliers ready and able to understand and deliver the nuclear quality that we need.

As Julia said, though, we expect and hope that what we have found on the first unit at Hinkley works better on the second unit, and if we can show that Sizewell is going ahead, that same supply chain has the prospect of future projects and will be better placed to do that. If the UK then has further nuclear after that—whether or not it is EPR or other technology—those same suppliers are set for that as well.

Q74 Graham Stringer: The previous witnesses said that one of the worries about the future of nuclear energy production was the supply of graduates and postgraduates. Do you recognise that problem, and can you quantify it?

Paul Spence: Some of your previous witnesses were kind enough to talk about EDF and the role that we play in the UK system. We have been able to attract the graduates, the PhDs and the apprentices that we need for our project and to run our existing stations. We started recruiting extra people into our stations 10 or 12 years ago, in readiness for some of the demographic challenges of an ageing workforce and for some of the new builds. We have been able to scale up for what we have needed so far.

As we look more broadly at the scale of the country's ambition, this needs to go beyond what we can do and become a national effort to ramp up on PhD skills, university skills, the supply chain and so on. For Hinkley, we set ourselves an aim of 1,000 apprentices. For Sizewell, I think we have said 1,500.

Julia Pyke: Yes, we are taking 1,500 apprentices. A programme is absolutely essential. A teenager in the UK today has to know that there is a programme and that they can have a career in nuclear. To mark the future for our operating team in Sizewell, we recently sponsored the primary school reception photographs of kids in Suffolk, because the people who will operate Sizewell during part of its life are aged five today.

This is a long-term industry—Sizewell will operate for at least 60 years, and very possibly 80, as will Hinkley—and you need a programme. We are delighted if there is subsequent nuclear, whether or not it is UK EPR, because a programme is essential for the supply chain and for recruiting the right workforce.

Q75 Chair: Mr Spence, you said that you had not yet made an estimate of—or at least had not disclosed—the impact of inflation on the costs. Clearly, that will only go in one direction: you will not find that it comes out as less. Is the consequence of that entirely borne by EDF rather than by the UK taxpayer or bill payers?

Paul Spence: The cost of the construction is for us, and we start being paid for the power that we produce from Hinkley only when we start producing it. There will be an effect on consumers, because with higher inflation the indexation of the price that we will receive will mean that the price is—

Chair: That is the national effect.

Paul Spence: Yes.

Q76 Chair: What about your specific costs?

Paul Spence: If there is a difference between the construction-cost inflation and the CPI, we bear it.

Q77 Stephen Metcalfe: You have already answered some of my questions about lessons learned from Hinkley. When do you think you will make the final investment decision on Sizewell, and when will it actually supply power into the grid?

Julia Pyke: You will have seen in the press that an announcement is anticipated that the Government will take 50% of the shares in Sizewell, and EDF will keep 50%. The project will get going physically in that format, and then we hope to take a final investment decision in 12 to 18 months' time. The project is already undertaking physical work on site today. As I say, we would then expect to take the final investment decision in 12 to 18 months' time. Of course, we have to take account of macroeconomics and wait for pension fund positions to settle down.

Q78 Stephen Metcalfe: But if you have already started work, you will just abandon that work—is that what you are saying?

Julia Pyke: If we were to abandon the project—which would be very highly unlikely—we would have to restore the ground.

Q79 Stephen Metcalfe: Right. So the work you are doing at the moment is pre-final investment decision.

Julia Pyke: That's right.

Q80 Stephen Metcalfe: And if that investment decision goes against the way we would hope it might go, you would have to return the land and walk away, having made a significant loss.

Julia Pyke: Yes, that's correct.

Q81 Stephen Metcalfe: Let us assume that does not happen, and it all goes according to plan; when will you be supplying power into the grid?

Julia Pyke: The construction period for Sizewell is between 10 and 12 years. The reason I am saying between 10 and 12 is not because I am not willing to give you an exact timeline; it is because some things are seasonally dependent—depending on when we start, we either start in the right season to clear the site or we have to wait six months, and so on. We have taken a cautious approach and not built into our plans any faster schedule than Hinkley. Of course, we would very much hope that in reality we would be able to build more quickly than Hinkley, because we are delivering Sizewell as units 3 and 4.

Q82 Stephen Metcalfe: So there are two units at Sizewell—I wasn't quite sure, because you talked about the third one earlier, but it is 3 and 4. Is that 10 to 12 years from today?

Julia Pyke: It is 10 to 12 years from the final investment decision, because that is when we are able to start spending the sort of quantum that we need to spend on an annual basis to get the site going in earnest.

Q83 **Stephen Metcalfe:** So 2036—is that what you are effectively saying?

Julia Pyke: We would very much hope to bring it in before 2035, because we would hope to be taking a final investment decision in 2033, and taking 10 to 12 years we would—

Stephen Metcalfe: Sorry, do you mean 2023?

Julia Pyke: Sorry—2023, yes.

Q84 **Stephen Metcalfe:** Great. That is based upon it being effectively Hinkley 3 and 4. If you adapt the design to be able to capture more energy from it, using cogeneration or technology to promote hydrogen production, does that change the risk profile?

Julia Pyke: No. We are very firmly not adapting the design. Just to talk a bit about some of the flexibility comments that were made in the previous session, the reactor is inherently flexible, so it can load follow within about 30 minutes to between 50% and 60% of its output. But the much more effective way in which we intend to achieve flexibility is by configuring the substation—not changing the nuclear design, but changing the way we wire the substation—so that the station is able to supply electricity to the national grid when it is all needed for the grid and is able to provide electricity into hydrogen electrolysis, for example.

We also intend to use some of the heat. If you take 400 MWt of heat out of Sizewell, which is consistent with the safety case, you have very little impact on electrical output, so your heat is very cheap. That is 400 MWt of clean steam and if we use it with the direct air capture technology that we are developing, that would offset the entire emissions of the UK's rail industry. It is a very large benefit.

As to whether that means we change the design, we do one thing, which is to put in one valve with the blanking plate. We are going to put in the blanking plate, which is already priced in—we are not changing the design—and then we will see in future years whether or not people wish us to extract the heat, but we will be able to do so.

Q85 **Stephen Metcalfe:** Okay, good. Professor Grubb said earlier that the contract that had been agreed between the Government and EDF could potentially mean that there is a distortion of the market and the promotion, or lack of promotion, of renewables. I wondered whether you wanted to comment on what he said.

Paul Spence: If I can start on that one, as a company we are involved in all of the range of technologies that are on the energy system today. We do a lot of thinking about the full system and the evolution of that system, and we look at what the circumstances are. What happens when there is a wind lull? What happens when there is a very windy day? What are the electricity needs? Our central expectations are that Sizewell B, Hinkley C and Sizewell C would run predominantly all the time, because the system will need them to run all the time.

As Julia said, we are starting to think about flexibility and options for a future system. In the contract for Hinkley, we have also made sure that the question of whether there is a need to curtail anything on the system is dealt with in the same way, fairly, for nuclear and for renewables. In many cases, the sensible thing for the system as a whole in that circumstance will be to say, first of all, "Can we export that extra electricity?", and secondly, "Who is best able to turn down for a short while?" It may be that the right answer on that is for some of the renewables to turn down. It's about location as well as absolute energy mix. The contract reflects a view of the current way in which that is done, which is that it is done economically for the whole system. We believe that that is the way it should be done for the future.

Julia Pyke: May I just add this? If Hinkley were on today, it would be saving consumers more than £4 billion a year. Although people have commented extensively on whether Hinkley is expensive, it would bring down consumer prices very considerably today, because energy security essentially has not been priced into calculations of the levelised cost of electricity.

The case for Sizewell with the Department was made well before the Ukraine crisis, and the case for Sizewell is that having the right amount of nuclear in your mix brings down household bills. Although we could never deny that nuclear is expensive to build, the fact is that it then runs for 60 to 80 years with very low operating costs. Its impact on household bills, completely leaving aside Ukraine and the current conditions and gas prices, is that it brings down household bills. In return for a small payment up front through the construction period, consumers are then literally better off with Sizewell on the system than not.

Q86 **Stephen Metcalfe:** On the balance between renewables, nuclear and other sources, you said talked about deciding "fairly"; who decides? Who is the arbitrator? Is it an internal decision or—

Paul Spence: That optimisation is done by the system operator, National Grid.

Q87 **Stephen Metcalfe:** They are the ones who decide fairly?

Paul Spence: They are the ones who have the rules that we all understand about what happens in those circumstances.

Q88 **Chair:** One final thing: on the question of the cogeneration that is proposed for Sizewell—to generate hydrogen—would it not be the case that Sizewell therefore would not be an exact copy of the Hinkley reactors?

Julia Pyke: No, it will be an exact copy of the Hinkley reactors—

Q89 **Chair:** It would be an exact copy?

Julia Pyke: Other than the addition of a valve to take out steam. What we are really talking about is: how do you use the electricity? One—

Q90 **Chair:** I understand that, but obviously a lot of the case for Sizewell is based on it not being the first of a kind—we have heard extensive evidence as to the increased costs of that. Your evidence to the Committee is that this continues to be not the first of a kind, notwithstanding the fact that unlike Hinkley it involves cogeneration.

Julia Pyke: It is an exact copy of the Hinkley design above ground—an exact copy—other than the addition of one valve to take out heat.

Q91 **Chair:** I don't want to be pedantic, but an exact copy that has one difference is not an exact copy.

Julia Pyke: It is an exact copy, other than the addition of one valve.

Q92 **Chair:** The implication of your reassuring tone on that is that it will not alter the costs and the approval.

Paul Spence: Our engineers have looked at it and assured themselves and us that that has no further implications for the wider design of the EPR. We can therefore be confident that it does not, as you say, affect the cost.

Q93 **Chair:** Has the regulator—the Office for Nuclear Regulation—given you a similar assurance?

Paul Spence: Yes. We present our analysis to them; they have seen our analysis and they have assented to it.

Chair: That is very helpful.

Paul Spence: If I may, Chair, we are clearly thinking a lot about the question, not just with the EPR but with some of the other future nuclear technologies, of the opportunities for nuclear heat. One of my responsibilities is to chair EDF's research and development activities here in the UK, and we are involved in the BEIS analysis of advanced modular reactors. We are looking, at our Heysham site, at opportunities for hydrogen generation from our existing nuclear station, and at how the electrolytic production of hydrogen, heat-assisted hydrogen production and, as Julia said, things such as direct air capture can be helped by nuclear. So there is a big system case for—

Q94 **Chair:** During the course of this inquiry we will be looking at that in more detail. You have been very kind in helping us with our first session today, but we may submit some more questions to you in the course of the inquiry.

In closing, Julia, you talked about 18 months, or thereabouts, for a final investment decision. Working backwards, does that require a commitment on the Government's part in the autumn statement expected in a couple of weeks for you to be able to plan for that?

Julia Pyke: We would very much hope to see a commitment in the Government's autumn statement, yes.

Chair: Thank you very much indeed for your evidence; it is very helpful.

That concludes this meeting of the Committee.