Select Committee on Risk Assessment and Risk Planning

Corrected oral evidence: Risk assessment and risk planning

Wednesday 10 March 2021

10.15 am

Watch the meeting

Members present: Lord Arbuthnot of Edrom (The Chair); Lord Browne of Ladyton; Lord Clement-Jones; Lord Mair; Baroness McGregor-Smith; Lord O'Shaughnessy; Lord Rees of Ludlow; Lord Robertson of Port Ellen; Baroness Symons of Vernham Dean; Viscount Thurso; Lord Triesman; Lord Willetts.

Evidence Session No. 12 Virtual Proceeding Questions 131 - 139

Witnesses

I: Dame Sue Ion, Honorary President, National Skills Academy for Nuclear; Professor Stephen Richardson, Emeritus Professor of Chemical Engineering, Imperial College.

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Examination of witnesses

Dame Sue Ion and Professor Stephen Richardson.

Q131 **The Chair:** Good morning and welcome to this evidence session of the Lords Select Committee on Risk Assessment and Risk Planning. This morning we will be dealing with issues around the nuclear, oil and gas sectors. To our witnesses, we are going to be taking a transcript of the evidence session; you will have the opportunity to correct that, where it is necessary. We have two panels this morning. The first panel is with Dame Sue Ion, the honorary president of the National Skills Academy for Nuclear, and Professor Stephen Richardson, emeritus professor of chemical engineering at Imperial College. I will introduce the second panel when we come to them.

Welcome, Dame Sue and Professor Richardson. Thank you very much for coming to give evidence to us this morning. Can you begin, please, by telling us what the greatest risks are that are faced by the nuclear, oil and gas sectors and, as a result of those, the country?

Dame Sue Ion: I will focus my response on the nuclear sector. Here in the UK, we are in serious danger of sleepwalking our way out of nuclear energy as a substantial contributor to low-carbon firm power. Decisions to ramp up our intentions with respect to replacement power stations are really taking far too long. Policy is still uncertain and the risks are too great for the private sector to mobilise, so the sector, long term, is definitely not resilient.

While much of the focus on the nuclear sector deal and the initiatives such as the 10-point plan is about trying to pave the way for new reactors to be built—whether large, gigawatt-sized ones, small modular reactors or, in the longer term, advanced modular reactors—and while this is vitally important, if we are even to come close to achieving net zero, we face a more immediate threat, which is to fuel.

The UK currently has a vital, nationally strategic asset in the nuclear fuel manufacturing plant at Springfields, near Preston in Lancashire. This plant made the fuel for all of the UK's retired Magnox reactors and makes the fuel for the AGRs, and has done throughout their lives, supplying fuel and intermediate products to the international marketplace. The site is currently leased and managed by Westinghouse as part of its global business, but the site ceased to make Magnox fuel two to three years before the last Magnox reactor retired.

With the AGRs due to retire later this decade, it will cease to make AGR fuel two to three years in advance of that final retirement. At that point, its viability will be questionable, because, without a domestic customer, it does not have the volume and fuel supply to be commercially viable. The skills and jobs that the UK has had for over six decades in a globally competitive nuclear fuel market will vanish quickly.

Although noises have been made in Whitehall and Westminster about UK fuel being the source for new reactors, there are two fundamental problems. The first is that the fuel for Hinkley Point was contracted by EDF to France, not just for the first core, which would be normal practice, but for 10 reloads, without any competition. This was a fundamental error made by officials negotiating the Hinkley Point C deal. A condition for Sizewell C, if it goes ahead—and there is still a big "if" about that—must be that, beyond the first core, the fuel has to come from the UK's national plant and that Hinkley reloads must also revert to the UK.

That still leaves a gap of some years between cessation of AGR production and the commencement of manufacture of fuel for the UK's new reactors, so a much more wide-ranging deal is necessary to secure fuel production in the later years of this decade and into the next, to close the gap.

We have an undue focus on other risks and have completely ignored what is an existential and immediate risk. If action is not taken with some urgency, the UK will no longer be able to make and control its supply of nuclear fuel, and we will have lost an essential and key element of energy security through a failure to maintain the key linkage between a reactor fleet and the plant that supplies it.

The Chair: That is not a take on the issue that we were expecting, but it is, none the less, helpful.

Professor Richardson: I am not well equipped to talk about the nuclear end. Sue is so much better than I am on that, but one small point I would add about sleepwalking is the training and education of engineers in the UK, and the expertise and know-how, as well as simply the kit. Certainly, at Imperial College, we were looking at nuclear courses; otherwise, the question is whether the UK has enough professionally trained and chartered engineers in that area. Sue will know the answer to that better than I do. That is my contribution on nuclear.

On oil and gas, we are, by and large, looking at ageing infrastructure, and that is starting to give us a problem in terms of where we are. Kit is towards the end of its life, if not, in some cases, well beyond the end of its design life. That is not to say it will fall over tomorrow; nevertheless, a lot of the platforms out in the sea—I am talking offshore at the moment; I will come to onshore in a minute—are relatively ageing structures, and there are issues to do with that.

By and large, they have had their design changed over the years—we will come on to that in a minute when we start looking at systems thinking, perhaps—but they are no longer doing the job they were originally designed for. The question about exactly what a design life is for an object like that starts to become an interesting one. Having said that, by and large, they work. We are mercifully free from accidents and issues like that.

Coming onshore, the UK has reduced the number of refineries—the onshore stations that can deal with oil and gas that we are producing or importing. That means that, now that we are down to relatively few of those, if one of those were, for example, to go out of action, for whatever reason, we could be into serious issues there.

A slightly related point is looking at the onshore gas transmission system, which was originally local and generally for town gas. Then we went for North Sea gas and have converted it for that. A lot of the talk at the moment around hydrogen is about putting it down the same gas mains, where possible. Having listened to innumerable talks on the risks associated with putting hydrogen down the gas mains, they are concentrating almost entirely, from what I can see, on fire and explosions. Of course, those are not good things—you do not want fire and explosions—but there are all sorts of other issues with hydrogen, simply because it is a very small molecule that can leak easily, and it also has interesting chemical properties with steel. I am not entirely sure that the whole job has been done yet.

The Chair: This is very interesting: a loss of skills and ageing infrastructure, which are not necessarily lines we were expecting this inquiry to pursue.

Q132 **Lord Robertson of Port Ellen:** First of all, I need to be up front and say that I have been a special adviser to BP for the last 11 years. It is not particularly relevant, but I thought I would just put it on the table.

I want to extend the debate about risks. The national risk register and, presumably, the national security risk assessment really focus on major events and high-risk disasters, and draw conclusions from that. Whether it is Fukushima, Piper Alpha, Three Mile Island or Deepwater Horizon, there is a preoccupation with these things. Given the answer that has just been given about ageing infrastructure and leaks from the gas mains, should we not be focusing a little more on the day-to-day risks such as waste storage, decommissioning, minor leaks, transmission and transportation, because therein lie many of the more likely risks that we are going to face in this field?

Professor Richardson: I agree with you completely on that. Even when you concentrate on big incidents, all of them start off as small ones, and it just happens that, on that particular day, a particular set of coincidences comes together and things go wrong, so I absolutely believe that you need to look at small risks. Not paying attention to those is really important. Every big incident started as a small one, and every big incident that I have investigated was knowable in advance. I have investigated about a dozen over the years.

In other words, by paying attention to the small risks, you are starting to learn lessons that prevent you from getting the very big ones. When I say "small risk", there are lots of small risks and relatively few big ones, and so, when you look at the overall risk to the UK population or whatever you want to regard as the world in that sense, lots of small

risks give you a bigger risk overall to the public than a few big ones. What you then get into is the whole issue of public aversity to risk. They pay more attention to 167 people dying on Piper Alpha than they do to the one person a day who is killed on the roads. How one looks at these things is really important.

I should briefly add that I do concern myself with end of life; I would guess that Sue will have much more to say on the nuclear end. As I have mentioned, in the North Sea, but also with some of the nuclear structures, we are looking at what you do afterwards. Paying attention to the complete life cycle is really important.

Lord Robertson of Port Ellen: Could I put the same question to Dame Sue but add on the fact that nuclear waste disposal is one of the big public issues, which has led to the unpopularity of nuclear and maybe then to the sleepwalking out of nuclear power that you referred to earlier?

Dame Sue Ion: First of all, I would agree with everything that Professor Richardson has said. The nuclear sector in the UK, as well as in other countries, has a robust and independent regulator and formally required mechanisms to make sure that risk assessment and safety protocols are adhered to. Our sites here in the UK are regulated by 36 licence conditions covering everything from day-to-day operations and small risks to assessments for proposals for modifications to existing facilities, as well as new plant and processes. If those procedures and protocols are not adhered to at all, the regulator is able to and does step in to demand that action be taken.

On the waste issue, it is true that, in the earlier days of nuclear power here in the UK, we did not pay as much attention to waste and end-of-life issues as we should have done, but latterly there has been a massive amount of progress on that. The bigger issue around waste is disposal and the identification of a long-term disposal site. The can has been kicked down the road for many years, but latterly, through the NDA and the RWM, which sits underneath the NDA, there has been progress towards discussing where such a site should be.

On the engineering that enables the waste to be safely packaged, that has been sorted out for many years. Ever since the late 1980s, waste has been packaged as it arises, as opposed to just being left, so we are dealing with legacy waste that has to be appropriately packaged for long-term storage prior to ultimate disposal. The ultimate disposal site still remains a question, and one where we are not doing as well as countries such as Sweden and Finland, which have identified sites where the waste should go.

Q133 **Lord Mair:** I want to ask a wider question about what challenges you both see in developing risk assessment processes. Before doing that, I want to just to follow on from what you were saying, Professor Richardson. This is an engineering question from an engineer. You spoke about the difficulty with small risks and having to be aware of what might

be happening. To what extent are you and, indeed, Dame Sue, in your industries making use of the latest engineering technologies? I am thinking of surveillance technologies like non-destructive testing, sensor technologies and data analytics. To what extent are those technologies being used as a means of improving warning or, in other words, the monitoring of potential risks?

Professor Richardson: The answer is a huge and significant increase in the use of such techniques, certainly in oil and gas, over the last 30 years. Piper Alpha made a big difference. It was recognisably 1950s and 1960s technology. The lessons learned from that mean that everybody is doing a lot more monitoring. Is there more monitoring that you can still do? Yes, of course, but with the amount of monitoring nowadays—non-destructive testing and instrumentation, et cetera—the issue is almost too much data. There is now a lot of academic work and work in industry about how we handle all this data and what things it can tell us that we have not even asked the questions on yet, so that we can look five years ahead to something failing, rather than where it is now. That that is a good sign and we are in a good place.

Lord Mair: Are those technologies that you have just been describing being used to update risk assessment processes the whole time?

Professor Richardson: I would hope so. I cannot give you an honest yes or no answer on that because I am not that close to it, but I cannot believe they would not be.

Dame Sue Ion: The UK nuclear sector is similar to oil and gas in terms of the comments that Professor Richardson has made. The use of things like surveillance capsules has increased massively over the years, and certainly there has been an improvement in the ability to use digital technologies and artificial intelligence. When it comes to building new assets, the most is being made of modern technologies.

On being able to assess and review legacy assets, as much as is possible is being done to deploy the tools and techniques of the 21st century into assets that are, in some cases, over 50 or 60 years old. As much as is possible is being done with respect to the acceptance of new and emerging technologies, and being used to very good effect.

We face the same issues as any large-scale industry would with data overload and making sure that you are able to use the data that emerges in an intelligent way to inform your risk processes, but we are certainly a million miles away now from where we were 40 or 50 years ago, or even a decade ago.

Lord Mair: Would you say that risk processes are being constantly reviewed and updated in light of these new technologies and new ways of monitoring potential hazards?

Dame Sue Ion: Risk processes are always updated. One of the mandates within the regulatory process is that you have to deploy technology to improve what you already have and to move towards risks

that are ALARA and ALARP—as low as reasonably achievable and as low as reasonably practicable—so you would expect the regulator to be focused on ensuring that up-to-date technology is used to further improve.

On exactly how much is deployed, like Professor Richardson in oil and gas, I am not as close as I used to be to the day-to-day operations that occur in the nuclear sector. You would probably have to ask one of the current operators to give you a definitive answer on that, but I would expect that as much as is possible is being deployed.

Lord Mair: On the wider point, what are the biggest challenges in developing and implementing these risk assessment processes?

Dame Sue Ion: Challenges are in education, in updating, in continual professional development and in ensuring that, right from the apprentices, graduates and postgraduates emerging from the education system, these tools and techniques are embedded as daily life to ensure that, when people come into the sector, they are ready and able to contribute to HAZOP and HAZAN studies and to risk assessment generally. I would see it as being the education of new people coming into the sector, but also of those who have been in the sector for many years, to be able to be updated and kept up to speed with what they should be deploying.

Professor Richardson: UK-wise, oil and gas is in a slightly different position, although I do not disagree with anything that Sue has just said. Technical solutions are generally implemented, and implemented well and very quickly, because they are not very expensive. The much harder bit is getting the people to do them. Because a lot of UK oil and gas is offshore, it is slightly harder to inspect and to do that regularly, et cetera.

My concern, which I have aired at meetings of oil and gas people—I am normally shouted down by what I might call the conventional view of life, and then people come up to me afterwards and say, "Yes, it is actually like that"—is that the rules can say one thing but life is not quite like that all the time. It is not a bad picture, but it is not quite as rosy as it is sometimes painted.

Lord Mair: Professor Richardson, you talked about how offshore oil platforms are ageing. Is there an inherent danger there that they are no longer fit for purpose or able to fulfil the tasks that they were designed for, let alone the new tasks?

Professor Richardson: There is a danger. There is a risk, but I would say it is a very low risk. They are inspected often enough that that is unlikely to materialise, but there is an issue. The way platforms and structures like that are recorded is that, on some of these drawings, there are the words "as built", or "as currently modified". I tell my students that there are two words in the English language that you must never believe, and they are as "as built"; in other words, it is about checking that it is actually like that. With an enormous infrastructure like

a big oil platform, and not very many people in the HSE to do it, checking that what you have is what you think you have is still an issue. Is it a huge issue? Probably not. Is it an issue? I am absolutely sure it is.

Dame Sue Ion: With respect to the issues that you raised in the nuclear sector, the very fact that radiation and potential contamination is involved tends to lead all players who work on the sites to extreme caution and to making sure that they ask questions or stop if uncertain. It is perhaps not quite the same as the issue that Steve raised in the oil and gas sector.

Q134 **Lord Rees of Ludlow:** I would like to follow up on what lessons have been learned and acted upon in the aftermath of the big disasters such as Piper Alpha and Fukushima. Could I start off with Sue Ion and ask about Fukushima and, in particular, about radiation dangers? One thing that has emerged from the Fukushima reports—there was one in *Science* last week—is that perhaps the reaction in terms of evacuations was excessive and that more trouble was caused by the evacuations than would have been caused by the radiation dosage.

This is very important because, not only in cases like that but in cases of radiation leakage, dirty bombs or other nuclear-related incidents, there will be an immediate decision on how much you evacuate. That determines what the impact is on public life. I just wonder if you would like to say something about whether you are happy with the guidelines. Are they appropriate, are they clear enough and will they lead to the right amount of reaction to an emergency, rather than an excessive amount?

Dame Sue Ion: All the information coming out of Fukushima indicates that the radiation risk was minimal and that far more issues, in terms of health, mental wellbeing and everything else, have been caused due to the stress of evacuation rather than the effect of radiation at the incident. It is a general issue with anything to do with radiation from nuclear power plants that dates way back to the days of Hiroshima, Nagasaki, et cetera, and the use of the technology in atomic weapons. There are many fears that are unfounded, but it has been almost impossible for the nuclear community, and Governments generally, which are often ill-informed, to get the facts as opposed to the myths across.

In the UK, we have good, robust rules and regulations. At the time of Fukushima, the UK instituted SAGE for nuclear. Sir John Beddington chaired that and I participated in it. We were able to give advice from that committee to the Government not to evacuate UK citizens from Japan at the time, because we were absolutely confident that the risk of radiation, even in the worst-case scenarios, was not going to affect people at large. A lot of the initial reaction in Japan was born of a fear that is there and real, even though it has no founding in fact. It is very difficult to dissuade people from running and being extremely fearful when media and social media are telling you one thing and when evidence and facts are telling you another. It is very difficult to get that voice heard.

One of the things that, as an entire community, we could do better is giving real advice on radiation issues and on what people should do about it. People do not have any problems at all going to hospital for CT and MRI scans, or taking nuclear isotypes to both diagnose and cure cancer, and yet that sort of information is generally not used very much to reassure people that, although there might have been a radiation leak, it does not matter, because it is not going to affect fundamentally their health and wellbeing.

Lord Rees of Ludlow: Has that message got through to the kind of people who might have to make urgent decisions if there was a radiation leakage or nuclear accident in some city? Otherwise, there would be a huge overreaction and, of course, even worse, if we take the nightmare scenario of a terrorist attack at Sellafield, there would be an absolutely massive evacuation, unless people took account of the lessons of Fukushima. I just wonder if you feel that there ought to be more effort to ensure that realistic protocols exist for these situations.

Dame Sue Ion: Certainly, the protocols exist and the technical advice going in would be accurate and evidence-based. Whether you would be able to prevent the general populace taking things into their own hands, irrespective of the advice, in terms of evacuation, is a completely different issue and, again, one that requires much more in the way of reinforcement and giving people confidence and trust in those best placed to give advice.

Lord Rees of Ludlow: Professor Richardson, do you have any thoughts on this?

Professor Richardson: I have minor ones. They will lead into the next-but-one question, which is around systems thinking. On Piper Alpha, there were lots of little bits specifically to do with Piper Alpha itself, but the big things that started affecting the UK and other people were to do with the interconnectivity of Piper Alpha with everything else.

I can give you three quick examples. One is that the fuel in the oil and gas lines feeding into or out of Piper Alpha fed the fires on it. The other platforms kept producing, so there is connectivity in that way.

On connectivity of communications, at the time every radio channel was full, so nobody could work out what was going on, because nobody picked up the phone. There were big issues around comms.

One that is slightly beyond this is to do with the finances. Forgetting the human cost, Piper Alpha cost, in kit, £1.5 billion, but the reinsurance market paid out £15 billion because of the multiplication factor from reinsurance. Lots of people were unaware of just how complicated a single event like that is when it is that big. It affects you in all sorts of different ways. It is about getting into what system we are looking at when something goes wrong.

Dame Sue Ion: If I can go back to Lord Rees's wider question on Fukushima and lessons learned, every time there has been an international issue, there have been significant lessons learned that have led to improvement across the entire sector, internationally as well as in the UK. At Fukushima, the then chief inspector of nuclear installations was charged by the Secretary of State for Energy and Climate Change with doing an instantaneous interim report and then a final report on what lessons could be learned for the UK. Subsequently, the European Commission did the same across Europe in something called stress tests. The lessons learned had common themes and were implemented. Things like ensuring that your back-up is not vulnerable to the same natural disaster as your main asset were key things that were learned and subsequently improved.

Lord Rees of Ludlow: Finally, is there adequate concern at Sellafield about all these issues, given the huge amount of radiation potentially?

Dame Sue Ion: Because of the issues at Sellafield, with the amount of material that is stored due to the legacy on the site, attention is absolutely given to these issues. If you want more detail, you would do better to ask one of the top Sellafield operators to give you chapter and verse on that.

Q135 **Viscount Thurso:** I have a question for Dame Sue. In an earlier question, Professor Richardson drew our attention to the fact that kit usually works; it is the human beings who pose the problem. I am paraphrasing very rapidly. You interjected and said that is not such a problem in the nuclear industry because you have radiation, so you proceed slowly and do things much more methodically.

This question comes from somebody who is a friend, not an opponent. I am speaking to you 10 miles from Dounreay on the coast of Caithness. At Dounreay, several of the incidents have involved people overriding alarms. For example, a cementation container was closed when it should have been open, so the waste spilled on to the floor. I spent last weekend reading the report on the Holliday inquiry. Although it is about procurement for Magnox, it is actually about people not doing the right thing and not enough human resource.

This morning in the *Times*, we have a report about the toxic nature of the harassment and bullying culture at Sellafield. I know that is from 2017 and that the management is very difficult. Can I just gently challenge you on that statement you made, because it seems to me that people are just as much a problem as systems?

Dame Sue Ion: That is a fair challenge, but I would say that, in the end, you cannot legislate for every single human error. You have to try to ensure that the design in depth helps you to ensure that operator intervention and error should not get you into deep and unsolvable problems. Training and encouraging the workforce to whistleblow and to always seek help upwards, if they are concerned about the way in which things are being done, are as important in the nuclear sector as they are

in the oil and gas sector. All I can say is that rigorous training, policing and oversight are the only other avenues that you have, apart from defence in depth in terms of design in the first place. You cannot rule human intervention out completely. I agree with that.

Professor Richardson: When you look at Piper Alpha, every single one of the divers, who were highly trained and used to working as a team, survived, including the man in decompression. The Trusthouse Forte employees died, almost to a man, because they were not trained. There are issues around being trained, working as a team and knowing what you are dealing with. Just because you are the person who cleans the beds or makes the food—you are still an important part of the game. I absolutely buy what Sue was saying just then.

Q136 **Lord Browne of Ladyton:** I would like to pose this question to Professor Richardson first. I know he has written on this issue and, in fact, has twice anticipated this question in his earlier comments today. I can unleash you now, professor. Despite the fact that risks are rarely isolated but sit within complex systems, the national risk register contains only discrete risks and does not show their interconnectedness. To go to the heart of this, could you please outline for the committee what systems thinking is and share with us your view of its usefulness in assessing risks and building resilience?

Professor Richardson: I was indeed anticipating a question of this sort. I am not going to give you a formal definition of systems thinking or systems engineering, because as many people as there are in a room will come up with slightly different definitions. I will describe to you what its characteristics are and are not.

Systems thinking is about understanding and exploiting the relationships in anything you happen to be doing. If I am looking at an oil or gas installation or a nuclear reactor, it is not about analysis, which is where science comes in—breaking things down and understanding them in detail; it is about synthesis and putting it all back together again, so that you understand how they are going to interact with each other. Analysis becoming synthesis is one key element of systems thinking here.

Secondly, isolation, silos and disconnectedness are bad. It is all about connectedness and how things work together. I gave you three examples on Piper Alpha to do with the oil lines, the communications and the money. If you do not understand that connectedness, you are not addressing the problem.

Systems thinking is not just a good thing but is absolutely essential when you are looking at the risks associated with any installation or anything you are doing that is more than making a piece of toast. It begs two questions. First, what is the system? At the time of Piper Alpha, they looked at the platform. They forgot about the gas and oil lines. Basically, it was a safety analysis of a structure sitting in the middle of the sea, which is the wrong answer.

The second bit is that it is looking at the installation, or whatever it happens to be, over the whole life cycle, from design right through to getting rid of it at the far end. Another phrase I always use is "big picture". If you are not looking at the big picture for anything that can go seriously wrong, you are not doing a proper risk analysis.

It is easier said than done, though, to define what the system is, because how big is big? Financially, Piper Alpha started affecting the world insurance market, so, in a sense, the system there was quite big. For oil and gas, you could probably confine it to the lines connecting it to the other platforms and the ones nearby, but that is where you need education, training and judgment. There is not a little book that you look up to see, "What is the system I am looking at?" You really have to think that through. It will vary with time and with the issues that you are looking at.

If I can give you a counter-example, Grenfell Tower and building regulations—get ready to shoot me—are an example of how not to do it. That is not systems thinking. It is saying, "Let me give you certification on fireproofing and staircases, but let us never think about how the whole thing works together, how the fire brigade is going to respond or how people are going to behave in that circumstance". The human bit is as important as the technical bit. That has probably bored you to tears.

Lord Browne of Ladyton: No, far from it. The Covid-19 pandemic has given us an outstanding example of just how big the system can be. If I may offer you an opportunity to contribute, Dame Sue, perhaps you could tell us whether systems thinking is taught at the National Skills Academy for Nuclear.

Dame Sue Ion: The National Skills Academy for Nuclear is an organisation that puts together training packages, all the way from apprentice up to postgraduate, and CPD training for the operating sites right across the sector. Systems thinking per se comes into some elements but not in the way that Professor Richardson is outlining. We need to do a lot better in big-picture systems thinking throughout. It tends to come into play in doing formal risk assessments, but the extent to which you move from building to site to region, et cetera, is the sort of thing that is done in looking at potential emergency situations or emergency evacuation zones.

We need to do a lot better on systems thinking overall, not just for the immediate risks but also in things like the future energy systems, with the linkages between the different sorts, such as renewables, nuclear and hydrogen. None of that is happening at the moment. Everything is being done in silos. With the interplay between them, the delivery between the assets that generate and the grid system, and all the way to the plugs in our homes, there is a complete absence of systems thinking throughout, certainly in future energy supplies and in pretty much everything else that we do.

I did some work with the Council for Science and Technology some years ago on the interconnectivity between the electricity, water and telecoms sectors. There was just no thinking about it at national infrastructure level. It needs to be much improved.

The Chair: Dame Sue, what you have just said is music to our ears.

Q137 **Lord Willetts:** I would like to follow up on this theme by asking how we could promote systems thinking. What needs to be done to make Britain a centre of expertise? There is a very fashionable idea at the moment of digital twins, which is an advanced version of a sophisticated model of a system. To what extent can we use that kind of research technique to promote a fully integrated account of how the systems on which you two are experts interact? Is that happening? Can it be promoted? What could we do?

Dame Sue Ion: I absolutely agree with you. There are very significant demonstrations of how well it has worked in addressing the Covid pandemic. Factories were set up to create more ventilators, CPAP devices and measurement devices. Stuff that would normally have taken months, if not years, was done in three weeks. The use of a digital twin by Siemens enabled it to commission a factory that worked within days, as opposed to the weeks that it would otherwise have taken. The building of digital twins, which is much more achievable now compared to even four or five years ago, is just fantastic. I would start with the group that looks at national infrastructure and do systems thinking from the very top—how things are connected and what the different impacts would be—as well as making it a mandatory part of training in our engineering degree subjects.

Lord Willetts: One suggestion is that the National Infrastructure Commission could be tasked to devote some of its enormous budget to R&D on infrastructure. Presumably, it could be used to drive exactly what you are calling for.

Dame Sue Ion: I would absolutely agree with you.

Professor Richardson: Just to pick up on what both of you have just said, the key to this is "education, education, education", to quote somebody else. I am surprised and shocked to discover, in quite a lot of engineering courses, how little there is on risk and systems thinking. I find it surprising that people can become chartered engineers basically understanding nothing about that. It should be part of everyday life; it is just the way you work. I am surprised that it is not.

Of course, I am talking from the perspective of chemical engineering, where it is drummed into us. To become a chartered member, if you have not done your risk course and you do not understand systems thinking, you are not going to get there. I am from the land of the saints, arguably. We have a lot of work to do, and a lot of engineering institutions really have a lot of work to do.

Lord Willetts: Is the UK doing worse than other countries, or is this an

area where we could establish a comparative advantage by being a leader? Going back to Lord Mair's questions, we have a strength in some of the key technologies that you need to incorporate into this.

Professor Richardson: I will give you a personal view, and then Sue can give you the correct view after I have finished. We have a lead here. This is not meant in a pejorative sense, but a lot of engineering education is scientific; in other words, it is reductionist analysis, whereas a lot of engineering education in the UK is much bigger than that. We can get bigger still and we have something that we can do for the world there.

Dame Sue Ion: I would agree totally with Professor Richardson. We have an advantage now and can build on that and really make an impact globally if we get it right and pursue it with vigour.

Q138 **Lord O'Shaughnessy:** A recurring theme in the sessions we have had to date has been the use, or rather lack of use, of external expertise in the process of risk assessment and planning. I am very keen to get your views on this in two senses. First of all, in the post hoc disaster response or inquiry work that you have done, how much have you used external expertise? Secondly, are there ways in which we could better use it in the prevention of such events? Whether it has been the bodies in the centre of government responsible for this or those who would like to contribute more, a consistent theme is that this has been an underused resource, so I would be very interested in your views on that.

Professor Richardson: I have done quite a lot of inquiries and investigations of that sort, and they have always worked better when you have as disparate and diverse a group of people as possible. They always come to a less good result when it is closed working. It is systems thinking but now applied to the process of how you investigate these things. I am an absolute advocate of this.

There is one small downside, which is that, on big inquiries, you always get an expert who is expert in subject X and is determined to prove that subject X is what caused the problem, and will suspend belief in terms of giving evidence and that sort of thing. That is a minor thing. By having diversity, you get a much better result. All my experience on inquiries has been that that has been done well.

In terms of preventing accidents, that is also good. There is no such thing as a stupid question, so you do not have to be an expert on that particular sort of installation; you can still ask questions. A way in which I can demonstrate this is that we send our third and fourth-year students to work in industry. They have had only three or four years of education in chemical engineering, but they often ask the question of the operators of a plant: "Why do you do it like that?" In one day, one group of mine saved Shell, a well-known oil company, £20 million a year by simply reversing the order in which they did things, simply by asking a question. I believe in educating people and then letting them loose.

Lord O'Shaughnessy: If I may just briefly follow up on that, you used a

wonderful phrase there, "By having diversity, you get a much better result". If that is so self-evidently true, why do the processes of risk planning and assessment that we have been exploring not seem to stick to that maxim? What is stopping that happening?

Professor Richardson: That is a good question, which I have not thought about before, so this is an off-the-cuff answer that is as valuable as that. Particularly when you are looking at risk and associated issues—things going wrong—a lot of organisations have difficulty in airing their linen in public. I have certainly come across that. On some inquiries I have had to be quite forceful, as the expert witness, in asking the judge to direct that certain evidence be produced. There are issues to do with the claims that are going to follow from this. It is not just about looking stupid in public; it is normally about money in the end, or claims to do with blame.

I am also a strong advocate of, where possible, no-blame reporting. Near-misses are where we can really learn things, and being able to do that without being blamed for it is important, unless you are wilfully negligent or whatever. As I said, virtually every accident was knowable in advance, and all the big ones were certainly like that. Someone knew about that and we did nothing about it.

Dame Sue Ion: I agree with what Steve has just said, particularly with respect to near-miss reporting and having rigorous systems in place for that. I have seen it done and be successful, where you end up with several similar near-misses, maybe in different parts of the site or on different sites. When you look at them together, you think, "There is something systemic about this that is at issue", and that causes a complete rethink of how things are done that have led to the near-misses in the first place: whether there are common factors or features, whether a new behavioural safety programme needs to be initiated, or whether some training element has not been as good as it could have been. It enables you to take a look at what is sitting beneath the iceberg. That certainly is something positive.

The other thing that has always helped is getting expertise from other high-hazard sectors, where the exact issue might not be the same, but you get different thinking from how another sector has handled something that might be similar. That is always extremely helpful, because there are only very small elements that are specific to a sector. A lot is general: HVAC systems, pipes, valves and electrical systems in installation are often the same across the high-hazard sector, even though they might be applied slightly differently. The ability to get a different set of thinking and a different set of eyes on the problem is always helpful.

Q139 **Baroness McGregor-Smith:** This is probably quite a difficult question to ask at the end of this session, with so much that has been said, but could you please suggest one policy recommendation only that this Committee should make to the UK Government?

Dame Sue Ion: It is perhaps a different one from the one I would have originally said. On the basis of the conversation that we have had, it is putting the systems issue into the infrastructure commission space, so that it takes account of the future planning for things like the UK's energy solutions to get to net zero. At the moment, we just have no chance, unless it is considered in a systems sense, because we are going to have to rebuild pretty much all of the energy system that exists today for something that will be in place by 2050. Systems thinking could really help to get us to something that is workable, endurable and safe in the post-2050 era.

Professor Richardson: Sue has almost completely stolen my thunder. The only little thing is the one I mentioned before, which is that I would require all graduate and professional engineers to be trained in risk and systems thinking; I cannot see why they are not.

Baroness McGregor-Smith: I was reflecting on some of your points when you talked about the human interaction around all of this. Is there more that we could do there? I know that you have talked about what the graduates could do, but you talked about Grenfell and the fact that we did things in bits and never got to the overall risk; what else could we do in that area?

Professor Richardson: It is not going to be an overnight cure. In my experience, when you are changing human thinking in safety, risk and generally how people behave, it takes a decade or two to make it happen. Do not expect answers overnight. It simply becomes natural. If you had a meeting of chemical engineers, I would fire anybody who was not thinking systems-wise and about the risk of what they were proposing to do. I would just say, "Sorry, end of conversation". That has to become natural everywhere—architects, buildings and everything.

The Chair: To both of our witnesses, thank you very much indeed for joining us this morning.