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Small nuclear power

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Summary

Small nuclear reactors—those that produce the equivalent electric power of less than 300 MWe—potentially have many useful applications. These reactors include a variety of designs and technologies that can be categorised in numerous ways. One grouping of particular interest is 'small modular reactors' (SMRs), which are designed in a way that allows them to be manufactured at a plant, brought to site fully constructed, and installed module by module, thereby potentially improving manufacturing efficiency and cost while reducing construction time and financing costs.

While we recognise that the nuclear industry's immediate priority is rightly the successful delivery of the UK's current conventional new build programme, we also recognise that SMRs—particularly those based on known nuclear technologies—are a viable proposition for future deployment in the UK in the next decade. They could potentially have a key role to play in delivering low carbon energy at lower upfront capital cost compared to large conventional nuclear reactors. That said, the commercial viability of SMRs remains unclear. Government should work with industry to better understand the economics of SMRs and set out a clear explanation of the conditions under which they are likely to be cost competitive in the UK.

We recommend the Government takes a proactive role in driving forward the development and deployment of these reactors in the UK. In the first instance, Government should help to establish the right conditions for investment in SMRs, for example through supporting the regulator to bring forward approvals in the UK, and by setting out a clear view of siting options. We would also like to see the Government steering industry towards deploying a demonstrator SMR in the UK. Existing nuclear sites could potentially host a demonstrator module with minimal additional infrastructure requirements and with the support of a skilled local workforce.

In the short term, deployment of SMRs is likely to be achieved through sharing the costs between the public and private sector. In the longer term, Government should identify and help to establish future sources of commercial finance for the further development and industrialisation of SMRs. Collaboration with international partners is important and the Government must ensure that UK companies are in a position to compete for opportunities to develop SMRs. The Government must also work with industry on a programme of proactive public engagement on SMRs.

In the future, new technologies may bring with them the possibility of improved technical features in nuclear reactors, for example through enhanced safety or through reuse of waste materials. We heard that there are a number of advantages to switching to a thorium fuel cycle. The UK must remain an active participant in thorium research and development. We recommend that the Government commission a study to confirm the potential benefits of thorium in the longer-term and how any potential barriers to its use might be overcome.

1 Introduction

1. Nuclear power stations have been growing in size, from a typical size in the 1950s of 60 MWe to modern plants up to 1.6 GWe.[1] At the same time many smaller nuclear power reactors have been built for naval use. The International Atomic Energy Agency defines 'small' reactors as those that produce the equivalent electric power of less than 300 MWe, while 'medium' reactors are those producing up to about 700 MWe. Some of the early Magnox[2] reactors in the UK would qualify as small using this definition: for example the four Calder Hall units were rated at just 60MW each.[3] However, although small in power output, "these were physically large units and lacked most of the characteristics of smaller reactors now under consideration".[4] In 2011 there were 125 small and medium units in operation and 17 under construction, in 28 countries, totalling 57 GWe capacity.[5]

2. Small and medium nuclear reactors potentially have many useful applications, including electricity generation and industrial process heat, desalination or water purification, and other cogeneration applications. Small and medium reactors include a variety of designs and technologies that can be categorised in numerous ways, for example by being classed 'fast' or 'thermal' reactors, by their coolant type, or by whether they have open or closed fuel cycles.[6]

3. One grouping of particular interest is 'small modular reactors' (SMRs), which are designed in a way that allows them to be manufactured at a plant, brought to site fully constructed, and installed module by module, thereby potentially improving manufacturing efficiency and cost while reducing construction time and financing costs.

4. In our 2013 report, *Building New Nuclear: the challenges ahead*, we recommended that the Department of Energy and Climate Change (DECC) monitor progress toward developing small nuclear reactors, so that the possibility of including these as part of the UK energy mix remains open.[7] The Government responded that ultimately it was a matter for developers and operators to decide what type of fuel and technology to propose for future reactor systems and for the UK's Nuclear Regulators to be satisfied that plants meet their safety, security and environmental requirements. However, the Government maintains a watch on a wide range of reactor technologies that have the potential to contribute to the future energy mix.[8] More recently, the Government commissioned a Small Modular Reactor feasibility study,[9] conducted by a consortium of companies led by the National Nuclear Laboratory. The study considered potentially valid SMR designs that are deployable within 10 years and draws together the evidence to form a view on:

- Whether SMRs could reduce the cost of nuclear power generation and therefore electricity;

1 MWe = Megawatt electric. GWe = Gigawatt electric.
2 An early type of gas-cooled reactor
3 National Nuclear Laboratory (SNP0014)
4 National Nuclear Laboratory (SNP0014)
5 World Nuclear Association, Small Nuclear Power Reactors (updated 25 October 2014)
6 National Nuclear Laboratory, Small Modular Reactors: Their potential role in the UK, July 2012
7 Energy and Climate Change Committee, Sixth Report of Session 2012–13, Building New Nuclear: the challenges ahead, HC 117
8 Energy and Climate Change Committee, First Special Report of Session 2013–14, Building New Nuclear: the challenges ahead: Government Response to the Committee's Sixth Report of Session 2012–13, HC 106
9 National Nuclear Laboratory, Small Modular Reactors (SMR) Feasibility Study, December 2014

- Whether and in which areas UK industry might have a role;
- The size of the market opportunity;
- The role innovation might play; and
- The most appropriate technologies and market applications. This will include safety, security and safeguards considerations.[10]

5. On 4 March 2014, we launched this inquiry to explore in more detail small nuclear power and its place in the UK. We received 32 submissions of written evidence and held four oral evidence sessions between June and September 2014. A full list of witnesses can be found at the back of this report. We also visited the Nuclear Advanced Manufacturing Research Centre in South Yorkshire to see first-hand the collaborative approach taken by academic and industrial partners from across the civil nuclear manufacturing supply chain. We are very grateful to all those who took the time to contribute to this inquiry.

6. Chapter two sets out the potential role of small nuclear power in the UK and in Chapter three we address some of the potential barriers to deployment and how these might be overcome. Our overarching conclusions on the way forward in the UK are set out in Chapter four.

10 DECC (SNP0002)

2 The potential role of small nuclear power

7. We have noted in previous reports that as a low-carbon source of electricity, nuclear power could contribute towards the UK's long-term climate change and energy security goals, but a new generation of nuclear plant will be required to deliver this.[11] In the medium term this contribution rests on plans set out by industry to develop up to 16 GW of nuclear power in the UK by 2025. However, there have been concerns about the length of time it takes to build new nuclear power stations and the costs of doing so.

Do all good things come in small packages?

8. Small modular reactors (SMRs) are an attractive proposition because:

- Unlike conventional nuclear power stations, which have tended to be positioned on coastal sites due to their cooling requirements, small reactors would open up potential inland sites;
- They may be suited to new customers: for instance, some heavy industrial users of energy have expressed interest in having secure, reliable power generation on-site or nearby, to provide a degree of insurance against future energy price volatility or interruption;
- If deployed closer to users they would not necessarily require substantial investment in transmission infrastructure;
- They may have a reduced capital cost, which opens up nuclear power to a wider range of electricity utilities who cannot contemplate the massive multi-billion pound outlay of the conventional large designs; and
- The ability to manufacture many parts (or the whole) of the reactor off-site in factory locations may lead to significantly shorter construction periods than their larger counterparts.[12]

9. Over the long term there are also potential costs savings from serial production of SMRs. That said, the nuclear industry's "immediate priority is the successful delivery of the UK's current new build programme".[13] Paul Stein, Chief Scientific Officer at Rolls Royce, agreed that:

> we have to get on with building the large reactors, […] but hot on the heels of that will come small modular reactors—not in a 15 to 20-year time frame but more like a five to seven-year time frame, as long as we use existing, proven designs. That can then take nuclear power on from, say, the first 16 GW up to the next 24 GW of nuclear power that the UK needs and will also provide an exportable product for the UK.[14]

11 Energy and Climate Change Committee, Sixth Report of Session 2012–13, Building New Nuclear: the challenges ahead, HC 117
12 National Nuclear Laboratory (SNP0014)
13 Nuclear Industry Association (SNP0004)
14 Q43 (Paul Stein)

The five to seven year timeframe suggested by Mr Stein was the most optimistic we heard, with others suggesting that bringing SMRs to market would take closer to 10 or 15 years.[15]

10. **Small modular reactors are an attractive proposition and we welcome the Government's work looking into the feasibility of these reactors in the UK. However, we recognise that the nuclear industry's immediate priority is rightly the successful delivery of the UK's current conventional new build programme.**

Choice of technologies and fuels

11. The length of time taken to develop SMRs and other small or medium reactors will to some extent depend on the type of technology chosen. Different technology options–including light water reactors, gas cooled reactors, fast spectrum reactors and molten salt reactors–are described in detail throughout many of the submissions we received.

12. New technologies may bring with them the possibility of improved technical features in nuclear reactors, for example through enhanced safety or through reuse of waste materials. For example, the Nuclear Decommissioning Authority (NDA) recently undertook some work on the management of separated civil plutonium stocks in the UK; it concluded that reuse is the preferred approach and is now investigating three technology options for reuse:

i) MOX in light water reactors;[16]

ii) CANDU EC6 reactors;[17] and

iii) PRISM fast reactors.[18]

13. The NDA previously noted that "all the technologies being considered have pros and cons and that no 'perfect' solution exists. It may be that a multi-track approach offers best value for money".[19] Dr Adrian Simper, Director of Strategy and Technology at the NDA, explained that the NDA continues to investigate technical matters such as what proportion of the plutonium stockpile could be managed through that proposed technologies.[20] He added that the NDA is also working with the Office of Nuclear Regulation (ONR) on licensing aspects to ensure that the technologies are licensable within the UK's regulatory framework.[21] Dr Eric Loewen, Chief Consulting Engineer at Ge-Hitachi Nuclear Energy, told us that he hoped that the NDA would, within the next two years, hold an open and transparent competition between the three different reuse options.[22] Liz Keenaghan Clark, Head of Nuclear Decommissioning Waste and Safety at DECC, informed us that the NDA is hoping to present its evidence towards the middle of 2015 so Government can then take a decision about the plutonium disposition programme.[23]

15 Q3 (Professor Freer) and DECC (SNP0002)
16 MOX = Mixed oxide fuel, such an approach has been proposed by AREVA
17 Developed by Candu Energy Inc – see Candu Energy Inc (SNP0038)
18 Developed by Ge-Hitachi – see Ge-Hitachi (SNP0022)
19 Nuclear Decommissioning Authority, Progress on approaches to management of separated plutonium, 20 January 2014
20 Q204 (Dr Simper)
21 Q204 (Dr Simper)
22 Q143 (Dr Loewen)
23 Q266 (Liz Keenaghan Clark)

14. In addition to looking at different technologies, we heard that a different choice of fuel cycle might also warrant consideration. Thorium fuel for example has been "successfully demonstrated in over 20 reactors worldwide, including the UK's High Temperature 'Dragon' Reactor which operated at Winfrith from 1966 to 1973".[24] In our *Building New Nuclear* report, we explained that thorium has several advantages including that it is more abundant than uranium and that thorium fuel cycles are intrinsically more proliferation resistant as the spent fuel is more difficult to use for nuclear weapons.[25] A more detailed appraisal of the pros and cons of using thorium is set out in the evidence we received.[26]

15. Despite the potential advantages of using a thorium fuel cycle, we heard from Dame Sue Ion, Chair of the Nuclear Innovation and Research Advisory Board (NIRAB), and Dr Fiona Rayment, Director of Fuel Cycle Solutions at the National Nuclear Laboratory (NNL), that the price of uranium would be the key to triggering a change from uranium to thorium fuel cycles.[27] Dr Rayment added that:

> 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.[28]

16. Dr Rayment also acknowledged that countries sitting on large thorium reserves, for example China and India, were looking at thorium from an energy perspective and that it was important for the UK to participate actively in collaborative research with international partners.[29] This might help to ensure that the UK would be in a position to accelerate deployment if that should be the likely route in the future.[30] The Rt Hon Matthew Hancock MP, Minister of State for Energy, stated that he would be "open-minded" to industry developed reactors based on different fuels.[31]

17. ***There are a number of advantages to switching to a thorium fuel cycle; however, the evidence we have heard suggests that this will not be a viable option unless the price of uranium changes drastically. The UK must for now remain an active participant in thorium research and development. We recommend that the Government commission a study to confirm the potential benefits of thorium in the longer-term and how any potential barriers to its use might be overcome.***

24 All Party Parliamentary Group on Thorium Energy (SNP0029)
25 Energy and Climate Change Committee, Sixth Report of Session 2012–13, Building New Nuclear: the challenges ahead, HC 117
26 Including: National Nuclear Laboratory (SNP0014); Nuclear Innovation and Research Advisory Board (SNP0017); Thorea (SNP0021); All Party Parliamentary Group on Thorium Energy (SNP0029); and Alvin Weinberg Foundation (SNP0031)
27 Qq160-161 (Dr Rayment, Dame Sue Ion)
28 Q161 (Dr Rayment)
29 Qq162-163 (Dr Rayment)
30 Q163 (Dame Sue Ion)
31 Q264 (Rt Hon Matthew Hancock MP)

Moving forward with known technologies

18. In order to move forward with small nuclear reactors, and SMRs in particular, we heard that focussing on known technologies would be the preferred approach for faster deployment times.[32] EDF Energy provided a helpful overview of the nuclear technology currently favoured in the UK:

> Globally, light water reactors are the dominant technology and have the greatest regulatory and operational experience. Additionally, future large-scale nuclear new build power plants in the UK are likely to deploy light water reactor designs (e.g. EPR, ABWR, AP1000). It can therefore be expected that the first SMR designs to be commercialised will be based on light water designs rather than more innovative technologies or more radical fuel cycles. Small light water reactors are also used for submarine and ship propulsion. All existing or proposed small nuclear designs would still require significant design work and component testing to gain regulatory approval and become competitive with large nuclear or other alternative generation technologies.[33]

Dame Sue Ion agreed that there was still a significant amount of detailed design work to do on SMRs and suggested that there was potential to work with other partners on the completion of the designs as well as on developing IP and manufacturing potential for the UK in the process.[34]

International interest in SMRs

19. We heard from a number of contributors to our inquiry that while the UK has the capability to push ahead with developing and deploying its own SMRs it was worth considering collaboration with international partners. Paul Stein, Chief Scientific Officer at Rolls Royce, considered that:

> the UK has a choice. We have the capability to do our own, if that is what we wish to do, and maybe that is the right thing to do, but we could also consider partnership with America, France, China or other nations that have similar designs. We need to look at the political landscape, at affordability and at what intellectual property the UK wants to end up with as a result of such a collaboration to give us the ability to create wealth and export, as well as to meet our climate change objectives.[35]

20. However, Dame Sue Ion, Chair of NIRAB, warned that while it was clearly possible for the UK to bring forward an SMR on its own, "in terms of the cost and the time that it would take to do that, we [would be] starting from behind".[36] For example, the US Department of Energy (DOE) is already helping to accelerate the timelines for the commercialisation and deployment of SMR technologies through its "SMR Licensing Technical Support program".[37] This six-year long $452 million program supports certification and licensing requirements for US-based SMR projects through cooperative agreements with industry

32 Q45 (Paul Stein, Dr Clarke, Peter Haslam)
33 EDF Energy (SNP0027)
34 Qq148-149 (Dame Sue Ion)
35 Q44 (Paul Stein)
36 Q149 (Dame Sue Ion)
37 DOE Office of Nuclear Energy, Small Modular Nuclear Reactors, accessed Nov 2014

partners, and by supporting the resolution of generic SMR issues. Partners that have received US DOE funding in support of their SMR projects include Generation mPower LLC and NuScale Power LLC. Governments of other nation states are also financing SMR design, with the intention to deploy.[38]

21. We spoke to representatives of Generation mPower and NuScale Power through the course of this inquiry. While they provided a useful overview of their experience to date, their enthusiasm was somewhat guarded as they were clearly wary of the obstacles to SMR deployment. Bill Fox, Chief Executive of Generation mPower, put this in context:

> 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 […] One of the concerns […] 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.[39]

22. In order for shareholders to see a return on their investment it is vital for these SMR projects to secure customers. Mr Fox recognised that the mPower SMR did not currently have any customers but that they were "preparing for deployments in the early to mid-2020s" and he believed "the customers will come".[40] He added that discussions with investors were also ongoing.[41] The Nuclear Industry Association stressed that:

> If SMRs are going to be developed in the UK, they will need to be financially competitive and they will clearly have to meet all the safety and environmental requirements, but most of all the prospective developer would need to be absolutely clear that the design was viable from an economic and regulatory perspective.[42]

In the next chapter we look at how developers seeking to show the viability of their reactors might deal with some of these barriers to deployment.

38 Q149 (Dame Sue Ion)
39 Q143 (Bill Fox)
40 Q89 (Bill Fox)
41 Q89 (Bill Fox)
42 Q43 (Peter Haslam)

3 Dealing with barriers to deployment

23. Many of the barriers to deployment of Small Modular Reactors (SMRs) in the UK are similar to the challenges of deploying larger conventional reactors, i.e. capital cost, lead times, uncertainty over both of these factors, regulatory approvals, and potential volatility in political and social support.[43]

Cost and investment risk

24. One of the main factors to consider in determining whether SMRs will be deployed in the UK is cost, in particular whether SMRs will be financially competitive with conventional nuclear reactors and other forms of energy generation. Professor Tim Abram, Director of the Centre for Nuclear Energy Technology at the University of Manchester's Dalton Nuclear Institute, reminded us that deploying large reactors is "enormously costly".[44] He added that the balance sheets of most industrial companies were "simply not large enough to sustain an investment of several billion".[45] Professor Abram considered that smaller units could be more affordable. He also thought that they could "be brought to the grid more quickly and generate revenues more quickly" and therefore might be affordable for a wider range of potential generators.[46]

25. Greenpeace suggested that nuclear reactors had become large over time "in order to minimise cost [of energy] per MWh" and that in doing so they had "developed a financing problem because the initial capital costs are so great. Moving to smaller reactor sizes could simply reverse the problem".[47] The National Nuclear Laboratory told us that "for some potential developers, the overall capital cost and the construction timeframe will be more important factors than the overall cost per MW installed".[48] Paul Stein, Chief Scientific Officer at Rolls Royce, added that:

> We should not underestimate the cost of capital. If one has to raise £7 billion or £8 billion—whatever it costs—for Hinkley C, that is quite a lot of money to raise. If one is looking to raise, say, a tenth of that sum for a small modular unit, the cost of capital and the ease of access to capital is far less. It is that economic argument that has driven the case for SMRs.[49]

26. We heard a range of views on whether the cost of SMRs per unit of energy produced would be financially competitive with conventional large nuclear reactors.[50] Paul Stein summarised the current level of understanding of SMR cost:

> The truth is no one really knows the answer to the question, but what we do know is this: the manufacture of small modular reactors is a completely different approach to that of the large reactors. […] One could envisage […] a factory making, say, one [SMR] a month in order to make the economics work,

43 National Nuclear Laboratory (SNP0014)
44 Q2 (Professor Abram)
45 Q2 (Professor Abram)
46 Q2 (Professor Abram)
47 Greenpeace (SNP0018)
48 National Nuclear Laboratory (SNP0014)
49 Q47 (Paul Stein)
50 For example: Q46 (Paul Stein); Qq96-98 (Bill Fox); Q103 (Thomas Mundy); Q147 (Dame Sue Ion); Institution of Mechanical Engineering (SNP0003); Nuclear Innovation and Research Advisory Board (SNP0017); and Greenpeace (SNP0018)

> and we would bring to bear all of our know-how in manufacturing technology to get the price down and to engage the supply chain in a way that could make the whole unit cost-effective.[51]

He added that there have been some studies looking at the economics of small modular reactors which suggest that SMRs may be able to "hit the same price point per kWh as the large reactors. But, as a company, we are not certain of that yet".[52]

27. The Energy Technologies Institute has commissioned a project looking at the "high level technical performance characteristics and business-case parameters of small thermal plants".[53] The project, expected to be completed by December 2014, is intended to include small modular reactors, enabling comparison with other small-scale plant, such as those powered by biomass.[54]

28. The Minister recognised the "medium to long-term potential" for small modular reactors, but added that "bringing [that potential] to market at a cost that is cost competitive, at least with conventional nuclear and ultimately with other low carbon, zero carbon sources, is an important and as yet unverified request, but that is what we need to work towards".[55]

29. ***The commercial viability of small modular reactors (SMRs) remains unclear. It is important to understand the cost comparison with large-scale nuclear reactors as well as the comparison with other small-scale energy generation. Government should work with industry to better understand the economics of SMRs and set out a clear explanation of the conditions under which they are likely to be cost competitive in the UK. The National Nuclear Laboratory's SMR feasibility study provides a useful preliminary financial analysis but itself acknowledges that a more detailed analysis is required.***

30. If mass production is the one of the key factors in making SMRs financially competitive, this opens up the question of how many reactors one might need to produce to make the initial investment worthwhile. Thomas Mundy, from NuScale Power, explained that he was in discussion with clients about the extent to which costs would drop as NuScale went from building "first of a kind" reactors to the "nth of a kind".[56] He added that "nth of a kind projections are based essentially around 12 to 15 modules" which could be deployed at one facility.[57] Bill Fox, from Generation mPower, also recognised that nth of a kind savings were likely, although he considered these would be delivered in the fourth, fifth or sixth module.[58]

31. These savings will not be realised unless a "first of a kind" SMR is initially deployed as a practical demonstrator. Dr Fiona Rayment, Director of Fuel Cycle Solutions at the NNL, told us that it would be "very difficult" for any single organisation to be able to bring forward a first of a kind SMR on their own and that some help in the form of Government

51 Q46 (Paul Stein)
52 Q46 (Paul Stein)
53 Energy Technologies Institute, ETI awards research contract into alternative small-scale thermal and nuclear power generation technologies to Mott MacDonald, 1 October 2014
54 Energy Technologies Institute, ETI awards research contract into alternative small-scale thermal and nuclear power generation technologies to Mott MacDonald, 1 October 2014
55 Q228 (Rt Hon Matthew Hancock MP)
56 Qq104-105 (Thomas Mundy)
57 Qq104-105 (Thomas Mundy)
58 Q106 (Bill Fox)

funding might be needed.[59] Dame Sue Ion, Chair of NIRAB, suggested that the investment risk for industry was too great without public support:

> Industry is very conservative and unwilling to dip its own hand in its pocket […] The timescale to deliver the first [SMR] 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.[60]

32. The level of Government commitment could vary depending on the extent to which it wants to hold intellectual property (IP) within the UK. Paul Stein, from Rolls Royce, explained that this was the key issue:

> If we want to be able to do the whole thing ourselves, we have to invest heavily as a nation ourselves to get there. If we don't want to invest heavily as a nation, we are going to have to accept some degree of input and sharing of the cake with other nations. That is inevitable if we choose not to fund the whole thing.[61]

33. The Minister told us that whether the Government decided to put any financial resource behind the development of SMRs was something he was "very open-minded" about.[62] He recognised that "you can't test whether something is commercially viable unless you have a go at seeing whether it is commercially viable" but added that a decision was yet to be taken on whether public funding would be provided for a demonstrator project.[63] He also added that if Government proceeded on this basis, it would want to make sure that it supported UK businesses as part of the process.[64]

34. **It is clear to us that Government support will be needed if small modular reactors are to be successfully deployed in the UK. The options for Government are discussed in more detail in Chapter four.**

Regulatory assessment

35. Regulatory assessment is one of the necessary challenges that SMRs–like all nuclear reactors–need to overcome. Any proposal in the UK would need to undergo Justification, Generic Design Assessment (GDA), site licensing and environmental permitting and security regulation, and developers would need to agree a Funded Decommissioning Programme (FDP). Sites would also have to be identified.[65] The National Nuclear Laboratory told us that:

> there is sometimes an expectation that the costs of regulatory approval for a small reactor will be substantially less than for a large design. This is not necessarily the case, especially if new technology is involved which has not

59 Q154 (Dr Rayment)
60 Q154 (Dame Sue Ion)
61 Q72 (Paul Stein)
62 Q229 (Rt Hon Matthew Hancock MP)
63 Q229 and Q242 (Rt Hon Matthew Hancock MP)
64 Q242 (Rt Hon Matthew Hancock MP)
65 DECC (SNP0002)

> been assessed before. Even a simplified design can expect a detailed and very rigorous examination by the regulators, which can take years.[66]

36. Dr Andy Hall, Chief Nuclear Inspector at the Office for Nuclear Regulation (ONR), explained that "the challenges [for SMRs] will be similar to those we are experiencing through the generic design assessment process for much larger reactors".[67] The ONR anticipates that taking a small reactor of novel design through a GDA process would therefore take a similar time to that taken to assess an evolutionary design of a large reactor–around four years depending on resource availability with an additional two or more years to review a subsequent site-specific licence application.[68] Bill Fox, Chief Executive of Generation mPower, suggested that licensing might be achieved in a "shorter period of time with a sense of urgency applied".[69] However, Dr Hall defended the length of time taken, explaining that:

> we have to do a very rigorous assessment of the designs that are being put to us and see whether the claims that the requesting parties make can be substantiated. In order to properly implement the standards that have been set by Parliament, we have to undertake that independent, robust assessment and it takes time. The length of time will depend on the quality of the safety submissions that the requesting parties make to us and whether they make those submissions on time.[70]

37. The importance of preparing high-quality safety submissions was recognised by Dr Eric Loewen, Chief Consulting Engineer at Ge-Hitachi Nuclear Energy, who told us that he encourages his team to find out what the regulatory agencies did not like about previous applications and address those issues in order to make it easier for the regulator.[71] This is helped by developers working closely with the regulators at an early stage. We heard that there was "a trade-off" between submitting a licence assessment early and waiting until later in the design process.[72] SMRs are still in the design phase and their designs are likely to develop as they go through the GDA process. This means that the GDA process will take "a bit more time".[73] The alternative would be to complete the full design upfront and then push that through the GDA process, but this would be risky for the developer.[74] Dr Hall told us that preparation was vital and developers needed to understand the UK regulatory system.[75] He added that the ONR was very happy to talk to developers and help them gain that understanding.[76] EDF Energy added that SMR developers would need to work with the ONR "to develop an appropriate framework for licensing and siting small nuclear reactor designs and resolve unique SMR features such as those relating to operations, maintenance, security and staffing requirements".[77]

66 National Nuclear Laboratory (SNP0014)
67 Q181 (Dr Hall)
68 Office for Nuclear Regulation (SNP0037)
69 Q136 (Bill Fox)
70 Q183 (Dr Hall)
71 Q137 (Dr Loewen)
72 Q170 (Dame Sue Ion)
73 Q170 (Dr Rayment)
74 Q170 (Dr Rayment)
75 Q223 (Dr Hall)
76 Q223 (Dr Hall)
77 EDF Energy (SNP0027)

38. The type of technology and novelty of the design will also have an impact on the length of time it takes to complete the GDA process. Dr Hall explained that it would be:

> easier to adopt an evolutionary approach, both for licensees because they do not have to develop vast new skill sets and for ourselves for similar reasons, where you work with an existing design or a class of designs like pressurised water reactors or boiling water reactors and then almost play tunes on that, rather than go to a completely different technology such as metal-cooled reactors or the thorium cycle. The further you move away from the area that the industry and ourselves understand very well, the more the work that will need to be done and the more the investment that will be needed in order to prepare both sides to deploy that technology.[78]

39. The Minister was clear that the GDA process needed to be robust but he recognised that "reduc[ing] the burden of the regulatory process while maintaining its clarity and effectiveness" was desirable.[79] He added that the Government was "actively looking at how we can improve the process".[80]

40. A regulatory process will however only ever be as good as the people running it. The work of the ONR is highly regarded; however, we heard that the ONR and the Environment Agency are already dealing with a good deal of work relating to "the operating fleet, potential lifetime extension, management of complex sites such as Sellafield and Dounreay, and the immediate new build programme".[81] If SMR designs were to come forward in the near future, resources for regulatory assessment "would be strained further".[82] The ONR recognised these resource implications and explained that it "would look to be guided by DECC" on which designs they wanted the ONR to consider at a particular time.[83]

41. ***We were surprised to hear it might take six years to give regulatory approval (including a site-specific licence) for a small modular reactor. However, we recognise the importance of ensuring that a rigorous safety assessment is made of the design. The Minister explained that the Government will take an active role in trying to improve that Generic Design Assessment process–Government should provide an update on these improvements in its response to us. We also call on DECC to ensure that the Office for Nuclear Regulation is adequately resourced to support SMR developers in the early stages of preparing their designs for approval.***

42. We also heard concerns that "the mindset of the regulator [was] not perfectly aligned to dealing with SMRs" but that "broader collaboration internationally with international regulators could help the UK develop the right sort of regulatory culture and learn from international experience".[84] There was great appetite from many of those we heard from for an international collaborative regulatory approach. Paul Stein, from Rolls Royce, suggested that:

> one option—and a perfectly viable option—is that we form a partnership with another nation to produce SMRs. If we were to do that, then as part of

78 Q225 (Dr Hall)
79 Q244 (Rt Hon Matthew Hancock MP)
80 Q244 (Rt Hon Matthew Hancock MP)
81 National Nuclear Laboratory (SNP0014)
82 National Nuclear Laboratory (SNP0014)
83 Q219 (John Jenkins)
84 Q27 (Professor Freer)

> that intergovernmental package we would perhaps agree a joint statement on regulation and a joint way of regulating the export of them, which at least would then create a joint market for SMRs between those two countries without having to go through the full GDA assessment, but that would be a minimum. We would have to try to take this as far as we can.[85]

Thomas Mundy, from NuScale Power, and Bill Fox, from Generation mPower, agreed that there were opportunities for the UK and US to collaborate on licensing.[86]

43. However, Dr Hall cautioned that "it would be very difficult for regulators in different countries, bearing in mind the different legal systems, simply to issue a joint statement of the acceptability of a reactor design".[87] The regulatory approaches in each country are different, the US is "very prescriptive" in its regulations, while the UK is more "performance based" whereby it must be demonstrated that risks have been reduced "so far as is reasonably practicable".[88] Both countries would have to issue an acceptance of the design in a way that aligned with their own legal and regulatory processes. Dr Hall was also wary that in working with other regulators there was a risk that one could end up moving "at the speed of the slowest in the group".[89]

44. Despite these concerns, Dr Hall explained that the ONR does work very closely with regulators in other countries.[90] He also explained that the safety objectives of all the major western countries were very similar and that was why the ONR was a member of the Multi-national Design Evaluation Programme (MDEP), an international grouping of regulators set up to share knowledge and experience of design assessments.[91] If a small reactor design was proposed for deployment in more than one country, then the design might be brought within the purview of MDEP for regulators to come to a common view, which would then be expressed in the terminology of each country's own legal systems.[92] Liz Keenaghan Clark, Head of Nuclear Decommissioning Waste and Safety at DECC, was satisfied that the regulator recognised the potential "for streamlining and for reducing eventual costs and lengths of processes if they learn from the regulatory process in other countries".[93] She hoped that "as the SMR work gets further developed" international collaboration on these matters would "bear fruit".[94]

45. ***There is scope for further international collaboration on regulatory approval of new reactor designs. We welcome the Office for Nuclear Regulation's involvement in the Multi-national Design Evaluation Programme, and encourage ONR to think innovatively about new ways to streamline its regulatory processes to ensure they remains robust and swift.***

85 Q59 (Paul Stein)
86 Q91 (Thomas Mundy and Bill Fox)
87 Q191 (Dr Hall)
88 Q95 (Thomas Mundy); Q191 (Dr Hall)
89 Q192 (Dr Hall)
90 Q185 (Dr Hall)
91 Q191 (Dr Hall) and Office for Nuclear Regulation (SNP0037)
92 Q191 (Dr Hall) and Office for Nuclear Regulation (SNP0037)
93 Q249 (Liz Keenaghan Clark)
94 Q249 (Liz Keenaghan Clark)

Siting considerations

46. As a result of their smaller size and lower power output SMRs can be accommodated on a wider range of sites than larger reactors.[95] For example, SMRs could be deployed at sites with limited cooling water with the ability to make use of the waste heat off-site. Dr David Clarke, Chief Executive of the Energy Technologies Institute, explained that:

> the concept of using a remote site that is a significant distance away from a centre of population for a heat network is well proven, but if you use SMRs, you obviously potentially bring that capability closer to centres of population, so you can use the waste heat more effectively.[96]

In other parts of the world SMRs might also be used to supply local energy needs in the absence of a national grid for power distribution.[97]

47. There are a number of potential sites for the deployment of SMRs in the UK, for example:

> In Wales, Trawsfynydd, which is a decommissioned Magnox reactor site, is due to be completely decommissioned in 2016, and we know the Welsh authorities are very interested in seeing whether that could be a site for an SMR [...] Quite a few sites in the UK could be candidates for a first-of-a-kind small modular reactor.[98]

48. We heard that there were a number of advantages to considering sites which have previously hosted nuclear capacity, such as Trawsfynydd, Berkeley, Bradwell and Chapelcross.[99] These existing sites have already been well characterised so there is a large body of information that exists and can be used in the licensing of a new facility at that location. There will also be a local skill base and inherent workforce that is used to dealing with nuclear technology, access to grid, access to cooling water and good public acceptance in the areas where the existing power stations are.[100] Furthermore, some sites that would have historically held small legacy reactors and may now be "inaccessible economically for a modern large gigawatt-scale reactor" but able to support SMRs.[101] However, Dr Hall suggested that many existing sites were "already owned by utilities which have other plans for them".[102]

49. Peter Haslam, Head of Policy at the Nuclear Industry Association, told us that "for the current nuclear programme, there was a strategic siting exercise, which ended up identifying the eight sites that are going to be developed by the nuclear industry. Something similar would probably need to be done to look at sites for SMRs".[103] There are currently outline plans for 16 GWe of generation at five of the eight approved sites.[104] The Minister acknowledged that the idea of using the remaining three existing sites for SMRs was an option "that undoubtedly [has] a smaller regulatory hurdle than getting new sites

95 Nuclear Innovation and Research Advisory Board (SNP0017)
96 Q43 (Dr Clarke)
97 Nuclear Innovation and Research Advisory Board (SNP0017)
98 Q55 (Paul Stein)
99 National Nuclear Laboratory (SNP0014)
100 Q117 (Thomas Mundy and Bill Fox); Q174 (Dame Sue Ion)
101 Q200 (Dr Simper)
102 Q201 (Dr Hall)
103 Q56 (Peter Haslam)
104 Institute of Physics (SNP0016)

approved".[105] Ultimately, we heard "it would be for DECC to determine the siting policy for a further tranche of reactors".[106]

50. ***The Government should support the use of existing nuclear sites for the deployment of small modular reactors. These sites could potentially host a demonstrator module with minimal additional infrastructure requirements and with the support of a skilled local workforce.***

Safety and security

51. Regardless of where they are sited, small nuclear reactors will generally raise similar questions of safety and security to large reactors. Dr Rayment, from the NNL, explained that:

> 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. [...] 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.[107]

52. The safety of any given reactor is to some extent dependent on the details of the individual designs. The PRISM reactor, for example, shuts itself down through a natural feedback loop if it gets too hot–it can reportedly "last not for days or months but forever removing the heat".[108] We also heard that the NuScale reactor makes "use of passive safety systems for decay heat removal and emergency core cooling, containment heat removal and control room habitability [to eliminate] the need for external power under accident conditions".[109] Dr Andy Hall, Chief Nuclear Inspector at the ONR, was cautious about suggestions of passive safety as the ONR had not yet been asked to assess these claims. He explained that it was important "to examine those passive systems and the claims very carefully to make sure there are not some circumstances when the passive system will fail".[110]

53. If it were possible to prove for a new reactor design that there was "no possibility of an offsite release and radiological consequences to the environment [...] that would mean that the siting options would be much broader than for other reactor types".[111] However, "with most reactors there will be some risk of an accident, no matter how remote, which would require offsite countermeasures to protect people and that would then affect the siting".[112] Dr Hall also explained that:

> Very often the proposals for small modular reactors involve having a number of the reactors on the same site. Although individually they might have less radioactivity in them, in combination they may have a similar amount of

105 Q253 (Rt Hon Matthew Hancock MP)
106 Q198 (Dr Hall)
107 Q176 (Dr Rayment)
108 Q120 (Dr Loewen)
109 NuScale Power LLC (SNP0007)
110 Q209 (Dr Hall)
111 Q193 (Dr Hall)
112 Q193 (Dr Hall)

> radioactivity and the potential for consequences that are similar to those of a larger reactor.[113]

54. It is possible, however, that SMRs could eventually be deployed at numerous sites across the country, rather than on the same site in an "eggcrate" approach.[114] One of the risks associated with widespread deployment relates to the "protection against non-proliferation of nuclear materials if multiple sites are involved which need to be secure or if highly enriched uranium is used in the fuel".[115] While the movement from factory to site of the reactors themselves–"a collection of pipework, vessels and wiring"–was not thought to be an issue, the transportation of fuel and spent fuel was an important issue to consider.[116] Professor Abram argued that "we have in place already the infrastructure and regulatory oversight to ensure that we are able to transport and deploy the fuel for such systems safely and securely".[117]

55. **We recognise that small nuclear reactors will generally raise similar questions of safety and security to those raised by large nuclear reactors. The UK already has robust processes in place to ensure the safe and secure operation and maintenance of the plant as well as transportation and management of fuel and spent fuel.**

Public engagement

56. The Centre for Low Carbon Futures suggested that "it would be wise for the Government to commission a detailed study of public opinion regarding the role of SMRs in the future energy mix to measure the level of receptivity".[118] Dame Sue Ion, Chair of NIRAB, shared her view:

> 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.[119]

Liz Keenaghan Clark, Head of Nuclear Decommissioning Waste and Safety at DECC, recognised that if the Government decided to pursue SMR deployment it "would have to make some kind of public policy statement and do some kind of consultation" but that this point had not yet been reached.[120]

113 Q197 (Dr Hall)
114 Q76 (Paul Stein)
115 EDF Energy (SNP0027)
116 Q37 (Professor Abram); Q179 (Dame Sue Ion); Q193 (Dr Hall)
117 Q37 (Professor Abram)
118 Centre for Low Carbon Futures (SNP0010)
119 Q177 (Dame Sue Ion)
120 Q257 (Liz Keenaghan Clark)

57. ***The Government must work with industry on a programme of proactive public engagement on small nuclear reactors–especially if such reactors might in the future be deployed in areas that are not currently considered suitable for nuclear power e.g. away from the coast, closer to centres of population etc.***

4 A way forward in the UK

Options for Government

58. There are a number of options open to the Government depending on its capacity for investment, appetite for risk and the requirement for SMRs in the UK. These include:

i) doing nothing and focusing on the delivery of the conventional nuclear power plants programme;

ii) facilitating the entry of SMRs into the UK by creating the right conditions for deployment e.g. site availability, Generic Design Assessment (GDA) and licensing resource, Contracts for Difference etc.;

iii) funding for the development of capabilities that could help UK companies to solve the existing manufacturability and cost problems associated with existing SMR designs before designs are submitted for certification; and

iv) developing an indigenous UK SMR design that would guarantee the development of UK skills and intellectual property.[121]

59. We do not consider the "do nothing" approach to be a viable option. The Government's Long Term Nuclear Energy Strategy, part of the Nuclear Industrial Strategy, sets out the need to keep an advanced and diverse range of options (including SMRs) open in terms of nuclear technology.[122] The Government suggested that it considers SMR technology to have potential.[123] The Minister told us that it looked as if SMR technology could "be cost comparable in the UK, even though it has not yet been brought to market, but also that there is the potential for global demand for SMRs," leading to potential export opportunities.[124]

60. The Minister understood that the Government has "a big role" to play in helping to develop a market for SMRs.[125] He explained that in addition to funding feasibility studies and supporting the regulators, the Government also defines the structure in which the energy market operates, and as a low carbon source, nuclear fits within that and would fit within the Contracts for Difference (CfD) regime. The Government would have to ensure that CfDs "worked appropriately" for SMRs.[126] The Minister also recognised that the US Government had gone further by working to bring two different SMR designs all the way to market, including by helping them through their own regulatory processes.[127]

Intellectual property and the supply chain

61. The prospect of SMR deployment in the UK and overseas opens up opportunities for UK companies to work alongside technology developers to advance intellectual property within the UK.[128] Rolls Royce explained that:

121 Rolls-Royce Plc (SNP0026)
122 DECC (SNP0002)
123 Q229 (Rt Hon Matthew Hancock)
124 Q233 (Rt Hon Matthew Hancock)
125 Q236 (Rt Hon Matthew Hancock)
126 Q236 (Rt Hon Matthew Hancock)
127 Q236 (Rt Hon Matthew Hancock)
128 NuScale Power LLC (SNP0007)

> The development of SMRs could enable UK companies to secure intellectual property and manufacturing skills within a technology with significant global export potential. SMRs remain at an early stage of development and still face challenges in proving the economics will be competitive. This key risk presents an opportunity for the UK to deploy its existing skills and capabilities, sustained as a result of the Nuclear Industry Strategy, to ensure the target economics are met. Within the Nuclear Advanced Manufacturing Research Centre, the National Skills Academy for Nuclear, and the UK nuclear supply chain, there exists specific capabilities in the areas of advanced manufacturing, in service plant management and civil construction, with the potential to deliver considerable cost savings to SMR developers.[129]

The Energy Technologies Institute further noted that UK organisations that supports the development of SMR technology for deployment between 2020 and 2035 will put themselves "in a stronger position to develop and secure long term Generation IV IP through R&D investment and participation in Gen IV forum".[130]

62. NuScale Power is in fact already working on SMR development with Rolls Royce in the UK. Thomas Mundy, from NuScale Power, explained:

> 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.[131]

63. Paul Stein, Chief Scientific Officer at Rolls Royce, told us that "it is not an exclusive relationship but [NuScale] came to us for manufacturing know-how".[132] NuScale Power also recently announced a new collaborative agreement with the Nuclear Advanced Manufacturing Research Centre.[133] Other organisations we heard from are also actively engaging with the UK supply chain.[134] The Government told us it was also "working with industry, nuclear reactor vendors and operators to help create and support a globally competitive UK nuclear supply chain".[135]

Conclusions

64. ***Small modular reactors (SMRs), particularly those based on known nuclear technologies, are a viable proposition for future deployment in the UK in the next decade. They could potentially have a key role to play in delivering low carbon energy at lower upfront capital cost compared to large conventional nuclear reactors.***

129 Rolls-Royce Plc (SNP0026)
130 Energy Technologies Institute (SNP0012)
131 Q106 (Thomas Mundy)
132 Q43 (Paul Stein)
133 NuScale Power press release, NuScale Power Links Up With UK Nuclear Engineering Sector, 18 November 2014
134 Qq128-130 (Dr Loewen and Bill Fox)
135 DECC (SNP0002)

65. ***We recommend the Government takes a proactive role in driving forward the development and deployment of these reactors in the UK. In the first instance, Government should help to establish the right conditions for investment in SMRs, for example through supporting the regulator to bring forward approvals in the UK, and by setting out a clear view of siting options. We would also like to see the Government steering industry towards deploying a demonstrator SMR in the UK. It is likely that this will only be achieved through sharing the costs between the public and private sector. In the longer term, Government should identify and help to establish future sources of commercial finance for the further development and industrialisation of SMRs.***

66. ***While current SMR designs have been predominantly developed outside the UK, there is scope for British industry to develop intellectual property and play a role in the deployment of the first SMRs. The challenges faced in making SMRs commercially viable represent an opportunity for our world-class manufacturing industry. Collaboration with international partners is important and the Government must ensure that UK companies are in a position to compete for these opportunities.***

Conclusions and recommendations

The potential role of small nuclear power

1. Small modular reactors are an attractive proposition and we welcome the Government's work looking into the feasibility of these reactors in the UK. However, we recognise that the nuclear industry's immediate priority is rightly the successful delivery of the UK's current conventional new build programme. (Paragraph 10)

Choice of technologies and fuels

2. There are a number of advantages to switching to a thorium fuel cycle; however, the evidence we have heard suggests that this will not be a viable option unless the price of uranium changes drastically. The UK must for now remain an active participant in thorium research and development. We recommend that the Government commission a study to confirm the potential benefits of thorium in the longer-term and how any potential barriers to its use might be overcome. (Paragraph 17)

Cost and investment risk

3. The commercial viability of small modular reactors (SMRs) remains unclear. It is important to understand the cost comparison with large-scale nuclear reactors as well as the comparison with other small-scale energy generation. Government should work with industry to better understand the economics of SMRs and set out a clear explanation of the conditions under which they are likely to be cost competitive in the UK. The National Nuclear Laboratory's SMR feasibility study provides a useful preliminary financial analysis but itself acknowledges that a more detailed analysis is required. (Paragraph 29)

4. It is clear to us that Government support will be needed if small modular reactors are to be successfully deployed in the UK. The options for Government are discussed in more detail in Chapter four. (Paragraph 34)

Regulatory assessment

5. We were surprised to hear it might take six years to give regulatory approval (including a site-specific licence) for a small modular reactor. However, we recognise the importance of ensuring that a rigorous safety assessment is made of the design. The Minister explained that the Government will take an active role in trying to improve that Generic Design Assessment process–Government should provide an update on these improvements in its response to us. We also call on DECC to ensure that the Office for Nuclear Regulation is adequately resourced to support SMR developers in the early stages of preparing their designs for approval. (Paragraph 41)

6. There is scope for further international collaboration on regulatory approval of new reactor designs. We welcome the Office for Nuclear Regulation's involvement in the Multi-national Design Evaluation Programme, and encourage ONR to think innovatively about new ways to streamline its regulatory processes to ensure they remains robust and swift. (Paragraph 45)

Siting considerations

7. The Government should support the use of existing nuclear sites for the deployment of small modular reactors. These sites could potentially host a demonstrator module with minimal additional infrastructure requirements and with the support of a skilled local workforce. (Paragraph 50)

Safety and security

8. We recognise that small nuclear reactors will generally raise similar questions of safety and security to those raised by large nuclear reactors. The UK already has robust processes in place to ensure the safe and secure operation and maintenance of the plant as well as transportation and management of fuel and spent fuel. (Paragraph 55)

Public engagement

9. The Government must work with industry on a programme of proactive public engagement on small nuclear reactors–especially if such reactors might in the future be deployed in areas that are not currently considered suitable for nuclear power e.g. away from the coast, closer to centres of population etc. (Paragraph 57)

Conclusions

10. Small modular reactors (SMRs), particularly those based on known nuclear technologies, are a viable proposition for future deployment in the UK in the next decade. They could potentially have a key role to play in delivering low carbon energy at lower upfront capital cost compared to large conventional nuclear reactors. (Paragraph 64)

11. We recommend the Government takes a proactive role in driving forward the development and deployment of these reactors in the UK. In the first instance, Government should help to establish the right conditions for investment in SMRs, for example through supporting the regulator to bring forward approvals in the UK, and by setting out a clear view of siting options. We would also like to see the Government steering industry towards deploying a demonstrator SMR in the UK. It is likely that this will only be achieved through sharing the costs between the public and private sector. In the longer term, Government should identify and help to establish future sources of commercial finance for the further development and industrialisation of SMRs. (Paragraph 65)

12. While current SMR designs have been predominantly developed outside the UK, there is scope for British industry to develop intellectual property and play a role in the deployment of the first SMRs. The challenges faced in making SMRs commercially viable represent an opportunity for our world-class manufacturing industry. Collaboration with international partners is important and the Government must ensure that UK companies are in a position to compete for these opportunities. (Paragraph 66)

Formal Minutes

Tuesday 9 December 2014

Members present:

Mr Tim Yeo, in the Chair

Ian Lavery	John Robertson
Dr Phillip Lee	Sir Robert Smith
Mr Peter Lilley	Graham Stringer
Christopher Pincher	Dr Alan Whitehead

The following declarations of interest relating to the inquiry were made:

24 June 2014, 8 July 2014 and 4 Nov 2014

> Sir Robert Smith declared interests, as listed in the Register of Members' Interests, in the oil and gas industry, in particular a shareholding in Shell Transport and Trading (oil integrated).
>
> Mr Tim Yeo declared interests, as listed in the Register of Members' Interests, in particular a remunerated directorship and shareholding in AFC Energy, and as Adviser to Meade Hall and Associates.

In the absence of the Chair, Sir Robert Smith was called to the chair.[1]

Draft Report (*Small nuclear power*), proposed by Sir Robert Smith, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 66 read and agreed to.

Summary agreed to.

Resolved, That the Report be the Fourth Report of the Committee to the House.

Ordered, That Sir Robert Smith make the Report to the House.

Ordered, That embargoed copies of the Report be made available, in accordance with the provisions of Standing Order No. 134.

[Adjourned till Tuesday 16 December at 9.15 am

1 Mr Tim Yeo withdrew from the inquiry following the evidence session on 22 July 2014. The Committee resolved on 10 September 2014 that Mr Peter Lilley would chair the session on that date. The Committee resolved on 14 October 2014 that Sir Robert Smith would prepare the draft Report and chair future meetings on this subject.

Witnesses

The following witnesses gave evidence. Transcripts can be viewed on the Committee's inquiry page at www.parliament.uk/ecc.

Tuesday 24 June 2014

Question number

Professor Rebecca Seviour, Chair, Thorium Energy Association, **Professor Tim Abram,** Director, Centre for Nuclear Energy Technology, The University of Manchester's Dalton Nuclear Institute, and **Professor Martin Freer**, University of Birmingham, representing the Centre for Low Carbon Futures — Q1-42

Paul Stein, Chief Scientific Officer, Rolls-Royce plc, **Dr David Clarke,** Chief Executive, Energy Technologies Institute, and **Peter Haslam**, Head of Policy, Nuclear Industry Association — Q43-84

Tuesday 8 July 2014

Bill Fox, Chief Executive Officer, Generation mPower LLC, **Thomas Mundy,** Vice President, Program Office, NuScale Power LLC, and **Dr Eric Loewen,** Chief Consulting Engineer, GE Hitachi Nuclear Energy — Q85-143

Dr Fiona Rayment, Director, Fuel Cycle Solutions, National Nuclear Laboratory, and **Dame Sue Ion,** Chair, Nuclear Innovation and Research Advisory Board — Q144-179

Tuesday 22 July 2014

John Jenkins, Chief Executive Officer, Office for Nuclear Regulation, **Dr Andy Hall,** Chief Nuclear Inspector, Office for Nuclear Regulation and **Dr Adrian Simper**, Director, Strategy and Technology, Nuclear Decommissioning Authority — Q180-225

Wednesday 10 September 2014

Rt Hon Matthew Hancock MP, Minister of State for Energy, Department of Energy and Climate Change, **Chris Pook,** Head of the Green Economy Team, Department of Business, Innovation and Skills, and **Liz Keenaghan Clark**, Head of Nuclear Decommissioning Waste and Safety, Department of Energy and Climate Change — Q226-268

Published written evidence

The following written evidence was received and can be viewed on the Committee's inquiry web page at www.parliament.uk/ecc. SNP numbers are generated by the evidence processing system and so may not be complete.

1 All Party Parliamentary Group On Thorium Energy (SNP0029)
2 AMEC Nuclear UK Ltd (SNP0034)
3 Barrie Skelcher (SNP0036)
4 Barry Snelson (SNP0006)
5 Brian Rl Catt (SNP0032)
6 Candu Energy Inc (SNP0038)
7 Centre For Low Carbon Futures (SNP0010)
8 David Lyn Bowen (SNP0001)
9 DECC (SNP0002)
10 EDF Energy (SNP0027)
11 Energy Technologies Institute (SNP0012)
12 Ge-Hitachi Nuclear Energy (SNP0022)
13 Generation mPower (SNP0015)
14 GF Nuclear Ltd (SNP0025)
15 Greenpeace (SNP0018)
16 Institution Of Mechanical Engineers (SNP0003)
17 IX Power Limited D/B/A IX Power Machines (SNP0013)
18 National Nuclear Laboratory (SNP0014)
19 Nuclear Industry Association (SNP0004)
20 Nuclear Innovation and Research Advisory Board (SNP0017)
21 Nuscale Power Llc (SNP0007)
22 Office For Nuclear Regulation (SNP0037)
23 Penultimate Power UK Limited (SNP0009)
24 Professor Robert Cywinski (SNP0005)
25 Professor William J. Nuttall (SNP0023)
26 Rolls-Royce Plc (SNP0026)
27 Socialist Environment Resources Association (SERA) (SNP0008)
28 The Alvin Weinberg Foundation (SNP0031)
29 The Institute Of Physics (SNP0016)
30 The University Of Manchester (SNP0033)
31 Thorea (SNP0021)
32 Thorium Technologies Ltd (SNP0024)

List of Reports from the Committee during the current Parliament

All publications from the Committee are available on the Committee's website at www.parliament.uk/ecc.

The reference number of the Government's response to each Report is printed in brackets after the HC printing number.

Session 2010–12

First Report	Emissions Performance Standards	HC 523 (807)
Second Report	UK Deepwater Drilling–Implications of the Gulf of Mexico Oil Spill	HC 450 (882)
Third Report	The revised draft National Policy Statements on energy	HC 648
Fourth Report	Electricity Market Reform	HC 742 (HC 1448)
Fifth Report	Shale Gas	HC 795 (HC 1449)
Sixth Report	Ofgem's Retail Market Review	HC 1046 (HC 1544)
Seventh Report	A European Supergrid	HC 1040 (HC 1684)
Eighth Report	The UK's Energy Supply: Security or Independence?	HC 1065 (HC 1813)
Ninth Report	Solar Power Feed-In Tariffs	HC 1605 (HC 1815)
Tenth Report	The EU Emissions Trading System	HC 1476
Eleventh Report	The Future of Marine Renewables in the UK	HC 1624
Twelfth Report	Consumption-Based Emissions Reporting	HC 1646
First Special Report	Low carbon technologies in a green economy: Government Response to the Committee's Fourth Report of Session 2009–10	HC 455
Second Special Report	Fuel Poverty: Government Response to the Committee's Fifth Report of Session 2009–10	HC 541
Third Special Report	The future of Britain's electricity networks: Government Response to the Committee's Second Report of Session 2009–10	HC 629

Session 2012–13

First Special Report	The Future of Marine Renewables in the UK: Government Response to the Committee's Eleventh Report of Session 2010–12	HC 93
First Report	Draft Energy Bill: Pre-legislative Scrutiny	HC 275
Second Report	The road to UNFCCC COP 18 and beyond	HC 88 (HC 633)
Second Special Report	Consumption-Based Emissions Reporting: Government Response to the Committee's Twelfth Report of Session 2010–12	HC 488
Third Report	Low-Carbon Growth Links with China	HC 529 (HC 748)
Fourth Report	Pre-appointment hearing with the Government's preferred candidate for Chair of the Committee on Climate Change	HC 555
Fifth Report	Consumer Engagement with Energy Markets	HC 554 (HC 1036)
Sixth Report	Building New Nuclear: the challenges ahead	HC 117
Seventh Report	The Impact of Shale Gas on Energy Markets	HC 785

Session 2013–14

First Report	The Green Deal: watching brief	HC 142 (HC 607)
First Special Report	Building New Nuclear–the challenges ahead: Government Response to the Committee's Sixth Report of Session 2012–13	HC 106
Second Report	A Severn Barrage?	HC 194 (HC 622)
Third Special Report	The Impact of Shale Gas on Energy Markets: Government Response to the Committee's Seventh Report of Session 2012–13	HC 609
Third Report	UK oil refining	HC 340 (HC 718)
Fourth Report	Smart meter roll-out	HC 161 (HC 719)
Fifth Report	Energy Prices, Profits and Poverty	HC 108 (HC 717)
Sixth Report	Local Energy	HC 180 (HC 749)
Seventh Report	Pre-appointment hearing with the Government's preferred candidate for Chair of Ofgem	HC 645
Eighth Report	Levy Control Framework	HC 872
Ninth Report	Carbon capture and storage	HC 742

Session 2014–15

First Special Report	Levy Control Framework: Parliamentary oversight of Government levies on energy bills: Government Response to the Committee's Eighth Report of Session 2013–14	HC 590
First Report	Intergovernmental Panel on Climate Change Fifth Assessment Report Review of Working Group I contribution	HC 587 (HC 732)
Second Report	Innovate to accumulate: the Government's approach to low carbon innovation	HC 747 (HC 733)
Second Special Report	Carbon capture and storage: Government Response to the Committee's Ninth Report of Session 2013–14	HC 638
Third Report	The Green Deal: watching brief (part 2)	HC 348 (HC 882)