



Select Committee on Science and Technology

Corrected oral evidence: Priorities for Nuclear Research and Technologies

Tuesday 21 February 2017

10.40 am

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Members present: Earl of Selborne (Chairman); Lord Borwick; Lord Broers; Lord Hennessy of Nympsfield; Lord Mair; Lord Maxton; Baroness Neville-Jones; Lord Oxburgh; Viscount Ridley; Baroness Young of Old Scone.

Evidence Session No. 1

Heard in Public

Questions 1 - 8

Witnesses

Professor Mike Tynan, Chief Executive, Nuclear Advanced Manufacturing Research Centre; Professor Grace Burke, Director of Materials Performance Centre, University of Manchester; Dr Michael Bluck, Director of Centre for Nuclear Engineering, Imperial College, London.

USE OF THE TRANSCRIPT

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

Examination of witnesses

Professor Mike Tynan, Professor Grace Burke and Dr Michael Bluck.

Q1 The Chairman: Could I welcome our three witnesses to the first evidence session on this new inquiry that we are undertaking on priorities for nuclear research and technologies? I think you will be familiar with the fact that over the last 15 to 20 years this Science and Technology Committee of the House of Lords has taken an interest in nuclear research and the need to determine strategy over what has been quite a long period, particularly noting the lacuna developing in nuclear research over many years as successive Governments have, quite frankly, failed to grapple with some of the issues. Could I invite the three witnesses, first, to introduce themselves for the record? We are being broadcast. If you would like to make an introductory statement, please feel free to do so. Would Professor Mike Tynan like to start?

Professor Mike Tynan: Thank you. My name is Mike Tynan. I am chief executive at the Nuclear Advanced Manufacturing Research Centre in Rotherham, which is owned and operated by the University of Sheffield. I have been with that organisation for almost four years. Prior to that my background was entirely in the commercial nuclear industry. I was chief executive for Westinghouse in the UK and, prior to that, managing director of UK Fuel Business for BNFL at Springfields. My principal interest is the development of a competitive UK supply chain for civil nuclear going forward and to ensure that we get maximum value from the UK civil nuclear industry, both at home and overseas.

Professor Grace Burke: Good morning. My name is Grace Burke. I am a professor of materials performance, and I am the director of the Materials Performance Centre at the University of Manchester. I have held that position for the past five years. Prior to that I was a consultant in materials technology at the Bettis Atomic Power Laboratory and with the Westinghouse Science and Technology Center. From my PhD days at Imperial College, I have close to 40 years' experience in nuclear research and development, focusing primarily on materials for nuclear power systems and power generation, and the effects of radiation and environmental degradation. We try, in the Materials Performance Centre, to ensure optimised materials for maximum performance, thus providing safe reactor operations in fission.

Dr Michael Bluck: My name is Mike Bluck. I am the director of the Centre for Nuclear Engineering at Imperial College. The college has in excess of 50 years' experience in nuclear, and the Centre for Nuclear Engineering is an umbrella body that supports research, education and collaboration across activities in the nuclear spectrum nationally, internationally and with industry.

Q2 The Chairman: Thank you very much. I have to remember, as do other members of the Committee, to declare an interest when first we speak. The only interest I have to declare is as a fellow of the Royal Society. Could I ask a very general question as a start? I mentioned earlier that

this Committee has taken a long-term interest and has produced several reports about the need for a long-term consistent strategy for nuclear research. Where do you think responsibility lies for ensuring that the United Kingdom has just that? I do not know who would like to start.

Professor Mike Tynan: In my view, the principal responsibility for the UK programme has to sit with government, and within government in the Department for Business, Enterprise and Skills. There has to be a mechanism for delivering that responsibility. I think the formation of the new Nuclear Industry Council is a positive step, and that council should be the instrument for taking forward the strategy for civil nuclear in the UK.

The Chairman: Would either of the other two witnesses like to add anything?

Professor Grace Burke: I, too, believe that the responsibility should lie with the Government. If BEIS is the appropriate organisation for a new entity that needs to be found, I agree.

The Chairman: Of course, there are a lot of different government departments. There is BEIS, as it is now called, and there are the devolved Administrations, which have an interest, and clearly there needs to be a degree of intergovernmental collaboration, at which we have not always been conspicuously successful, particularly as there seems to be a completely different nuclear strategy in some of the devolved Administrations.

Dr Michael Bluck: Yes, that is a problem. Nevertheless, I would agree that clearly—and I think you have already made the point—we are missing a strategy. That has to come from government. How that plays through in the delivery is open to question. We used to have the UKAEA as was, as opposed to the current incarnation, which was tasked with delivery of that. That should sit under BEIS. You could look at the US model to a degree, where there is a far closer relationship and far more coherent model of nuclear within the DOE. I think they have benefited from that, although the US has its own issues.

The Chairman: Professor Burke, I know that you have some experience of working in the United States. What could we learn from the research and development system adopted in America? Is there anything that we should take note of in order to have a more effective long-term strategy?

Professor Grace Burke: Yes. Following on from what Dr Bluck said, the Office of Nuclear Energy in the Department of Energy is the focal point for the research that is funded in the US, so there is policy as well as research funding. In the UK, most of the funding comes from the EPSRC, the Engineering and Physical Sciences Research Council. I think there has been great benefit from the research councils being linked with the US system. This has been done with the Nuclear Energy University Programs—the NEUP. We have had several programmes where we partner with colleagues in the US. Proposals are written and evaluated in the US under the DOE guidelines. It funded the UK Research Council sponsors of funds, the UK participants, so a team effort has developed.

That has been incredibly effective. However, it is very small scale. Generally, a maximum of three or four programmes per joint cycle are funded that way. I think that something along these lines could be expanded and that it would maximise the benefit to the UK by partnering and doubling the funding going into research efforts. It is also good for international collaborations and getting excellent people in training.

The Chairman: Could any of our witnesses give a view on the expanded remit of the Nuclear Industry Council compared to the previous role of NIRAB?

Professor Mike Tynan: I am a member of the Nuclear Industry Council, so perhaps I could start with that. The role of the Nuclear Industry Council encompasses the entire scope of a programme for nuclear in the UK. I think it is important to ensure that we link civil nuclear with defence, and that strategies for nuclear should encompass the entire market, because that will drive issues such as research and development, supply chain development and skills programmes. If you look at the industry itself and move down through the supply chain, a lot of the suppliers are supplying into the entire industry, which includes defence and civil nuclear. That is one benefit for the Nuclear Industry Council.

Secondly, if the Nuclear Industry Council can help to develop an overall strategy, contribute to overall industrial strategy and develop a sector scheme for nuclear, that will encompass the broad range not just of product that we will need for nuclear but all the supporting and facilitative activities that go with it, as opposed to NIRAB, which was a board that attempted to co-ordinate research across civil nuclear and defence. Its principal role was to identify priorities going forward for R&D and it was restricted to that remit. It had no oversight of those programmes. It had no responsibility for executively delivering those programmes. Again, that is a difference from the Nuclear Industry Council: it can take a role in delivering strategy.

The Chairman: Thank you.

Lord Hennessy of Nympsfield: Can I follow up on that? I should declare that I have nibbled a little at the history of civil and military nuclear power, so I should declare I am a fellow of the British Academy and a professor of contemporary British history at Queen Mary University of London. Would I be right in thinking, Professor Tynan, that the Nuclear Industry Council already has that civil military remit right across the piece? For example, will you have anything to do with the development of the PWR3 for the new Dreadnought-class submarines?

Professor Mike Tynan: That is interesting, because the first meeting of the new council is not until tomorrow.

Lord Hennessy of Nympsfield: Tell us the agenda.

Professor Mike Tynan: One of its first challenges is to develop an appropriate agenda to keep it strategic. The previous Nuclear Industry Council was formed from the Nuclear Development Forum in 2007-08, which was focused principally on nuclear new build. It was a forum for government to help to develop and understand how things were

progressing with facilitative actions, such as the development of GDA, infrastructure planning and funded decommissioning plans. That turned into a committee that started to get involved in a lot of the detail of civil nuclear and then started to incorporate decommissioning and existing operations. That committee grew organically. The new Nuclear Industry Council, which is much reduced in membership and is intended to be more strategic, should address the defence issue and be prepared to put some action plans in place to make sure it happens.

Lord Hennessy of Nympsfield: Thank you.

Lord Maxton: The Chairman quite rightly raised the question of the devolved Administrations, but I live in a part of the United Kingdom that has said no to all nuclear energy. It is going to run down the nuclear plants it has and will not build any new ones, even where they are proposed. Does this affect in any way the policies that you would propose? Does it, for instance, affect the research done by the Scottish universities?

Professor Grace Burke: I would imagine that if the UK wants to be a world player in nuclear energy, and if the plants are not built here, but if there is an interest to moving to SMRs on an international scale and for the UK to provide international guidance and expertise, the research would still need to be performed.

Q3 **Lord Mair:** I should start by declaring an interest. I am a fellow of the Royal Academy of Engineering and a fellow of the Royal Society. I am also a professor of civil engineering at Cambridge University, and I am an engineering adviser to the Laing O'Rourke group, which is the civil contractor for Hinkley Point.

My question follows on from what we have heard about and the question of co-ordination between the various bodies involved in nuclear research. Is that good enough at the moment? If not, how can that be improved?

Dr Michael Bluck: In one sense, given the remit that we have inherited, which is a remit to deal with waste and decommissioning, I think that we probably do a good job. I think the co-ordination is quite good, given the funding that has arisen out of it.

On the question reactor engineering, looking forward to a strategy through which we develop reactors, again I think there are some very good relationships between national labs, facilities, universities and industry. There are some very good models. That is not to say it is sufficient for an ambitious project that involved a significant programme. Again, we go back to the issue of co-ordination and some degree of authority that can take action and make strategic decisions and impact right across the sector. We have rightly looked at the industrial aspect of this, but what feeds industry is skills development at all levels. Universities are an obvious candidate for focusing in that area, and they have a great deal of skills in nuclear.

Having said that, we lack co-ordination, again because the co-ordination that we have is based on the small number of modest projects that we

have fought for together. We are a friendly club but one that probably picks up fairly piecemeal activities, frankly. We are not really engaging, or able to engage, in a large programme. Any large programme of new build, or industrial activity, would have to be supported by an appropriate educational strategy in support of that. The current system is to let universities provide those skills and do what they like, and to hope that demand drives that capability. I do not think that is enough. There has to be a strategic overview to say throughout skills development, "We need to take action to provide that if we are going to fulfil our role".

Lord Mair: May I follow up on that? That is very interesting. Do you think there is a single body in an ideal world that could co-ordinate this in a much better way? Which body should that be?

Dr Michael Bluck: In skills development?

Lord Mair: Not only in skills development but more in research and development. Is there a single body that should co-ordinate R&D?

Dr Michael Bluck: You have to look at where we were when we were building reactors. We had a very coherent set of bodies. We had the UKAEA, of course, and we had the support of the CEGB and its associated national laboratories. They had extremely good relationships with universities that maintained skills and capability throughout. So, yes, I think there is, and I think it is necessary.

Lord Mair: Who should do it?

Dr Michael Bluck: In this context, everything is under BEIS. That said, we are stretching out into different departments, such as the Department for Education, so it is not the only one. We need something with executive authority that is tasked with meeting a strategy that it could be measured against rather than the piecemeal activities that we currently have.

Lord Mair: Are you talking about the Nuclear Industry Council?

Professor Grace Burke: I was going to add that the Office of Nuclear Energy of the Department of Energy in the States handles all of that. The industry group that interacts with the DoE on nuclear energy is the Electric Power Research Institute and its component that deals with nuclear energy¹.

Professor Mike Tynan: Can I break down the problem with co-ordination into two pieces? The first is the co-ordination of funding, which is an issue for nuclear R&D. There are different sources of funding. We are now seeing a growth in potential regional funding, so LEPs can fund

¹ Additional information: The US Dept. of Energy Office of Nuclear Energy also receives advice/input from the Nuclear Energy Advisory Committee-NEAC, which is composed of representatives from US national laboratories, industry, universities and foreign experts. In the US, the Nuclear Energy Institute, an industry-based organisation in Washington, DC, campaigns for legislation and regulatory issues affecting the nuclear industry and serves as a "think tank" to influence US policy. Furthermore, the DOE also engages with the Nuclear Innovation Alliance and the Nuclear Infrastructure Council, both of which are nuclear industry organisations.

locally on activities that they believe will create value. You have central funding, which tends to come from BEIS, and that could be on a business programme or on innovation, and the sources of that funding are different. Then you have commercial income on collaborative work on research and development. There is an issue as to whether we understand exactly where the funding streams are and whether they are addressing the right things.

I believe that there should be one organisation that co-ordinates research and development activity. Coming from industry, one of the things that works is clear accountability. Who has the clear accountability for delivering a programme that is centrally supported for nuclear R&D in the United Kingdom? In my opinion, that should be a national lab. I am not saying the National Nuclear Laboratory, I am saying a national lab. Currently there are a couple of organisations that fit that bill. One is the National Nuclear Laboratory, referred to as the NNL, and the other is the United Kingdom Atomic Energy Authority. There are lots of other organisations with an interest in nuclear research and development in the UK, but in my opinion it should be brought together under one executive authority, and that executive authority should be responsible to BEIS. BEIS's principal mechanism for its strategy would be the Nuclear Industry Council.

The Chairman: There is a recurring theme in many of the reports that we have done leading up in particular to the industrial strategy, which has recently been announced, of a need to bring together industrial research and academia—publicly funded, that is. Professor Tynan, wearing your Nuclear Advanced Manufacturing Research Centre hat, how would you like to see this develop? Clearly, every sector likes to see better collaboration. What do you think the opportunities are in the nuclear research field?

Professor Mike Tynan: The very first comment I would make is that the Government have placed nuclear R&D back on their agenda after a 20-year or so absence. That started in earnest in 2011 with the Beddington report, and we have a reasonable focus on that now. We must not let that slip back off the agenda again. That is the first point I would make, on whichever aspect of nuclear research.

From my experience, we should reflect on things we do well and look to build upon that. In the world I live in, which is trying to link government intent and funding with industry ambition and funding, and academic input and research council funding, one of the things that has worked well is the High Value Manufacturing Catapult. That brings seven centres together across the UK and Scotland as local catalysts, not just to focus on what happens in a region with a particular technology but to help to bring a sector focus. We have a sector focus on nuclear, a sector focus on aerospace, a sector focus on automotive, a sector focus on materials such as composites, and a sector focus on processes such as big machining and big welding. Those centres have provided a mechanism for bringing together interested industry, government intent and academic research. It has worked extremely well. Any mechanism such as that that facilitates collaboration, not just on intent and research topics but on funding, and

brings commercial funding into it to give some direction so that we can lead from generic research right through translational research into product, brings indigenous value to the entire UK through an R&D programme that supports industry.

There are another couple of other things. One of the things I have seen work well in the industry is UKTI, which every year has a showcase over two days of what is available in the UK civil nuclear industry. There is scope for some form of UK nuclear research and development showcase that helps to show people the opportunities that UK research and development.

Finally, when we develop a sector deal for nuclear and propose a sector deal, a fundamental element of that should be the forward R&D programme.

Lord Broers: You are focusing on one part of that?

The Chairman: Are you declaring an interest?

Q4 **Lord Broers:** I suppose so, yes. I am a fellow and past president of the Royal Academy of Engineering and a fellow of the Royal Society. I am also a member of the US, Chinese and Australian academies, where I have had interests in energy. This question relates to NNL, your experience of working with NNL and whether it has an appropriately defined role and remit. I think, Professor Tynan, you have had direct experience with this and have helped to restructure BNFL, its precursor. How is NNL doing?

Professor Mike Tynan: I can talk about it from past experience and current experience. Currently, the nuclear MARSEA's experience of four years working with NNL is very positive. We find them supportive, collaborative and professional. They have unique experience in the United Kingdom, and probably thousands of man-years of experience in civil nuclear and the challenges it faces. That exists within their organisation. The difficulty for NNL, I think, is that its role as a national lab is unclear. It has a commercial remit and I think that has the potential to reduce its independence. It also drives programmes that are commercially driven and not necessarily on research priorities, so its resource can be diverted from possibly national imperatives by having to focus on commercial business. Neither is the National Nuclear Laboratory a university, so it is not purely academic. Its current mission, between having to sit in this quasi-commercial position and to some extent being an independent adviser to government yet funding itself through commercial work and work with commercial clients is a difficult role for it. I think some clarification of that role would help.

Also, there are some challenges that National Nuclear Laboratory is specifically equipped to deal with, and that is waste management and decommissioning for the long-term programme. However, we should not forget they have the ability to do front-end work on new technology and for fuel manufacture, and the UK is a fuel manufacturer. I have a positive view of NNL. However, I think its remit, if it is to be the national nuclear laboratory, needs to be significantly clarified.

Lord Broers: What about it becoming a catapult?

Professor Mike Tynan: That is an interesting concept.

Lord Broers: The High Value Manufacturing Catapult is a huge all-embracing one, with particular manufacturing emphasis, but it would seem to me, as we evolve a strategy in nuclear, particularly if we want to become a world supplier of nuclear stuff, that it might be an idea as we begin to understand what catapults can achieve.

Professor Grace Burke: My colleagues and I have also had experience with the NNL going back several decades. As a national laboratory to generate the most cost-effective research, development and possibly the catapult concept, ideally it should be fully funded and not diverted into commercial contract work. As it is, it is incredibly difficult to have NNL participants in research programmes in which specific staff are uniquely qualified in the UK and the world. Currently, it is not impossible to have them formally involved with EPSRC programmes as they require direct funding to their participation. If it is a national nuclear laboratory and you intend to get the best world-class research and development out of it, in an ideal world it would be solely funded and not have to rely on soliciting commercial contracts.

Lord Oxburgh: I am a fellow of the Royal Society and the Academy of Engineering, various overseas academies and chairman of three small energy-related companies. Can we pursue the NNL position at the moment? I think it is a schizophrenic organisation in the sense that its funding can only come from its commercial activities. On the other hand, it has the role of adviser to government and in fact overseeing a strategy that it has no funds to implement, in essence. Would that be a fair assessment?

Professor Mike Tynan: Yes.

Professor Grace Burke: Absolutely perfect.

Dr Michael Bluck: It is important also to stress the sort of numbers involved in research activity: the contract work that it does principally for Sellafield.

The Chairman: Your recommendation to the Committee, when we come to write our report on this, is that it should be solely government funded.

Professor Grace Burke: In an ideal world.

Dr Michael Bluck: If it is doing a good job on waste and decommissioning, there may be no particular reason to interfere with what may be a good system, but if that releases a paltry amount of cash based on that profit that it has only recently been allowed to recirculate into research, then plainly, as everyone has said, it is not fit for purpose as a national nuclear laboratory.

Professor Mike Tynan: There are two points about its funding. A principal customer for NNL is Sellafield Limited. Sellafield Limited is funded by the Nuclear Decommissioning Authority, which is funded by government. While the National Nuclear Laboratory competes for work,

there is certain work that only it can do. That adds some complexity to the situation. You could argue that government is already funding a substantial part of it anyway.

Secondly, we must not forget the United Kingdom Atomic Energy Authority. There is some fantastic skill there, too. Culham is a world-leading facility with 1,000 or more people with tremendous knowledge. It is a tremendous research base for the UK. We would have to consider what a national lab looks like as an entity, rather than saying that the National Nuclear Laboratory should be funded as it currently exists. The idea of a catapult concept that someone can co-ordinate but that brings together some tremendous institutions in a very collaborative and co-ordinated way, as the High Value Manufacturing Catapult does, is worth thinking about, but let us not forget about the Atomic Energy Authority.

The Chairman: Perhaps we should move on to SMRs, and Lord Oxburgh.

Q5 Lord Oxburgh: Yes, indeed. There is a lot of current interest in SMRs. Clearly the proponents of a particular technology are keen to say that it is a great thing, a thing of the future. What do you think SMRs could bring to the UK electricity generation system as a whole? It is probably going to be 10 years before an SMR can make a significant contribution to the UK electricity energy system. The system itself has certain characteristics at the moment, which are broadly clear. Clearly there will be some traditional nuclear, and clearly there will be intermittent sources coming in from it. What do you see as a key role for SMRs in this future system? It will involve significant investment. Can one justify it in terms of the system?

Dr Michael Bluck: The answer to that question depends very much on which SMR to a degree. If you want to deploy one in 10 years you are looking at relatively conventional technology. The argument one could make is that they could be located more effectively within a distributed mixed grid, although you then have to throw in the licensing and public acceptance issues.

Lord Oxburgh: Yes.

Dr Michael Bluck: It is not always clear that it is vital for the SMRs to contribute to that. That is a complex argument. The ability of a fluctuating grid to mitigate intermittency again depends on the technology, because some technologies do not necessarily lend themselves to load following, although some do.

Lord Oxburgh: The French flex their big reactors for load following, probably damaging them quite a lot.

Dr Michael Bluck: They do. They would not necessarily choose to do that, but they would be better suited than large reactors perhaps, depending on the technology, to mitigating intermittency.

Lord Oxburgh: Presumably the time constants of response are short because they are small.

Dr Michael Bluck: That is right. They can be relatively short, but there are more complex and more innovative approaches to dealing with the sort of timescales that you want that to respond to. It does not have to be an SMR solution; there are other combinations of technologies that you could use with it.

Professor Grace Burke: I agree with my colleague. While there may not be huge demand in the UK, the SMRs, even those based on gen III+, the light-water reactor design, have strong possibilities as an international player in the nuclear field, particularly for remote areas. Canada is a particularly well-suited candidate, as are countries in South America, in Africa possibly, and in some European countries. If the UK were to embark on this or continue to move forward on the SMR, I think it would stand a very strong chance of positioning itself as a major international player, an expert in the field, so I would encourage the work on SMRs.

Lord Hennessy of Nympsfield: This ties in with the conclusion of the National Nuclear Laboratory's small modular reactor feasibility study a couple of years ago, when they concluded, as you have, that this is a great opportunity for the UK to regain technology leadership and the ownership and development of all this. I do not know whether you accept this view, but I think that quite a deep psychological scar has been left on our nation since we ceased to be the manufacturer that we like to imagine ourselves to be. A particularly deep, scored scar is the loss of what we regarded in the 1950s and early 1960s as a very promising civil nuclear leadership in the world. Is there not a danger—I do not want to sound sceptical—of what the great Alan Watkins, the political commentator, used to call a new dawnism, and that those of us who are rather keen on a nuclear revival, and I would include myself in that, tend to fall into a kind of psychologically comforting sleeping bag: that this time it might be all right—we did it once, we led the world, we let it go for 20 years, this Select Committee never gave up on the case but many others did. Are we not all collectively succumbing to dawnism?

Professor Grace Burke: I do not believe so, because with the state of knowledge that has been gained over the last couple of decades—even with the UK not being really active, particularly in the Gen III+ arena, as there is only one PWR here in the UK—now, internationally and through our linkages, we have come to a position where we can capitalise on our international collaborations, on the new expertise, and move forward in this area.

Lord Hennessy of Nympsfield: What has to be there that is not there for that to happen? There is an air of tentativeness about all this, and a kind of alphabetical soup of all the oversight bodies. Where is the driver that this time will make the difference, so there is no more slippage?

Professor Mike Tynan: For nuclear?

Lord Hennessy of Nympsfield: Yes, for the SMRs.

Professor Mike Tynan: There are two things to consider with the SMRs, broadly speaking. The favoured models for quickest deployment at the moment are LWR and PWR derivatives. With them you could broadly

meet the 10 to 12-year timescale, and we might have something operational by 2030. Who would argue that as part of a balanced portfolio of energy production in the UK it would not be a sensible thing to do?

Two things would stimulate that. First, the SMR has to be economically viable and bring indigenous value to the UK. To put that into context, it would have to mean value derived from significantly cheaper energy prices, certainly cheaper than the current prices quoted for gigawatt-plus units, so SMR would need to deliver on that. It would have to create long-term, sustainable, high-value jobs. It would have to stimulate the UK supply chain, particularly for advanced manufacturing. It would have to provide intellectual property ownership for the UK. That would have to translate into value by export sales. One of the challenges is not to forget that the rest of the world might move with SMR—seriously competitive countries such as China could move with it—so SMR development, if you want to deploy globally, could be a first-mover opportunity, and if you do not move first you could be second and you will struggle to get into the market. That is a consideration.

The second tranche of benefit is what I would describe as an economic transition to a low-carbon economy. SMR could also provide that. Indigenous economic value and economic transition to a low-carbon economy both sit in the Department for Business, Energy and Industrial Strategy, so it is clear where that would sit. If we cannot provide significant, long-term indigenous value from an SMR, the case is not made. The challenge for developers is to make that case. They are attempting to make that case through the competition.

The other challenge is that if you are further down the line, and if it is government investment that we are talking about here, does government invest in long-term technology? I know there is an issue with gen IV technology, so that becomes a bit of a challenge. If we want to develop gen IV technology, is the money available to do that and to develop a current derivative of PWR that would help us in the energy challenge in the short term?

Lord Oxburgh: Just to pursue that question, given that a lot of the advantages of PWR are that you can build off site and prefabricate, the economies come into the volume, do they not—the fact that you have lots of them?

Professor Mike Tynan: Yes.

Lord Oxburgh: Do you have any inkling of the sort of scale of deployment you would need to have for example in the UK for this to be a sensible activity and to provide the base for deployment in other countries? How many would you be looking for?

Professor Mike Tynan: It is the second point that is important. If it was just an SMR for the UK market, I do not think that would be viable.

Lord Oxburgh: No. I am starting from the position that no one is going to buy your stuff unless you also deploy it at home. I am asking what you think is a reasonable number to be thinking of as the UK deployment on

which you could build much wider deployment elsewhere. Do you have a view?

Professor Mike Tynan: I could speculate that you would need at least 15 to 20 units minimum in the UK.

Lord Oxburgh: Okay. That is the sort of feeling.

Professor Mike Tynan: Yes.

Baroness Young of Old Scone: I was looking at this from the other end of the telescope and starting with British energy.

The Chairman: Do you have any interests to declare?

Baroness Young of Old Scone: I should declare my interest as a chancellor of Cranfield University and a newly elected honorary fellow of the Royal Society of Edinburgh.

The Chairman: Congratulations.

Lord Oxburgh: No nuclear there.

Q6

Baroness Young of Old Scone: No nuclear there. Looking at the principles of the current Government's energy strategy and at the potential development of SMR, how realistic is it that the SMR programme will get to a point where it is genuinely economically competitive in energy output? It is quite a long way away from that at the moment.

Professor Mike Tynan: No. I think it is completely viable. If decisions were made now and we could get technology into generic design assessment, we could be through generic design assessment in 2021, 2022. Then, with appropriate investment, it is realistic to see units online before 2030. The big units might come online at Hinkley Point, Wylfa, Moorside and Sellafield in the mid-2020s at the earliest. I suspect that for the bulk of the unit it will be beyond that. The first unit might be online in 2026, 2027. I think that is very realistic and that the developer's claim to be able to get this in the current wave of development has a solid foundation.

Baroness Young of Old Scone: The only comparative costs I have seen on the cost of energy generated in that way have been comparisons with the larger-scale reactors. How about the rest of the energy market? It is pretty expensive energy.

Dr Michael Bluck: That is a broader issue. It was said, when Hinkley C was being debated, that these appear to be very big numbers. As you said, there is a great degree of uncertainty in those numbers. As we look forward, everything that we are talking about are 60, 70 or 80-year programmes. In particular, it addresses your issue of new dawnism, as you called it. The short-term, more conventional designs, if you like—the PWR, the light-water reactor designs—are well-understood technologies. It is not a new dawn of some claim to new technology. Of course, we already make reactors of that sort of size for our submarine fleet. They are very different in nature, but the manufacturing challenges are challenges we already meet. Some of the significant cost challenges of

the very large reactors, the very big capital investments, are in part mitigated by the ability to run a production line of development, so you are tightly focusing skills on a single activity running along the production line rather than having to do this very inefficient thing of building something on site and moving everyone somewhere else. You have tighter control over consistency and quality.

Quality is a big issue, as you have seen for the large reactor designs. These are all controllable things. The costs are much more controllable. I do not think there is the technological uncertainty, at least for light-water reactors, that there is for the more ambitious designs down the road. Of course, one possibility is to go for an ambitious design that leapfrogs the technology, but that is a hugely risky activity. It would probably be better to go with a more conventional technology that you have a high degree of trust in. You have some bound on the cost that would give you the capability further down the road.

The Chairman: Lord Ridley, did you want to come in?

Viscount Ridley: I thought that might be a good cue to go on to the next question.

The Chairman: One point, to wrap up. Baroness Young phrased her question in terms of energy production, but as I understand from Professor Tynan we have to think very much wider than energy production. You talked about advanced manufacturing, presumably combined heat and power, chemicals, and the like. Presumably all these have to be put into the economic valuation if a case is to be made, and we must not restrict ourselves to thinking energy. Do I understand you correctly?

Professor Mike Tynan: Yes, you do.

The Chairman: Thank you.

Lord Broers: Chairman, I have one final question on SMRs. What do you see the international competition being? I would see our most serious problem as being that we will think that we can do it in good old British time, and somebody else will do it in about a third of that time.

Professor Grace Burke: The Department of Energy in the US has already embarked on an extensive programme funding SMRs, and I believe it has committed a total multi-year sum of about \$452 million (2013)^{2,3}. I would imagine that the US will move along quite merrily on that.

Lord Maxton: What is the timescale for that?

² This figure relates to the two advanced reactor designs being pursued by DOE-NE.

³ Furthermore, the DOE Office of Nuclear Energy has committed approximately \$82 million cost-shared with two consortia for Advanced Nuclear Technology in 2016, which includes further development of two reactor designs: 1) X-Energy Xe-100 Pebble Bed Advanced Reactor (with BWXT, Oregon State University, Teledyne-Brown Engineering, SGL Group, Idaho National Laboratory and Oak Ridge National Laboratory); and 2) Southern Co. Services Molten Chloride Fast Reactor (with TerraPower, EPRI, Vanderbilt University and Oak Ridge National Laboratory).

Professor Grace Burke: They have already started the SMR development program (2013), and had allocated approximately \$450 million. I am not certain about the end date on this and whether it is a 10-year programme or not.

Q7 **Viscount Ridley:** I want to take that leapfrog to generation IV technologies: molten salt, molten lead—that sort of thing. Before I do so, I declare that my only energy interest is in coalmining in Northumberland, but Lord Hennessy reminds me that coal has uranium in it, although at a concentration of less than 20 parts per million. The question is: should the UK be involved in the development of generation IV technologies? In particular, should that UK activity include the development of one or more test reactors?

Professor Grace Burke: I believe that Generation IV reactors are fairly far off into the future. The price to be involved in this endeavour would be quite high, so I think it will require a lot of serious research funding to develop appropriate designs and the materials research that is needed to go with that.

Viscount Ridley: Do we sit back and let the Chinese do it, then?

Professor Grace Burke: There are activities going on in Europe and in the States, either via collaborations or partnerships. I believe there is a good route forward if the UK wants to be involved with Gen IV, but there is a long lead time on that (for successful completion).

Professor Mike Tynan: There are two bets here. We can participate in existing gen III technology ownership through an SMR, but we are not going to achieve that through a gigawatt-plus reactor; they are designed and through licensing, and have their schemes. SMR allows us to participate in current activity. However, if the UK wishes to be a genuine technology owner, we will have to look 50 to 100 years hence. We simply must do that; there are no short-term decisions in nuclear. My answer to your question is a resounding yes, we should participate in gen IV reactors and, yes, we should develop a test reactor in the UK. That needs a decision that the UK will move back into technology ownership in nuclear and that it will seek to deploy that on a commercial basis around the world. That is the strategic decision that has to be made. As Grace says, that is not going to be cheap. It is a long-term investment and a real strategic move is needed to do that.

The alternative, as you say, is that we are a nuclear nation in that we have nuclear electricity on our grid, so do we allow people to come here with their technology and we become excellent operators, maintainers and decommissioners and maintain a nuclear industry that is about a service industry rather than technology ownership? That is part of the debate that will go into the strategy, I think, with the Nuclear Industry Council. Do we move into technology ownership in the long term? My answer is yes, I think we should.

Dr Michael Bluck: It is very easy to see gen IV, which is quite a distant technology, from the perspective of 2017. What it will not be, come 2040 or 2030, or whenever we embark on these things, is anything like what

we see now. To make decisions based on current technology and the challenges there, based on a technological status as we see it, is short-sighted. I agree with Mike that light-water SMR gives us a capability. Together with the co-ordination—we have also discussed those aspects—that is a good stepping-off point and a good step towards engaging in gen IV, or whatever generation is appropriate at the time, that meets these desires to deal with waste.

Viscount Ridley: I have heard the argument put that if everybody is trained in light-water reactors there will not be good enough people to train them in molten salt reactors, for example, which is a very different technology.

Dr Michael Bluck: Again, that is exactly why we need something to co-ordinate activity, so that, yes, we are doing light-water reactors but we also have an activity that early on may be more in the university sector in order to start thinking blue skies about some of these activities. That would clearly be an enabling technology. We need strategic oversight so that somebody can decide, "This is an activity that we wish to promote. We do not know where we are in it, but we need to be technologically prepared for it, and this is our light-water activity." Materials activities are common. The only difference that we are talking about might be the speed of the neutrons and their various different aspects. The expertise, the ability to own microstructure and the effect that has on structural integrity, and all other technologies that Mike has mentioned that are beyond nuclear will be brought to bear. There is no reason why we should make an either/or decision. I would not want to choose a gen IV technology today.

Professor Grace Burke: And there are no materials available for those yet. There are severe materials challenges for aspects of Gen IV reactor systems.

The Chairman: We are coming to the end of the session. Lord Broers has the final question.

Q8 **Lord Broers:** What effect will leaving Euratom have on the UK's participation in long-term nuclear research and development projects? What relationship should the Government seek with Euratom after the UK has left?

Professor Grace Burke: I can probably take the first stab at that question, as a non-UK citizen. It is disheartening that the Government are going to withdraw from Euratom, as Euratom predates the EU and the common market. We have built up a lot of collaborations and common policies and shared a lot of expertise with Euratom. It will be a negative on our research environment. It will probably be possible to engage in a similar manner to non-European countries such as the States, Canada and Japan. However, it is a negative.

The Chairman: On the Euratom issue, as the Brexit Bill goes through Parliament we will have an opportunity to try to get greater clarity from the Government, which is clearly much needed. It is clear that since Euratom was originally formed we have had something called the

European Union (Amendment) Act 2008, which joins the European Union and Euratom at the hip.

The Leader of the House, in her speech yesterday, which opened the debate that is being conducted at the moment, said, "Our future relationship with Euratom will be a matter for negotiations, and the Prime Minister has made clear that this is a priority area", and she went on to say how important it is to continue to have effective arrangements for civil nuclear co-operation with our international partners. I think we have an opportunity, during the Committee stage, to try to get greater clarity without necessarily tying down the negotiating hand.

The trouble with this particular announcement, which came in the Explanatory Notes on the Bill, is that no one quite realised that if you left the European Union it followed automatically, because of the 2008 Act, that you had to leave Euratom. When you start mentioning some of the other implications, such as being subject to EU law and therefore to the European Court of Justice, you realise that you are in something of a complex area here, and it is not just a question of making sure that we remain collaborative members of Euratom.

Lord Oxburgh: May I ask one quick question? Which of the UK nuclear interests interact with Euratom? Where are the Euratom interactions?

Professor Mike Tynan: Fusion is the biggest interaction and potentially the programme that could suffer most.

The Chairman: There was great consternation at Culham when this announcement was made. I am not sure that they are any the wiser as to what relationship is likely to be developed. That is a negotiating matter. Alas, this Bill is not going to solve it, but we might be able to elucidate the issue. We also have an opportunity in this Committee to ask the Minister further on that, but it is a worry.

Dr Michael Bluck: It has an impact on the transport of materials. With greater decommissioning and waste, we are not fully geared up to where we want to be on reactor engineering, and that will require investment. There will be facilities that we do not have, and that may involve the transportation of materials to and from facilities in Europe that we use.

The Chairman: This is one area where greater clarity would be nothing but helpful. We heard yesterday how we must not be tied down on negotiating, but given that there is a very clear expression of will to continue our links with Euratom, it would be enormously helpful to spell out where they would like to be on this issue. There we are.

I am afraid we have run out time. This has been a helpful start to our inquiry. If there are any issues you would like to come back to us on, which you felt you had not had an opportunity adequately to answer, please feel free to come back. You will, of course, get the transcript for minor alterations if we have made any errors. Could I thank our three witnesses very much for helping us this morning? Thank you.