



Energy and Climate Change Committee

Oral evidence: [Small Nuclear Power](#), HC 347 Tuesday 8 July 2014

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Written evidence from witnesses:

- [Generation mPower LLC](#)
- [NuScale Power LLC](#)
- [Ge-Hitachi Nuclear Energy](#)
- [National Nuclear Laboratory](#)
- [Nuclear Innovation and Research Advisory Board](#)

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Members present: Mr Tim Yeo (Chair); Dan Byles; Ian Lavery; Dr Phillip Lee; Mr Peter Lilley; Albert Owen; Christopher Pincher; Sir Robert Smith; Graham Stringer; Dr Alan Whitehead

Questions 85-179

Witnesses: **Bill Fox**, Chief Executive, Generation mPower LLC, **Thomas Mundy**, Vice President - Program Office, NuScale Power LLC, **Dr Eric Loewen**, Chief Consulting Engineer, Ge-Hitachi Nuclear Energy, **Dr Fiona Rayment**, Director, Fuel Cycle Solutions, National Nuclear Laboratory, **Dame Sue Ion**, Chair, Nuclear Innovation and Research Advisory Board, gave evidence.

Examination of Witnesses

Witnesses: **Bill Fox**, President and Chief Executive Officer, Generation mPower, **Thomas Mundy**, Vice President, Program Office, NuScale Power Llc, and **Dr Eric Loewen**, Chief Consulting Engineer, GE Hitachi Nuclear Energy, gave evidence.

Q85 Chair: Good morning and welcome to the Committee. We have about an hour with you, so that should be sufficient to cover the ground that we want to. As I think it is the first time you have been here, could you introduce yourselves very briefly to the Committee, please, perhaps starting with you, Mr Fox?

Bill Fox: Good morning, and thank you for the invitation. My name is Bill Fox. I work with the Generation mPower company. I am the President and the Chief Executive Officer.

Thomas Mundy: Good morning. I am Tom Mundy. I work for NuScale Power. I am the Vice-President of programme management.

Dr Loewen: Good morning. My name is Dr Eric Paul Loewen. I am a Chief Engineer with GE Hitachi Nuclear Energy.

Q86 Chair: Thank you. I would like to ask a general question: what role you think could be played by small nuclear power, both in the UK and elsewhere?

Bill Fox: Okay, anyone?

Chair: Anyone.

Bill Fox: I will take the lead on that question. The SMRs—particularly the mPower design—is a traditional light water reactor with a long history of operations around the world, more than 40 or 50 years' worth. It has a very safe record. It is a small modular reactor that allows it to be replicated and put in different places. The role of it in the UK is no different than the role it would have in any country around the world, which could be deployed in increments as you need them, not upsetting the power grid and able to grow the system as the system capacity is required.

Thomas Mundy: Yes, to add to that, I think they can complement the existing large base solar-build programmes, in that they can fit in areas and regions where those large base solar units may not necessarily fit well, in terms of transmission, system capability, site sizing, population density and the emergency planning zone that is required for those facilities, and water limitations that may exist and other things like that associated with the siting. They would also fit well for other kinds of applications, other than just straight electrical generation, so to the extent that the region needs processed heat or other ancillary services, such as desalinisation, they would fit well in those kinds of markets as well.

Dr Loewen: In 1981 when Margaret Thatcher was the Prime Minister GE Hitachi looked at how do you fundamentally make nuclear power different? We said: how do we shrink this so you can make things in a factory? Because we do very well making jet engines, microwaves, toasters, ovens, those sorts of things in a factory and that was where we started with the reactor called PRISM in 1981. That small modular reactor started a Government programme in 1984 that ended in 1994. We were the first small modular reactor to submit our design to the Nuclear Regulatory Commission and they issued that there were no impediments. The reason why I am here today is we are looking at an integrated solution for the disposition of plutonium, the 140 metric tonnes in the Sellafield site using the PRISM reactor.

Q87 Chair: What has your experience been in developing the small nuclear technology in the US?

Dr Loewen: For General Electric, we were the first ones to get the first order from the US Navy to build a small modular reactor called the Seawolf submarine, Westinghouse got the second one. As a company we built the smallest submarine called NR-1 and then our light water reactor, boiling water reactors we continued to grow those in size with a sodium-cooled reactor with

PRISM. We looked at that as for a small modular reactor. We have been on both sides as a nuclear vendor.

Q88 Chair: Why are you focusing on deploying the PRISM reactor here rather than elsewhere?

Dr Loewen: The Nuclear Decommission Authority put out a public consultation in 2011 saying, “We have this problem. Our mission is for site restoration, we cannot do site restoration with uranium and plutonium still on site, so how do we disposition those nuclear materials?” We came forward saying, “Here is why PRISM is fundamentally different. We turn the oxide into a metal fuel. That metal fuel we then run through the reactor to make electricity to offset the cost of that disposition, and then that fuel would go into the geologic disposal facility”.

Q89 Chair: Mr Fox, despite the fact we have heard you have support from the US Department of Energy, your mPower SMR project does not have customers or investors. Do you know why that is?

Bill Fox: Generation mPower is supporting an mPower SMR for deployment in the US. It does not have customers right now in the US because I guess the customers are watching and waiting. There is a time for that. We are preparing for deployments in the early to mid-2020s for the US. The customers will come we believe. As far as the investors go, the investors are looking at us. We are still discussing it with potential investors and still in negotiations with the Department of Energy in a path forward in the programme.

Q90 Chair: Mr Mundy, how is your partnership with Rolls Royce going?

Thomas Mundy: The relationship with Rolls Royce I would characterise as being excellent. I singled them out and I identified them as a key project participant in our DOE award application. They are currently providing project management and subject matter expertise in helping us inform the design-related activities, particularly in the areas of advanced manufacturing and factories engineering in a number of other technical areas. We continue to work with them on a regular basis. They support us here in our efforts and on the project as well.

Q91 Chair: What advice would you all offer to the British Government about whether they should have a programme that is competitive for the US or whether we should be looking for greater collaboration?

Thomas Mundy: Let me speak to that. There would be great benefit to the programme in the advancement of the SMR programme if there was collaboration between the two countries on the development. NuScale Power are receiving considerable support from the US Department of Energy. There are opportunities where the two Governments could collaborate on that kind of support and also in the licensing and export areas for the technology itself to collaborate, particularly between the NRC and the ONR and the licensing of this technology and also on the development side.

Chair: Any other advice from anybody?

Bill Fox: I agree with Mr Mundy that there is tremendous opportunity for collaboration, particularly in the licensing and the regulatory issues that are before the SMR community.

Q92 Chair: Have you had a lot of experience of collaborating with other countries from the US?

Bill Fox: We have had informal discussions with the NRO within the mPower for the mPower design in the past and also talking to other countries, but nothing formal in terms of a formal programme of collaboration.

Q93 Chair: It does not sound as though there is a lot of enthusiasm for it, does it?

Thomas Mundy: I think it is obviously going to be necessary. As we continue our development programme here it is going to be necessary to collaborate and to work with the UK regulator on the process, similar to what we do in the US with the US NRC. We have not had direct interaction yet at NuScale Power with the UK regulator with ONR, but we have talked to a number of entities that do do business and do collaborate frequently and received some advice. We are planning on introductions with that organisation and will be working with them here.

Q94 Albert Owen: Dr Loewen, thank you for reminding us that Mrs Thatcher was the Prime Minister in 1981 to begin with.

Chair: My Labour colleagues had forgotten that.

Albert Owen: But the serious point is, you said that there was progress made between 1981 and 1994, I think those were the dates you gave. What happened in 1994 that it went off the agendas?

Dr Loewen: All good democracies have elections and President Clinton was elected and nuclear power was put in the long grass. That programme, along with other nuclear power programmes, was stopped during the Clinton administration.

Albert Owen: I am making reference to this country.

Dr Loewen: What happened in 1994?

Albert Owen: In this country, yes. My understanding of your response was that there was a programme progressing in this country between 1981 and 1994.

Dr Loewen: I am sorry, sir. What I meant was I was trying to give context of when GE got in to the small modular reactor business was in 1981. The US Government started a programme in 1984 that lasted for 10 years in the United States until 1994. Then when we switched administrations in 1994 that programme was stopped, so I did not mean to imply that here. I apologise.

Chair: That clears that up, thank you.

Q95 Sir Robert Smith: I should declare an interest in energy in the shareholding in Shell, an oil and gas company. From the experience of the oil and gas industry, the regulatory safety culture and regime is very different in the UK in its philosophy from that in the US. I wonder—and you were mentioning about co-operation—how you saw the two regulatory regimes in terms of their philosophy. In the offshore one, one is goal setting and one is prescriptive. I do not know, is the nuclear one in the US goal setting or—

Thomas Mundy: In my view the distinction between the two, the US is very prescriptive in its regulations and what you must follow in order to receive approval of design. The UK programme is more performance based, focused and less prescriptive. Ultimately I think their goals are the same: to approve designs to the utmost safety in the course of that review. In my view—and I come from an operational background—generally in the nuclear industry there is a significant effort worldwide through industry organisations, world nuclear associations, nuclear power operations and through the regulators, the IEA, to foster an extremely strong nuclear safety culture around the world in connection with the operation and certification of these designs.

Q96 Graham Stringer: What more work needs to be done to determine whether small modular reactors are economically viable?

Bill Fox: I am sorry your question is: what needs to be done to determine if they are—

Graham Stringer: What extra work needs to be done to determine whether these things are going to ever wash their face, whether they are going to be economically viable?

Bill Fox: The mPower programme has done enough work to determine that they are very economically competitive, especially on large scale nuclear deployments, both in overnight cost as well as the life cycle cost of electricity. The cost of nuclear power is a derivative of the level of effort or the level of detailed design that is completed. In many of the technical issues that are addressed, the mPower is far advanced in that technology and is able to come up with a conceptual economical model that puts it right in the middle of a competitive dollars per kilowatt with the large scale nuclear power plants.

Q97 Graham Stringer: Then what needs to be done to make small modular reactors more desirable to potential private sector investors if you have done the work on the economic viability? Why are private sector investors not queuing up?

Thomas Mundy: On the case of NuScale Power we share a similar view that our design is advanced significantly enough for us to be able to conclude also that we feel that our design is certainly competitive with current large scale advance reactor deployments, both on a dollar per kilowatt basis and on a life cycle basis as well. While these designs are based on proven 50 year-old technology they still have not yet been constructed. The programmes: in our particular case, we are about a quarter of the way through. It is a lengthy and expensive proposition to get all the way to development, and the companies that would be interested in supporting these programmes still need to see that there is a viable market and that there is a commercial opportunity in it for them.

Q98 Graham Stringer: When you say they are competitive, does that mean the small modular reactors would be producing electricity at the same price per kilowatt hour as large reactors? Is that what “competitive” means?

Bill Fox: For the case of the mPower reactor, I absolutely think it is at least or better than the dollars per kilowatt or pounds per kilowatt hour than the large gigawatt plants are producing today.

Q99 Graham Stringer: Would it help to show viability as opposed to pen and paper viability if there was public funding towards a demonstrator project?

Bill Fox: Before I answer that question I want to go back to your previous question and talk about why aren’t customers lining up to supplement what Mr Mundy said. There are three large hurdles to overcome to make SMRs attractive, as it would be in deploying any new technology across any of the industries. The first hurdle that has to be met is the licensing challenges. The GMP programme has spent nearly \$500 million of work toward licensing and detailed design and testing of the mPower reactor. That is the first hurdle that we are prepared and well on our way to continue for the submission of the design certification application to the NRC.

The second hurdle that has to be overcome, which is one thing I believe that is holding back customer orders, is the completion of the detailed design engineering that is absolutely required to provide cost certainty and schedule predictability in any deployment model or any deployment type of programme. That is a lift that no single entity that I am aware of is ready to take on their own, especially in the private sector, by publicly funded companies, publicly owned companies. That design is done one time and the benefit is realised over a series of deployments. We have not found the success path for that yet and certainly helping, from a public funding perspective, a kick start is certainly something that I think is necessary. It goes back to the collaboration between not only regulatory bodies but also governmental bodies to help fund that body of work that is required to make these a viable option.

This is back to your original question, as far as a demonstration project, mPower has invested over \$100 million in an integrated testing facility which full scale in the vertical direction replicates the entire model. We feel that that has demonstrated and proven the technology; proven the viability of the SMR for mPower and the demonstration product is not necessary to prove success of the deployment programme. So what is necessary to prove success is completing the design engineering to further solidify a predictable and costed schedule for the programme.

Chair: Thank you. That is very interesting.

Q100 Dan Byles: Is it a case that the economics of small modular reactors fundamentally do not depend on the nuclear technology, it depends on the manufacturing process? Isn’t the whole point to getting into a production line philosophy of large numbers of identical, small units instead of going into these mega projects that the large reactors effectively are?

Thomas Mundy: In the case of new scale design, ours is unique in that the entire nuclear power module which encompasses the containment vessel, the reactor vessel—which includes the integrated steam generator and internal pressuriser and all of the primary systems associated with that—was one contained unit that is completely factory manufactured. In our case there are definitely learning opportunities between manufacturing the first of those modules and the nth of a kind of those modules so we believe that there would be good opportunity for processing.

Q101 Dan Byles: That was really my point. My point is, isn't the economics of this driven by the fact that instead of a small number of individual large nuclear power stations you can develop a standardised module that you are churning out, effectively in a production line?

Thomas Mundy: In our case, certainly for the production of the nuclear power modules, that is the case.

Q102 Dan Byles: Yes, so my follow up question there really is, doesn't the economics depend on the scale of that level of production, as in these won't work if you are building five of them? The whole point is, these work if you are regularly building them, X number per month, X number per month, X number per month?

Thomas Mundy: Well certainly the number is a function of what kind of investment the manufacturers need to put into investing additional capital to expand existing facilities. In the US there are current manufacturers who advocate the ability with current manufacturing facilities to manufacture a certain number of these. Now whether or not it is warranted for them to consider expansion of those facilities is a function of what their order book is going to look like for them. So it is just a question of what can they do with existing capacity; what should they do given commercial orders in a book of business to expand that capacity.

Q103 Dan Byles: You have talked about them being competitive in terms of cost per megawatt hour or kilowatt hour. Do you have any figures you can give us? Can you give us an example of the cost per kilowatt hour you expect?

Thomas Mundy: In the case of Nuscale Power we have done a lot to refine our cost estimates at this point but the actual numbers we believe are commercially sensitive but what we can say is that given information that is published by, say, the Energy Information Agency of the US Department of Energy in which they produce a comparable matrix for large light water reactors—I think the model that they use in their current studies is the AP1000 design—both on a levelised cost of energy basis, and also on overnight capital costs, then our design is clearly competitive with those numbers produced there.

Q104 Dan Byles: What I am trying to get at—which I do not think I really am, though—is how much is that dependent on the scale of production? If you had an order for five of these and you never built more than five, does the same apply or does it depend on this becoming an established technology for which you end up building 50 over a period of time? Do you see what I mean?

Thomas Mundy: Certainly the numbers that we talk to our clients about—in fact we do have a client project that we are currently working on with deployment in 2023—because our modules are self-contained we have a fairly rapid learning curve associated with them, a reference plant. One of our facilities is a 12 module facility, and the learning curves associated with the production of those 12 modules is fairly steep so we are going to realise those learnings fairly rapidly. In the discussions with our clients—so we are talking about the first of a kind costs—we have projections of what we believe that number will drop to, based particularly on our experience with the US nuclear ship building industry where we have had consultation from the two large nuclear manufacturers as to what we can realise potentially in nth of a kind of savings, but right now we are talking about what the first of a kind costs are going to be. Probably the nth are going to be better.

Q105 Dan Byles: All right. When it comes to the ideal, the nth of a kind, how much does that depend on a global market and export market or how much could that be realised, I guess at the moment, from the US context? Can you achieve the sort of levels that you would like to achieve without a significant export market?

Thomas Mundy: Our nth of a kind projections are based essentially around 12 to 15 modules, so construction of one facility. By that time we are demonstrating nth of a kind savings on the projection so, given the fact that we have a US project already in the works, we believe that we are going to see that realisation of those nth of kind savings with that first project so anything beyond that is a benefit to the customers.

Q106 Dan Byles: I will come to you in a second, Mr Fox. If the UK did take this up, would you anticipate these modules being manufactured in the US and shipped to the UK or could you foresee any manufacturing taking place in the UK?

Thomas Mundy: In our particular case we are a technology development company. We do not have manufacturing capability, so we are looking for strategic partners who can provide manufacturing capability and expertise. For us the UK market is a very good market because there is extensive manufacturing capability here. The cost of shipping and the expertise needed to produce these things, there are limited companies that can do that. There are companies here who can do that. It would make sense not only to manufacture here for this particular market in the broader region, but also to utilise that expertise that exists to develop the IP needed for successful manufacturing.

Dan Byles: Brilliant, thanks. Mr Fox, you want to come in?

Bill Fox: I would like to add to your line of questioning on the lifecycle cost and how many are required to achieve the goals that we really want to establish. I agree with what was said in terms of a first of a kind and we look at that too. First of a kind, not only cost but construction schedules as well. One of the basic fundamental assumptions on achieving cheaper cost for the nth of a kind is repetitiveness, not only in the manufacturing process, as you accurately identified, but also in the means and methods of construction in terms of how you develop your work packages. You do not necessarily need consistency in the trade group but you need consistency in processes and the procedures you use for construction.

For the mPower design, the first of a kind, we discovered an nth of a kind cost could be achieved probably in the fourth or fifth or sixth one. Globally, there are enough studies around the world that define there is a point of diminishing returns once you complete the first, second, third and fourth along the line. The savings from the fourth to the fifth and fifth to the sixth become very small at that point and any blip in the manufacturing processes could increase that cost for a further down unit. We believe very strongly that consistency in manufacturing is a key as far as the UK goes. The UK is in a prime position for the mPower SMR to lead the world in SMR deployments and ultimately become an exporter of this technology, and we very well look to localisation of our reactors to a country that steps out and could be a manufacturer for deployments globally for the SMRs.

Q107 Christopher Pincher: My question is to Dr Loewen about plutonium re-use. In your submission to the Committee, Ge-Hitachi said that DECC officials have said that their expectation is that some options for plutonium re-use would ultimately lead to a loss to the Treasury. By contrast, you say that a 60 year operating life for your low carbon electricity outputs will enable it to generate significant revenue. I wonder what you think the model is that the Treasury is using to suggest that it would cause a loss to it, whereas the model you are using suggests that it—and I assume you mean the Treasury—will gain significantly?

Dr Loewen: I think the model that the Treasury was using was the 10 option report that DECC put out on the 10 different options. That study came up with the preferred option that was MOX, and that was to build a MOX plant and then you would have to sell that fuel to a utility to use. So fuel would have to go onto the market at a significant discount. If you look at what is going on in the United States for MOX Fuel. In the case of PRISM, it is an integrated solution where we easily manufacture the fuel into a metallic form, put that into the reactor and make 600 megawatts of electricity on the grid for the 60 years. Depending on how you put that into the marketplace—is it in an independent generator from the Big Six or it integrated into the grid—that is where that revenue stream would come from.

Q108 Christopher Pincher: Was the Treasury using the same period do you think from MOX of 60 years, or have you picked that figure out of the air just to give you a different set of final figures?

Dr Loewen: We did not pick it out of the air. The 60 years comes from the design life of the reactor, so all reactors have a design life because materials become changed when they get hit with neutrons and that is where that 60 years comes from. I do not think the Treasury has looked at ours. We are in close consultation with the NDA, so they want to see if we are a credible option and then I think that material then gets turned to the Treasury and they will then look at it from a business plan approach.

Q109 Sir Robert Smith: Mr Mundy, you mentioned defence marine reactors. I wonder how much of a read across there is, in terms of costings and so on, given the different culture of defence procurement versus the fact that these reactors in the UK are going to have to work in a liberalised energy market?

Thomas Mundy: We did not utilise data that was available from the US nuclear navy shipbuilding in terms of the cost of those but rather just the learnings that they have experienced from first of a kind to nth of a kind; what that curve looks like in terms of diminishing cost over the production of a number of units.

Sir Robert Smith: Thank you.

Q110 Albert Owen: If I could just move on to licensing regulations and potential siting of SMRs, what do you see as the main challenges with licensing SMRs compared to large nuclear reactors?

Dr Loewen: I personally do not see any. When I look at the Office for Nuclear Regulation there are approximately 350 safety analysis principles, and when I look at the design of the PRISM reactor I see those very much in concert with what they are after with those safety analysis principles. So it is getting started and going forward, looking at that reactor design under the lens of ONR's safety analysis principles.

Thomas Mundy: For us, certainly the NRC has not licensed an SMR but the technology that is premised in what we are developing is based on tried and true 50 year-old technology: the same kinds of fuel, pressurised like water reactor technology. But we have implemented an extensive interaction programme to make sure that we produce full and complete application for the NRC, and what is more important—and we are very confident the NRC will review and prove that—is we need to make sure that it is done in a timely manner. I think that in all instances, whatever regulator you are dealing with, you need to make sure that you give them a full and complete application so they can do a thorough and timely review of it.

Bill Fox: I think the challenge is not necessarily in the technology but understanding the differences between large reactors and SMRs. They are different and there are quite a few safety case analyses that are not required in an SMR that may be required in a large reactor, just because it is new and not been licensed before, understanding those differences. For example, some of the policy issues on control room staffing, because we are trying to push through this, it is not necessary to have those same requirement on an SMR that is required on a large reactor; smaller EPZ, Emergency Planning Zones, for example because of the smaller cores; defence in depth, large-break LOCAs; security staffing; those kinds of things are challenges. Those are the issues that we are dealing with on a basis with the regulator: not necessarily challenges to the technology.

Q111 Albert Owen: Do you feel that the GDA, the Generic Design Assessment, should be modified to suit SMRs?

Bill Fox: I think it would be an advantage to do that, to set the bar. For example, in the US mPower has our design specific review standard, which was a deviation from the standard review plan on which they licensed all prior large reactors to, so we have a site plan specific review standard. I think it would be advantageous for the UK to adopt a similar type of approach.

Q112 Albert Owen: Coming back specifically to the United Kingdom, if I can, the GDA has just been set up. We have one project that has gone through it, and a second is unproven technology in this

country so we are in a similar situation to SMRs. My question is: can the current procedures be modified, in your opinion?

Bill Fox: I am not completely familiar with the UK procedures, but I do not see any show stoppers at this time.

Thomas Mundy: Yes, our licensing experts are advising that because the UK process is very performance-based that it should be processed similar to what we will experience ultimately to get through the NRC's review of the application.

Q113 Chair: Mr Loewen, have you any comments on the GDA?

Dr Loewen: I would like to put our design into it. I do not see you need to change the process, per se, so I am a little bit in disagreement with my colleagues here. It is a robust process that asks those questions. The safety analysis principles are still the same and you need to show where there are exceptions, and the ONR has a great history of licensing a wide variety of technologies. They also work on the military technology, so I think they have that skillset to be able to enter in with the current process that they have.

Q114 Albert Owen: Thank you. Should the UK partner with the United States—or indeed another country—agree on a joint statement on regulation and a joint way forward?

Thomas Mundy: As I previously mentioned, there would be greater efficiency and benefit if there is the ability for the two organisations to collaborate and rework in connection with their examination of the same technology and the application. There are a lot of things that each will be doing in the first instance, and to the extent that they can share the learnings that they are doing in that area would make for an overall more efficient process.

Q115 Albert Owen: Any other comments? What experience have you had with the UK regulator, the Office of Nuclear Regulation, in particular; do you recognise the concerns that they may be under-resourcing?

Dr Loewen: Our experience has been working with the NDA we had a meeting with the Office of Nuclear Regulation along with the two other teams that are looking at plutonium disposition. To my knowledge, all three teams submitted a 100-page report to the Office of Nuclear Regulation where they had information that they wanted to be able to evaluate the three different plutonium disposition options. My interaction with them has been very professional. They are cordial. They know exactly what they are after so I was very impressed with them.

Q116 Albert Owen: Any other comments? Because this is important. It is a relatively new system in our country as well. It has just started up and there might be an issue where there is a lot on their plate at the moment and slightly under-resourced; here comes a new technology with potential. So do you recognise there could be some under-resourcing?

Bill Fox: I recognise there could be. However, our interfaces with the ONR is that—first, we have not kicked off any formal interfaces with them. We have had multiple exchanges informally. We have had representatives of that organisation visit our facilities in Lynchburg, went to our design centre, also our testing facilities as recently as November last year. We continue to have dialogue with them but nothing formal has been set up. I think they are getting an appreciation for the challenge as far as what the resources they may need. I cannot address their capacity to address those needs.

Q117 Albert Owen: If I could just move to the siting of SMRs in the future. Why might existing power generation sites be good candidates for siting SMRs?

Thomas Mundy: Existing sites have been well characterised in terms of what needs to be examined for the siting of a nuclear power plant. So there is a large body of information that already exists that can be used in the licensing of a new facility at that location. The site itself has certain advantages because it has been a location where nuclear expertise has been developed. So, in terms of the workforce and those kinds of things that are available to new nuclear development at that location, it is beneficial.

Bill Fox: I agree completely, because the other two things you look for on a site is access to the grid and access to the water and existing sites clearly have those needs met.

Q118 Albert Owen: So should the UK Government be looking at a strategic siting review, as it has done with the larger reactors? Should it go through the process again? How do you feel the Government should move forward when it comes to potential siting?

Thomas Mundy: As I understand, the existing sites that may be potentially suitable for new nuclear development not all may necessarily have the needed size for the placement of large nuclear generation, so those sites certainly could be a consideration for smaller SMR technologies at that location. Certainly my experience, as a nuclear developer for a large power company, is that we look to existing sites where there is nuclear technology for all the benefits that you get, the access to the water, the transmission, the workforce and the characterisation that already exists for that location. Certainly they are much better and much more suitable to consider first as opposed to another brownfield or greenfield location.

Q119 Albert Owen: So those that may not have been successful in the strategic siting assessments, the first round, you think could be suitable for SMRs? My question is: do you think the Government should look again at this so that we can get another exercise or is the information available to them?

Bill Fox: I think that is clearly a governmental decision. There are sites that are clearly available and can support SMRs; those ought to be looked at first. Any opening up of any other sites is a UK decision.

Albert Owen: I will leave it at that.

Q120 Ian Lavery: On the issue of safety security and public acceptance, are smaller nuclear reactors safer than the larger reactors?

Dr Loewen: When you look at a reactor safety is: when it is operating can you make a power excursion that is unsafe. When it is turned off a nuclear power plant still generates heat and if you do not take that heat away then you are going to have core damage. In the case of PRISM for controlling the reactivity or controlling the power, if it gets too hot it shuts itself down, so it has that natural feedback loop. When you turn the machine off, when it still generates heat to remove that heat, we do not have automatic pumps or valves or any sort of system, we just have air that naturally flows down beside the reactor vessel and up out of a stack and that naturally removes the heat. So we can last not for days or months but forever removing the heat, so that is the safety features of PRISM from controlling the power from removing the heat. Also this is the only nuclear facility that is built on seismic isolation bearings, similar to the bearings that are used in buildings in Los Angeles and Tokyo, so that earthquake is not going to cause structural damage. Those are some of the features of why PRISM is safer than a water cooled reactor.

Bill Fox: Once a nuclear power plant has been through the regulatory reviews and determined to be safe, they are all safe. There may be some challenges to margins to safety. If you want to take the probability of an accident to zero it does not come without cost, so you have to consider that. The regulations are very clear in the US where we are licensing our reactor that has to be at a certain core damage frequency, and we are well above that. It is safe. To say that one plant is safer than another is somewhat arbitrary. Once it passes regulation all plants are considered safe. Core damage frequencies are very low and certainly our mPower design meets all those standards.

Q121 Ian Lavery: Dr Loewen, I am not sure if I picked you up right, but do you believe that the improvement in safety is basically due to the different choice of technologies, rather than the difference in the size between the smaller reactors and the larger reactors?

Dr Loewen: It is the approach onto design fundamentally, so we started the design in 1981. At that time the nuclear industry had active systems to remove heat after it was shut down. To make sure that active system was there we added another active system, then we had a backup. That is how we approached industry as a whole in the early 1980s. So the PRISM design said, “How do we do that with physics so that we do not have to rely on a system or pumps or automatic control or humans?”, and it just fundamentally went differently with the design. In that case I would agree with you, it would be the approach to how you do the technology.

Thomas Mundy: In the case of the new scale technology, the cornerstone of our design is on safety innovation. In fact that was the key criteria that the DOE used when it selected us an award recipient, was along the safety parameters of our design. One thing that sets our design apart from others is what we call the triple crown for nuclear safety, and that is during a station blackout event—like a Fukushima type event—where you lose all electrical power, our design is capable of dealing with those events with no operator action, no need for AC or DC power, and no need to add any additional water to the facility for an unlimited period of time. How that differs from others is most designs have some kind of coping period that can typically deal with the event for seven to 14 days. Ours can deal with that for an unlimited period of time.

In terms of the safety parameters that are used to measure the safety significance of the design—you mentioned core damage frequency—the current light water technology, advanced passive light water technologies, indicators are around 10 to the minus seventh, ours is 10 to the minus ninth. Two orders of magnitude lower in safety performance of those other current passive designs. So safety is key. Some of those are due to the size. Our technology is small. We only have 5% of the fuel of a large light water reactor and, as a result of having less fuel, our source terms are less, our release fractions are less and our overall safety performance is improved as a result of that.

Q122 Ian Lavery: Staying with the safety side of things. Obviously there are many considerations when prioritising investment in the development of these new technologies. Should safety be the main priority?

Dr Loewen: I think safety is where you start from in any sort of product that we put out to the public from airplanes to consumer products to reactors. So safety has to be the cornerstone. With our three companies, safety is the cornerstone. It is our safety culture. It is internal to the process, so of course that is the first part that you have to have that safety.

Thomas Mundy: Yes. I totally agree. Safety is our number one. The design of our technology has to meet very specific safety parameters and achievements first and then we will deal with the commercial issues.

Q123 Ian Lavery: Would you like to comment on any public engagement you have had with regards to the small nuclear power issues, in particular? Has there been any public engagement? What is the feedback if there has been?

Dr Loewen: We held a supply chain event in Cumbria to look at what sort of industry was in the UK that would be interested in supplying the supply chain, so we had that as a public event. We had a public event at the House Church, where we talked about our technology. We have a Memorandum of Understanding with the Dalton Institute at the University of Manchester, and we have a Memorandum of Understanding with the National Nuclear Laboratory. So we have started the process of having that public engagement here in the UK.

Thomas Mundy: We have also started our reach here within the UK Advanced Manufacturing Research Centre, the University of Sheffield. We are in discussions with them about how they can support our programme with the National Nuclear Laboratory and how they can also provide some fuel and related design engineering support. We have not had any specific public outreach here. We are not in a position to do that yet, but certainly in the US that is one of the cornerstones of what we try to do, is to advance the appreciation and support for our reactor and certainly something we would have to do here as well to move into this market.

Bill Fox: One of the features of our design is the fact that we have taken this design and almost completely put it underground, almost giving it a Wal-Mart shopping centre type of effect where there is just a facility, the façade above the ground. It does a couple of things. Number one, from a public acceptance standpoint, it is things that they are more used to seeing around industrial parks. Secondly, it eliminates completely the airplane crash analysis that is critical in the safety case, by eliminating that possibility. Taking the EPZ, evacuation zone, down to the plant boundary

is something else that has been very well received. So we do not have to engage wide geographic regions for evacuation planning, again contributing to a lower cost as you operate that plant as well. We are not anything formal but certainly, as we engage public and presentations around the circuits, we get that feedback that it is favourable.

Q124 Ian Lavery: Dr Loewen, is public acceptance of nuclear power higher for technologies that make use of existing stocks of nuclear waste?

Dr Loewen: Yes. As a Past President of the American Nuclear Society, one of the things that I faced going around the world talking broadly about nuclear science and technology issues is when you specifically talk about nuclear power the question always comes up: what are you going to do about nuclear waste? As an industry, that is one of the things that we are still trying to figure out and need to come to closure with to get even better public acceptance of this technology.

Q125 Ian Lavery: Touching on what Mr Owen was on about before, do you think that the concerns about security and proliferation would be greater if the SMRs were individually deployed across multiple sites, rather than located as forms of SMRs at a single site? I touched on that before but do you think that would be the case? Forms or individual sites are basically the question.

Dr Loewen: So the case for PRISM what we are looking at is an integrated solution at the Sellafield site, either at the Sellafield site or adjacent to it. For the disposition of plutonium, there is no transport of plutonium around the country so you can get out of those proliferation concerns. You manufacture it into a fuel and you put it into the reactor. That used fuel then goes into the geological disposal facility to complete the mission for the NDA of site restoration. That is where we think our integrated solution addresses those proliferation concerns and mitigates them by putting that facility very close to the Sellafield stores of plutonium.

Thomas Mundy: I do not think there is a particular advantage in trying to group the SMRs in one location. I think the security features of the facilities are state of the art. The means to store spent fuel on site has been factored into the design, so I do not envisage that there is any unique proliferation challenge that is presented by distributing the SMRs at different locations as opposed to trying to group them all in one location.

Bill Fox: I agree that we are indifferent to the farms versus distributed sites.

Q126 Dr Lee: Specifically on security, do you detect a greater reluctance to pursue nuclear power in general because the threat from terrorism has changed in the last 10 - 15 years, that we have gone from a fear of other states to a fear of individuals who are radicalised who are more committed in terms of their determination to destroy something? You talk about your designs being resistant to planes flying in, but if you are a committed, radicalised individual who has become a member of the staff, and then the switch happens and they turn up and they have a little device—we have had the recent problems with mobile phones, now changing their regulations on flying into the US airspace—do you detect any reluctance now on the part of Governments to commit to more numerous sites because of this and, if so, have you started changing the ways you design these things or implementing different regulations within sites as a result of that?

Dr Loewen: I would say, when you look at our three designs all of ours are below ground, so when you look at that threat from the air I think all of our designs mitigate that. With the new cell phone—which I will grapple with when I go back on Saturday to see if I can get back on the plane with my two cell phones—so let's say you had that magic cell phone in the PRISM control room, the way we designed our architecture for the control is the control room is a control room. It is not part of the safe operation of the plant. The safe part of the plant is on the nuclear island, which is isolated from the control room where you do not have personnel. Also, as I spoke to earlier with the physics of the fuel, even if the magic cell phone got out of the control room on to the nuclear island then when the reactor gets too hot itself it shuts down. That is the fundamental principles of physics, of the metal fuel expanding that turns power. Those are the sort of things of advanced technology that addresses those concerns about security.

Bill Fox: I do not think it has deterred from the mission of building nuclear power plants. Force-on-force drills for individual security operations have certainly changed over the years to address these individual actions but I do not think it has changed fundamentally.

Thomas Mundy: The existing units, as a result of some of the more recent events, have caused them to try to back-fit and retro-fit the facilities to deal with those kinds of things. For the new plants I think there is a greater expectation that the design itself will deal more robustly with the ability combat security-type issues and there is greater expectation from the regulator in terms of the design. For example, our technology is underground, both the reactor modules are underground and the control structure and the building is extremely hardened for a number of events. By design, security is factored into the design itself. As this facility is conceptualised security aspects are built into the design to make it hardened and robust to deal with security-type issues. So it is part of the process now as opposed to trying to be a back-fit. I think the public expects that; the regulator expects that and that is part of the design that we are dealing with now. Because we are doing that I think there is still great acceptance for these facilities.

Q127 Dr Lee: Would you say that in the past there were some weaknesses in terms of if somebody was committed it was possible? What I am trying to get to is that, in my experience, the public's view of nuclear power is not particularly well informed and there is a fear of it and I think particularly these terrorist acts. This comes up if you speak to people: what if the terrorists blow it up? But what you are saying is that technically that is not possible in the same way as blowing up a plane. I am trying to put this in the public sphere. There is not the same vulnerability that we would associate with transport hubs, planes and the like?

Dr Loewen: I think the industry—

Dr Lee: Is that a yes? Technically, a chap cannot walk in with his mobile phone and blow up the nuclear reactor?

Dr Loewen: That is a yes because, when we look at different infrastructure we have across the board from the early deployment of nuclear technology, this infrastructure has always been a hardened infrastructure.

Q128 Dr Whitehead: You mentioned the existence of skills and supply chain in the UK in general terms. What is your view of the compatibility of the UK supply chain skills base with the sort of production that we have been talking about today?

Dr Loewen: From the event that we had in Cumbria we see the supply chain very compatible. As a company we build infrastructure wherever we go. If you look at our history, we came here to the UK in the 1930s. We have 20,000 employees. It is your fourth biggest manufacturing company. We see that building the PRISM reactor for the mission of plutonium disposition we would be able to leverage that and grow the supply chain, so that when the PRISM reactor was built elsewhere the UK is the supply chain because it was the first mover.

Q129 Dr Whitehead: What sort of gaps do you perceive there to be in those supply chains and skills, in terms of the proposals you are putting forward today? Are there areas where you might say that there are potential issues, as far as either deployment at scale or in the case of PRISM the particular technologies that you are wanting to progress?

Dr Loewen: As far as metallurgy, forging and making those sorts of things, I do not see those. I do see a gap. We have to make electromagnetic pumps. Nobody makes those any more. We used to make those, and so that would be something where you would have to stand up the skill base in a manufacturing facility.

Bill Fox: Personally, we are already working with a couple of companies in the UK on the mPower design. For example, Sheffield Forgemasters are already in discussions with us about the first set of forges for the reactor module. We are currently using Morgan Technical Ceramics on some of the products for CRDM work, so I think there are skills sets here that can certainly do that. From getting ready to enter this market, lessons learned from the States side work is that vendors and contractors are going to be more engaged with the supply chain upfront early, to prepare them for the requirements, the quality and the safety culture that they will have to operate in. I do not think there is a show stopper there either. It is just a matter of making the expectations clear and making sure that the supply chain can meet those requirements.

It is something that we have learned in the US and are catching up with. But certainly, getting ahead of that in the UK, I do not see a large gap, particularly if we are talking about build-to-print type of operations including making nuclear fuel.

Thomas Mundy: It is a similar experience for us. We have examined the supply chain opportunities here. We think this market has great supply chain capability. That is based on our discussions with our programme partners, like Rolls Royce, and others that we have talked to in this market. The owner of our company, Fluor Corporation, has been here since 1958. It has over 2,000 engineers in the Farnborough area and it is also able to advise us as to what the supply chain capabilities are. Given the fact that this is a very established nuclear market, we feel very comfortable with the supply chain capabilities here in this market.

Q130 Chair: Does that include working alongside or aiding the advance of UK-owned intellectual property, as well as importing intellectual property and perhaps asking the supply chain skills base to replicate that? What is the balance that you see between the two?

Dr Loewen: I see first movers and supply chains ending up with their own intellectual property and keeping them in the supply chain as you go forward. That is how you get in on the ground floor. What is intellectual property? It is making something better, cheaper, faster and you are

only able to do that if you start making something better, cheaper and faster. You get that initial infusion of intellectual property and then the supply chain then grows it; if you look at technologies across the board that is typically how it happens. That is why I am excited that if we come to the UK and if the NDA chooses through the competition that the PRISM integrated solution goes forward, that is the advantage of standing up that supply chain.

Q131 Dr Whitehead: Is that the driver for your particular view of locating in the UK? You mentioned the competition, the particular needs on disposable fuel but is there a particular supply chain and skills driver in your decision-making process or is that secondary?

Dr Loewen: I would say that is the way we do it as a technology company, that we build infrastructure where we go. We are going to build infrastructure in the UK to do that, just like when we did when we showed up in 1930.

Q132 Dr Whitehead: Then does that mean in terms of, say, siting employment in Cumbria, that in your view that could lead to a base that is capable of becoming world class, capable of taking technology on further in other countries?

Dr Loewen: Yes.

Thomas Mundy: If I may comment for NuScale, since we are not a manufacturer we really need to look to develop our strategic supply chain partners. I believe there are entities here that can provide that. We are not looking at deployment of the technology just within the UK but more broadly and globally than just this particular market. For those who get involve with us and are going to help us figure out how to suitably fabricate manufactured test and inspect the equipment that we need—particularly our nuclear power modules—and play a strategic role for us in the delivery of that, there is an intellectual property right capability for that entity and great commercial capability as well.

Q133 Mr Lilley: As I recall it took barely 10 years, from design through development to building construction, to delivery of electricity from the first nuclear power plant in this country at Calder Hall. You are talking about technology that has been in operation for 50 years and you are saying you need 10 years to get it up and running. Can you explain why you cannot do it in half that time?

Bill Fox: The first of a kind plant, the first half or more of that 10 year period is through licensing.

Mr Lilley: Now?

Bill Fox: Now today. Quite frankly, if we had been through the licensing case and had the standard plant design engineering complete, we are talking about less than half that time to actually deploy technology.

Q134 Mr Lilley: Why does it take five years to license something?

Bill Fox: There is a set of timescale before you submit the licence and then, of course, regulators will want two, three or four years to do the review.

Q135 Mr Lilley: You say “of course”, it is not obvious to me that it should take that long. It would be better to do it fast rather than slow I would have thought.

Bill Fox: We do not think it should take that long either, for sure, especially for this kind of technology but once a safety case is determined and you have your licence then it is a matter of how quick do you want to go to construction with a fraction of the design complete. Of course my view of the world is you get as much done as you can to provide cost and schedule certainty and predictability. So we are talking about less than half the time of 10 years.

Q136 Mr Lilley: Do you think that if the regulatory authorities had a sense of urgency they could complete the licensing, without skimping on safety or cutting corners, in a significantly shorter time? In this country there is no sense of urgency about anything; everything takes 10 years before you start. It seems to apply to nuclear, like High Speed Rail, like building houses. Is it the same in your country?

Bill Fox: It is the same and my view of the world is, again, I think it absolutely can be done in a shorter period of time with a sense of urgency applied. There are examples of those kinds of programmes. If you go back to the Manhattan project and look at what they accomplished in very short order of timescale when there was a sense of urgency and a force that was brought to bear, unmatched previously.

Thomas Mundy: The NRC review process, which I am most familiar with, has been established over a long period of time as to what they examine and the degree to which they examine. Right now the NRC is committed to trying to review and approve design certification applications within 39 months, premises on the applicant submitting a full and complete application. What that means is debateable but they have established a very extensive process that takes a lot of time, not only for them to review it but to prepare the application to make it full and complete takes several years before you are in a position to submit it and then have them go through that review process. I understand GDA takes about four years as well.

Q137 Mr Lilley: When you were building these things for nuclear submarines, you did not have to do a lot of this anyway?

Dr Loewen: In the United States you did not have the Nuclear Regulatory Commission. We had naval reactors. It is a little bit different to what you do in the UK. On licensing, what I say to my engineering team is, “You had better know all the mistakes everybody else has made ahead of us” because actually it is best in the nuclear industry to be second. It is like the Tour de France, you do not want to lead the whole way. So what we need to do, when we look at the licence or the big reactors in the United States and the GEA process in the UK, find out what the regulatory agencies did not like so that when we submit our application it is a quality submittal that addresses those sorts of thing. I tell my engineering team, “You had better know what everybody else has made their mistakes on because we are not going to make the same ones”. So I think

that is how we need to have the sense of urgency so that we have a better quality submittal so it is easier for the regulatory body.

Q138 Albert Owen: Can I just come in? I am with Peter 100% on this, safety is paramount. Here we have technology that has been proven in submarines and what we are talking about is we have had the large reactors that have been proven over many years to be safe, one of the safest forms of producing electricity. Yet what we are talking about here is SMRs, which follow the same path, and I cannot understand why you are at this early stage in the development of it. I am really finding it difficult. We understand that the GDA is there. We understand it can be modified and if it is a safe, proven form of generating when why can't we move forward rather quickly and less cautious than yourselves?

Thomas Mundy: One of the things that drives the process in the US is the built in activities associated with public comment and intervention. So they allow a certain amount of time during the course of their overall review programme for the public to submit written comments, participate in hearings, the rule-making process, and those times are fixed by regulation. In some cases the timeline is set for those activities. But I would certainly agree with you to the extent that there are opportunities to shorten it, because it is technology that has already been examined, certainly it would be a benefit.

Q139 Mr Lilley: Is it easier to build one of these things onshore than for a submarine or because a submarine is at sea do you not have to worry about lots of things you have to worry about when you are building one onshore?

Thomas Mundy: I am not in a position to comment on how the submarine programmes are built or constructed. I do not know if my colleagues are.

Bill Fox: I cannot elaborate too much on that but once you get to the nth of a kind in a naval programme, for example in submarines, it is much easier to replicate.

Mr Lilley: That would be nth of a kind anywhere but it seems to me it must be quite a task miniaturising it to fit in a submarine. You are less constrained if you are building it on land. It ought to be easier, simpler and not have many of the complexities that a submarine would involve, and that is an uninformed impression.

Q140 Dr Lee: This is a question I asked another a week or so ago: do you feel constrained by democracy in your business?

Dr Loewen: No. Democracy is a good thing because it allows the marketplace where you can have three different vendors here before you.

Q141 Dr Lee: I guess my point is that you said that in 1994 a change of administration precipitated the stop of the relationship between the UK and the US—

Dr Loewen: Sorry, Dr Lee, it wasn't between the US and the UK. It was just the United States stopped their programmes.

Dr Lee: Yes, the decision, rightly or wrongly, was precipitated by a change of President.

Dr Loewen: Correct.

Dr Lee: I wonder whether you would find the UK market easier to work in if Albert and I were deciding what the nuclear strategy was over 10, 15, 20, 25 years for this country. That is my question: would you find it easier?

Dr Loewen: I think democracies make public policy frameworks that allow things to go forward. If you look at the "Atoms for Peace" speech that was in 1953 and, in 1954, the US changed the Atomic Energy Act to allow private sector investment. That really started about a \$20 billion business worldwide. The next change happened in the 1992 Energy Policy Act where you could privatise enrichment. So that was a secure policy framework and you saw there the private sector. I think if Government sets up that policy framework correctly—where industry sees that it is stable—then you will see those sorts of investments, skills and manufacturing that allow them to go forward.

Having been in China and the United States and the UK I would prefer democracy.

Chair: We are getting into interesting philosophical territory that is slightly—

Dr Loewen: Okay. I will keep my engineer head on then, sorry.

Q142 Dr Whitehead: Just briefly—and this is perhaps a naive question—but to return to the submarine question. The popular view of this might be that if you have a reactor in a submarine, and what would be the maximum output of a submarine reactor, electricity? What would be the output of yours?

Thomas Mundy: Each one of our power modules is 50 megawatts gross, so 160 megawatts thermal.

Dr Whitehead: So you have the equivalent of a district size energy plant, what is the fundamental technological problem of literally taking that module out of the submarine? That is, you have the exact module there but no submarine around it and you then plug it in to a district energy system. Is there a fundamental problem with that? Is there a fundamentally new design that needs to be undertaken at that point or can you literally manufacture more of those and forget submarines?

Thomas Mundy: Presumably that technology would have to be licensed commercially. I do not know how it is licensed for the naval nuclear programmes but, to the extent that it would have a land based commercial application, presumably it would have to be licensed and reviewed and approved separately by your regulator.

Dr Whitehead: That is not the question I am asking.

Thomas Mundy: I think we are at a little bit of a disadvantage because I don't know if any of us come from the naval nuclear programme where most of the details of their designs are confidential.

Dan Byles: You might have security issues as well. For example, there is a treaty that prevents the UK from making use of military submarine nuclear technology commercially. It is a US/UK treaty that goes back many decades. Some of this is military—

Q143 Chair: We can have a conversation between Committee members at a later date. I have an old friend coming for lunch and he will say to me, "What was your Committee like this morning?" and I will say to him, "We had these three extremely knowledgeable and very measured senior people from the nuclear industry, whose collective experience of the industry I should think must be comparable with any three we might have picked". I will say, "But they seem curiously unenthusiastic". None of you have leant across the table and said, "Yes, this is a great opportunity for Britain. You really need to get into this market. You have a favourable background here. Public opinion is probably as sympathetic to civil nuclear development in this country as anywhere in the world. We have a regulator who is trusted by the public. People who live near a nuclear power station want to have more nuclear power, not less". But none of you guys seem to have any real sort of passion about it.

Bill Fox: Let me come in here and address that and I think it will put in context the guarded passion, if you will. The mPower broad programme is an excellent technology. We are very much committed to it; passing it through licensing; our testing facilities have confirmed the design; it is buildable; we have a very good partner Bechtel who supports it, a top notch AE that has been involved in nuclear for many, many decades. One of the concerns, as we talked about earlier, is the timescale to deploy and also the cost, the hurdles that have to be overcome with getting this project through licensing, and then that other large funding capital investment that is required to finish the detailed design engineering. Enthusiasm and passion does not work very well in especially Government or publicly traded companies. Shareholders are looking for returns in shorter order than five years or 10 years. So some of the passion for this: clearly we are here, we are in business, we are taking a restructured look at it to better align our efforts to what is important in terms of licensing, but at the same time we are guarding our passion because the reality is there is a funding gap—both in the US and I would sense it is here in the UK as well—before this thing can come to reality.

We have had several industry meetings in the United States with different technologies, Department of Energy and other stakeholders, that have all recognised this. So you have to balance the passion for the technology and support of this and seeing this thing come to realisation, but you have to have money to do it.

Dr Loewen: I am conserving energy. About two years from now is when we hope that the Nuclear Decommissioning Authority will have a competition between the three different plutonium reuse options, so the French AREVA team, the Canadian team and then GE Hitachi Nuclear Energy. What we are hoping for is a fair and transparent open competition and you will see plenty of passion from me then.

Thomas Mundy: We are a new company. We were established in 2007 with one single purpose to design and develop a new small innovative scaleable small module reactor. That is all we do.

That is our sole purpose. I am disappointed in myself for not sharing the enthusiasm, and if you brought your chequebook I am happy to sell you one today because we are ready to move on that. I have lived for the last 25 years five kilometres from a nuclear power plant, and I have seen the community be very supportive of that plant and receive the benefits of being a member of the community within that. We see great promise, both in the US and here for the deployment of SMR technology.

Chair: Thank you. I think we would be sympathetic about the concerns about the time it takes to get through the licensing process, and that is perhaps something we want to address there. All I would say is that the only nuclear project currently planned here has been the subject of lengthy negotiations, which concluded in what some people regard as quite a generous deal for the developer. That is another reason why I think you should not be too depressed about the prospects of making money out of nuclear power in this country. I think the prospects are rather good from that point of view. Thank you very much for coming in. It has been very interesting from our point of view and we are grateful for your time.

Examination of Witnesses

Witnesses: **Dr Fiona Rayment**, Director, Fuel Cycle Solutions, National Nuclear Laboratory, and **Dame Sue Ion**, Chair, Nuclear Innovation and Research Advisory Board, gave evidence.

Q144 Chair: Good morning, and thank you both for coming in. I think you probably heard what has gone before. Could I begin by asking if you could update us on the SMR feasibility study and specifically what the key findings are and when you expect to publish them?

Dame Sue Ion: Chairman, I am afraid the study is running slightly later than originally envisaged, so the details of the interim report are not yet available. They will probably be available towards the end of July or throughout August.

Q145 Chair: Who has been involved so far in terms of industry?

Dame Sue Ion: It is a project that has been set up by a combination of DECC and BIS, in partnership with companies. The ones involved so far are Atkins, Rolls Royce and AMEC, together with the National Nuclear Laboratory, which is leading on the project. We are the independent project director appointed by BIS and DECC.

Q146 Chair: In terms of international partners?

Dame Sue Ion: In terms of international partners there are none so far because the purpose of the study is to examine the potential of SMRs for the UK by looking at whether there is genuinely a global market for SMRs, what the route to market in the UK might well be, what the options are in terms of technology, realistically, and where the opportunities are for capture of UK manufacturing capacity and IP within both a UK and a global context.

Q147 Chair: What role do you think small nuclear power could play in the UK?

Dame Sue Ion: You start first and I will go second.

Dr Rayment: In terms of where SMRs can play a prominent role, in my view going from potential opportunity of going beyond 16 gigawatts electrical to perhaps needing more than that in terms of nuclear energy into the future, I think what SMR technology can do is offer another alternative to current large nuclear power plants, especially where you get to a situation where there is perhaps a lack of grid infrastructure across certain parts of the UK; perhaps the need for more industrial capability in terms of being able to support industry from an electricity production perspective, and being able to get to the situation where perhaps getting as much as 30 gigawatts electrical could be supplied by nuclear energy. I think the SMRs could be a component for that.

Dame Sue Ion: Yes. In terms of a potential role, it is a potential role because there are a number of benefits that may flow. One is the ability to add smaller amounts to the grid, so better from a grid management perspective and better from a siting perspective if you do not have access to large grid capacity, but also potentially in terms of the economics. The thing that dominates the cost of nuclear energy is the capital required and its cost of financing, which is close on 60% of the overall generating costs, certainly greater than 50%. That is what it means. It is getting increasingly difficult to finance the very large plants as we found with Hinkley Point, where it is even beyond the balance sheet of a large company like EDF and required Chinese investment in order to make the project go ahead.

Small modular reactors, although they may be the same or even more expensive on a bit per kilowatt, bits per megawatt, the fact that you can build them in small slugs means that you borrow money over a shorter period of time and the amount you have to borrow is a smaller absolute amount of capital. It means they are potentially easier to finance than the large base load units that we see elsewhere in the market.

Q148 Chair: How quickly could we see small modular reactors deployed in the UK?

Dame Sue Ion: The study that DECC and BIS are financing—so it is a UK study—one of the ground rules was that the systems that were examined should be deployable within a period up to 2025, so that limited somewhat the technologies that were going to be examined. But it depends on: what does the market look like and is there a serious commitment to invest? You heard from the three other witnesses prior to our session. There is still a significant amount of detailed design to go on these systems. You cannot just pour concrete now. There is still a lot more to go. That is why there is potential for the UK to look at partnership in closure of the designs and developing IP and manufacturing potential for the UK in the process.

Q149 Chair: Therefore, do you think there is scope for greater collaboration between the UK and other countries?

Dame Sue Ion: Yes, I do because it is difficult to see how we could do an SMR from scratch ourselves. Clearly it is possible but, in terms of the cost and the time that it would take to do that, we are starting from behind. The Americans have already pumped hundreds of millions of dollars, both corporate investment and state investment, into moving the SMR projects along. Other

nation states are also with their Governments financing small modular reactors design, with the intention to deploy.

Dr Rayment: There is a real opportunity in terms of collaboration internationally, both in terms of collaborating with key vendors in terms of working with various manufacturing organisations and bringing best practice together, in terms of being able to do that, but also in terms of looking at the whole regulatory regime and looking at best practice in terms of being able to take that forward. In terms of what we have in the UK, we have a world class regulatory regime but looking at what other countries are doing now, in terms of streamlining processes and so on, it is the sort of thing that I think ONR and other organisations like that could be involved in.

Q150 Graham Stringer: I am going to ask similar questions to those that I asked the last panel. What more work needs to be done to determine whether small modular reactors are economically viable?

Dame Sue Ion: There is still a lot of detailed design to do and assessment of that, so engagement with potential vendors is something that is important in terms of the detail but you will not know until you have built the first one just how good or not they are going to be. It is only in closure of the detailed design and the ability to manufacture in bulk—as opposed to single units or twos and threes—that you will find out whether or not they can economically compete.

Dr Rayment: A number of these units that are being offered up at the moment are very much going through that design phase at the moment, and I would just augment what Sue has said, in that any such system needs to get beyond first of a kind before you can start to determine how economic that particular system is.

Q151 Graham Stringer: Then is it reasonable to expect the small reactors to attain the same price point per kilowatt hour as large reactors? You are saying that you will not really know a lot until you have built one, so is it reasonable to assess them on that basis?

Dame Sue Ion: You can make some general comparisons when you get the bill of materials, which will tell you how much capital per megawatt installed. You can get a reasonable judgment on that basis. The real benefits you will not be able to assess until you can look at mass manufacture in a factory—as has been mentioned by previous witnesses—rather than a lot of the work that still has to be done onsite with the large systems. The potential is certainly there to get better than the current price point but until you do more detailed work, both in terms of the engineering design and the competitiveness of the various competing technologies, you will not know for sure.

Dr Rayment: For example, many of these designs are smaller versions of larger BWR facilities, and so I think it is very fair to assume that they would be able to compete with that type of facility in terms of price, but it needs to be underpinned before that can be taken forward.

Q152 Graham Stringer: Dr Rayment, in your written submission you said that these kinds of reactors might be attractive to large industrial users of energy. Are those potential users, are they involved in any way in trying to promote this technology, to help get it deployed?

Dr Rayment: Not at this moment in time. There are a number of discussions that are ongoing on where small modular reactors could offer a lot of value and opportunity, and I think that it is still up for debate in terms of small modular reactors would be of best use within industry in terms of taking things forward. But the key areas where there seems to be real optimism, in terms of where they could be used, are being able to site them close to that industry. So where you have issues, for example, currently with grid infrastructure and so being able to have a power plant that is very close to where that industry needs the electricity, could offer value. Especially if you have a plant itself that can load follow, that can deal with peaks and troughs in demand, which some of these systems very much can. That could add some further value from that perspective.

Q153 Graham Stringer: Do we really need a publicly funded demonstrator before there will be sufficient confidence in the market to go forward with this technology?

Dr Rayment: A number of these systems are already going through protocol at the moment. As discussed previously, there are a number of these systems that have already been proven, in terms of the various engineering loops and pressure systems that are in place and have been tested from that perspective. Any first of a kind is a demonstrator in its own terminology, but I think that any prototype that we take forward when proven can very much then be put onto the bars and start to generate electricity and bring in a return at that stage. So my view would be that first of a kind is a prototype or a demonstrator but there is no reason to then be able to turn that into a system that can generate electricity.

Q154 Graham Stringer: I understand what you are saying. It is the public funding for the demonstrator I am trying to get to, whether the taxpayer needs to fork out before this will get going.

Dr Rayment: With any first of a kind because of the level of money that we are talking about, I think it would be very difficult for any one, single organisation to be able to take that forward in their own right so it may well need some help from a Government funding perspective.

Dame Sue Ion: Industry is very conservative and unwilling to dip its own hand in its pocket, unless there is significant commitment as evidenced by Government also investing in anything going forward. The timescale to deliver the first one and get income back from it is still very significant. In the United States the companies that are involved are in partnership with their Government. They are not wholly funding it themselves, neither is the United States Government funding it wholly itself. So, in order to take this technology forward, the general consensus is that some form of significant commitment from Government would be required.

Q155 Graham Stringer: A final point: the Contracts for Difference model, is that going to be an extra barrier to getting a demonstrator built?

Dame Sue Ion: It is one mechanism for trying to attract investment in. It is not the only mechanism. The Government would have to look at what options it has in order to progress this technology and see it come to fruition if it wants to do that. CFD is one way, there are other ways.

Dr Rayment: I don't think it is any different than a large nuclear power plant. The Contracts for Difference has been highlighted as one option. I do not see it being a barrier specifically. I think that is an option that should be considered in terms of being able to get people into the market.

Dame Sue Ion: If I may just a final comment. One question that was asked of previous witnesses was about democracy. One thing that would help, and has helped to a certain extent with the current situation, is that at the moment the Coalition and the Opposition are supportive of nuclear energy and the United Kingdom being part and parcel of the overall energy mix. Party consensus in taking nuclear technology forward is pretty important because almost all systems go over the length of more than one Parliament, so certainty in policy space and support from all the main parties of Government is quite important.

Q156 Sir Robert Smith: You were mentioning or discussing a demonstrator. Given the range of companies and ideas and designs, what are you demonstrating? Are you demonstrating the size or are you happy to pick the winning company, which you are going to demonstrate for, to then take it forward and roll out that technology, or will there be more than one competing technology? Is our market big enough if it takes off?

Dame Sue Ion: We would have to wait until the study that is underway concludes to get a comprehensive answer to that question. It would be unusual if more than one demonstrator were to go ahead, given the amount of public funding that might have to go behind it. It would all depend on how the potential vendors approach the idea of the UK being a very receptive market where Government investment is likely to go in, in which case you could see competition between vendors to build the first one in the United Kingdom, but we still have some work to do.

Q157 Sir Robert Smith: What is the public money demonstrating with the first because we know that we have small scale reactors in submarines and all that?

Dame Sue Ion: Yes. Submarine technology is very, very different from technology deployed in the civil sector, and I would not want anybody here to think that there is a direct comparison between the two. There isn't. The issue is the competition between the potential other sectors, like water reactor technology is available. The Government funding in partnership with industry is phrased very much to say, "We have had an interim step at the moment. There will be a request to proceed and to take the study further, so that the UK is in a better position to judge which of the technologies is worth pursuing in some detail" and then it will be a question as to whether or not one technology or more technologies are pursued.

Dr Rayment: The bottom line is that it needs to be able to show that it can generate at the capacities that basically the literature says that it can, and that it is available to do that for that period of time, and if it is a technology that is going to load full in terms of the demand on the system then it can do that. If you take submarine technologies, it is a very different technology in terms of what they are trying to do. It is not just all about load following or high levels of demand for long periods of time. It is usually high levels of demand for small periods of time and operating in a much different environment.

Q158 Dr Lee: Following on from what I said earlier about democracy, do you harbour any concerns about the way in which we are currently trying to fund nuclear? Because the economics of what we are talking about here implies the same, that there is a propensity for politicians to perhaps mortgage the future because it is easier and—going back to the electoral cycle—it is pushing it into the distance, and that that may dissuade because, when we look at the books 10 years down the line and we see that Hinkley has cost X plus, plus, plus, it may dissuade proper long-term investment and commitment to nuclear power. Do you have any concerns about the way in which we have decided to currently fund?

Dame Sue Ion: No. In terms of the way the current funding has proceeded, no, because the risk is not with Government ultimately in terms of over-runs, it is with the provider of the power.

Q159 Dr Lee: Yes, but we have committed to paying them double what electricity currently can be sourced from elsewhere. So I wonder whether in view of the shale gas thing in the background, which is essentially why America's economy is booming: its price of energy has fallen in relative terms to the rest of the world. Is there a fear that when we come to perhaps rollout SMR, or whatever the technology is, that when we look at the books nuclear is—before we start talking about the management of waste—seemingly costing much, much more?

Dame Sue Ion: I think that is a broader energy policy question, but in the end all technologies are not the same cost and although the currently projected price for electricity seems high, it is not as high as other forms of energy that are already contracted. Shale gas may or may not realise its potential here in the UK. The engineering challenge and the manner in which it is extracted here is very different than the United States, so the jury is out on how cost competitive shale gas will be in the United Kingdom versus the United States.

The important thing is—and this is a personal opinion and not particularly a NN Lab opinion—that if you have a balanced energy portfolio then you require a balanced suite of technologies and some are more expensive than others.

Dr Rayment: As well, in terms of the current nuclear power plant programme, we are talking about a 60 year time horizon. When we come to talk about small modular reactors we could be talking about a smaller time horizon, for example. So there could be some different models that need to be looked at from that perspective. I do think that public perception is something we all have to work at, in terms of ensuring that there is the view in terms of what nuclear can do and that the opportunities are there for nuclear going forward. I think that is an area that needs to continue to be addressed.

Q160 Albert Owen: Can I go to technology-specific and talk about fuel cycle? Given the huge capital investment in industrial infrastructure that now underpins the global nuclear supply chain, what would it trigger to change the fuel cycle from, let's say, uranium to thorium?

Dame Sue Ion: It would require the price of uranium to be very, very significantly higher than it already is. The cost of fuel in a nuclear power system is tiny in the overall scheme of things, and so it would require a very, very significant rise in the price of uranium to get anybody seriously interested in use of thorium as a fuel. Even India, which is sitting on significant reserves and

probably has one of the more advanced programmes looking at thorium, is going to fuel its mainstream reactors for the foreseeable future with uranium.

Dr Rayment: I agree with everything that has been said, and it would also depend on the size of the nuclear power programme that we are talking about globally and also in the UK, which of course will then go back and impact on the price of uranium from that perspective. What we have here in the UK at this moment in time is an infrastructure that is very suitable for a uranium fuel cycle. A lot of the skills and expertise, and also the facilities that are in place all understand how that fuel cycle can operate. That being said, that does not mean that at some point in the future a thorium fuel cycle isn't something that we should perhaps consider should uranium prices go up by a significant amount and new build going up by a significant amount as well.

Q161 Albert Owen: You both agree that the price of uranium is key to triggering a change?

Dr Rayment: Yes.

Q162 Albert Owen: From what you can gauge from industry or Government, there is no appetite to move to another fuel cycle?

Dr Rayment: In the UK?

Albert Owen: In the UK.

Dr Rayment: Not at this moment in time.

Albert Owen: Or globally?

Dr Rayment: Perhaps globally. I think there are a number of countries that are sitting on large thorium reserves, like China, like India, like in Scandinavia where a number of these countries are looking at sustainability of supply and looking at energy security, and from that perspective you could see why, if they haven't already developed up their own fuel cycle, they might want to look at a thorium fuel cycle in terms of taking that forward. Here in the UK, as I said, we currently have a uranium fuel cycle. We have a lot of skill and capability in terms of taking that forward right now. I think where we are at the moment is being involved in international collaboration, in terms of these programmes and also having a watching brief in terms of where thorium technology can move forward.

Q163 Albert Owen: Are we not in danger of locking ourselves in to this fuel cycle, when you talk about developing countries having a big appetite for energy in the future. If they are sitting on these reserves they could determine price in the future of fuels, and the whole technology could move and we could be left in the slow lane.

Dr Rayment: That is why we need to continue to have a watching brief at this moment in time to understand exactly what is happening in other parts of the world, and be involved in some of these programmes. For example, within the National Nuclear Laboratory we are involved in some

thorium fuel research with a consortium in Scandinavia, and looking at thorium plutonium fuel as a potential opportunity going forward. I think that by doing that we will continue to make sure that we are involved in these programmes as they develop and if there is a time or a switch as the viable alternative going forward, we are in a position to be able to advise on that.

Dame Sue Ion: It is important from a research standpoint that we are able to offer credible opinions on the international stage about the various fuel cycle options and, therefore, to maintain an active participative role in those programmes, so that we are able to both comment and seek to accelerate deployment if that should be the likely route in the future.

Q164 Albert Owen: Thank you. If I can move on to the three options that the NDA are looking at: reuse of MOX in light water reactors, reuse of the CANDU EC6 reactors and the reuse of the PRISM set out by the NDA for reuse of plutonium waste stocks. What is your view on this?

Dame Sue Ion: That is a matter for the NDA in terms of its consultation and request for options to deal with the UK's plutonium stockpile. It is a separate issue from the discussions on small modular reactors, while two of those options, one smaller than the other, are smaller than the big systems that we see on the grid today they are one-shop solutions for the plutonium disposition question. They are not in the same pool as small light water reactor modular systems for gigawatts worth of electricity generation. They are two completely different issues.

Q165 Albert Owen: Accepting that, we are interested in your opinions on these matters. Dr Rayment?

Dr Rayment: First of all, I would definitely ask NDA when you see NDA where they are up to, and Dr Simper will be able to talk about that in an awful lot more detail. But in terms of what we are working on within the National Nuclear Laboratory, we are working with the NDA in terms of understanding the whole behaviour issues associated with plutonium within the fuel. We are working with the three vendors in terms of how that fuel might be able to be applied within their particular reactor systems going forward. I think that at this moment in time the approach is very much to look at the credibility of all three fuel types and all three reactor systems, and see which is the feasible one going forward. I do not think that we could say categorically at this moment in time which option is the best option. What we can say is that in terms of fuel that has already been developed so far, there is much more been done on MOX on a commercial and industrial scale. Therefore, we have much more technology underpinning data in terms of how that fuel will behave over time, in comparison to perhaps what we would be putting into a CANDU reactor or a PRISM reactor. Hence the reason why there is work going on in these areas at the moment to be able to do that comparison and hopefully come to a conclusion, at some point in the near future, around which is the best economic alternative for the UK.

Q166 Albert Owen: Sure. That was a very useful answer because you know that in the debate over the years the weak link has been: how do we deal with nuclear waste, and here is the possibility of recycling for the future. If I can ask a very general question. We are not talking just about civil nuclear here, we are talking about defence nuclear, waste and also medical?

Dr Rayment: Yes, there is a possibility here that we could be looking at some medical radioisotopes as well that could be put into some of these fuel types. Probably not in MOX fuel but there is very much the possibility at looking at medical radioisotopes in terms of how that could be used in the future as well, yes.

Q167 Albert Owen: But my point is that we are not just talking about what has been produced in civil nuclear power stations. We are talking about waste that has been produced by atom bombs and various things as well as in the medical.

Dr Rayment: The NDA programme is very much looking at civil plutonium and looking at the whole concept of being able to take that civil plutonium stockpile and use that for future nuclear energy production. That is the focus of that programme at this moment in time.

Dame Sue I am just going to add that it is not about waste generally, for which a solution in terms of a final site of disposition has to be found. It is about the UK civil plutonium stocks and the best way of dealing with those going forward.

Q168 Albert Owen: Why don't we include the defence? I am sorry to ask, it might be an elementary question to you. But if you are producing research and you are producing some dangerous goods that could be recycled why is it separate?

Dame Sue Ion: Plutonium is not waste, per se. It is an energy asset. In terms of waste, we are talking about the total general UK waste inventory that would go down the repository, and there will be some defence waste associated with that. So it is not separation in that context.

Q169 Albert Owen: Is it possible to get a figure of what—I know you do not call it all waste—waste for argument's sake is from civil, what is from defence and what is from medical research and hospital?

Dame Sue Ion: Probably.

Dr Rayment: I believe that information does exist.

Dame Sue Ion: Yes. There is an inventory that is collected by Government—I am not sure which piece now—that does articulate that on a reasonably regular basis.

Albert Owen: It would be useful to get that.

Dr Rayment: It is the radioactive waste management inventory. I would need to go back and check but I believe the last time it was issued was two years ago. That is definitely available and it is on the NDA website so we can get that.

Albert Owen: Thank you very much.

Q170 Ian Lavery: With regard to the regulation and licensing of the site, it is obvious that there are challenges associated with the licensing of the SMRs and indeed the larger reactors. Can you explain very briefly what the difference is?

Dame Sue Ion: The large reactors that are currently going through licensing are at a slightly later stage in the design than the SMRs. The SMRs still have some way to go for the completion of the detailed design, which is why there is always a trade-off between when do you submit for a licence assessment or not because the more design that you have done the easier it is from the point of view of the questions back and the adjustments that you might have to make. For light water reactors, which is what the main content of the discussion today has been, they are evolutionary developments of systems that have been around for 30/40 years. Although they are different in detail, in concept they are similar.

Dr Rayment: I would agree with that. What I would say is that, because a number of these SMR designs are still going through the design phase at this point of time, there will be a number of iterations as they go through the generic design assessment. That will mean that there will be modifications made to that design as they are developed through that design assessment, which is why it sometimes takes a bit more time for them to go through. The alternative is to do the full design upfront and then push that through, but then there is a risk associated with the vendor in terms of how much time and effort they would need to put in upfront before engaging the regulator in terms of how that design could be applied within a particular country.

Q171 Ian Lavery: Do you think the model should be tailored for small nuclear reactors and do you think it is possible to do that? If you do, how could that be done?

Dr Rayment: Again I think we should talk to ONR around that, and I am sure you will when you see them later on this month. The GDA itself has been set up very, very well for the nuclear power plants that are currently going through the system. I think a similar thing can be done for small modular reactors. We need to recognise the fact that a number of these designs are first of a kind and, as a result of that, as they go through that evolutionary process it will take time to take that through. I think though that it would be useful to look at the SMR design and see whether there are areas that could be streamlined, but I don't know whether that would be the case at all. I suspect that that is something that ONR will look at.

Dame Sue Ion: One of the benefits that the UK regulatory system has is that it is flexible and it is goal oriented, not rule tick-in-the-box based. The regulator does have flexibility but still very rigorous safety assessment principles. One of the real benefits of the opportunity that SMR gives us now is that they are going through licensing in the United States to design and, therefore, there is an incredible opportunity for the two regulators to work together with respect to global regulation of this particular type of technology. It is the first time in a generation where the UK has got an opportunity to be there and on the front foot, especially if a first deployment were to occur here in the United Kingdom. It would give us an enormous competitive advantage as a nation on the global stage.

Q172 Ian Lavery: If the SMR is to be successfully deployed in the UK in, say, the next decade or so do you think there will be a need for greater resources for the Office for Nuclear Regulation?

Dame Sue Ion: In terms of the numbers of systems going through the assessment process, then clearly that is a question you would have to pose of ONR. But realistically, probably yes. There are ways for ONR to exercise its duties by some subcontracting out into the independent marketplace for qualified players here in the United Kingdom, so the regulator does have some flexibility in the manner in which it exercises its duties.

Q173 Ian Lavery: Do you think the Environment Agency would need greater resources?

Dr Rayment: In terms of both organisations, I think that if you have a multiple number of reactor power plants going through the system then more resources will be required in terms of being able to deal with that. I do think we have quite a significant skill base still in the UK, in terms of people who understand how nuclear power plants operate. So if we are going to do it this is the time to do it in comparison to a few years hence, because that skill base still exists. As well, organisations like the Environment Agency and ONR are fundamentally increasing that skill base at this moment in time. I also think that it is a matter of programming because if you look at the whole programme, in terms of how many UK power plants you are going to bring through at any particular moment in time, I think there is a way of being able to do that so you can programme them in so that you do not have too many going through in any particular month.

Q174 Ian Lavery: With regards to the siting of the SMRs, do you agree with what was said by the earlier panel that existing power generation sites look to be the best candidates for the siting of the SMRs? Do you agree with that?

Dame Sue Ion: Yes.

Ian Lavery: If you agree with that why would that be the case?

Dame Sue Ion: For some of the reasons that were given by previous witnesses: the skill base, the inherent workforce that is used to dealing with nuclear technology—we are talking about existing nuclear sites here—access to grid, access to cooling water and good public acceptance in the areas where the existing stations are. Those are some of the reasons that I would give.

Q175 Ian Lavery: Do you think there is a need for the Government to undertake a strategic siting exercise for the SMRs?

Dame Sue Ion: That is obviously a matter for Government, but the siting exercise that was carried out for the existing first wave fleet and the designated sites ruled some sites out on the ground of size and cooling water because of the large systems that were foreseen. Clearly, the small systems do not benefit from some of the weaknesses of large systems, so it may be prudent to do a revision to the strategic siting assessment to assess some of the sites that were first ruled out for SMR potential.

Dr Rayment: Yes. The existing sites that were reviewed are definitely sites that should be looked at again from an SMR technology perspective. I think by going back and revisiting where we are

at now, because it is different criteria that we are using now in terms of these SMR systems in comparison to the NPP, the large nuclear power plants. That would be the optimum approach. I also think that, following that, there may be some other sites at various industrial facilities that may also be sites that we may want to look at as well. So if that review was to happen we might want to broaden it out a bit at that time.

Q176 Dr Whitehead: Are small nuclear reactors inherently safer than the larger reactors that we are currently embarked upon, simply because of their size or because of the technological development that is going into the specific issue of those small reactors?

Dr Rayment: First of all, I would like to compare similar systems. So if you take a large nuclear power plant that is, say, a pressurised water reactor and a small modular reactor that is a pressurised water reactor. Simplistically, the only difference is you are talking about less energy production coming out of the system, and you are talking about a smaller reactor. In terms of is it safer? A lot of the reactors that are developed nowadays are developed as passively safe systems. Therefore, it is relying on nature to be able to make the reactor inherently safe. From that perspective, I would say that both are comparable. Then when you start to look at: should there be an accident and actually looking at the fuel within the reactor system and looking at basically how long that fuel will take to cool, with a large nuclear power plant there will be more fuel in the system in comparison to a smaller nuclear power plant. So the difference there is that the small nuclear power plant has less fuel to cool. But if you have a passively safe system you would be able to deal with that anyway. So I would say from that point of view they are actually quite comparable.

Dame Sue Ion: There is no doubt about the safety of the currently foreseen larger units, and small modular reactors may achieve improved safety standards via different methods: some through passive technology, some through different active technology. It really depends on the details of the individual designs.

Q177 Dr Whitehead: You might think that one of the purposes of moving to small modular reactors would be to introduce a much greater flexibility and deployment, the localisation of power as a result of those smaller power stations. So presumably that would mean that a number of the issues that you would perhaps say were avoided in the original strategic assessment, which mostly turned out to be sites upon which there had previously been nuclear reactors and, therefore, there could be new nuclear reactors on those sites. The suggestion might be that that would require a whole new engagement with the public about safety, siting and various other issues. Is that something that you would consider would be necessary to start all over again, or might there be work under way as part of the programme that is being undertaken at the moment in that sphere?

Dame Sue Ion: If I understand you correctly you are asking me, if the potential sites were extended to include sites that do not currently have nuclear reactors on them, it would require gross public engagement and assurances. Is that correct?

Dr Whitehead: Yes.

Dame Sue Ion: I think if you were to consider using sites of any type that are not currently designated nuclear sites, then you would need to look at a very serious programme of

engagement, probably for a number of years, in matters associated with radiation, not just nuclear radiation, any radiation, as well as nuclear powers benefits, and also safety to convince people that it would be the right thing to do. It is much easier to look at deployment on sites that are already nuclear sites, where there is a much greater awareness within the population and where there is a much greater enthusiasm for new nuclear technology on those sites. As a first start you would look at existing nuclear sites, perhaps ones that were ruled out in the first stage assessment, rather than to look at completely different sites. I would say my personal judgment would be that that would come much later.

Q178 Dr Whitehead: Might that in any way be related to security issues in as much as if you have existing sites and perhaps you deploy a number of smaller reactors on those sites they are perhaps more secure, simply because of the nature of those sites than perhaps a number of deployments on an individual basis in various parts of the country?

Dr Rayment: I do not think we say it is a matter of security. I think it is more around the fact that these sites have already been licensed in the past. The infrastructure is already available in terms of being able to connect up to the grid. There are people in the area that most likely already have the skills and expertise to understand nuclear and also because nuclear technology has been there for a while. There is also the aptitude for bringing more nuclear to bear within that particular neighbourhood because people have recognised that there is an economic benefit for them locally, in terms of them engaging with nuclear in that area. So I think it is much more around that. I think security would be taken into account no matter what site is implemented going forward, based on both reactor design and also all of the ancillary physical and cyber security issues that would have to be dealt with.

Q179 Dr Whitehead: I can imagine if you have, say, a large number of deployments of individual sites across the country for relatively small reactors, the relation of the security of those sites to the actual product, shall we say, may look disproportionate. Whereas, if you are on existing sites the security is already there and I am not sure of the metrics of security to production, so let us say you had a site three miles away from Southampton that had to be presumably made secure for the purpose of production. Would the process of that security outweigh the advantage of having a localised power production, which appears to be the promise at this kind of scale?

Dame Sue Ion: Certainly you would look to the existing sites first. I think we should remember that the original Magnox reactors were small, in the context in which we are discussing reactors at the moment. Many of our sites would fit the criteria for SMR, although they clearly were not modular reactors. So starting there would certainly seem to be the right first step, for the reasons you already have: the security and confidence and the ability to deploy. We have many high hazard industries in the United Kingdom that are not located far from the population, and yet we do not appear to have the same scrutiny with respect to security in the context that we are discussing here. The thing to remember is that transported fuel is the most important issue to consider, and that has been carried out between the existing reactor sites in terms of transporting the fuel there and transporting the spent fuel away to Sellafield. So the security arrangements could be made robust for reactors that are located closer to industrial use but, realistically, I would start on existing nuclear sites.

Chair: We have come to the conclusion. Thank you very much for coming in and for your contribution to a very interesting session.