

HOUSE OF LORDS

Select Committee on Science and Technology

3rd Report of Session 2010–12

Nuclear Research and Development Capabilities

Ordered to be printed 15 November 2011 and published 22 November 2011

Published by the Authority of the House of Lords

London : The Stationery Office Limited
£price

HL Paper 221

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References in footnotes to the Report are as follows:

Q refers to a question in oral evidence;

NRD refers to written evidence.

SUMMARY

Introduction

The context of this inquiry is the Government's commitment to delivering a mixture of energy sources that will provide a secure, affordable, low-carbon supply of electricity for the future. The Government have said that nuclear energy will play an important role in achieving these goals. Nuclear energy currently supplies 16%¹ of the UK's electricity (10–12 gigawatts (GW) of capacity²). Scenarios for future electricity generation suggest that between now and 2050 nuclear power could supply between 15% and 49% (12 and 38 GW³) of the total. To meet the UK's legally binding target of reducing greenhouse gas emissions to 80% below 1990 levels by 2050 it is likely that between 20 and 38 GW of nuclear power will be needed.

Focus of our inquiry

The focus of our inquiry was not on the arguments for or against nuclear energy; but on whether or not the Government are doing enough to maintain and develop UK nuclear research and development (R&D) capabilities, and the associated expertise to ensure that nuclear energy is a viable option for the future. We have concluded that they are not. The absence of leadership and strategic thinking in Government in this area has resulted in a lack of co-ordination of nuclear R&D activities and a perception amongst international partners that the UK is no longer a serious player in the field. There is also a failure to recognise that although, at present, the UK has a number of strengths in nuclear R&D and expertise, those strengths are built on past investments and will soon be depleted as many experts near the end of their careers.

The need for fundamental change

During our inquiry we were struck by the extraordinary discrepancy between the view, on the one hand, of some senior government officials and the Secretary of State, and on the other, those of independent experts from academia, industry, nuclear agencies, the regulator and the Government's own advisers. A fundamental change in the Government's approach to nuclear R&D is needed now to address the complacency which permeates their vision of how the UK's energy needs will be met in the future. We make a number of recommendations for the Government to take action to ensure that this change takes place.

Policy development, an R&D roadmap and R&D Board

Some of our recommendations are intended to bring about high-level changes in the Government's approach to policy development for nuclear. These include:

- the development of a **long-term strategy for nuclear energy**;
- the development, as part of that strategy, of a **nuclear R&D roadmap**;
- the establishment of an **independent Nuclear R&D Board**, made up of representatives from the Government, industry and academia, chaired by an independent, expert, authoritative Chairman.

¹ *UK Energy in Brief 2011*, DECC, 2011. (Figures for 2010)

² The final output for 2011 will be dependent on plant closures throughout the year (see *Nuclear Fission*, The Energy Research Partnership, September 2010 ("the ERP Report") p 8–9)

³ The percentages of electricity supplied from the nuclear GW capacity is heavily dependent on the energy scenario used to project future supply and demand, these percentages should therefore be regarded only as an indication of the range of contributions that nuclear could supply to the overall electricity portfolio. (see Box 2, page 27.)

A long-term nuclear energy strategy

According to the Government, the UK's future supply of nuclear energy will be determined by the market. Other evidence indicates that, although electricity market reform may deliver the necessary incentives in the period up to 2025, in the longer term it will not be enough to maintain the necessary nuclear R&D capabilities and associated expertise. The nuclear industry, Government and the regulator rely on the research base to help to train the next generation of experts and, once lost, these capabilities will not easily be replaced. For this reason, the Government need to set out a long-term nuclear strategy which will, in particular, explain how they intend to maintain the nuclear R&D capabilities and associated expertise required to keep the nuclear energy option available into the future.

Furthermore, without a long-term strategy, companies will have little incentive to invest in longer-term nuclear R&D in the UK. As a result, the UK will be in a poor position to take advantage of the very large global commercial opportunities that nuclear R&D could provide. With appropriate Government investment in nuclear research and by developing a new generation of experts, UK companies could capture a significant part of the global market.

A nuclear R&D roadmap

The nuclear long-term strategy should include development of a nuclear R&D roadmap which would, in particular, make provision for closing gaps in UK nuclear R&D capabilities, such as: facilities to carry out research on post-irradiated materials, research on deep geological disposal, on the disposition of the plutonium stockpile, on advanced fuel recycling and reprocessing, and on Generation IV technologies. The roadmap should also aim to establish the UK as a credible partner for international collaboration, including a commitment by the Government to resume active participation in the Generation IV Forum and to ensure that the internationally important Phase 3 facilities at the National Nuclear Laboratory (NNL) are commissioned.

An independent Nuclear R&D Board

To assist the Government in the development and implementation of the long-term strategy and the R&D roadmap, we recommend the establishment of a Nuclear R&D Board. To ensure its independence, we propose that the new Board should be set up as a statutory Non-Departmental Public Body (and, pending the necessary legislation, as an Executive Agency), led by an externally-appointed, expert, authoritative Chairman. In addition to advising the Government, the Board would monitor, and report on, the Government's progress with regard to the strategy and the roadmap. It would have an R&D budget.

We also envisage the Board having a co-ordinating function to remedy the fact that the present arrangement for the support of nuclear R&D and training is haphazard, with the activities of the various organisations involved in nuclear research determined by their own narrow remits with, no single, overarching body responsible for aligning them into a coherent programme that meets national needs. The Board should also be charged with: examining mechanisms to ensure that the UK is able to take a central role in international nuclear research collaborations and signal to the international research community that the UK is a credible and willing partner for such collaborations, assist in the commercial exploitation of nuclear research and play a role in public engagement, recognising that the public acceptability of nuclear power will be a crucial factor in determining its future use.

Who pays?

The Department for Energy and Climate Change seem determined to relinquish any responsibility for funding, or helping to secure funding, to maintain nuclear R&D capabilities and associated expertise in the UK. In our view, the Government, along with all other beneficiaries of nuclear R&D (particularly industry), should ensure that there is adequate funding to support the nuclear R&D roadmap. Without an increase in funding for fission research in the order of £20–50 million a year, the Government's intention that nuclear should play a part in meeting the UK's future energy needs simply lacks credibility. This is a small sum—equal to around 1% of the annual spend of £2.8 billion on decommissioning the UK's legacy waste—and compared with £90 million a year spent on the highly successful programme of fusion research.

Responsibility for specific types of nuclear R&D capability

The current arrangement of organisations that carry out, or commission, nuclear research do not make the most effective use of existing facilities and expertise. We recommend that the role of the Nuclear Decommissioning Authority in handling, and commissioning research on, waste from new power stations should be clarified, and that the Government should determine which body should have responsibility for R&D in advanced fuel recycling and reprocessing to ensure that these capabilities are not lost. We also recommend that the current, very short-term, contract for the National Nuclear Laboratory (NNL) should be extended and that NNL should be charged, under the direction of the Board, with carrying out applied research relevant to long-term strategic needs in partnership with academia, other laboratories and industry.

Nuclear Research and Development Capabilities

CHAPTER 1: INTRODUCTION

1. The UK's energy policy aims to achieve the following objectives. (I) Energy security, protecting consumers against fluctuations in the supply of fossil fuels from outside the UK. (II) Reductions in greenhouse gas emissions to meet the legally binding commitments of the Climate Change Act (2008). (III) Affordability, ensuring that consumers are not obliged to pay more than necessary. (IV) Safety of supply. The Government have said that it will deploy a portfolio of energy sources including nuclear, renewables and fossil fuels with carbon capture and storage (CCS)⁴. There are a range of scenarios with different proportions of these three sources, but it is widely agreed that nuclear energy will play a significant role in the portfolio.

Scope

2. The purpose of this inquiry is to consider whether the UK has sufficient research and development (R&D) capabilities and associated expertise to support current plans for new nuclear build in the UK and what capabilities will be required in the future in order to meet our energy needs safely and securely. Although this inquiry does not attempt to look at the more fundamental issue of the arguments for or against nuclear energy, we recognise that public acceptability of energy technologies is a key factor in determining their future use. We have therefore also considered the need for social science research into the use of nuclear technologies. Equally, although we have not attempted to look at the R&D needs for other energy technologies, we recognise that such R&D will be an important consideration in the future within the energy portfolio.
3. The UK's nuclear interests extend beyond national borders to international non-proliferation and security policies and we acknowledge the critical importance of these policy areas and their relevance to nuclear R&D capabilities. However, for the purposes of this inquiry, we have focused principally on UK nuclear fission R&D and associated expertise and the UK's ability to meet future nuclear energy requirements, touching on other related policy areas only where they have implications relevant to this inquiry. R&D capabilities for nuclear fission overlap with nuclear fusion and we have considered this overlap where relevant.⁵ We have also focused on the R&D capabilities and associated expertise needed to deliver the UK's radioactive waste management and disposal programmes, which are an integral part of the current and future plans for nuclear energy. Given that fusion energy is not predicted to have an impact on the energy portfolio until after 2050, and will not therefore be able to contribute to meeting the UK's

⁴ As well as increasing energy efficiency and reducing demand.

⁵ Fusion releases energy from the fusion of two smaller atoms into a larger one. Fission releases energy during the process of splitting a single larger atom.

2050 emission reduction targets, we do not consider what fusion energy R&D capabilities may be required over this period.

4. The decision to conduct this inquiry was taken before the serious incident at the Fukushima Daiichi nuclear power plant in Japan following the earthquake and subsequent tsunami in March 2011. Safety R&D capabilities are an inherent requirement for the safe and secure supply of nuclear energy in the future. As a result, the discussion of safety R&D capabilities takes place throughout the text of this report. In recognition of the increasing focus on safety internationally, however, in Chapter 6 we consider the additional R&D requirements that have come to light as a result of the incident.

Up to 2050 and beyond

5. The Government have developed a number of scenarios for the UK's future energy needs (see Chapter 3) with a time horizon of 2050. Although setting a deadline is essential in terms of measuring the likelihood of achieving emission reduction targets, it is less useful if applied as a cut off date for planning nuclear energy infrastructure needs, including, for example, maintenance of R&D capabilities and associated expertise necessary to continue operating the UK fleet. For this reason, where possible, we have tried to look beyond 2050. We were, however, limited by the fact that the majority of scenario work to-date has not focused beyond this timescale.

Structure of the report

6. In Chapter 2 we look at the changes that have occurred within the nuclear industry over the last few decades, and the influence these have had on the bodies that fund or conduct nuclear research today. In Chapter 3 we discuss the range of potential future contributions that nuclear energy could make to the energy portfolio up to 2050 and beyond. In Chapter 4 we provide an analysis of the Government's current energy policies concerning nuclear energy. In Chapter 5 we consider what R&D capabilities and associated expertise will be required in the UK up to 2050 and beyond, and whether the UK's current capabilities are adequate to meet the future needs. In Chapter 6 we look at what measures need to be taken to ensure that the UK's R&D capabilities are adequate and in Chapter 7 we examine the role of various bodies that fund or carry our nuclear R&D, and whether their remits could be improved in order to achieve this more effectively. In Chapter 8 we also consider the wider range of policy areas to which nuclear R&D is relevant and the implications of the cross-over between these policy areas for future energy policies. These include civil and defence nuclear programmes, security and non-proliferation, radioactive waste and disposal programmes and commercial opportunities. A list of abbreviations and acronyms is provided in Appendix 6.

Acknowledgements

7. The membership and interests of the Science and Technology Committee are set out in Appendix 1 and those who submitted written and oral evidence are listed in Appendix 2. The call for evidence with which we launched our inquiry is reprinted in Appendix 3.
8. In April 2011 we held a seminar to which academics, representatives from Government departments and agencies and a variety of other organisations

contributed. A list of those who presented at the seminar is set out in Appendix 4. In July 2011 we visited the National Nuclear Laboratory (NNL), the Nuclear Decommissioning Authority (NDA) and the Sellafield site. A further visit by Lord Jenkin of Roding and Lord Wade of Chorlton took place in September 2011. A note of the first visit is set out in Appendix 5. We are grateful to all those who assisted us in our work.

9. Finally, we would like to thank our Specialist Adviser, Professor Robin Grimes, Director of the Centre for Nuclear Engineering and Professor of Materials Physics at Imperial College London, for his expertise and guidance throughout this inquiry. We stress however that the conclusions we draw and recommendations we make are ours alone.

CHAPTER 2: THE NUCLEAR R&D SECTOR—PAST AND PRESENT

Historical context

10. During the mid-twentieth century, the UK was a world leader in nuclear fission R&D and in the development of nuclear technology. The UK developed Magnox reactors (Generation 1 technology systems) in the 1950s and gas-cooled systems during the 1960s and 70s (Generation II Advanced Gas-Cooled Reactors (AGR)(see Box 1). Since the 1970s, the dominant technologies deployed worldwide have been Generation II light water reactor systems (either Pressurised Water (PWR) or Boiling Water (BWR) systems) and then Generation III systems. These designs offered evolutionary improvements to the Generation II designs. It was not until the late 1970s that the UK shifted its attention away from involvement in technology design to the adoption of light water reactor systems technology, building the UK's first PWR, Sizewell B, which began operating in 1995.⁶

BOX 1

Nuclear Reactor Technologies

Since the United States Department of Energy launched the Generation IV initiative in 2000, “Generations” have become the commonly used terminology for reactor types. Most Generation I to III designs require a moderator material to slow down the speed of neutrons (through a transfer of energy) and thereby increase the rate of the fission reaction. These are known as thermal reactors because the (thermal) neutrons have the same effective temperature as their surroundings. They also require cooling systems to remove the heat released. (This can also be the moderator as is the case for water reactor systems.) Heat from the reactor is then converted into steam to power turbines to generate electricity. Generation IV reactors are either advanced thermal reactors, which build on the Generation III designs but operate at very high temperatures to improve their efficiency, or fast reactors which rely on fast neutrons (that have not been moderated) to stimulate fission and also breed new fissile material. Fast reactors require even more effective cooling systems to remove the heat generated.

Generation I reactors include prototype thermal power reactors and the first designs that were connected to the grid. The UK's Magnox reactors, for example, are carbon dioxide cooled and graphite moderated. (Magnox is the name of the alloy used to clad the rods in the reactor.)

Generation II reactors include current operating reactors (built from 1970 to 2010). In the UK these are mainly AGR and one PWR. Other countries have mostly built PWR but also BWR.

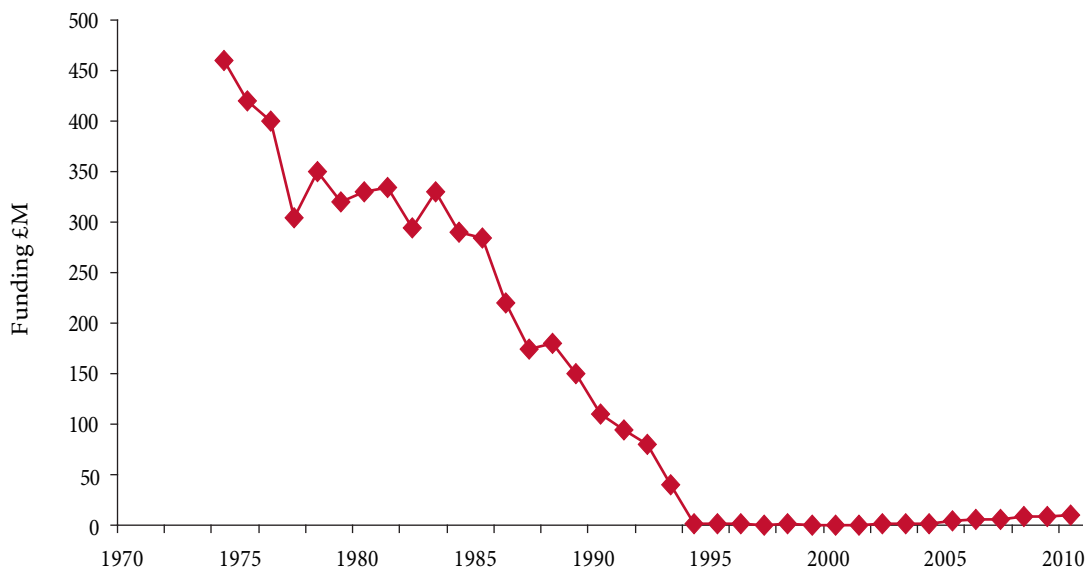
Generation III designs are about to be deployed. In the UK they will be PWR with advanced safety systems, including a degree of passive safety so that human intervention is not required in order for the reactor to remain in a stable or contained state in the event of a loss of coolant.

⁶ *A Review of the UK's Nuclear R&D Capability*, Sherry, A.H. et al, Technology Strategy Board, 2010.

Generation IV reactor systems will be available for deployment only after about 2030, in most instances, and are presently being designed or prototyped. To qualify, these reactors must have safety systems that are entirely passive, with efficient utilization of the fuel. Generation IV reactors could have vastly improved fuel efficiency and this could lead to a significant reduction in the amount of waste produced due to the type of reaction that takes place. Some designs have the ability to convert waste materials into fuel and effectively “breed” fuel, thereby reducing the need for new fuel. However, Generation IV designs represent significant challenges in terms of producing materials that can withstand the conditions within a reactor.

11. By the start of the 1980s, an estimated 8,000 people were involved in the UK’s nuclear R&D programme, working at British Nuclear Fuels Ltd (BNFL), the UK Atomic Energy Authority⁷ or the Central Electricity Generating Board (CEGB). This programme received Government funding of about £300–350 million a year (at this time) which included support for a number of R&D facilities for studying highly active materials around the country including facilities at Harwell, Berkeley and Windscale (see Figure 1).⁸

FIGURE 1
UK public sector fission R&D funding⁹ (£ millions)



⁷ The United Kingdom Atomic Energy Authority is a Non-Departmental Public Body within the Department for Business, Innovation and Skills (BIS). Originally formed in 1954 to carry out nuclear research for the Government, the Authority now manages the UK fusion research programme (Culham Centre for Fusion Energy, CCFE) and operates the Joint European Torus (JET) on behalf of the European Fusion Development Agreement at Culham, Oxfordshire. In 2008, the Authority announced the formation of a new wholly owned subsidiary, UKAEA Limited, to focus on nuclear decommissioning and environmental restoration management. In October 2009, Babcock International Group plc acquired UKAEA Limited. Thus, the United Kingdom Atomic Energy Authority and UKAEA Limited are now entirely separate entities.

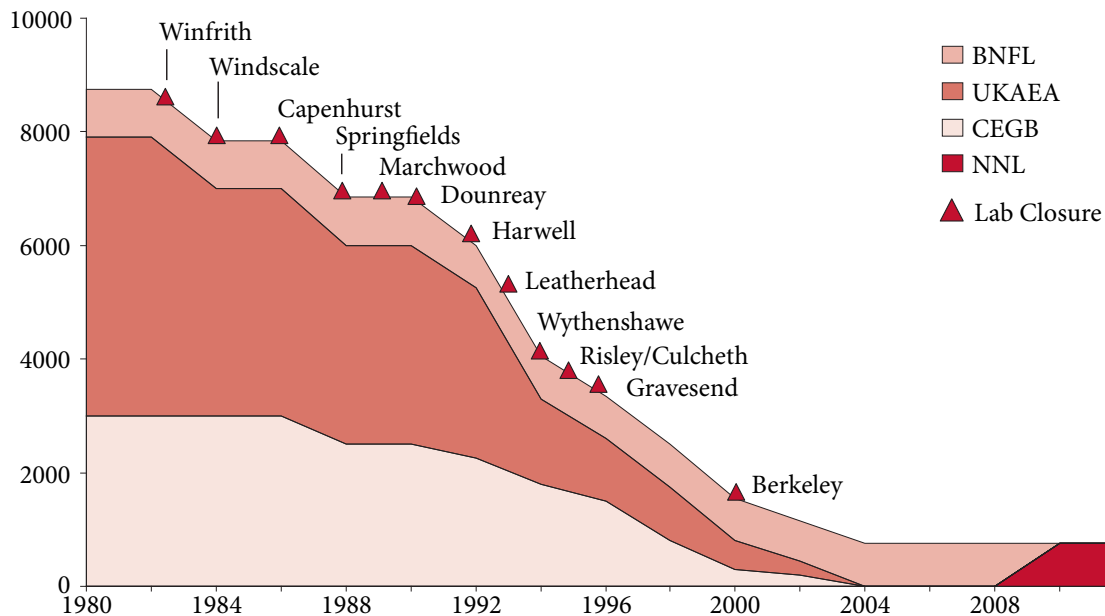
⁸ NRD 23

⁹ Reproduced by courtesy of NNL.

12. Throughout the 1980s and 90s, the UK played no part in the development of new reactor designs to follow Generation II reactors, and in the mid-90s the nuclear industry was privatised with the break-up of BNFL following the completion of the PWR at Sizewell B, the last nuclear plant to be built in the UK.¹⁰ As a result, Government funding for nuclear R&D and associated expertise declined significantly, the research programme for developing advanced reactor designs was shelved. Furthermore the research focus switched to maintaining the existing fleet and to decommissioning and waste management to deal with legacy waste.¹¹ Today, Sellafield Ltd estimate that fewer than 2,000 people work on UK nuclear fission R&D in the private and public sectors¹² (around 550 of whom are situated at NNL) and only a small number of public research laboratories remain (see Figure 2). In 2009, recognising the need to preserve some nuclear R&D capabilities and associated expertise in the UK, the Government set up NNL, staffed from the remaining R&D capabilities still present at BNFL and utilising the facilities available at Sellafield and other sites (see paragraph 30).

FIGURE 2

UK Nuclear R&D Workforce: showing the reduction in workforce following the closure of Government nuclear laboratories¹³



Recent developments

13. More recently, given the need to reduce greenhouse gas emissions and concerns over security of supply, countries (including the UK) have expressed renewed interest in nuclear power generation. In 2010, 438 reactors were operating worldwide (totalling 374 gigawatts (GW) capacity) and, a report by the Energy Research Partnership (ERP) entitled *Nuclear*

¹⁰ *Nuclear Fission*, Energy Research Partnership, September 2010.

¹¹ NRD 23, 13, 22, 39, 44

¹² NRD 23

¹³ Figure reproduced by courtesy of NNL. The remaining workforce at NNL consists of 780 staff, about 550 of whom are research staff, and 230 administration and technical support staff.

Fission (“the ERP report”)¹⁴ estimated there were plans to build 52 reactors (primarily in China and Russia) with a further 143 on order or planned and 344 proposed (in total, potentially delivering a further 363 GW). Forecasts from the International Energy Association (IEA) suggest that, by 2050, global capacity will increase to 1,200 GW, providing 24% of global electricity generation.¹⁵

14. These forecasts were made before the serious incident at the Fukushima Daiichi nuclear power plant in Japan in March 2011. It is too early to tell what impact this will have on global plans for nuclear new build. Some countries, notably Germany, decided to halt current plans for building new nuclear power stations following the incident. In September 2011 the Prime Minister of Japan, Yoshihiko Noda, also committed to reducing the country’s reliance on nuclear energy in the longer-term.¹⁶ Most countries with significant nuclear programmes, however, including the UK, are pressing ahead with their programmes. An analysis by the Economist Intelligence Unit reported that a review of forecasts for the 10 largest nuclear power producers showed that the growth is likely to continue and that capacity will increase to 405 GW by 2020 within these countries.¹⁷

The nuclear sector in the UK

15. The nuclear sector in the UK consists of over 200 companies concerned with activities ranging from energy production to decommissioning and participation in the supply chain. In total, they employ around 44,000¹⁸ people, making a significant contribution to the UK’s economy.¹⁹
16. At present, the UK has 10 nuclear power stations in operation, generating around 10–12 GW, or 16% of the UK’s electricity supply (down from 25% in the 1990s). It is anticipated that, in the next 15 years, all but one of the existing fleet will be closed. So far, industry has committed to building up to 16 GW of new plant by 2025, with EDF submitting the first bid to build a plant at Hinckley Point in October 2011.²⁰

Spending on research

17. As Figure 1 demonstrates, there has been a significant decline in funding for nuclear fission R&D since the mid-1970s as a result of the shift away from the UK’s involvement in reactor design. This reached a low in the 1990s to almost zero. The total spend has increased in recent years as a result of the

¹⁴ *Nuclear Fission* op.cit.

¹⁵ Ibid: *Energy Technology Perspectives, Scenarios and strategies to 2050*, IEA, 2010.

¹⁶ *New Japan PM Noda in Nuclear Restart Call*, BBC News Asia Pacific, 13 September 2011 <http://www.bbc.co.uk/news/world-asia-pacific-14895182>.

¹⁷ *The future of nuclear energy: One step back, two steps forward*. A special report from the Economist Intelligence Unit, June 2011.

¹⁸ 24,000 employed directly by the nuclear operating companies and 20,000 by the supply chain. Of the 24,000 personnel directly employed, decommissioning accounts for 12,000, electricity generation for 7,500 and fuel processing for 4,500.

¹⁹ *Power People, the civil nuclear workforce 2009–2025*, Renaissance nuclear skills series 1, Cogent, 2009.

²⁰ According to the ERP Report *op. cit.*, in September 2010, EDF were looking to build 6.4 GW of capacity at Sizewell and Hinkley Point; Horizon Nuclear Power, a consortium between E.ON and RWE, were intending to build 6 GW at Oldbury and Wylfa; Iberdrola, GDF Suez and Scottish and Southern Electricity (SSE) had plans to build 3.6 GW at Sellafield (although SSE pulled out of these plans in September 2011). Horizon Power completed purchase of land at the Wylfa site in October 2011.

new build programme and is estimated to be in the region of £11 million a year (£6.5m from the research councils and £4.5m from the Euratom programme), representing about 4% of total spend on energy R&D by the research councils. This is still low, however compared to £94 million²¹ a year spent on the successful and world-leading fusion research programme (about £34m from the Research Councils and £60m from Euratom), representing roughly 23% of the total energy programme spend for 2010–11. This compares poorly with other countries within the OECD which spend significantly more, ranging from a low of 4.5% to a high of 63.1% of their total energy spend on nuclear fission R&D (see Table 1).

18. Recent reviews (such as the Engineering and Physical Sciences Research Council and Science and Technology Facilities Council *Review of Nuclear Physics and Engineering* (“the EPSRC/STFC review”) and the *Review of Energy* of the Research Councils UK (“the RCUK review”))²² and the evidence we received from, for example, AMEC²³ indicate that the decline in funding over recent decades has caused the UK to move from “world leader and technology developer” to “niche player” (with the exception of fusion). Other countries, such as the United States and France, are now in the lead in terms of expertise.²⁴ In addition, countries such as China, India and South Korea are overtaking the UK through significant investments in research programmes to underpin their nuclear plans.²⁵
19. Nevertheless, the UK has retained some residual strength in a number of areas built up from previous investments. These are discussed in paragraphs 20 to 22 below.

TABLE 1

Comparisons of government-funded research on energy and nuclear fission (figures for the latest available year²⁶)²⁷

Country	Fission R&D (€M)	Total energy R&D (€M)	Fission R&D as proportion of total energy (%)	Date
Australia	8.214	184.524	4.5	2007
Belgium	39.442	97.184	40.6	2007
Canada	140.444	531.408	26.4	2009
Czech Republic	12.779	36.556	35.0	2009
Finland	9.452	170.606	5.5	2008

²¹ NRD 35, 61

²² *Progressing UK Energy research for a coherent structure with impact*, Report of the International Panel for the 2010 RCUK Review of Energy, 24–29 October 2010 (“the RCUK Review”); *The EPSRC/STFC Review of Nuclear Physics and Nuclear Engineering*, EPSRC and STFC, 2009 (“the EPSRC/STFC Review”).

²³ NRD 41: AMEC is the largest UK-based private sector supplier of programme and asset management and engineering services to the civil nuclear sector.

²⁴ NRD 41, 37; *Progressing UK Energy research for a coherent structure with impact*, op. cit.

²⁵ NRD 07, 36, 45, 65

²⁶ The reported spend figures in the table cover different time periods. We have not been able to verify if the reported spend in each country includes all sources of funding. Comparisons between the different countries should therefore be treated with some caution.

²⁷ *R&D Budgets for Energy Technology 2010—Nuclear Fission R&D*, IEA Data Services, 2010.

France	445.665	931.277	47.9	2008
Germany	41.98	563.715	7.4	2009
Italy	35.816	373.438	9.6	2007
Japan	1835.532	2907.79	63.1	2009
South Korea	131.998	323.456	40.8	2007
Netherlands	9.58	138.905	6.9	2006
Norway	9.163	127.781	7.2	2009
Spain	4.038	89.818	4.5	2009
Sweden	7.433	121.091	6.1	2009
Switzerland	16.574	118.674	14.0	2009
United Kingdom	4.493 ²⁸	292.992	1.5	2009
USA	560.664	8466.969	6.6	2009

The UK's strengths in nuclear R&D and associated expertise

20. Despite the diminished role of nuclear energy in the UK in recent years, the UK has retained strengths in nuclear R&D capabilities and associated expertise across some areas. These have been shaped by historic R&D programmes and include “MOX fuel development, spent fuel management (pond storage and reprocessing), waste management, and decommissioning” and “gas-cooled reactor technology”.²⁹ This breadth of knowledge acquired across the “whole fuel cycle” is considered by many to be the UK’s “unique selling point”.³⁰ However, as Professor Paul Howarth from NNL and others have stressed, given the small number of experts involved, the depth of knowledge within the UK is a cause for concern with only a few or often a single expert covering many areas of research.³¹ Given the ageing demographic of the R&D workforce this is a cause for concern.³² (This issue is considered further in paragraphs 92–99 below).
21. In 2010, the Technology Strategy Board (TSB) carried out a review of the UK’s nuclear R&D capabilities entitled *A Review of the UK’s Nuclear R&D Capability* (“the TSB review”). The review concluded that, although expertise had been allowed to decline the UK still had residual strengths in the following areas (some of which are applicable to Generation III and IV technologies):
- Advanced modelling and analysis of reactor cores of all types;
 - Thermal hydraulics and major accident modelling;
 - Fuel design, manufacture and performance modelling;
 - Fuel enrichment and recycling;

²⁸ UK spend in 2009–2010 was approximately £6.5 million for the RCUK energy programme.

²⁹ NRD 32 and 04, 07, 14, 21, 23, 26, 27, 28, 30, 32, 33, 36, 39, 40, 45, 49; QQ 46, 373

³⁰ NRD 49, 36, 30; Q 321; *A Review of the UK’s Nuclear R&D Capability*, op. cit.

³¹ Q 328, NRD 13, 29, 30

³² NRD 27, 29

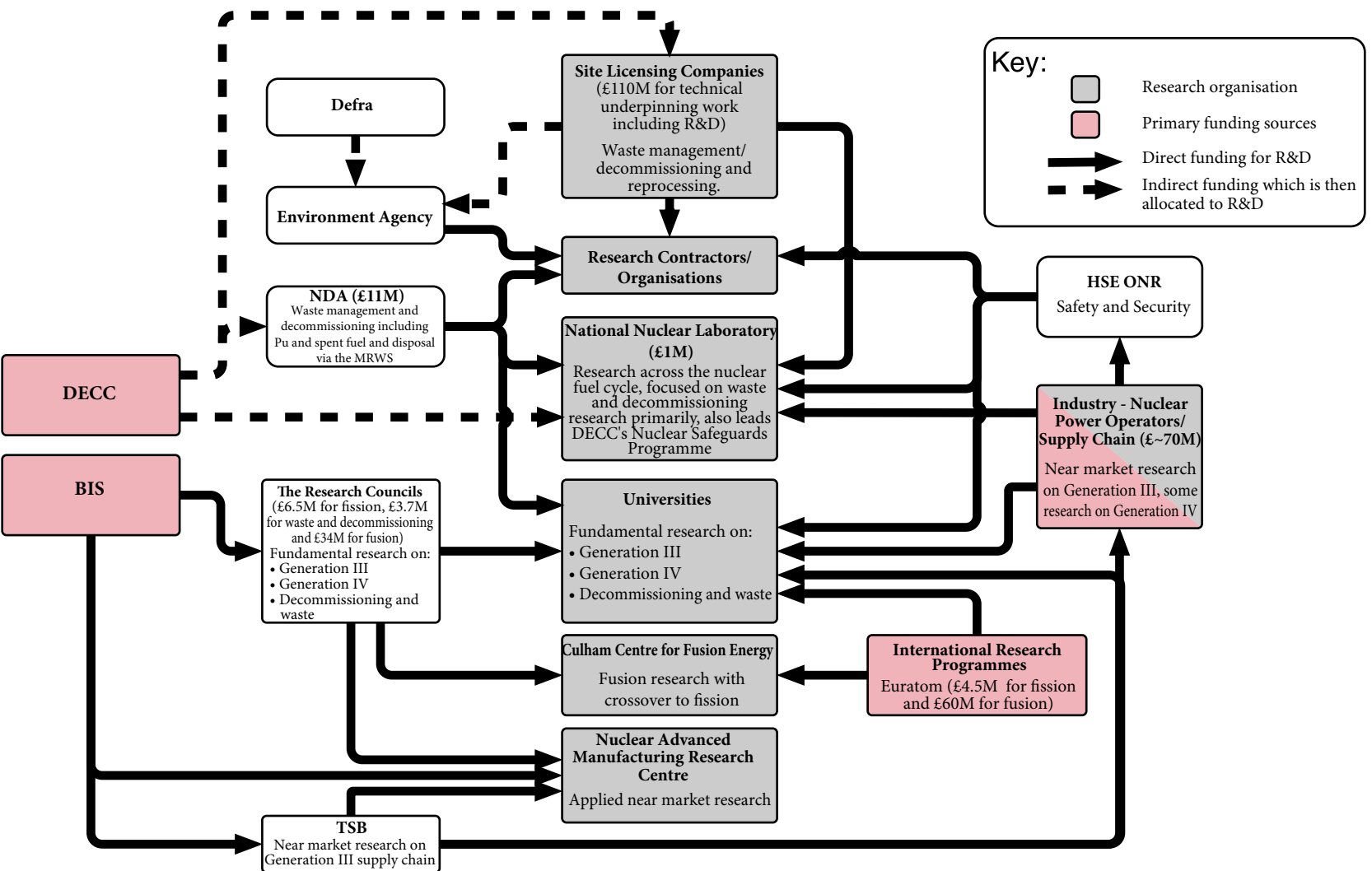
- Non-Destructive Evaluation and structural integrity of materials and structures;
 - Advanced construction methods;
 - Materials degradation;
 - Decontamination and decommissioning;
 - Waste treatment and management; and
 - Fuel cycle assessment.³³
22. In addition, the UK's world-leading fusion programme, lead by the UK Atomic Energy Authority at Culham, involves many disciplines which are applicable to, and overlap with, fission research capabilities such as reactor physics, advanced structural materials and irradiation damage in materials.³⁴ Expertise developed through the UK's nuclear security R&D programme and the nuclear submarine programme also has relevance to the nuclear fission programme.³⁵

³³ *A Review of the UK's Nuclear R&D Capability*, op. cit.

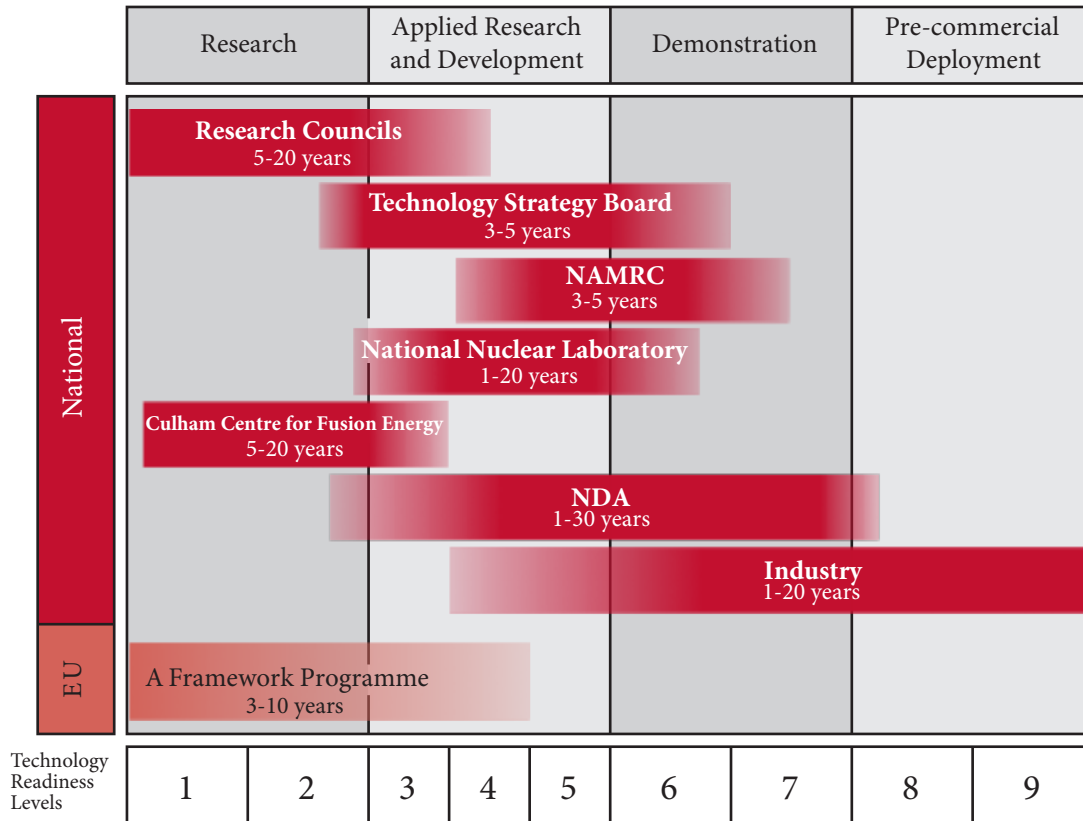
³⁴ NRD 21, 27, 25, 38, 40, 49; *Progressing UK Energy research for a coherent structure with impact*, op. cit.

³⁵ NRD 37

FIGURE 3
The Civil Nuclear Fission Research Landscape



Source: Dr Michael Rushton, at the Centre for Nuclear Engineering at Imperial College London.
Where available, annual spend on R&D is provided.

FIGURE 4**The Nuclear Fission Research Funding Landscape: Overview of Technology Readiness Levels³⁶****Organisations that fund or carry out nuclear R&D**

23. Interactions between the bodies that fund or carry out nuclear R&D in the UK are complex (see Figures 3 and 4 on pages 19 and 20). Such responsibility as there is for co-ordinating and conducting different aspects of R&D is spread across numerous public and private bodies.

Private industry

24. The nuclear industry relies on research capabilities to underpin their operations, not only to meet regulatory standards and ensure the safe and secure supply of energy, but also to develop new technologies, to make improvements to current technologies and to ensure a steady supply of skilled workers at both graduate level and above. The industry carries out a substantial amount of applied research and some fundamental research to support its requirements for plant operation including decommissioning and clean-up. EDF Energy, for example, spends in the order of €300 million on nuclear R&D a year, €25 million of which is spent in the UK.³⁷

Research councils

25. The research councils are primarily responsible for fundamental research into fission energy, and decommissioning and waste, directed through either

³⁶ Courtesy of Dr Michael Rushton, at the Centre for Nuclear Engineering at Imperial College London.

³⁷ NRD 49; Q 236

investigator-led (responsive-mode) grants or themed research programmes. The Engineering and Physical Sciences Research Council (EPSRC) funds nuclear engineering research, and the Science and Technology Facilities Council (STFC), funds nuclear physics research and some of the major research facilities used in the UK for nuclear fission research, such as ISIS.³⁸ The Natural Environment Research Council (NERC) also funds some work on waste and decommissioning, but at a much lower level.

26. Although most of the work in the nuclear physics programme funded by STFC does not relate to nuclear fission for energy generation, a small number of nuclear physicists are needed by the sector and physics departments provide valuable training. The research, skills and expertise required by the industry and regulator relate largely however to nuclear engineering.³⁹ Such research is primarily co-ordinated through the EPSRC-led energy programme (previously through the consortium grant, Keeping the Nuclear Option Open programme (KNOO)). Individual councils also fund relevant research through responsive-mode programmes and research for materials comes through the Materials, Mechanical and Medical Engineering programme of the EPSRC.⁴⁰
27. As a result of the new build programme, the research councils have increased their funding for nuclear fission R&D in recent years from a very low base. The current spend is around £6.5 million a year (2009–10), up from about £128,000 in 2000–01 (see Table 2). This annual figure is set to increase by approximately £2 million a year over the next few years, with an overall current and forward commitment to programmes spanning a number of years of £59 million.⁴¹ This is still significantly lower, however, than the Organisation for Economic Co-operation and Development (OECD) average (see paragraphs 17 to 19).

TABLE 2

Annual Research Council spend on nuclear fission (£)⁴²

2000–01	2001–02	2002–03	2003–4	2004–5	2005–6	2006–7	2007–8	2008–9	2009–10
127,562	324,879	307,195	212,239	111,947	951,643	2,812,548	2,962,960	4,254,066	6,449,604

28. Waste and decommissioning research is funded through activities such as the DIAMOND (Decommissioning, Immobilisation and Management of Nuclear Wastes for Disposal) consortium grant, which totalled approximately £4 million over four years. NERC currently supports £4 million worth of responsive-mode grants in this area over a number of years. NERC also supports a portfolio of research into radioactive waste

³⁸ ISIS is the pulsed neutron and muon source at the Rutherford Appleton Laboratory in Oxfordshire, a world-leading centre for research in the physical and life sciences. It is owned and operated by the STFC.

³⁹ NRD 61

⁴⁰ See *Nuclear Fission* op. cit. and *the EPSRC/STFC Review of Nuclear Physics and Nuclear Engineering* op. cit. for a detailed breakdown of activities.

⁴¹ NRD 33, 61

⁴² The RCUK Energy Programme as a whole over the Comprehensive Spending Review (CSR) period will be investing £540 million in energy related research, which will include research and training related to nuclear fission. At this stage it is not possible to give figures for spend on nuclear fission over the CSR period. Priorities for the whole RCUK Energy Programme will be regularly reviewed with advice from the programme's Scientific Advisory Council (NRD 61).

management at the British Geological Survey (BGS) with a budget of £170,000 for this year and a Radioecology Group at the Centre for Ecology and Hydrology with a budget of approximately £380,000 for this year. In total it is estimated that the research councils spent about £3.7m in 2010/2011 on decommissioning, waste management and disposal (2.25m of which is included in the annual research council spend outlined in Table 2).⁴³

Universities

29. Within the UK there are a number of universities which have continued to provide a good base in nuclear science and engineering research and training, despite the reduction in public funding. They include the University of Manchester (Dalton Institute), Imperial College London (Centre for Nuclear Engineering) and the Universities of Bristol and Oxford joint Nuclear Research Centre.⁴⁴ Groups of universities form broad research collaborations, often funded by the EPSRC, and sometimes include NNL or the Navy nuclear propulsion laboratory at HMS Sultan as a partner. Following the recent increase in funding from the EPSRC, a number of universities are now offering nuclear engineering and technology courses at either undergraduate or Masters-level. There are concerns however that they may not be enough to meet the needs of the sector. (This issue is discussed further in paragraphs 118 to 130 below).

Other public bodies

30. NNL is a Government-owned, contractor-operated (GoCo) body which carries out short-term applied commercially-focused research for its customers within the nuclear sector including the industry, the NDA and the Ministry of Defence (MoD). It also self-funds a small amount of longer-term applied research of relevance to its programme of work focused on meeting strategic national needs, amounting to £1 million a year (see paragraph 230 to 235 and 240 to 254).
31. The NDA has responsibility for the decommissioning and clean-up of the UK's civil nuclear reactors and for implementing geological disposal plans. It co-ordinates the majority of applied research work on waste management and disposal, primarily through its Site License Companies but also directly through research contractors, such as NNL, to meet its objectives. In 2009–10 it invested £11 million in R&D directly, with an estimated £110 million spent across the NDA estate by the Site Licensing Companies on technical underpinning work (see paragraphs 213 to 223).⁴⁵
32. The Office of Nuclear Regulation (ONR) within the Health and Safety Executive (HSE) also co-ordinates safety work through plant operators and has the ability to fund some R&D on safety aspects of nuclear operation when it is not covered by the industry (see paragraphs 191 to 202).⁴⁶
33. Near-market research (five to ten years from application) is carried out by the Nuclear Advanced Manufacturing Research Centre (NAMRC) at the

⁴³ NRD 19, 61, 66

⁴⁴ A full list can be found on the Nuclear Liaison website at: <http://www.nuclearliaison.com/nl-research>

⁴⁵ NRD 19

⁴⁶ NRD 11

University of Sheffield, in partnership with the University of Manchester and industry partners. The Centre was established in 2010 to encourage the translation of research and the development of the supply chain for the nuclear industry (with £15 million of investment from the Strategic Investment Fund). The TSB has also put forward a £2 million call for feasibility studies to strengthen the UK supply chain with investment in the Technology Readiness Levels⁴⁷ (TRL) 3–6 in-between fundamental research and demonstration and application within industry, and intends to award a further £10 million to successful studies.

International research collaborations

34. Due to the nature of nuclear research in terms of length of time, scale and cost of activities, most countries which conduct nuclear R&D participate in international collaborations in order to keep up with developments worldwide.⁴⁸ According to Westinghouse Electrical Company, the sheer scale of effort and expense required for the development of nuclear technologies and of geological disposal facilities makes such cooperation critical.⁴⁹
35. The UK is currently involved in a number of international research programmes including the European Atomic Energy Community (Euratom) programme and, through Euratom, the Generation IV Forum (GIF). This is mainly however through individual researcher involvement as opposed to a more co-ordinated approach and it is argued that the UK should be more involved in these activities. The NDA has developed relationships with other countries on decommissioning and waste management to share experience and good practices,⁵⁰ and the ONR is also involved in international activities. The UK received around €21 million from the first four years of the current Euratom Framework Programme (equivalent to approximately £4.5 million a year).⁵¹ (We discuss the roles of these bodies and UK limited involvement with them further in paragraphs 154 to 161 below.)

⁴⁷ TRLs describe the spectrum of research activities from fundamental through to commercial application: TRLs 1–2 cover fundamental or basic research, TRLs 3–6 more applied research, and TRLs 7–9 demonstration through to commercial application. They are not distinct categories and research can cross several of the levels.

⁴⁸ *Progressing UK Energy research for a coherent structure with impact*, op. cit.; NRD 22, 15, 32, 41, 50

⁴⁹ NRD 32

⁵⁰ NRD 21

⁵¹ Q 150

CHAPTER 3: THE ROLE OF NUCLEAR IN THE ENERGY PORTFOLIO UP TO 2050 AND BEYOND

A “portfolio approach”

36. There are inherent uncertainties involved in looking into the future as far as 2050. In the context of this inquiry, these include the variable costs of raw materials and the unpredictable rate of technology development.⁵² For this reason, Chris Huhne MP, Secretary of State for Energy and Climate Change, said that the Government were adopting a “portfolio approach” to meeting the UK’s future energy needs. He also confirmed that nuclear energy would continue to play an important part in this portfolio.⁵³
37. Many witnesses agreed with this approach and said that nuclear energy, as a low-carbon energy source, would be a significant and essential part of the energy portfolio in the future, alongside renewable sources, fossil fuels with CCS and other measures.⁵⁴ Professor Paul Ekins of the UK Energy Research Centre (UKERC) told us that “we would do well to keep all the big low-carbon options open, to develop them to the extent that we need ... to see what will happen to their costs”.⁵⁵ In this chapter, therefore, we explore the range of realistic scenarios for the contribution that nuclear energy could make to this portfolio. In Chapter 4, we go on to consider what R&D capabilities and associated expertise would be required to keep this range of options open.

What contribution could nuclear make to the energy portfolio?

38. In 2010, nuclear energy contributed about 16% to the UK’s electricity supply, from around 12 GW of capacity. Gas-fired generation accounted for 47% of total supply, coal-fired 28%, wind 3%, oil 1% and 5% came from other sources.⁵⁶ Attempts have been made to develop scenarios which model the UK’s future energy portfolio on the basis of different levels of nuclear capacity up to 2050 and beyond, the majority focusing on the period up to 2050. The ERP report summarises the various scenarios.⁵⁷
39. We received a range of evidence about the role that nuclear could play within the energy portfolio. All future scenarios have consequences for the rest of the portfolio. Professor Ekins told us, for example, that it is “quite possible to have the amount of electricity that we both want and need, low-carbon, by 2050 without nuclear” by pursuing other low-carbon options, particularly energy efficiency.⁵⁸ Dr Douglas Parr, Chief Scientist at Greenpeace UK, shared this view.⁵⁹ However, as many witnesses agreed, there would be considerable economic, structural and social trade-offs to pursuing such a

⁵² The ERP report identifies the main uncertainties affecting the future of nuclear energy as the timing, availability and costs of CCS, the cost of natural gas, the overall carbon reduction target for the sector, the scale of demand and the cost of new nuclear.

⁵³ Q 444

⁵⁴ NRD 08, 14, 21; QQ 2–3, 79, 231, 445

⁵⁵ Q 3

⁵⁶ *UK Energy in Brief 2011*, DECC, 2011.

⁵⁷ *Nuclear Fission, op.cit.*

⁵⁸ Q 3

⁵⁹ QQ 3, 8

policy.⁶⁰ Katherine Randall, 2050 Team Leader at the Department for Energy and Climate Change (DECC) said, for example, that “while it is possible, technically ... to generate a pathway that does not use nuclear”, it is not desirable.⁶¹ This is because various analyses of the future energy portfolio have shown that excluding nuclear would put significantly more pressure on supply and the use of other technologies, some of which, such as CCS, are unproven. It would, she told us, also require “a great deal more effort ... on the demand side” which has so far proven to be difficult and a “significant effort on balancing” the supply of electricity in the system.⁶²

40. As a relatively mature low-carbon technology, nuclear is therefore, in our view, an important option which should be retained within the energy portfolio, not least as a contingency in the event that other, unproven, low-carbon technologies such as CCS develop at a slower pace than anticipated. There are those who believe, as the Secretary of State told us in oral evidence, that shale gas could play a significant role in the future.⁶³ Uncertainties around the viability of CCS, a technology that would be needed to make this a low-carbon energy source (not to mention other uncertainties, for example, about the environmental impact of such extraction or the size of the UK’s reserves), suggest that, in our view, it may not be wise to rely heavily on this energy source to meet our future needs (see paragraph 46).
41. Witnesses also suggested that nuclear energy was a cost-effective option. Commenting on a Climate Change Committee (CCC) review entitled the *Renewable Energy Review* (May 2011) (“the CCC review”)⁶⁴, Adrian Gault, Chief Economist at the CCC, said that “nuclear looks likely to be the most cost-effective low-carbon generation option ... [and that the CCC] would see nuclear playing a very significant role in moving towards low-carbon generation”.⁶⁵ The Energy Technologies Institute (ETI) agreed. They calculated that the likely additional system costs to the UK of not building Generation III reactors would be £9 billion⁶⁶ a year to 2050.⁶⁷
42. The ERP report suggests that, realistically, “between 12–38 GW of installed [nuclear] capacity will be required” to achieve a secure, reliable and low-carbon energy system in 2050, with 12 GW likely to be the minimum amount of nuclear generating capacity needed (see Box 2 for an overview of some of the scenarios presented in the report).⁶⁸ Given however that the UK’s nuclear capacity is currently around 12 GW it is not clear to us how adopting the minimum 12 GW pathway would enable the UK to meet the target of reducing greenhouse gas emissions by 80% (from 1990 levels) by 2050, without a dramatic increase in the contribution of renewable sources and CCS (particularly since the Government intend to electrify the transport sector over this period, which currently accounts for 37% of primary energy consumption in the UK).⁶⁹ We were not surprised therefore that the ETI and

⁶⁰ QQ 3, 5, NRD 08, 29

⁶¹ QQ 3, 5

⁶² Q 5

⁶³ Q 442

⁶⁴ *Renewable Energy Review*, the Climate Change Committee, May 2011 (“the CCC review”).

⁶⁵ Q 2

⁶⁶ At today’s rates.

⁶⁷ NRD 08

⁶⁸ *Nuclear Fission*, op. cit

⁶⁹ *UK Energy in Brief 2011*, DECC, 2011.

others took the view that a higher contribution from nuclear would be inevitable.⁷⁰ The ETI suggested that 35–55 GW would be the “optimum” level.⁷¹ Dame Sue Ion, Chair of the Euratom Science and Technology Committee for the European Commission, agreed. She told us that:

“various studies that have been done ... have said that the mathematics and the engineering do not add up [for 12 GW of nuclear energy]; ... you need closer to 40 GW in order to stand even a fighting chance [of meeting the UK’s greenhouse gas reduction targets], even then with a very significant reduction in demand of the order of 26% to 30%”.⁷²

43. More recent scenarios also indicate the need for more nuclear capacity and suggest that a greater dependency may be likely before 2030. Mr Gault of the CCC told us that “various modelling analyses” find that “early decarbonisation of the power generation sector” will be necessary to achieve an 80% reduction in carbon emissions by 2050, with significant reductions necessary through the period to 2030.⁷³ The CCC has calculated that achieving the necessary energy supply by 2030, and reductions in carbon emissions from 500 grams per kilowatt hour (g/(kW.h)) to a level of 50 g/(kW.h) in 2030, will require 30–40 GW of low-carbon investment between 2020–30, on top of approximately 16 GW of capacity that will be required before this period. In a scenario where renewables contribute 40%⁷⁴ to the UK’s electricity supply, which is considered to be an achievable but technically very challenging target, they estimate that, in total, 22 GW of nuclear capacity will be required before 2030, significantly higher than the commitments to date from the energy sector under the new build programme of approximately 16 GW of capacity by 2025⁷⁵ (see Box 2).
44. **Some experts suggest that 12 GW of energy generation is the minimum contribution that nuclear could make to the energy portfolio up to 2050. However, the weight of evidence indicates that a significantly higher contribution of around 22–38 GW is likely to be required to enable early decarbonisation of the sector before 2030 and to meet the UK’s long-term greenhouse gas emission targets up to 2050 and beyond.**
45. **The Government should now put in place plans which provide for a range of contributions from nuclear energy to the overall energy portfolio—from low to high—to meet the UK’s future energy needs up to 2050 and beyond. These plans should ensure that the UK has adequate R&D capabilities and associated expertise to keep the option of a higher nuclear energy contribution to the energy portfolio open and recognise that maintaining sufficient capabilities and suitably trained people will require a long lead time.**
46. Given the weight of evidence we received and that CCS is still an unproven technology, we do not believe that the Government can base the UK’s energy future on the assumption that fossil fuels, including shale gas, with

⁷⁰ NRD 08, 16

⁷¹ NRD 08

⁷² Q 58

⁷³ Q 2

⁷⁴ *Renewable Energy Review* op. cit.

⁷⁵ Under this scenario 10 GW of supply will come from fossil fuels with CCS and 42 GW from wind (equal to 19 GW supply due to intermittent supply around a 40% load factor).

CCS will enable the UK to meet its greenhouse gas reduction targets safely and securely. (We discuss this issue further in paragraphs 81 to 86 below.)

BOX 2

The contribution that nuclear energy could make to the energy mix: future energy scenarios

There is considerable variation between the different energy scenarios that have been produced due to differences in the assumptions that underpin them, such as the demand for energy in 2050, the cost of different technologies or the market incentives selected within the scenario. These can be found in the relevant publications. For this reason, the scenario results should be taken only as an indication of the range of contributions that nuclear could make to the overall energy portfolio.

UKERC scenarios

At the lower end of the future scenarios which UKERC set out in its report *Making a transition to a secure and low-carbon energy system* (“the UKERC report”),⁷⁶ it is estimated that around 12 GW of nuclear energy capacity would constitute 15% of the total electricity supply in 2050.⁷⁷ At the high end of the scenario range, around 38 GW of nuclear energy by 2050 would equal to about 45–49% of total electricity supply.⁷⁸ Neither of the scenarios specifically looked at the ability to meet the 80% reduction target. The higher scenario represents a 90% reduction or a “least cost” scenario and the lower scenario represents a pathway that favours earlier decarbonisation and more rapid action than is possible from nuclear technologies, reaching a 70% reduction by 2050.

For UKERC’s “low-carbon core” scenario,⁷⁹ which assumes that the 80% target will be met, it is estimated that 29 GW of nuclear energy will be needed by 2050, and will generate 38% of the UK’s total electricity supply.

DECC 2050 Pathways Analysis

The DECC pathways analysis⁸⁰ included a range of pathways (or scenarios), from 0 GW capacity up to 146 GW (between 0 and 98% of total electricity supply—the highest technically feasible contribution) but did not consider the cost implications of each technology. The Alpha pathway looked at contributions from various technologies within the energy portfolio, where nuclear supplied about 39 GW or 30% of total electricity supply. DECC will be producing a pathway in late 2011 which includes consideration of the costs of different technologies.

*The CCC Review*⁸¹

To be on course to meet the 80% target by 2050, the CCC’s central scenario⁸² estimates that, by 2030, 40% of electricity will come from renewables and 22 GW of electricity supply will come from nuclear, equal to 38% of total electricity supply.

⁷⁶ *Making the transition to a secure and low-carbon energy system*, UKERC, 2010.

⁷⁷ From the 50-CCSP scenario, see page 39 of the UKERC report for a description of the scenario assumptions.

⁷⁸ From the 50-CCP and 50-CSAM scenarios, Ibid.

⁷⁹ From the 50-CAM scenario, Ibid.

⁸⁰ *2050 Pathways Analysis*, HM The Government, July 2010, p21 Pathway Gamma.

⁸¹ *The Renewable Energy Review* op. cit.

⁸² For the central scenario, see page 156 of the *Renewable Energy Review* op. cit.

The role of different nuclear technologies and fuel cycles

47. Nuclear energy generation, to a greater or lesser extent, will be an important part of the UK's energy portfolio up to 2050 and beyond. That much is clear. Less certain is which of the different nuclear technologies will be most effective in providing this capacity. This will depend, in part, on the point at which the supply of uranium begins to operate as a cost driver or constraint on the sector.
48. The Government, the CCC and the ETI each stated that, even for scenarios involving a higher contribution from nuclear, demand for new nuclear plant could be met through Generation III technologies and a once-through fuel cycle (see Box 3).⁸³ This is because, in their view, uranium will not be a cost driver in the period up to 2050. The Cambridge Nuclear Energy Centre supported this view and noted that a recent study by the Massachusetts Institute of Technology on fuel cycles suggested that nuclear fuels were more abundant than previously thought and could be extracted at a cost below that of re-cycled fuel.⁸⁴ This would mean that light water reactors (LWRs) and the once-through fuel cycle option would be the most cost-effective option for this century. AMEC however took a different view: "It is predicted that uranium demand would exceed identified reserves in about 2060 and exceed estimated (as yet undiscovered) reserves by 2100—based on the projected growth of LWRs. Commercial deployment of fast reactors with a closed fuel cycle by 2050 would maintain the uranium demand within the estimated reserves indefinitely". They stated that "a decade delay in implementing fast reactors could result in uranium shortages towards the end of the century".⁸⁵ Due to the risk of such constraints, many countries, such as France, are currently investing in research to close the fuel cycle. France plans to ensure that the country has a sustainable supply of fuel by 2100 (see Appendix 5).
49. There are also uncertainties about the rate of development of advanced nuclear reactor technologies, many of which have yet to be demonstrated.⁸⁶ (We consider the implications of this uncertain picture for the assessment of our future nuclear R&D needs and associated expertise in Chapter 5 below.)

BOX 3

The nuclear fuel cycle

There are three categories of fuel cycle, which differ depending on the number of times and manner in which the uranium and plutonium in the spent fuel is recycled.

Open fuel cycle

This is also referred to as "once-through" because the fuel passes through a reactor only once, after which it is disposed of without chemical processing. Currently, with uranium being relatively abundant, most countries rely exclusively on a once-through fuel cycle. However, only 3–5% of the original uranium is consumed if the fuel is used in this way.

⁸³ NRD 08, 21; Q 19

⁸⁴ NRD 31

⁸⁵ NRD 41

⁸⁶ NRD 31

Closed fuel cycles

In this case the used nuclear fuel is recycled multiple times to improve fuel utilization and reduce the long-term waste burden. After fuel has been in a reactor, the remaining uranium, plutonium and other transuranic elements are chemically separated from the fission products—that is, the fuel is reprocessed. A closed cycle will generally involve the use of a fast reactor. In this case a very high proportion of the uranium can be utilized (70–90%). France, Japan and Russia employ a closed fuel cycle in certain nuclear facilities.

Modified open fuel cycle

This involves a limited number of separation steps, conventional reactors and ideally the uranium, plutonium and transuranic elements remain together in order to lower proliferation risks—if the plutonium is not separated it cannot be weaponised. While not all the uranium is used, substantially more (6–12%) is used than in the open fuel cycle.

CHAPTER 4: ENERGY POLICIES

50. Whilst it is beyond the scope of this inquiry to consider the Government's energy policies more generally, there are two inter-related aspects of particular relevance: first, whether enough is being done to encourage industry to invest in nuclear (or other low-carbon) sources of energy needed to enable the UK to meet its long-term emissions targets and to develop the R&D capabilities and associated expertise required to support those energy sources; and, secondly, how the Government intend to meet their energy security objective of reducing reliance on fossil fuels.⁸⁷ In considering these issues, we have also looked at issues relating to the commercial exploitation of opportunities resulting from nuclear R&D and associated expertise.

Background

51. The previous Government's Nuclear Energy White Paper (2008) and the current Government's Annual Energy Statement to Parliament (July 2010) both stated that nuclear energy should have a role to play in the UK's energy portfolio alongside other low-carbon sources in meeting greenhouse gas emissions targets. The Government's current policy approach is to remove any unnecessary obstacles to investment in new nuclear build. Beyond 2020, the Government told us, their targets were "focused on an 80% reduction in greenhouse gas emissions alongside secure, affordable and available supply of electricity rather than the exact contribution of specific electricity generation technologies to the energy mix".⁸⁸
52. In September 2009, the Office of Nuclear Development (OND) was established to remove potential barriers to investment and signal clearly to the industry the serious intent of the Government to push forward nuclear new build.⁸⁹ This was followed by a National Policy Statement on Nuclear which received parliamentary approval in July 2011 and the Generic Design Assessment process for new nuclear plant. More recently, planned reforms to the electricity market set out in the Electricity Market Reform (ERM) White Paper (July 2011) are designed to encourage energy companies to invest in new low-carbon energy capacity in the UK, including nuclear. The Government intend to legislate for the key elements of these reforms in 2012.

Long-term plan to encourage the development of low-carbon technologies

53. We received a significant amount of evidence which argued that the Government's approach to energy planning was short-term and lacked the long-term clarity needed to maintain the R&D capabilities and associated expertise necessary to keep future nuclear options open.⁹⁰ Industry appears generally to support Government efforts with regard to the new build programme. Keith Parker, Chief Executive Officer of the Nuclear Industry Association (NIA), for example, told us that "in terms of [the] Government

⁸⁷ See *UK Energy Supply: Security or independence?* House of Commons Energy and Climate Change Committee, 8th Report of Session 2010–12, 25 October 2011 (HC1065) for an in-depth overview of this issue

⁸⁸ NRD 21

⁸⁹ DECC Website: http://www.decc.gov.uk/en/content/cms/meeting_energy/nuclear/new/office/office.aspx

⁹⁰ NRD 05, 07, 08, 13, 14, 22, 27, 28, 30, 33, 37, 39, 42, 50

support and commitment to nuclear” both the previous and current Governments are to be “applauded” for what they have done to get the programme up to 2025 started.⁹¹ Paul Spence, Director of Strategy and Regulation, EDF Energy, agreed.⁹² Both said however that the current Government approach was not sufficiently long-term. Mr Spence suggested that the Government “need to think about what happens as we go beyond 2025 and nuclear starts to play an even bigger role at the heart of a low-carbon energy system”, adding that “we need to do things now to prepare for that”.⁹³

54. Without long-term clarity, we question how adequate consideration can be given to assessing the R&D requirements and associated expertise needed to support a new nuclear programme beyond 2025 across a range of potential futures. Dame Sue Ion told us that both the RCUK review and the ERP report indicated that “a roadmap to define the UK’s likely plans for nuclear energy within the national energy mix was essential” as well as a long-term strategy for the development of nuclear power.⁹⁴ A recent Royal Society report also called for such a strategy.⁹⁵ NNL, supported by the NIA and others, said that “a roadmap and longer term civil nuclear strategy”, owned by Government, was “essential to provide the framework to define R&D requirements for both academic research and applied R&D to underpin nuclear energy options to 2050 and beyond”.⁹⁶ (We return to the issue of the need for an R&D roadmap in paragraphs 132 to 142 below.)
55. According to EDF Energy:
- “... there is currently an opportunity in the UK to provide a clearer, more effective framework within which Government and major parts of the industry and others can work together on developing long term UK nuclear infrastructure, including R&D ... The Government is currently working hard to ensure that the processes to enable new nuclear development are completed effectively and that the Managing Radioactive Waste Safely programme moves forward. EDF Energy recognises the effort being deployed and does not wish to deflect attention from these areas; but we believe that the wider infrastructure issues associated with supporting what will in future be a very important part of UK energy supply do need to receive more attention.”⁹⁷
56. Given this, we were pleased to hear from Professor David MacKay, the Chief Scientific Adviser for DECC, that the department is conducting some foresight work on future R&D needs by carrying out a Technology Innovation Needs Assessment (TINA) on nuclear which will look beyond the 5–10 year timescale of efforts to-date to try to “quantify the value for money” of the sector and “make a strong case for R&D support”.⁹⁸ This will be completed by the end of 2011. We were also pleased to hear that DECC will be producing “hedging pathways” to identify what carbon reduction targets mean in practice

⁹¹ Q 236

⁹² Ibid.

⁹³ Q 236

⁹⁴ NRD 29; the ERP Report op. cit; the RCUK Review op. cit.

⁹⁵ *Fuel cycle stewardship in a nuclear renaissance*, Royal Society, October 2011

⁹⁶ NRD 07, 28, and 05, 13, 14, 22, 27, 28, 30, 33, 37, 39, 42, 50

⁹⁷ NRD 49

⁹⁸ QQ 69, 71, 81

and what needs to be done to achieve them. We note however that, although a number of attempts have now been made to model our future energy needs, there has been little Government action so far to follow this up. We look forward to the completion of DECC's work on the "hedging pathways" and the TINA. **It is important that the Government provide leadership and take action to ensure that the findings of this work are taken forward in a new long-term nuclear energy policy.** (We make a recommendation about how this should be done in paragraph 63 below.)

57. Despite the evidence we received about the need for long-term clarity, the Secretary of State was adamant that the current policies were adequate:

"Out of the four elements that we consulted on, three are now absolutely clear and certain. There is policy clearance for us to go ahead with the second Energy Bill, which will land in May next year and will be through in the second session. It will introduce the contracts for difference that I described. That will provide exactly the clarity and certainty. It is a system that has been used in other countries ... I think you will find that the big energy investors will now know exactly where they stand. Although you may have had feedback to that effect ahead of the electricity market reform White Paper, I do not believe that it would be legitimate after that publication ... that uncertainty that you describe has been lifted by the Government's very clear commitment in the White Paper. I could not make it clearer if I tried that we want to see nuclear play a part in our energy."⁹⁹

58. In response, Mr Keith Parker of the NIA, with others, told us that he agreed with the Secretary of State's statement that "there is now clarity in the UK's energy policy" which will "help provide investors with the certainty they need to proceed with new plant". But he reiterated his earlier point that "too little consideration has been given so far to the R&D and other requirements that might be necessary to support any new nuclear programmes that could be required beyond 2025 in the period to 2050". Without a clear plan going into the future, he said, "we will simply become reliant on skills and technologies from elsewhere and ... be unable to take full advantage of the opportunities a new programme could bring, particularly to the UK's manufacturing sector".¹⁰⁰ (We discuss the commercial opportunities further in paragraphs 64 to 79 below.)

59. Mr Spence from EDF also pointed out that "industry involvement in R&D will stretch over at least the lifetime of these Generation III reactors, which have a design life of at least 60 years, and so we expect that our R&D efforts will be shaped by Government policy up until 2050". As yet, however, in his view, the Government's "long-term policy remains undefined".¹⁰¹

60. Dr Mike Weightman, Her Majesty's Chief Inspector of Nuclear Installations and Executive Head of the ONR, also highlighted the importance of looking at a longer timescale to meet the regulator's needs:

"We should start by thinking about existing facilities and having to deal with the legacy of the last 50 years ... That will be with us for decades and we need the capability, knowledge and experience to understand

⁹⁹ Q 463

¹⁰⁰ NRD 63

¹⁰¹ NRD 68

what is happening far into the future. The plants that are going on now will operate for some years and the immediate new build will operate for 60 or perhaps 80 years, so you need to have the knowledge and experience far into the future. To do that, you have to have nuclear research capability to build-on to generate the world-leading people we should have here. ... we need a longer-term strategy, because the timescales here are large. If I think about demographics and building up that capability, even if we identified some people today who are just coming to the end of their school careers, it may be 20 years before we would find them useful, so I think that we have to think longer-term.”¹⁰²

61. Professor Howarth of NNL told us that other countries were taking a longer-term view:

“If we look at lots of other countries at the moment, they all have that view; they all look at it from what is going to happen to the nuclear fuel cycle ... Take France, for example: they have plotted out a 100-year vision associated with how to get self-sufficient in nuclear material. That needs to start now. They show how they track through the availability of the nuclear materials that they are going to need in order to get self-sufficiency in 2100. It is a really long timescale that we need to look over.”¹⁰³

62. The Secretary of State said that the Government “see nuclear as an important part of the mix going forward”. He also agreed “that means inevitably that we have to have the R&D capability to ensure that we can play our part and that we can safely use a new generation of nuclear power stations and, indeed, safely use the ones that we have. We also need to have a major investment in skills because of the ageing demographic of the existing nuclear industry”.¹⁰⁴ But in his oral evidence he did not acknowledge that, to achieve this, the Government need to set out a long-term strategy. Neither did he recognise that there are a wide range of areas where R&D and associated expertise are important and where long-term support is required.
63. Given that both the industry and regulator are calling on Government to adopt a long-term view on nuclear energy policy, we find the Secretary of State’s comments worrying and complacent. The Government have stated that nuclear energy will be an important part of the energy portfolio over the period to 2050. If they are serious about this, they need a credible long-term plan to ensure that their energy policies are underpinned by adequate R&D capabilities and the associated training and expertise. **We recommend that the Government should set out a long-term strategy for nuclear energy, outlining:**

- **how they intend to keep the options open to ensure that, if required, nuclear can contribute more to the energy portfolio beyond the current plans for new build up to 2025; and**
- **how R&D capabilities and the associated expertise will be maintained to keep the different nuclear energy options open.**

The strategy should extend up to and beyond 2050.

¹⁰² Q 492

¹⁰³ Q 323

¹⁰⁴ Q 452

Commercial opportunities from nuclear R&D and associated expertise

64. The potential commercial opportunities that nuclear R&D and associated expertise presents for the UK can be split into two overlapping areas: R&D of relevance to the supply chain for the current new build programme and the UK's involvement in future technology development.

Developing the supply chain for the new build plans

65. The UK's new build nuclear programme will involve billions of pounds and will require a significant input from the engineering supply chain.¹⁰⁵ Mr Keith Parker of the NIA told us that the UK has “a pretty well established supply chain”, although he recognised that due to the lull in nuclear activity over the last two decades the UK faced a challenge in “bring[ing] the supply chain back up to speed”.¹⁰⁶
66. Dr David Clarke, Chief Executive of the ETI, said that, for the Generation III reactors being built, there was a need to reduce the costs involved in building and running them: “we need to understand how we will really engineer those systems such that we take the cost out, and the industry then sees the UK with its supply base, and the research base that sits behind it, as an attractive place to deploy those solutions”.¹⁰⁷ The ETI believed that, as the global market grows, “there are strengths there that we could build on in a global context from an export point of view”.¹⁰⁸
67. The TSB has estimated that the global nuclear fission market is worth about £600 billion for new nuclear build and £250 billion for decommissioning, waste treatment and disposal over the next 20 years.¹⁰⁹ The TSB review identified considerable opportunities for UK businesses in the supply chain to benefit from the new build programme, building mostly on the UK's strengths in areas such as non-destructive testing (NDT), condition monitoring, decommissioning, waste disposal, and advanced manufacturing and materials. For example, the review estimated the size of the market for non-destructive evaluation (NDE) and NDT to be £10 million for each reactor for construction, and £100s of millions through the lifetime of a plant.¹¹⁰
68. To “stimulate technology development and innovation for the benefit of UK industry in areas that offer the greatest potential for boosting the UK's economic growth”,¹¹¹ the TSB launched a £2 million applied R&D competition for feasibility studies targeting small and medium-sized companies (SMEs) which could become part of a new nuclear supply chain. Given the strength of interest received, Mr Derek Allen, Lead Technologist for Energy at the TSB, told us that they were “likely to be taking that forward into another round of R&D investment”¹¹² of about £10 million for the future competition which would be for larger collaborative R&D.¹¹³

¹⁰⁵ Q 52

¹⁰⁶ Q 254

¹⁰⁷ Q 11

¹⁰⁸ Q 18

¹⁰⁹ NRD 27, and *a Review of the UK's Nuclear R&D Capability* op. cit.

¹¹⁰ NRD 27 and 05, 21, 28, 43

¹¹¹ Q 104

¹¹² Q 114

¹¹³ Q 115

69. In addition, the TSB provides funding for the NAMRC at Sheffield, established in 2010¹¹⁴ and dedicated to helping UK companies to drive down manufacturing costs and drive up reliability and durability of materials to compete in the market. The NAMRC will also be one of the seven partners of the first Technology Innovation Centre (TIC) focused on high value manufacturing¹¹⁵.
70. The NAMRC has been generally supported by both the academic community and industry¹¹⁶ and is showing early signs of success with “16–20 industrial partners”.¹¹⁷ It is built on a model of public/private partnership that has, according to Professor Andrew Sherry, Director of the Dalton Institute in Manchester, proven to work for other sectors such as the aerospace industry. But several witnesses stressed that it was early days and raised a number of issues in evidence which warrant further attention.¹¹⁸ For example, Mr Ric Parker, Director of Research and Technology at Rolls Royce, warned that the centre would not be “self-sustaining”, and would require further Government funding. He said that “a key element ... [of funding] was the Regional Development Agencies (RDAs) that brought capital investment to it”. However this element had now gone and the TSB does not have a capital investment mechanism.¹¹⁹ Mr Keith Parker of the NIA also commented on the withdrawal of funding from the RDAs, stating that “the public funding, which was small but welcome, has now pretty much dried up”.¹²⁰
71. Professor Sherry said that the centre was based on a powerful model but thought that it lacked “focus, investment and strategy to drive it forward”.¹²¹ Professor Keith Ridgeway, Director of NAMRC, agreed: “At the moment I do not feel we are part of a national strategy that will take us past 2020, 2025 and the next-generation new build. I think we need a focus and strategy going much longer term”.¹²² In our view, there is a clear need therefore for Government and industry and academia to come together to consider whether the current support mechanisms to develop the supply chain are adequate, and to look at the role of the NAMRC within the UK’s wider nuclear energy strategy. (We make a recommendation about this issue in paragraph 79 below.)

Developing new technologies

72. Rolls Royce and Professor Mike Fitzpatrick, Lloyd’s Register Educational Trust Chair in Materials Fabrication and Engineering at the Open University, acknowledged the need to develop the UK supply chain to support the new build programme and to allow UK businesses to benefit from the opportunities this would create. They were less optimistic however about the size of the export market for UK companies in the supply chain for

¹¹⁴ Q 116

¹¹⁵ NRD 27

¹¹⁶ NRD 08, 21, 27

¹¹⁷ Q 130

¹¹⁸ NRD 08, Q 131

¹¹⁹ Q 131

¹²⁰ Q 249

¹²¹ Q 50

¹²² Q 123

Generation III technologies.¹²³ In their view, one shared by others, the real opportunity would be “taking a lead now in the development of some of the technologies for future systems” so that the UK had an exportable technology in two, three or four decades time and could take advantage of the “£1.7 trillion of investment worldwide” in these technologies.¹²⁴

73. In order to build an industry with export potential, Rolls Royce said that it would “be necessary to ... produce products that contain new technology and intellectual property both in ... design and manufacture,” this could be achieved through either “a UK vendor of reactors [which the UK doesn’t have] or UK industrial involvement in the design stage of an international reactor”.¹²⁵ Professor Ridgeway of the NAMRC supported this view.¹²⁶
74. Mr Ric Parker of Rolls Royce told us that “there are two clear areas for the UK” to play a role in the development of these technologies: “the prime investment is in high-integrity manufacturing, monitoring and some of the technical and engineering support for these new facilities. Another great opportunity is ... small reactors, of the 200-, 300-megawatt size [which could] be a major earner for the UK.”¹²⁷ In his opinion, the UK has both the “strength” and the “intellectual horsepower” to generate some real intellectual property and therefore lock-in value for the UK from involvement in Generation IV reactor development, particularly given the UK’s strengths in the field of high temperature reactors.¹²⁸ The NIA said that “given the international dimension to the nuclear market there could also be significant benefits in international collaboration, not only in developing new Gen IV reactor designs ... but generally across the fuel cycle”. In their view, and others, “involvement in relevant programmes could provide useful opportunities for UK industry as the work translates from R&D to demonstration—which might be lost without UK participation”.¹²⁹
75. Developing materials for the supply chain is another overlapping area where the UK has strengths and which is relevant to future technologies. Professor Steven Cowley, Chief Executive Officer of the UK Atomic Energy Authority and Director of the Culham Centre for Fusion Research, told us: “If you look at the intellectual problems that are challenging for Generation IV, a lot of them lie in the materials areas, such as whether we can build materials that survive in that environment. Somebody will have to supply those materials—the specialised steels and so on—and the development of those materials will put somebody in a competitive advantage in the marketplace.”¹³⁰ Mr Allen of the TSB agreed. He also stressed that “there are other areas around condition monitoring of the power plant, again, where the UK has good niche markets and could become world exporters of this technology”.¹³¹ (We consider the issue of how the UK can exploit the commercial opportunities from such expertise further in paragraphs 76 to 80 below.)

¹²³ NRD 37, 44

¹²⁴ Q 52, Q 231, NRD 37, 44

¹²⁵ NRD 37

¹²⁶ Q 140

¹²⁷ Q 139

¹²⁸ Q 134

¹²⁹ NRD 28 and 07, 37

¹³⁰ Q 51

¹³¹ Q 134

Building a framework to promote commercial exploitation

76. At present, the TSB does not have a remit to fund work that is so far away from market. This means that there is a gap for applied long-term research within the current bodies that fund or conduct research (see Figures 3 and 4 on pages 19 and 20). Industry is also reluctant to provide funding without a clear steer from Government on long-term policy direction.¹³² According to Rolls Royce, as a result, the Government would have to “intervene” if they wanted to “create a strong and vibrant UK industry” because the “timescales and returns are so long there are clear market failures”.¹³³ In their view, and others, the Government need to decide whether they wish “UK industry to take a co-ordinated approach to developing this high technology, high value export market” and provide a signal to allow it to do so.¹³⁴ Mr Spence from EDF agreed: “... what the UK needs is a view about its role in an international system. ... We have some very specific areas of strength, and we should focus on playing our role in those”.¹³⁵
77. Mr Allen of the TSB suggested that the Government could play a much more constructive role if they “clearly articulat[ed] [their] future priorities, providing a framework that allows the funding agencies in particular to work with industry to ... join up the TRL levels from basic through to applied research”.¹³⁶ The TSB review argued that if the UK was going to capture a significant share of the nuclear energy market, the country had to invest in those areas of nuclear engineering where there was existing capability and experience and where it was perceived by the rest of the world to be strong. It also argued in favour of more collaborative working with other countries where the UK could make world class contributions to advanced reactor systems.¹³⁷ Mr Ric Parker of Rolls Royce also referred to the need for “UK industry to be able to actively participate in ... European programmes,” to exploit the commercial potential, and highlighted the need for some Government encouragement to do so.¹³⁸
78. When we asked the Secretary of State about the Government’s position on technology development, he said: “I agree with you that we need to do more on nuclear, but I am not convinced that on a 20 year view we can get into a position where we are going to be a world leader on nuclear ... on a longer-term outlook for low-carbon technologies I would not have seen a major investment in this area as being where we could hope to get the best possible return for the UK.”¹³⁹ Mr David Willetts MP, Minister for Universities and Science at the Department for Business, Innovation and Skills (BIS), on the other hand, recognised that there were “issues in the longer term about what kind of role we think Britain can play in the world nuclear market 20 years out”.¹⁴⁰ Whilst we agree with the Secretary of State that it may be unrealistic to expect the UK to become a world leader in the design of new large civil

¹³² NRD 27, Q 240

¹³³ Q 112

¹³⁴ Q 105, NRD 37, 27, 14, 50, 16

¹³⁵ Q 232

¹³⁶ Q 111

¹³⁷ *A review of the UK’s Nuclear R&D Capability*, op. cit.

¹³⁸ Q 118

¹³⁹ Q 451

¹⁴⁰ Q 365

nuclear reactors, we share the view expressed by the Minister for Universities and Science that there is a need for the Government to outline the role that the UK should be playing in the world nuclear market in the longer term. We do not believe that the Government have given sufficient consideration to how the UK's strengths could contribute to specific important developments in future nuclear technologies in collaboration with the lead developers of new reactor designs.

79. **Further to the recommendation in paragraph 63 above, the Government should set out in the proposed nuclear energy strategy how they intend to support the exploitation of the UK's strengths in the research base for the commercial benefit of the UK, and the role they envisage the UK playing in the global nuclear market over the period to 2050 and beyond. This should cover both the development of the supply chain for Generation III technologies and the UK's involvement in the development of new nuclear technologies in the future.**
80. We put forward our ideas for how such a strategic approach could be facilitated and how research efforts should be co-ordinated in paragraphs 131 to 143 below.

Energy Security

81. The Secretary of State defined energy security as not only “our ability to access imports of crucial physical supplies of energy ... [and] our ability to withstand serious shocks to the economy from price movements” but also as “a situation where we have an energy portfolio that is more balanced and less reliant on fossil fuels, given the potential shocks that can come from world fossil fuel markets”.¹⁴¹
82. In the UK, there has been a growing reliance on imports of fossil fuels as the UK's gas and oil production has declined. The UK was a net importer of electricity, coal, crude oil and gas in 2010.¹⁴² The UK's net import dependency has increased in recent years to almost 29%,¹⁴³ with fossil fuels accounting for the majority and imports of natural gas increasing by almost a third between 2009 and 2010.¹⁴⁴ This trend is projected to continue into the future¹⁴⁵. Mr Charles Hendry MP, Minister of State for Energy and Climate Change, said that the share of imports in the UK's overall energy portfolio was set to increase by around 60% over the next 10 years.¹⁴⁶
83. When we questioned the Secretary of State about how current energy policies would decrease our reliance on fossil fuels, he told us that they allow the market the flexibility to come forward with the most cost-effective solution “in a range of circumstances and be robust to a range of

¹⁴¹ Q 443

¹⁴² *Digest of UK Energy Statistics 2011*, DECC, p 12

¹⁴³ *Ibid*, p 16

¹⁴⁴ *Ibid*, p 1

¹⁴⁵ We recognise however that energy security is not reliant solely on the percentage of imports. It also relates to the diversity of the supply. See *UK Energy Supply: Security or independence?* House of Commons Energy and Climate Change Committee report op. cit.

¹⁴⁶ Speech on Sustainable Energy Security, 8 June 2010, <http://www.decc.gov.uk/en/content/cms/news/hendry8jun2010/hendry8jun2010.aspx>

circumstances”.¹⁴⁷ He went on: “the White Paper on electricity market reform ... [and the] feed-in tariffs for low carbon generation, which will involve a contract for difference ... [will mean that], if you are investing in renewables or in nuclear, you will know that you have a guaranteed price over the lifetime of the project and you can take that to your bank. ... you will therefore have the certainty necessary to go ahead and build projects that have a very high capital cost up front but a very low marginal cost.”¹⁴⁸

84. The CCC stated in its Fourth Carbon Budget report¹⁴⁹ that, as a supplier of reliable baseload¹⁵⁰ power, where the supply of fuel has a limited risk of interruption, nuclear can make a crucial contribution to a technically secure and diverse low-carbon power system. We therefore welcome this market certainty for low-carbon sources such as nuclear and renewables. We are concerned, however, by the illustration the Secretary of State provided to show how this would work in the longer-term. He offered two extreme scenarios: first, “a world of quite serious constraints on oil and gas supply, so fossil fuels will be increasingly hard and increasingly expensive to come by. In that context, we will be relying much more for our own electricity generation ... [from] non-fossil fuel generation, particularly nuclear and renewable”; and, secondly, “a world in which unconventional gas is available at a very much cheaper price ... You would have a lot more gas, obviously with carbon capture and storage, and correspondingly a lot less nuclear and renewable”.¹⁵¹ An example of the latter scenario would be if the Government allowed the extraction of shale gas reserves within the UK.
85. We find the Secretary of State’s argument unconvincing. We fail to see how leaving the market to respond with the most cost-effective option will improve the UK’s energy security in the longer-term and cause a move away from a reliance on fossil fuels if he foresees the possibility of a future where cheap fossil fuels could dominate. The latter scenario would not, in our view, encourage the uptake of more expensive but lower-carbon technologies such as renewables or nuclear which require long lead times to build. This is particularly concerning given that CCS would be required to make this option low-carbon and, as we have commented before, it has yet to be proven.
86. **The Government have made a commitment to improve the UK’s energy security by reducing reliance on fossil fuels. But in oral evidence the Secretary of State indicated that he could envisage a future in which fossil fuels will dominate. This apparent inconsistency causes us to question whether the current policy framework is sufficient to encourage more secure, low-carbon sources such as nuclear energy and renewables (see paragraphs 40 and 46 above).**

¹⁴⁷ Q 442

¹⁴⁸ Q 448

¹⁴⁹ *The Fourth Carbon Budget—Reducing emissions through the 2020s*, the CCC, 7 December 2010.

¹⁵⁰ The “baseload” refers to the amount of power that is required to meet minimum demands based on reasonable expectations of customer requirements.

¹⁵¹ Q 442

CHAPTER 5: ARE THE UK'S CURRENT R&D CAPABILITIES AND ASSOCIATED EXPERTISE SUFFICIENT TO KEEP THE NUCLEAR ENERGY OPTIONS OPEN?

87. In this chapter we consider what R&D capabilities and associated expertise we need, both now and in the future, to enable the UK to act as an intelligent customer and to meet the regulatory requirements for the safe and secure supply of nuclear energy. We look first at the needs of the existing fleet and the new build programme (representing 12–16 GW of capacity) out to 2050 and then consider the implications of an extended nuclear programme (representing up to 38 GW of capacity) over this period. In examining these issues, we have drawn on extensive work which has already been undertaken, including the ERP report, the EPSRC/STFC review, and reports by the NIA,¹⁵² NNL¹⁵³ and the Royal Academy of Engineering.¹⁵⁴

Meeting our current commitments: R&D capabilities and associated expertise to meet the needs of the existing fleet and a new build programme of 12–16 GW up to 2050 and beyond

88. The existing fleet and new build programme require long-term R&D capabilities and associated expertise to enable:
- the safe running of the current fleet and life extension options;
 - the safe operation of the new fleet for 60 years or more;
 - decommissioning and waste management of legacy and new build waste, including spent fuel;
 - continuation of the UK's reprocessing commitments up to 2018; and
 - implementation of the UK's geological disposal plans.
89. With regard to the existing fleet, the UK needs R&D capabilities and associated expertise to meet the challenges of ageing reactors and to assess how long they can be run safely and efficiently. Dame Sue Ion commented that, for a 12–16 GW nuclear fleet, “the R&D investment and scope is probably adequate at today's level”.¹⁵⁵ This view is supported by the ERP report, the EPSRC/STFC review and by the Government who told us that they were “satisfied that there are the right capabilities and infrastructure to deliver the objectives [to meet the UK's current and future needs for a safe and secure supply of nuclear energy]”.¹⁵⁶
90. The Chief Executive of the EPSRC, Professor David Delpy, supported this position: “The simple answer to your question is that I think that we have quite a well balanced portfolio of research funded by the research councils and other agencies. The overall capability for the UK at its current level of nuclear power is adequate ... I believe that since the Government announced the decision about further growth and investment in nuclear power, that investment has enabled us to provide the skilled manpower that we certainly

¹⁵² *Securing Investment in Nuclear in the Context of Low-Carbon Generation*, NIA and KPMG, 2010.

¹⁵³ *UK Nuclear Horizon: An independent assessment by the UK National Nuclear Laboratory*, NNL, March 2011

¹⁵⁴ *Generating the Future: UK Energy Systems fit for 2050*, Royal Academy of Engineering, 2010.

¹⁵⁵ NRD 29

¹⁵⁶ *Ibid.*

need in the initial stages. The rapid growth in the funding from us and the energy programme will enable the UK to meet its current demands”.¹⁵⁷ Professor Adrian Smith, Director General for Knowledge and Innovation at BIS, and the Minister for Universities and Science shared that view.¹⁵⁸

91. The ERP report, however, highlighted two important caveats to this assessment. The first relates to the age profile of the expert nuclear workforce (considered immediately below) and the second concerns the presence of gaps in the research base (considered in paragraphs 101 to 104 below).

An ageing workforce

92. The UK’s nuclear capability is vulnerable because it is dependent on an ageing workforce which is thinly spread with little depth in many areas due to a lack of investment in the last few decades (as discussed in paragraphs 10 to 35 above). NNL told us: “most of our experts are of the older age, so, 45 plus. In the next five years we will lose 93 of our staff ... Many of those are experts who could be classed as both national and international experts”.¹⁵⁹ This is perhaps the reason for Professor Delpy’s comment that the research base will be able to provide the skilled manpower only for the “initial stages” of the nuclear programme and not in the longer term. Dr Weightman also told us that the capabilities were only “sufficient for now” and that “when we look towards the future and look at our demographics, as a regulator, as an industry and perhaps as a nation, we need to have a basis for the future as well”. He went on: “we are living off our past capability; our reputation is built on some of our past capability, and our ability to operate internationally is built on that as well. We have people available who have international reputations, but they grew up in a system that had a wide research base.”¹⁶⁰ In terms of responding to international incidents and protecting citizens wherever they are in the world, he said: “we need the capability to understand the technologies around the world ... and the ability to develop world-class people for the future so that we can still look after our own facilities properly but also act as a world leader where we can”.¹⁶¹
93. Professor Laurence Williams, of the University of Central Lancashire and the Government Chief Nuclear Inspector from 1998 to 2005, also expressed concern about the UK’s ability to sustain its R&D capability and associated expertise in the longer term: “if we do not do something about it we will not have it available in 20 years’ time”;¹⁶² and the Government Chief Scientific Adviser (GCSA), Professor Sir John Beddington, agreed. He told us that “to deal with the Japanese disaster in Fukushima, I was calling on people who were very senior in their organisations, who had worked in the nuclear industry for a very substantial time”. He had “real concerns” that if some sort of problem like Fukushima occurred in Europe, the UK may not have “people with the experience of the industry” to contribute in the future.¹⁶³ Given that the nuclear sector is reliant on the research base, not only for

¹⁵⁷ Q 176

¹⁵⁸ QQ 177, 365

¹⁵⁹ Q 337

¹⁶⁰ Q 475

¹⁶¹ Q 476

¹⁶² QQ 413,414

¹⁶³ Q 90

research but also for training and the supply of a steady flow of graduates to join the workforce, and that it can take years to produce suitably qualified and experienced personnel (SQEP) in the field with industry experience, we find this particularly worrying (see paragraphs 118 to 130 below).

R&D Capability and associated expertise requirements specific to the new build plans

94. The reactor designs incorporated into the UK's current new build programme involve buying in mature technologies which have been demonstrated to be safe and secure. It is argued, therefore, by, for example, Westinghouse Electric Company, that the new reactors will not require significant basic R&D to allow them to be built and operated in the UK.¹⁶⁴ Other witnesses, however, argued that a significant number of R&D needs, linked to the safe operation of the reactors, remained. Professor Sherry, for example, said that “the building of the PWRs is just the beginning. ... [they] have to operate and be maintained for 60 years”,¹⁶⁵ and there was still a need for research to understand the effects of radiation on materials within the new reactor designs, over the length of their operation.¹⁶⁶ The Cambridge Nuclear Energy Centre referred to the R&D capabilities and associated expertise required to look at reducing costs, life extension, alternative fuel systems, passive systems development and more robust fuels.¹⁶⁷ Professor Andrew Taylor, Director of ISIS, the pulsed neutron and muon source at the Rutherford Appleton Laboratory in Oxfordshire, told us that such research would require more nuclear engineers in the UK: “This is not about understanding the nucleus; we understand that rather well. Doing engineering with nuclear materials is the area that we need to address”.¹⁶⁸
95. Professor Williams questioned also whether the UK had “got the research and development to understand the safety implications of new fuel designs, not only in terms of operation but in how they respond under fault conditions”. In his view, the UK needs the research capability “to undertake the monitoring—for example, of steel samples to understand how the steel in the reactors is changing in relation to extended use”.¹⁶⁹ Other witnesses also referred to gaps in R&D capabilities for health and safety research.¹⁷⁰ Dame Sue Ion, for example, said that the UK was “lacking in numbers in those with in depth expertise born of many years involvement in BWR systems and LWR systems more generally. What we have is concentrated in a relatively small number of individuals either already retired or at the upper end of their working careers.”¹⁷¹
96. According to Serco Energy, the current capabilities, although adequate, were at a minimum level:

“With current trends, the UK will just be able to procure and licence Generation III reactors intelligently. ... the current UK R&D capabilities

¹⁶⁴ NRD 32

¹⁶⁵ Q 53

¹⁶⁶ Q 53

¹⁶⁷ NRD 31

¹⁶⁸ Q 180

¹⁶⁹ Q 414

¹⁷⁰ NRD 18, 26

¹⁷¹ NRD 29

... have reduced significantly over the past few years. Many experienced staff have retired, or are reaching retirement ... The laboratories and test rigs have declined at least as rapidly and have not been effectively replaced by access to facilities in other countries”.¹⁷²

97. Mr Ric Parker from Rolls Royce and others felt that more needed to be done.¹⁷³ He told us that although recent efforts to increase R&D efforts were a big improvement on a few years ago—with a considerable increase in effort in the universities and in the UK generally—there were still some major gaps. He went on: “We do not want to get ourselves to a position where our skill base gets so low in the UK that we are totally reliant on China or India for our support and the safety of our reactors, going forward.”¹⁷⁴
98. The Government told us, however, that because nuclear is a mature technology and the UK does not have reactor vendors, they were not sponsoring research into Generation III technology.¹⁷⁵ It was, they said, for the operators and vendors to do the research necessary to prove it was safe to the satisfaction of the regulators and to improve it in whatever way they believe to be appropriate.¹⁷⁶ This seems to us to be indicative of a lack of understanding about why we need sufficient R&D capabilities and associated expertise in the UK. As Dame Sue Ion said, “the opinion that, because you are buying something that is already developed, you do not need to do any R&D at all” is flawed; “all the rest of the world ... is buying the self-same systems and yet they do not absent themselves from R&D on those systems. You require a nationally competent workforce ... and regulator”.¹⁷⁷ Professor Williams made a similar point: “You have to understand the technology that you are actually operating; you cannot just abdicate that to a third party ... You have to take responsibility. That means that, in the United Kingdom, the nuclear inspectors who will be available in 2050 probably have not even been born yet. We need to think about a sustainable system ... to ensure that we can produce well-trained, well-educated scientists and engineers and other disciplines to underpin this demanding technology”.¹⁷⁸ As Dame Sue Ion pointed out, this does not happen in a vacuum: “you get the skills base to service both the utilities and the vendors, ... and the regulators, by building the expertise and the skills pipeline and by having a sensible R&D programme that services today’s systems as well as tomorrow’s”.¹⁷⁹
99. **We do not believe that the UK has sufficient R&D capabilities and associated expertise to be able to cope with the current nuclear programme up to 2050, let alone a significantly extended programme. This is because the UK’s current R&D capability is, to a significant extent, based upon an ageing pool of experts built on past investments in R&D. This means that in a few years’ time, there will be crucial gaps in capabilities.**

¹⁷² NRD 22

¹⁷³ NRD 49, 44, 29, 59, Q 43

¹⁷⁴ Q 105

¹⁷⁵ Q 36

¹⁷⁶ Q 33

¹⁷⁷ Q 3

¹⁷⁸ Q 42

¹⁷⁹ Q 3

100. **A new stream of experts will need to be generated in the near future if the UK is to retain sufficient capabilities to be an intelligent customer and regulator in the future up to 2050. It takes years to develop a significant cadre of suitably trained experts with industry experience and the sector is reliant on the research base to train these experts. Sufficient investment in the research base will therefore be necessary in order to make up for the lack of investment in the last two decades.**
101. **The evidence we received demonstrates a significant difference of opinion between, on the one hand, the Secretary of State and some senior Government officials who appear to believe that no action is required to sustain the nuclear research base and, on the other hand, other stakeholders, including the GCSA and DECC CSA, who argue that serious action is required. The Government’s view that the need for R&D capabilities and associated expertise in the future will be met without Government intervention is troublingly complacent.** (We make recommendations about how to ensure that such R&D capabilities and associated expertise are maintained in the future in paragraphs 131 to 143 below.)

Additional gaps in research capabilities

Facilities for studying irradiated materials

102. Serco Energy suggested that international vendors planning to build nuclear plants in the UK would also require significant assistance from UK R&D facilities, not for fundamental design, but for detailed or site-specific investigations or to underpin the claims made in the safety cases¹⁸⁰ for these reactors.¹⁸¹ Professor Williams agreed that the UK needed “facilities not only to produce fuels that might be needed for extended use in reactors but also to have the ability to do ... post-irradiation examination ...”—unfortunately, “gradually over the years the United Kingdom’s facilities have declined”.¹⁸² (We make recommendations about filling this gap in capabilities in paragraphs 174 to 185 below.)

Legacy and existing systems waste

103. We also need R&D capabilities and associated expertise to enable us to deal with the large quantity of legacy waste generated from the existing fleet.¹⁸³ According to the NDA, “there are sufficient R&D capabilities in place from the NDA estate and other technology suppliers in the UK and internationally to ensure the current safe delivery of our mission”.¹⁸⁴ Professor MacKay agreed.¹⁸⁵ Some witnesses, however, suggested that there were gaps. Dame Sue Ion told us, for example, that: “significant additional work must be sponsored to underpin work to disposition the UK’s plutonium stocks, to pave the way for a geological repository and to develop waste forms and

¹⁸⁰ A “safety case” is a document that satisfies the regulator that the plant will operate as designed under normal and aberrant conditions.

¹⁸¹ NRD 22

¹⁸² QQ 413, 414

¹⁸³ NRD 22

¹⁸⁴ NRD 19, Q 263

¹⁸⁵ Q 92

processes to deal with the UK's historic legacy and existing systems".¹⁸⁶ Serco Energy, NNL and others shared this view, and stressed that significant geological research would be required for the disposal programme.¹⁸⁷

104. We put the discrepancy between the views of the research community and those of the Government to Professor William Lee, Deputy Chairman of the Committee on Radioactive Waste Management (CoRWM). He suggested that the Government's assessment was based on meeting their immediate needs and that, although R&D capabilities and associated expertise were adequate to meet the present requirements for the "treatment, packaging, storage and transport of radioactive waste" (save for the need for facilities to examine highly active radioactive materials (see paragraphs 167–178 below)), they were not adequate for the longer-term requirements of, for example, "geological disposal, both from the facilities perspective and ... from skills".¹⁸⁸ NNL also told us that longer-term R&D programmes were needed in the UK in order to maintain R&D capabilities and associated expertise in these areas.¹⁸⁹ (We discuss these issues further in paragraphs 186 to 191 below.)

Meeting the needs of an extended nuclear programme: R&D capabilities and associated expertise required for up to 38 GW of nuclear energy capacity up to 2050 and beyond

105. A 38 GW capacity is a higher but realistic nuclear future for the UK, where it is projected that nuclear energy could account for the supply of approximately 45–49% of the UK's electricity (see Box 2 on page 27). There was widespread agreement amongst our witnesses (and a view shared by the ERP report and the EPSRC/STFC review) that, regardless of the technologies deployed, a nuclear energy capacity of around 38 GW would require a significant increase in nuclear R&D capabilities and associated expertise in the future.¹⁹⁰
106. Both the RCUK review and the ERP report suggest that, if nuclear were to be a significantly higher component of the energy portfolio in the future, fuel recycling would have to be considered, alongside the likely deployment of Generation IV in the post 2040 era (as discussed in paragraphs 47 to 49 and Box 3 on page 28). This would, according to Dame Sue Ion, require "a rethink of the Government's policy of once-through and dispose" with the need for closed fuel cycles and "an R&D programme in advanced system development including recycling of nuclear fuel".¹⁹¹ This would be necessary for two reasons: first, the volume of waste produced from a once-through cycle would present substantial challenges to geological disposal; and, secondly, there would potentially be difficulties in accessing future supplies of uranium resources, given that a once-through cycle requires considerably higher quantities of fuel and the uncertainties surrounding the size of the global supplies of, and demand, for uranium in the future.¹⁹²

¹⁸⁶ NRD 29

¹⁸⁷ NRD 22, 07 and 47, 16, 17

¹⁸⁸ Q 273

¹⁸⁹ NRD 07

¹⁹⁰ Q 106, NRD 29, 30, 44 *Nuclear Fission* op. cit; *Progressing UK Energy research for a coherent structure with impact* op. cit.

¹⁹¹ NRD 29

¹⁹² NRD 29

107. However, many witnesses, including the Government, took the view that up to 2050, the majority of nuclear electricity supply, regardless of the quantity, is likely to be through Generation III nuclear plant rather than Generation IV (because of the relatively early stage of development of Generation IV technology) and that uranium would not be a limiting resource over this period (see paragraphs 47 to 49 and Box 3 on page 28). They argued therefore that R&D capabilities and associated expertise in advanced reactor systems and fuel recycling need not be a primary consideration up to the middle of the century.
108. We believe that this argument for not supporting R&D on Generation IV technologies or advanced fuel recycling is fundamentally flawed. First, regardless of the technology used, fuel recycling R&D capabilities and associated expertise for the higher capacity scenarios would still be required due to the sheer volume of fuel involved. For this reason, the ETI has recommended that the UK should focus R&D efforts not only on addressing the critical cost drivers of the manufacturing supply chain capacity for Generation III, but also on the uranium supply capacity and fuel processing to mitigate any issues that may affect the Generation III plant.¹⁹³ Secondly, within the next 30 to 40 years, the UK may start procuring Generation IV reactors as their use grows globally, irrespective of whether the UK is in the lead in the development of this technology. Given that this is a viable future option, albeit uncertain, it would be “prudent”, as Professor Fitzpatrick told us, to begin investing now in “the knowledge and skills base that will support the development, analysis, purchase and operation” of such reactors in the future.¹⁹⁴ Professor Williams also argued that:
- “the United Kingdom needs to be involved, not only to fashion and influence the various options for the different reactor designs that will potentially be available to us in 20 years’ time, but also to ensure that there is a strong understanding of safety and an increasing understanding of security as well [which] can have a significant impact on the design of a plant”.¹⁹⁵
109. The ONR and others also stressed the need for the UK to be involved in programmes developing future technologies to be able to understand and regulate such technologies in the future.¹⁹⁶ Dr Weightman told us “from a regulatory perspective, I would want to be able to keep knowledge and experience and keep my people up to speed with developing technologies, so that not only can we understand them but we can also influence them to ensure that safety is built in from the start”; he also said that this would be beneficial in terms of providing expert advice to the “60 new nations that want to get involved in nuclear power”¹⁹⁷ who came to the UK “for assistance in developing nuclear technologies and the nuclear regulatory approach”.¹⁹⁸
110. Furthermore, as Dr Adrian Simper, Director of Strategy and Technology at the NDA and others stated: “Generation IV ... supports the development of

¹⁹³ NRD 08

¹⁹⁴ NRD 44

¹⁹⁵ Q 410

¹⁹⁶ NRD 11, 47

¹⁹⁷ Q 485

¹⁹⁸ Q 487

experience and expertise that will better support ... the proposed new build fleet”.¹⁹⁹ The EPSRC/STFC review suggested also that the best way to maintain teaching capacity was to continue to support research and development in universities in cutting-edge areas such as Generation IV technology and advanced fuel cycles.²⁰⁰

111. However, the Government told us that, given that the preferred option is to buy in the technology from outside, the UK was, in their view, sufficiently involved in Generation IV activities through the Euratom Programme and the research councils. Mark Higson, Chief Executive of the OND at DECC, said: “the Government is sensibly positioned ... to continue to take a view about whether and in what timeframe these technologies are likely to become deployable”; in his view, “if Generation IV was required to build a very large nuclear programme ... there would be time for that to be phased in ... there is a stage when it is important to keep a watching brief on technologies. I think there is another stage when it is important to make more significant investments if you want to get commercial advantage”.²⁰¹
112. But this misses the point. It takes years to build these capabilities and Mr Higson’s answer fails to address the concern that the Government should be involved in Generation IV R&D now if they are to be able to act as an intelligent customer and regulator in the future. Serco Energy expressed this concern in the following way:

“Generation IV technologies generally push the physics and engineering conditions of existing plant to higher levels, [in that] Generation IV designs generally have higher temperatures, higher pressures, more corrosive environments, and generally more materials challenges than exist in today’s plants. Currently, the UK has minimal participation in these developments and so will have no expertise in them when it comes to adoption of the designs. With the current position of little engagement, the UK would be in the position of being an unintelligent customer and an uninformed regulator and a large amount of R&D would be required to endorse the technology.”²⁰²

113. Although, in recent years, the research councils have increased their funding for R&D and associated expertise relevant to Generation IV, Dame Sue Ion and others felt that “Government attention to these issues has been, and continues to be, woefully inadequate”. She went on: “the Government [have] ... completely absented [themselves] from any responsibility and left it all to the market as far as next generation technologies are concerned, terminating any meaningful R&D investment in reactor systems and associated fuel cycles pre-2004”.²⁰³
114. Professor MacKay appeared to have a more considered and far-sighted view than that of the Government:
- “I think there is widespread agreement around Europe and the world that, to keep options open, energy research should always adopt a considerably wider approach than the energy policy of any particular

¹⁹⁹ NRD 43

²⁰⁰ *The EPSRC/STFC Review of Nuclear Physics and Nuclear Engineering, op. cit.* p14.

²⁰¹ Q 33

²⁰² NRD 22

²⁰³ NRD 29

day. Even if UK nuclear power were to be provided by Generation II and III reactors only for the next 40 years, there is still a case for supporting Generation IV research because it is a very good way to spin out other benefits. It is a way to develop and retain experts and educators who can serve the role of advisers and inspectors and who have expertise in other countries' reactors, so that when accidents occur in other countries we can give good advice to the Foreign Office. All of those roles: educators, advisers, inspectors and teachers, are needed by a Generation III programme today, so I think there are compelling arguments for involvement in advanced research along the lines of the Generation IV programme.”²⁰⁴

115. We welcome Professor MacKay's comments and share the view that, if the UK is to keep the option of an increased nuclear energy capacity open in the future, the UK must be more actively involved in Generation IV R&D to gain “a seat at the table”. This will enable the UK to act as intelligent customer and regulator, and also to contribute to the training and maintenance of the research base needed for both Generation III and IV reactor technologies. (We consider ways of improving the UK's involvement in Generation IV research in Chapter 6, paragraphs 163 to 173 below).

Fuel recycling and reprocessing

116. Not only will fuel recycling and reprocessing R&D capabilities and associated expertise be required in relation to Generation III and IV technologies, they will also be needed to deal with the UK's plutonium stockpile should the Government decide to reuse it, in the future, for example, as MOX fuel in a conventional LWR or as metallic fuel in a fast reactor (which also uses plutonium as the fuel and so provides an alternative to a new MOX plant).²⁰⁵ Dame Sue Ion and others warned however that, although the UK was seen as having “internationally competitive resources in reprocessing and advanced recycling technologies”,²⁰⁶ they were at risk of being lost in the near future. Professor Graham Fairhall of NNL agreed: “In terms of the capabilities, we are particularly vulnerable in the back-end of the fuel cycle, the reprocessing side, as we go forward”.²⁰⁷ Given that the UK may stop reprocessing in the near future, he went on, “if we do not rejoin Generation IV programmes or do not get involved in advanced fuel cycle work, then my belief is we will start to lose our reprocessing technical capability completely”.²⁰⁸ Professor MacKay also took the view that current levels of research in this area were not adequate to keep the option of reprocessing open for the future.²⁰⁹ He suggested that participation in Generation IV programmes or in advanced fuel cycle research would help to maintain capabilities in reprocessing.²¹⁰ The ONR told us that the Government will need to engage with “international partners with research expertise” in order to strengthen UK capability in this area if they do decide to continue reprocessing at some stage in the future.²¹¹

²⁰⁴ Q 79

²⁰⁵ NRD 14, 16, 19, 30

²⁰⁶ NRD 29 and 13, 05

²⁰⁷ Q 320

²⁰⁸ Q 336

²⁰⁹ QQ 92, 94, 95

²¹⁰ QQ 92, 94, 95

²¹¹ NRD 11

117. We find it astonishing that there are currently no plans to maintain the UK's fuel recycling and reprocessing R&D capabilities and associated expertise, given that they will be required in most future scenarios up to 2050 and beyond. (We address this issue in paragraphs 141 to 143. Who should be responsible for maintaining such capabilities is considered further in Chapter 7, paragraphs 209 to 220).

Skills provision

118. The research base not only provides knowledge for the nuclear industry and regulator but also provides training and skilled people to work in these areas. The sector is reliant on the research base mainly for the production of graduates and postgraduates from Masters and PhD courses. EDF Energy told us that “the industry ... has a continuing need for a number of people with the specialist technical skills needed to support the industry and traditionally many of these specialists have been recruited from universities offering postgraduate research where these critical nuclear skills are maintained and developed”.²¹² Whilst we have not considered the skills needs of the sector comprehensively, a number of issues were raised during the inquiry which we believe warrant further attention.
119. In a report entitled *Next Generation—Skills for New Build Nuclear* (March 2011) (“the Cogent report”), Cogent, the UK's industry skills body for nuclear and other businesses set out the workforce needs of the nuclear sector to 2025 on the basis of 16 GW of new build capacity. Because of the ageing profile of the current workforce, in particular the highly skilled and more experienced parts of the workforce (where 70% will retire by 2025), Cogent estimate that the nuclear industry will require in the order of 1,000 new graduates a year up to 2025 (including Science Technology Engineering and Maths (STEM) graduates and others).²¹³ They also identified capacity issues with regard to the supply of apprentices, scientists and engineers, including a shortage of STEM graduates and apprentices being attracted to, and retained by, the industry. When we asked why this workforce could not be sourced from other countries, Mr Ric Parker from Rolls Royce told us that, given the current global nuclear renaissance, the global competition for this workforce was fierce—the company AREVA, were, for example, looking for 1,600 new engineers—“if we are not careful, the pot in the UK will be drained”.²¹⁴
120. The EPSRC/STFC review looked at the requirements for an increase to 30 GW capacity by 2030. Under this scenario, they anticipated that the requirement for skilled, knowledgeable personnel across the whole spectrum of top-end skills in the civil nuclear industry would increase markedly, requiring a great deal more nuclear engineering R&D and more courses in nuclear science and technology at undergraduate and postgraduate level. Professor Williams has also conducted some analysis of the future needs of the regulator (see paragraph 128). We found, however, that apart from this work, little has been done to assess requirements for a skilled workforce up to

²¹² NRD 49

²¹³ *Next Generation—Skills for New Build Nuclear*, Renaissance Nuclear Skills Series: 2, Cogent, March 2011 (“The Cogent report”).

²¹⁴ Q 109

2050 in the event of a significantly increased nuclear contribution to the energy portfolio or to meet the current requirements beyond 2025.

Graduates

121. When we asked Professor Delpy of the EPSRC whether the research base could provide the graduates required by the nuclear sector in the future, he commented: “I do not think that you can separate the question of the supply of scientists and engineers trained in the nuclear area from the general question of the supply of STEM graduates. The energy industries in general require a range of STEM skills, and probably only a small percentage of their need is people specifically trained in some of the specialities of nuclear energy”.²¹⁵ In his view, there was not a sufficient number of STEM graduates coming in overall “who would want to go into that area as opposed to many of the other growth areas in energy, including the renewables, such as offshore wind and marine”.²¹⁶ Science and engineering graduates are increasing in number according to Higher Education Statistics Agency figures, but they are sought after in the economy generally and engineering graduates in particular are in shorter supply.²¹⁷
122. In addition to the need to encourage uptake of STEM subjects at A-level and degree level, the EPSRC/STFC review argued that there was also a need for “a significant uplift in training provision at a number of levels to support the new build programme including graduates having gained an appreciation of nuclear issues relevant to their mainstream science and engineering degree”.²¹⁸ The Cogent report recommends that, in order to help resolve the supply issue, industry and the Government should expand support for foundation degree courses in nuclear topics (which will then provide a route into higher degree courses).²¹⁹ We were pleased to hear therefore that increased funding has been provided for such courses to-date and would urge the Government to accelerate work with industry and academia to increase this support in line with the needs of the sector in the future.

Postgraduates

123. The EPSRC/STFC review also noted a need for more training provision at Masters and doctoral levels, recommending that the funding councils should work collaboratively to ensure an adequate supply of relevant Masters and PhD programmes. Professor Delpy thought that the current supply of postgraduates was “adequate ... but ... not generous”.²²⁰ The EPSRC has funded a number of doctoral programmes in recent years in anticipation of the new build programme,²²¹ including a joint Doctoral Training Centre at the Universities of Manchester and Sheffield, considered to provide an exemplar internationally. Professor Neil Hyatt, Royal Academy of Engineering and NDA Research Chair in Radioactive Waste Management at

²¹⁵ Q 178

²¹⁶ Q 190

²¹⁷ *Current and future demand for skills in the science based industries: UK Sector Skills Assessment 2011*, Cogent, 2011

²¹⁸ *Progressing UK Energy research for a coherent structure with impact*, *op. cit.*

²¹⁹ *Next Generation—Skills for New Build Nuclear* *op. cit.*

²²⁰ Q 178

²²¹ NRD 33, 38, 44

- the University of Sheffield, felt, however, that more could be done and that consideration should be given to expanding this capability.²²² Others shared this view.²²³
124. When we asked Professor Delpy whether the current research base could meet the demands of a 30 GW fleet, he replied that “the number of training courses that we have currently [for a supply of skilled nuclear engineers, with a smaller number of physicists] would probably not be able to meet that requirement. However, one can switch that on relatively quickly—it requires a four-year or five-year lead time”.²²⁴
125. We question Professor Delpy’s optimism: if the Government are not giving sufficient attention to maintaining the R&D capabilities and associated expertise required in the future, we will not have the international experts in the research base to teach these courses and may not therefore be able to acquire these experts as quickly as suggested. We have been struck by the lack of attention that seems to have been given to this issue by Cogent and others, compared to the need for graduates at first degree level. No assessment appears to have been made of the overall number of Masters or PhD students currently studying nuclear engineering subjects or of the number required to support either the current new build plans or an extended programme up to 2050.²²⁵ This is particularly worrying given that, according to the Institute of Physics, there is currently a lack of funding for MSc courses in nuclear technology (physics and engineering) due to the withdrawal of funding following the spending review,²²⁶ a concern also raised in the EPSRC/STFC review.
126. According to Professor Williams, “there is need for a more detailed analysis of the skills needed to deliver effective nuclear safety, nuclear security and nuclear safeguards” which “should include the needs of all organisations including, Government departments, the nuclear licensees for all parts of the nuclear fuel cycle, the Civil Nuclear Constabulary, the supply chain and the nuclear regulators”.²²⁷ We understand that Cogent is now conducting further work to understand the skills needs of the sector and we look forward to the outcome of their work.
127. As part of their ongoing work, **we recommend that Cogent should conduct a comprehensive assessment of the current provision of undergraduate, Masters and PhD courses relevant to the nuclear sector to determine whether they are sufficient to meet the future needs of the research community, the regulator and industry for both the current plans for new build and an extended programme up to 2050.**

Regulatory needs

128. Building on the Cogent findings, Professor Williams looked at the nuclear safety and security skills needs for the current new build plans for the

²²² NRD 48

²²³ NRD 24, 32, 39

²²⁴ Q 190

²²⁵ *Progressing UK Energy research for a coherent structure with impact, op. cit*

²²⁶ NRD 38

²²⁷ NRD 62

regulator and provided figures for the skills needs up to 2050.²²⁸ Professor Williams' assessment was that, to meet the regulator's needs, an estimated 60 additional graduate-level regulatory staff would be required up to 2050 in addition to the current 280 staff. He estimated that the demand for regulators would increase by an additional 70 to 210 graduate-level staff²²⁹ up to 2050 for a significantly increased nuclear programme. Dr Weightman suggested that these figures underestimated demand and that the ONR "have had for a long time a problem with recruiting nuclear inspectors".²³⁰ Given that the regulator needed world-class people to provide challenge to industry, recruitment was mainly from industry or senior academics, not at the graduate level.²³¹ In effect therefore the regulator is reliant on a healthy research base within industry and academia to train up a sufficient number of graduates to be the senior level inspectors for the future.

129. Since May 2008, the ONR have recruited 95 nuclear safety inspectors, increasing the total from 158 to 228, having lost 20 people to retirement. In the immediate future, the ONR has 77 vacancies to fill to meet the needs of the new build programme.²³² Highlighting the problem of the ageing workforce (see paragraphs 92 to 101 above), Dr Weightman observed that over 50% of the ONR's "higher level, superintending inspectors and principal inspectors, are aged 57 or over".²³³
130. The ONR's ability to recruit the additional expert staff to-date has been the result of interim arrangements on pay, which, Dr Weightman told us, "[would] stop this coming autumn".²³⁴ There is a risk therefore that ONR may lose ground again, although the ONR reassured us that: "it was always the intention to seek continuation of special reward arrangements for nuclear specialists, if there was a business need, beyond this autumn. These are now under active consideration and it is hoped that a helpful agreement can be arrived at shortly".²³⁵ Dr Weightman said that to allow the ONR the "flexibility" to pay their inspectors the going rate, to compete in the global market in the longer term, the ONR "need to get into a position that the Government have decided on" to convert the organisation to "a totally independent ... statutory corporation".²³⁶ At present, DECC are planning to convert the ONR to an independent statutory corporation, through primary legislation to be introduced into Parliament for consideration in 2012. We return to this issue in paragraph 199 below.

²²⁸ Ibid.

²²⁹ From today's levels.

²³⁰ Q 477

²³¹ Q 484

²³² Q 477

²³³ Ibid.

²³⁴ Ibid.

²³⁵ NRD 69

²³⁶ Q 465

CHAPTER 6: KEEPING THE NUCLEAR ENERGY OPTIONS OPEN

How to maintain R&D capabilities and associated expertise to keep the options for different nuclear futures open

131. In this chapter we consider what action needs to be taken to ensure that the UK's R&D capabilities and associated expertise are sufficient to enable a range of nuclear options to be kept open for the future.

R&D Programmes and Roadmaps

The need for a national R&D roadmap

132. Several witnesses, including Dame Sue Ion, argued that a national programme of research was necessary—regardless of what the future may be—in order to “attract bright young people” into the field.²³⁷ Professor Cowley expressed a similar view. He told us (in response to Mr Higson's comments quoted in paragraph 111), the Government's position to maintain a “watching brief” on Generation IV research was not adequate as “no bright young person is going to want to watch”.²³⁸ Without a meaningful programme now, according to Dame Sue Ion, the “internationally recognisable experts borne of the history of the 1970s, 1980s and 1990s” will not be around to guide and inform that programme and to mentor the young people who join the sector.²³⁹
133. In terms of the research base, the international energy research review conducted by the EPSRC²⁴⁰ warned that, without a focused strategic R&D agenda in nuclear fission, there was a distinct possibility that the “human products” of these schemes will seek work abroad where there are more opportunities, given that, as Professor Joyce, Head of Engineering at Lancaster University, told us, at present there are “very few career opportunities [or clear career paths] for post-docs to pursue an academic career in nuclear energy research”.²⁴¹
134. When we asked whether the current R&D programmes were adequate to provide such a draw, Professor Fitzpatrick of the Open University, said: “the programmes of research that have been initiated in the last seven years have been welcome and necessary but there needs to be urgent recognition that the research base needs to be broadened and deepened to provide a sustainable R&D base as well as a supply of skilled engineers and scientists to a growing high-technology industry”.²⁴² This view was supported by Dr Simper of the NDA, and others who said that it was vital that R&D should be carried out into “all aspects of the nuclear fuel cycle from reactor design, enrichment, fuel fabrication, spent fuel management and waste management,

²³⁷ Q 53 and 64, NRD 07, 16, 18, 19, 23, 32, 37, 39, 45, 51

²³⁸ Q 64

²³⁹ Q 65

²⁴⁰ *Report of the International Panel for the 2010 RCUK Review of Energy*, op. cit.

²⁴¹ NRD 39

²⁴² NRD 44

... [to] generate ... national expertise and experience [to allow] us to refresh our regulatory abilities”.²⁴³

135. A large number of organisations fund or conduct nuclear R&D, each with their individual remits and each with an R&D programme to meet their individual needs. But, although the GCSA, Professor Sir John Beddington, acknowledged that the NDA were “doing some excellent work” and “the research councils have increased their spend substantially on nuclear fission”, he said that he did not “feel comfortable that [this activity was] all joined up in an overall policy to take it forward and actually meet our R&D needs”.²⁴⁴ Several witnesses, for example Professor Joyce, suggested that there was currently “insufficient co-ordination and no one single body” responsible for the “oversight” of R&D capabilities and associated expertise which is evident from the significant gaps in research capabilities that we identified in key areas (see paragraphs 76 and 102 to 117).²⁴⁵ Dr Weightman agreed that there was a need to take a more “co-ordinated approach” and “strategic view” and said that there was “a wider issue about applied research, more long-term strategic research and the need to underpin the UK’s capability”;²⁴⁶ there was also a need for “everybody to co-operate and contribute, and not to leave it to some other body”.²⁴⁷ Others also commented that current R&D programmes were primarily focused on requirements relating to existing plant or on short-term commercial interests, with little attention being given to longer-term research or translational research necessary to underpin the UK’s future energy needs.²⁴⁸
136. As a result, witnesses were almost unanimous in their support for a Government-led, long-term national R&D roadmap to improve co-ordination, set national priorities, fill gaps in research and attract the brightest and best into the sector—with the overall aim of maintaining necessary R&D capabilities and associated expertise.²⁴⁹ It was also suggested by Mr Allen of the TSB that encouraging private sector investment in longer-term nuclear R&D required such a roadmap from the Government to “clearly articulate its future priorities, providing a framework that allows the funding agencies in particular to work with industry to actually join up the TRL[s] [Technology Readiness Levels]... from basic through to applied research”.²⁵⁰ This was necessary because “at present, academia and industry are uncertain about the future of nuclear research funding and so are somewhat unwilling to commit to long term plans that are needed to develop products and services for Gen III and Gen IV technologies”.²⁵¹ EDF Energy confirmed that they would “support a UK R&D strategy [or roadmap] that was based on developing long term R&D collaborations that offered economic and strategic benefits ... to its activities throughout the EDF Group”.²⁵² The call for a nuclear R&D roadmap is not unique to this report,

²⁴³ NRD 43

²⁴⁴ Q 74

²⁴⁵ NRD 39 and 05, 07, 09, 14, 16, 18, 19, 23, 27, 30, 32, 36, 37, 38, 39, 40, 43, 44, 45, 50, 51

²⁴⁶ Q 490

²⁴⁷ Q 491

²⁴⁸ NRD 04, 05, 14, 23, 24, 28, 30, 39, 40

²⁴⁹ NRD 07, 16, 18, 19, 23, 27, 32, 39, 45, 51

²⁵⁰ Q 111

²⁵¹ NRD 27

²⁵² NRD 49

organisations including the TSB,²⁵³ NNL,²⁵⁴ Rolls Royce,²⁵⁵ the Royal Society²⁵⁶ and the ERP²⁵⁷ have all called for a roadmap. Despite this, the Government have not, so far, taken any action.

Government response to the call for a national roadmap

137. To provide some direction and to encourage the Government to come forward with such a roadmap, NNL and others are developing their own roadmap (following the ERP report), looking at the implications of a 12 GW and 38 GW future for R&D over the period to 2050. The Government said that they welcomed this work but that it would be “premature to comment further on specific requirements when [it] is still to be completed”.²⁵⁸ Whilst we understand the Government’s response, we see no reason why they cannot commit to the need for a Government-led R&D roadmap in principle.
138. We asked the Secretary of State for Energy and Climate Change, about this issue. He acknowledged that “embarking on a new generation of nuclear reactors ... will involve real commitment on research and development” and a need for “a considerable programme of replenishing our human skills as well as our R&D skills if this is to go forward”.²⁵⁹ He appeared not, however, to recognise that this would require a Government-led R&D roadmap.²⁶⁰

Developing a national roadmap

139. Many witnesses, such as Mr Spence from EDF Energy, suggested that DECC should lead the development of a roadmap, through either the OND or the Low Carbon Innovation Group.²⁶¹ Many others, including AMEC, thought that NNL was well placed to provide the necessary strategic oversight and co-ordination for Government.²⁶² Mr Ric Parker from Rolls Royce and other industry representatives emphasised the importance of including industry in the process,²⁶³ referring to successful roadmapping exercises such as the “the Aerospace Innovation and Growth Team, which ... came out with a strong roadmap and strategy for UK research in aerospace” and the Space Innovation and Growth Team which “gave a clear steer to Government and industry of what was needed and generated considerable interest in Government”.²⁶⁴ EDF Energy suggested that:

“a next step would be for the Government to bring together the key organisations who can help them determine and then implement a UK nuclear R&D strategy as part of the infrastructure necessary to support

²⁵³ NRD 27

²⁵⁴ NRD 07

²⁵⁵ NRD 37

²⁵⁶ *Fuel cycle stewardship in a nuclear renaissance*, op. cit.

²⁵⁷ *Nuclear Fission*, op. cit.

²⁵⁸ NRD 21

²⁵⁹ Q 450

²⁶⁰ Q 454

²⁶¹ QQ 111, 141, 246, 287

²⁶² NRD 05,27, 23, 30, 28, 07,30

²⁶³ QQ 129, 242

²⁶⁴ QQ 121, 142

its role in delivering a low carbon future and to enable the UK to exploit this significant area of national competence”.²⁶⁵

140. Mr Ric Parker from Rolls Royce suggested further that a joint industry and government body should be set up for nuclear “so that we get a common understanding between industry, Government and the universities ... of exactly what is needed, by when and what the role for the UK is going to be in that”.²⁶⁶ He went on to suggest that industry and the Government “have to study the options together” to “jointly arrive at the route map, at a clear statement of the needs of the UK and a clear understanding of the possibilities for growth in this area”.²⁶⁷
141. If the Government intend to keep options for nuclear energy open for the future, this is unlikely to be achieved if the present haphazard arrangement for the support of nuclear training and research continues. A number of different organisations include some aspects of nuclear research within their responsibilities. But which elements they support is determined by their own criteria and judged against other (in some cases non-nuclear) priorities. There is no individual or group charged with the responsibility for ensuring that the UK has a coherent programme that meets national needs. We are in no doubt therefore that there is a need for a long-term national nuclear R&D roadmap to:
- improve co-ordination of R&D and associated expertise and ensure that research on strategically important and vulnerable areas, such as Generation IV technologies and advanced fuel recycling and reprocessing, is covered within a national R&D nuclear programme;
 - ensure that the UK maintains a healthy research base to attract people into the field to maintain capabilities for the future;
 - provide clarity and attract potential international collaborators (this issue is discussed further in paragraphs 155 to 162 below); and
 - provide industry with sufficient clarity to encourage them to invest in R&D and associated expertise in the UK.
142. **We recommend that, as part of its long-term nuclear energy strategy, DECC should lead the development and implementation of a long-term R&D roadmap in collaboration with industry, academia, NNL and the Culham Centre for Fusion Energy (CCFE) to ensure that the UK has adequate R&D capabilities and the associated expertise to keep a range of nuclear energy options open up to 2050 and beyond.**
143. **We recommend further that the Government should establish a body (which we suggest may be called the Nuclear R&D Board: “the Board”) with both advisory and executive functions.**

(a) Composition

The Board should be made up of experts drawn from the Government, industry and academia. It should have an independent, expert, authoritative chairman who commands the respect of the

²⁶⁵ NRD 49

²⁶⁶ Q 142

²⁶⁷ Ibid.

public and industry, and members which include non-executive members. The members should be appointed through the Appointments Commission.

(b) Status

The Board should, at the earliest opportunity, be established as a statutory Non-Departmental Public Body accountable to the Secretary of State for Energy and Climate Change. Pending the legislation needed to bring this recommendation into effect, the Government should, as an interim measure and without delay, establish the Board as an Executive Agency within DECC.

(c) Purpose

The purpose of the Board would be to:

- advise DECC on the development and implementation of the nuclear R&D roadmap and the Government's nuclear energy strategy;**
- monitor, and report on, progress by DECC with regard to the development and implementation of the roadmap and the strategy;**
- advise the Government, industry and academia on involving UK researchers in national and international collaborations and, where appropriate, facilitating such involvement;**
- examine what mechanisms are needed to signal to the international research community that the UK is a credible and willing partner for international collaborations;**
- maintain a strategic overview of nuclear R&D (including research facilities) and related training, and where appropriate, facilitate the co-ordination of activities within the research community;**
- establish a clear link between fundamental and applied research through to commercial exploitation for the benefit of the UK;**
- identify R&D areas of strategic importance that are either missing or vulnerable and, where necessary, commission research to complement the current R&D activities; and**
- facilitate public engagement activities on the use of nuclear technologies.**

(d) Reporting

The Board should report annually to the Secretary of State on its assessment of DECC's progress with regard to the development and implementation of the roadmap and the strategy, and other activities. The Secretary of State should be required to lay the Board's annual report before Parliament.

(e) Funding

The Board should be given a modest amount of new funding (not drawn from BIS's science and research budget) to carry out its activities. It should also have the power to attract money from

industry and elsewhere. (We consider sources for this funding in paragraphs 144 to 153 below.)

Funding for Research

144. Many witnesses, for example Professor Fitzpatrick, suggested that, given the importance of nuclear fission to the short- and medium-term generation of energy in the UK, the level of funding provided for nuclear fission research (£6.5m a year from the research councils and £4.5m from Euratom) was low compared with other areas of research on energy (such as nuclear fusion which receives £94m a year (£34m from UK funding and £60m from Euratom)²⁶⁸ and compared with other OECD countries (see paragraph 34). For example, the UK's spend on nuclear fission of around 4 % of the total energy research budget is considerably lower than the US which spends around 7% or, at the higher end, France at almost 50%.²⁶⁹ Professor Howarth from NNL commented that:
- “At the moment, compared with other nations we are outgunned by a factor of 10 in terms of our investment in fission nuclear by Germany, Italy, Belgium, Canada, the Czech Republic, Holland, Norway—which does not even have a civil nuclear programme—Sweden and Switzerland. I will not even give you the figures for Japan, South Korea, China, America and France. It is orders of magnitude.”²⁷⁰
145. Dame Sue Ion also told us that, at present, the only UK public funding mechanisms for nuclear fission research were “coming from the research councils or the NDA [£11m a year on decommissioning and waste research]”; and that the “actual monies deployed on advanced nuclear systems and the fuel cycles that go with them are in the single millions” with “no remit in next-generation systems or in sustaining advanced fuel cycle technology for a reprocessing mission”. She noted that NNL received no funding from Government for such work²⁷¹ and that “other countries [were] not trimming back their investment in advanced system and fuel cycle R&D”; in fact, she said, they were doing “quite the reverse”.²⁷²
146. The Dalton Institute said that the “UK is fairly exceptional amongst nuclear countries in no longer having a directly funded nuclear research programme”.²⁷³ The Cambridge Nuclear Energy Centre pointed out also that “other countries are providing increased funds for nuclear R&D,” for example, the US had recently added \$120million a year to their programme and France recently announced an additional €1billion for new demonstrators for advanced reactors.²⁷⁴
147. Representatives of industry suggested that the Government should be providing public funding for nuclear research on advanced systems, beyond that provided by the research councils, in order—according to Mr Keith Parker of the NIA—to “give credibility to the UK's position within ...

²⁶⁸ NRD 44, 33, 61; Q 54

²⁶⁹ NRD 43

²⁷⁰ Q 341

²⁷¹ Q 55

²⁷² NRD 29

²⁷³ NRD 09

²⁷⁴ NRD 31

international fora, ... as well as evidence of a government commitment to the work that is going on internationally”.²⁷⁵ As Professor Sir Adrian Smith of BIS pointed out: “in this particular arena and given the international dimension, the scale of the investments is in a different place from the kind of conversations that we were having about moving stuff around between the TSB and the research councils ... the scale of the investment here is of a different order”.²⁷⁶

148. We are not however talking about a return to the £100s of millions spent on nuclear fission research in the past or about diverting funds from other areas of research within BIS’s science and research budget. We are talking about a modest investment of the order of £10s of millions from other sources. NNL estimate that, based upon previous involvement when the UK was actively involved in Generation IV programmes, a modest investment “of the order of between £10 million and £20 million a year” would be enough for the UK to participate meaningfully in international research activities. Rolls Royce also thought that the spend required would be in the £10s of millions stating that an R&D roadmap that encouraged the exploitation of the UK’s strengths in R&D would “require significant investment (likely value in the £10s M/yr).”²⁷⁷ However, the detail of this investment was not provided.
149. Given the expenditure outlined in this report to support the commissioning of the Phase 3 laboratory at Sellafield (£20 million), and for a programme of research in Generation IV technologies to take part in international collaborations (£10–20 million a year), as well as other research activities required (outlined in paragraphs 102 to 117, and 163 to 205), we estimate that an investment in the region of £20–50 million a year would be sufficient. In Rolls Royce’s opinion, “failure to invest leaves UK industry as a poorly placed commodity supplier in a competitive international market place”.²⁷⁸ The TSB review also concluded that in order for the UK to maintain its nuclear industry heritage and status, as well as benefit from the global nuclear renaissance, public sector investment in R&D and technology development was essential and justified.²⁷⁹
150. When questioned about the level of funding for nuclear research, the Secretary of State said, referring to the CSR: “we have had to have an eye-watering settlement overall and every single penny that is spent on one thing has had to come off something else”.²⁸⁰ A proposal to spend more on nuclear fission R&D capabilities and associated expertise would have to be off-set with “suggestions for spending less on something else”. We recognise that the current climate of financial stringency has meant that some tough decisions have had to be made about the balance of funding for research. This does not however obviate the need to ensure that the Government’s declared policies are underpinned by the required R&D capabilities and associated expertise to deliver them. If the Government really are committed to meeting greenhouse gas emissions reduction targets and to the current new build programme for nuclear, they need to ensure that these plans are

²⁷⁵ QQ 234 and 236

²⁷⁶ Q 243

²⁷⁷ NRD 37

²⁷⁸ NRD 37

²⁷⁹ NRD 27

²⁸⁰ Q 456

backed up with sufficient funding to maintain R&D capabilities and associated expertise in the UK, as other countries have done.

151. Professor Fairhall argued also that, if the Government wanted the UK to benefit commercially from nuclear R&D, they needed to be involved in international research programmes and to put forward funding to encourage industry to do the same: “Without the ability to get involved in those programmes up front, we will sit here and watch the rest of Europe and other parts of the world do this ... For every other country that is involved in these types of programmes, the Government have a remit to fund a certain amount of this work. I believe if you had a programme, you would probably find that industry would co-fund it as well.”²⁸¹ Government are investing in high-value and specialist manufacturing to promote growth and innovation and devoting £1.4 billion to the Regional Growth Fund to help to achieve this. We believe that the nuclear industry is a potential growth area that the Government should be supporting further.
152. **We recommend that the Government should discuss with the relevant stakeholders what additional funding is required to implement the R&D roadmap. This funding might come from a combination of stakeholder contributions or the reallocation of funding from other sources (for example, reallocation of around 1% of the £2.8 billion allocated to decommissioning and clean up each year).** This should not come from the BIS science and research budget. Spending a few £10s of millions a year on R&D would help to develop technologies which give rise to much less nuclear waste, and would help to find better ways of dealing with the waste we already have.

What should be in such a roadmap?

153. We received a range of evidence about some key components of a national nuclear R&D roadmap. The first one concerns UK participation in international research programmes.

Participation in international research programmes

154. Several witnesses described the benefits of international co-operation. They include:
- leveraging and maintaining national capabilities and expertise;
 - influencing international research agendas;
 - access to key international facilities and expertise;
 - harmonisation of international research efforts;
 - networking and access to markets for exploitation; and
 - access to international research results and relevant data.²⁸²

International collaboration on research is, witnesses told us, important to maintain R&D capabilities and associated expertise because of the increasingly global nature of nuclear research and the scale of effort required. Collaboration with international experts refreshes and broadens the domestic research agenda,

²⁸¹ Q 331

²⁸² NRD 07, 22, 32, 33, 39, 41, 44, 45, 50; QQ 282, 342–344

helping to ensure that the national focus remains internationally competitive. For this reason, we believe that it is essential for the UK to be involved in international research collaborations (see paragraph 35 above).

155. According to Dame Sue Ion, there are three essential elements for effective participation in international research programmes:

“You need people who are experts and who are recognised as credible experts to contribute. You need to have meaningful projects on which you have decided to focus—you cannot do everything or be all things to all men. That is why the roadmap is important because then you can start to choose where the UK might play ... And you have to have facilities that your people can work in and where you can attract international players”.²⁸³

156. This view was supported by many witnesses who reiterated the importance of including in an R&D roadmap investment in dedicated UK facilities which would add value in specific areas of need internationally (see paragraphs 173 to 184 below).²⁸⁴ Denis Flory, Deputy Director General and Head of the Nuclear Safety and Security Department, International Atomic Energy Agency (IAEA), suggested that this was particularly true for safety research and the need to have a “strong nuclear safety research base in your own country”.²⁸⁵ Dr Weightman agreed.²⁸⁶

157. The UK research base is involved in a number of international programmes of nuclear research, including the Euratom Programme through individual university participation (see paragraph 35). Several witnesses, however, suggested that the UK was not sufficiently involved and lacked a strategy for involvement.²⁸⁷ Dame Sue Ion noted that most countries “maintain some involvement in the international R&D scene deliberately and in a focused way to help underpin their government’s policy”;²⁸⁸ and that a “modest commitment of £10 million a year would gain the UK access to programmes and projects amounting to £1–2 billion”.²⁸⁹ NNL, Westinghouse Electric Company and Engineering the Future supported this view.²⁹⁰

158. Although the UK has considerable strengths in a number of areas (see paragraphs 20 to 22), we were told that the UK research base was perceived internationally as weak because of a lack of clear leadership from Government on nuclear policy or R&D; and that this perception was exacerbated by the recent decision to withdraw from membership of the Nuclear Energy Agency (NEA) and a decision to withdraw from active membership of GIF in 2006 (see paragraph 162 to 172 and Box 4).²⁹¹ As a result, according to the RCUK, UK activity is underestimated and opportunities for UK academics to engage in wider international activities are limited.²⁹² Mr Keith Parker of the NIA told us

²⁸³ Q 59

²⁸⁴ NRD 05, 14, 38, 40, 36, 51, 39, 10

²⁸⁵ QQ 398, 404

²⁸⁶ Q 474

²⁸⁷ NRD 09, 17, 48, 50

²⁸⁸ Q 63

²⁸⁹ NRD 29

²⁹⁰ NRD 07, 32, 50

²⁹¹ NRD 33, 39, 40, 43, 45, 40, 50; Q 163

²⁹² NRD 33

that, when trying to promote UK nuclear interests abroad, there was a “perception that we no longer have the capability or the industry”. He gave the following example: “I recall that at my first meeting in China with the China National Nuclear Corporation we were asked, ‘What are you doing here?’ We were not regarded as a serious player; ... We did not have the credibility that other countries perhaps had”.²⁹³

159. We found the Secretary of State’s response to this perception of weakness to be again somewhat complacent. In his view: “By virtue of having new nuclear within the energy mix for 16 GW of new plant, we are going to be the world leader in investment, apart from China. That size of the market and the skills associated with that and the intelligent or well-informed customer aspects mean that we are very firmly going to have a place at the table.”²⁹⁴ The evidence we received about the international perception of the UK suggests otherwise. Professor Fitzpatrick, for example, told us: “If we are to be able to make a convincing case that we should be filling one of the seats at the table, then that needs us to look very critically at our activities to make sure that what we offer is world-leading in terms of facilities—and not just nuclear facilities but some of the other science and engineering facilities such as our neutron sources and synchrotron X-ray sources, which can significantly contribute to research on nuclear generation technologies.”²⁹⁵ In his opinion, “The UK needs to redevelop an identity as a leader in nuclear research in order to gain a position as a partner of choice for research collaborations”.²⁹⁶ In order to promote the UK’s strengths in R&D internationally and to encourage participation in international activities, the UK needed, in his view, a national lead to represent the capability at international meetings.²⁹⁷
160. Westinghouse Electric Company also argued that “other countries tend to have a more strategic approach to [how they deliver R&D provision] and often establish their own national laboratories” to lead it internationally. In their view, the UK may become “excluded or marginalised” from international collaborations by not having such an organisation.²⁹⁸ (We discuss the need for a national lead and the role of NNL further in Chapter 7.)
161. **We recommend that, in order to improve the international perception of the UK’s research base, as part of the development of an R&D roadmap, the proposed Nuclear R&D Board should outline a strategic approach to the UK’s involvement in international collaborations (through programmes such as Euratom) to ensure that the UK has sufficient expertise, national programmes and facilities to be seen as an attractive and credible partner for research collaborations.**

Involvement in research on future nuclear technologies

162. A range of future nuclear technologies are being developed globally, including six reactor designs under the umbrella of GIF.²⁹⁹ Whilst we

²⁹³ Q 238

²⁹⁴ Q 461

²⁹⁵ Q 59

²⁹⁶ NRD 44

²⁹⁷ Ibid.

²⁹⁸ NRD32

²⁹⁹ NRD 1, 25, 38, 39, 46

acknowledge the importance of all these other technologies, we focus in this section on Generation IV technologies.

The Government's approach to involvement in Generation IV

163. We have already drawn attention to evidence suggesting that UK involvement in Generation IV technologies research is inadequate (see paragraphs 105 to 115).³⁰⁰ When we put this point to the Government, they said that, in their view, sufficient efforts to “maintain awareness of and involvement in developments on advanced reactor designs” were being made through Euratom and the research councils, and they referred to a recent increase in funding by the research councils intended “to ensure that the UK can innovate in appropriate areas of Gen IV technologies, be able to identify advantageous opportunities in the UK and to be able to inform stakeholders what market opportunities may emerge”.³⁰¹
164. Other witnesses, however, suggested that there was currently a lack of strategic approach to maintaining capabilities in this area of research.³⁰² Such an approach was needed, Dame Sue Ion argued, because of the “long timescale of Generation IV work” which was “[outside] the remit of the TSB and probably the [Technology Innovation Centres] TICs”. It was also “beyond the planning horizons and plans of companies in the private sector”.³⁰³

Generation IV Forum (GIF)

165. Given the scale of effort and funding required globally to develop these technologies, activities relating to Generation IV technologies are mainly through international programmes such as GIF and require active research to take place nationally in order to participate (see Box 4).³⁰⁴ In 2006, the Government withdrew from active membership of GIF however. According to Professor MacKay, the decision was made for financial reasons—“money was tight”.³⁰⁵

BOX 4

The Generation IV International Forum

GIF is a co-operative international endeavour organised to carry out the R&D needed to establish the feasibility and performance capabilities of the next generation nuclear energy systems.

GIF has 13 members which were signatories to its founding document, the GIF Charter. Argentina, Brazil, Canada, France, Japan, Korea, South Africa, the UK and the United States signed the GIF Charter in July 2001. Subsequently, it was signed by Switzerland in 2002, Euratom in 2003, and China and Russia, both in 2006.

All GIF members are signatories to the GIF Charter. Ten members have since signed or acceded to a Framework Agreement which establishes system and project organisational levels for further co-operation on R&D (active members). Non-active members are those among the nine founding members which have not acceded to the Framework Agreement.³⁰⁶

³⁰⁰ NRD 43

³⁰¹ NRD 21

³⁰² NRD 4, 8, 13, 29, 43, 44, 49

³⁰³ NRD 29

³⁰⁴ NRD 14, 16, 22, 32, 39, 41, 44, 47, 50

³⁰⁵ Q 79

³⁰⁶ Generation IV Website: <http://www.gen-4.org/index.html>

The UK signed the Agreement in 2005 but withdrew in 2006, reportedly because active GIF membership was based on an intention to pursue the development of one or more of the Generation IV reactor designs and the UK ceased to have an active research programme in next generation technologies at that time. The UK was involved in three reactor design research programmes. The funding for research into these systems was provided by BNFL until 2006, supplemented by UK participation in the EU's Framework programmes, and by funding from the EPSRC for underpinning science within the KNOO programme. When this funding stopped the UK ceased to be an active member.³⁰⁷

166. Several witnesses expressed concern at the Government's decision and called for active membership to be reinstated as soon as possible.³⁰⁸ Given the Government's response that the UK had adequate involvement in the forum through membership of Euratom,³⁰⁹ we asked Mr Bernard Bigot of the Commissariat à l'énergie atomique et aux énergies alternatives (CEA) in France why active participation in GIF, rather than through Euratom, was necessary to maintain R&D capabilities and associated expertise in the UK. He said that "If you are not so sure that the EURATOM policy would cover all your concerns, and you wish to be able to concretely participate in the debate and influence the joint working programme, I would recommend [active membership]".³¹⁰ Dr Simon Webster, Head of Unit Fission at the DG for Research of the European Commission, also warned that without active membership of GIF, the "UK was less able to direct where the programme is going." and that participation through Euratom was "severely limited in what it can do in advanced nuclear systems because they require unanimity in the EU Council to get programmes passed, and unanimity in Europe on advanced nuclear technology is very very difficult".³¹¹ It also precluded UK involvement in discussions, meaning that the UK would not be in a position to benefit commercially from the development of these technologies or the intellectual property generated when they take off.³¹² Commenting in a personal capacity, Dr Webster warned that "the UK will always be limited by what Euratom can support in this field, which is currently quite limited and may well even decrease in the future as a result of the need to have unanimous EU Member State support for the content of Euratom Framework Programmes".³¹³
167. Professor Howarth of NNL said that other countries saw benefit in individual membership in terms of "training and the development of capability ... [and] wanting to understand where nuclear reactor and fuel cycle technology is going". According to NNL, membership through Euratom was "not adding

³⁰⁷ *Generation-IV nuclear power: A review of the state of the science*, Adram T and Ion S, Energy policy, 36 (2008), pp 4323–4330.

³⁰⁸ NRD 07, 22, 30, 38, 40, 41, 43, 49

³⁰⁹ NRD 21

³¹⁰ Q 360

³¹¹ QQ 154–160

³¹² Q 172

³¹³ NRD 53

any benefit to the UK”.³¹⁴ Commenting on the programme Professor Fairhall, also of NNL, said:

“an organisation can join a programme and then it gets allocated to be part of Generation IV. Just because an organisation is involved in that programme and can get access to the results of that programme, it cannot get access to the whole of the Generation IV programme. As an organisation, if we are not involved in a programme we cannot get sight of the results that take place, so the Government cannot get results that come out. If you are a member of Generation IV as an independent country then you can shape the programme, you can decide which you want to be involved in and you can get results from the collaboration.”³¹⁵

168. AMEC and others told us that, from an industry perspective, active membership was crucial to “win work in the global marketplace” as well as providing a “vital industrial training route”.³¹⁶
169. The arguments for UK active involvement in GIF are, we believe, strong. But it requires a clear R&D programme of engagement within the UK and also the availability of facilities.³¹⁷ Mr Keith Parker of the NIA said that the “Government should be paving the way for the involvement of British academics and British industry” in such programmes.³¹⁸ The University of Central Lancashire suggested that the Government should provide a lead and set the priorities for research into future technologies, with a contribution from industry where there were potential co-benefits.³¹⁹ Bearing in mind limited budgets, Professor Joyce also suggested that the focus should be on R&D “on a small handful of technical priorities [on future technologies and] commit[ment] to own[ing] a particular aspect of the Gen IV design challenge”.³²⁰
170. Given the weight of evidence against the Government’s decision to withdraw from active membership of GIF, we asked Professor MacKay for his view. His answer was encouraging: “I have listened carefully to the evidence from the experts that says this is a pressing matter and the decision should be revisited as early as possible within the next three years, so I will be raising it within DECC before the next Spending Review”.³²¹ We hope that the Secretary of State will take into consideration these concerns, in conjunction with the conclusions from the TINA for nuclear (see paragraph 56).
171. **We recommend that, as part of the development of a nuclear R&D roadmap, the Government should consider what level of engagement in future technologies is necessary at both the national and international level to enable the UK to maintain sufficient capabilities within this area of research, focusing on strategic areas of UK strength.**

³¹⁴ Q 344

³¹⁵ Q 345

³¹⁶ NRD 41

³¹⁷ Q 360

³¹⁸ Q 237

³¹⁹ NRD 30

³²⁰ NRD 39

³²¹ Q 79

172. **We recommend also that the Government reinstates UK active membership of GIF at the earliest opportunity.**

Research facilities

173. A key consideration in developing a nuclear R&D roadmap is whether the UK has sufficient research facilities to ensure the next generation of nuclear experts and the nuclear innovation needed by the UK. Although the research councils have increased their funding for nuclear fission research and also the number of courses available for students, these steps have not, according to Dr Simper and others, been accompanied by increased provision for facilities to enable “hands-on development and experience leading to ideas that can then be picked up by commercial organisations”. The decline in UK nuclear laboratories over the last two decades (see paragraph 12 and Figure 2 above) has led therefore to a situation where the UK has “no significant post irradiation examination capability and no hot cells for highly active research”.³²² Professor Delpy agreed that this was a problem.³²³

Hot facilities

174. Several witnesses, including the Government, referred to a lack of key facilities in the UK for research involving the handling of higher active waste (known as “hot facilities”) to enable post-irradiation examination. These facilities are required, according to Sellafield Ltd, to address “both new nuclear build challenges and to deal with known historic issues, such as [plutonium] disposition ... environmentally sensitive immobilisation, and innovative solutions for deep geological disposal”.³²⁴ Many other witnesses agreed.³²⁵ Professor Delpy, for example, thought that lack of access to hot facilities was “probably one of the most constraining things in terms of doing research on nuclear materials” in the UK,³²⁶ although he also told us:

“With the National Nuclear Laboratory, we have recently made a £1.6 million investment to support analytical equipment in the central laboratory—the hot laboratory. The University of Manchester and the NDA have invested in the new Dalton Cumbria facility, which is a £20 million investment. We have begun to tackle this. We have access to international facilities through some of our international networks—India and the facilities in Karlsruhe, for example. We are also talking to the Norwegians about access to their test reactor. We are dealing with the acute shortage.”³²⁷

Why do we need facilities to handle highly active material in the UK?

175. We asked whether access to non-UK hot facilities would meet the UK’s needs, because, as EDF Energy pointed out, “facilities like test reactors, hot cells, advanced manufacturing and computational modelling are expensive and decisions within the UK on providing for this type of R&D must take

³²² NRD 43

³²³ Q 192

³²⁴ NRD 23

³²⁵ NRD 17, 24, 25, 33, 34, 36, 43, 44, 48

³²⁶ Q 192

³²⁷ Q 192

into account the availability of such facilities worldwide, the UK industry's requirements, and the strategic significance of the work undertaken".³²⁸ RCUK thought not and, as a result, "academic research is limited" causing "difficulties in training the next generation of nuclear researchers".³²⁹ Furthermore, as we have already noted in paragraphs 148 to 150, maintaining world-leading facilities in the UK is necessary to enable the UK "to take part in international collaborations on Gen IV".³³⁰

176. At present, radioactive facilities (above low levels of radioactivity) for undertaking civil nuclear R&D are limited mainly to those operated by NNL at the Central Laboratory, owned by the NDA, at the Sellafield site. These facilities are only partially commissioned. Whilst there are plans to commission the Phase 2 "alpha R&D laboratories" (see Appendix 5),³³¹ in addition to £1.6 million funding of analytical equipment by EPSRC and others,³³² there are no agreed plans to commission the Phase 3³³³ laboratory required for research on highly irradiated materials (for example, to understand the long-term behaviour of materials within the reactor pressure vessel or high level waste packages).³³⁴ According to NNL and others, if the facilities were fully commissioned, they would be "world leading" and an "integral part of a network of laboratories within Europe to undertake international collaborative programmes".³³⁵
177. We asked Mr Bigot if he thought there would be sufficient call internationally for hot facilities at NNL. He thought that they "could be of real interest" but cautioned that there was a need for a "global vision" of what research could be done in UK facilities or in French facilities with "some programming of the work to be done jointly".³³⁶ In France, some of the national equipment (such as the hot laboratories and research reactors) was over 40 years old and, as a result, France was considering the issue of renewal of facilities and in the process of introducing new nuclear research reactors.³³⁷
178. During our visit to Sellafield, we were told that NNL was in discussions with the international research community about developing a business case to commission facilities. They estimated that it would cost about £20 million to commission the Phase 3 laboratory. However they have struggled to make the business case because, under current financial arrangements, they have to demonstrate the value of the facility in terms of meeting NDA objectives rather than the benefit to the wider research community. They have not therefore considered the value more generally in maintaining R&D capabilities and associated expertise to underpin the UK's energy policies. Given that the NDA's remit only covers the UK's decommissioning and waste management responsibilities and they will have access to the newly

³²⁸ NRD 49

³²⁹ NRD 33

³³⁰ Q 59, NRD 29, 50

³³¹ Phase 2 facilities support programmes covering plutonium management in the UK.

³³² NRD 33

³³³ The Phase 3 laboratory at the Sellafield site refers to the facility that is able to handle gamma-radiation from higher active materials to allow research on irradiated materials to take place.

³³⁴ NRD 07

³³⁵ NRD 07, and 29, 50, 59

³³⁶ Q 358

³³⁷ Q 356

refurbished Windscale Laboratory³³⁸ which will enable a limited amount of research on the study of irradiated materials, the cost of the facilities could never be justified for the NDA alone. Professor Howarth found this exasperating:

“You cannot build an economic case where the NDA can show, in pounds, that it is of benefit to them to commission it. They would love to commission it for the benefit of UK plc internationally, but when they look at the NDA’s remit, they cannot make the economic case to commission it. What we need to do is treat it as a national strategic asset that would benefit the UK in taking a leading position internationally in terms of the low-carbon economy, fuel cycle technology, safeguarding nuclear material, etc.”³³⁹

179. Sellafield Ltd also told us that the current “lack of strategic long term R&D programmes has made it impossible to produce a robust business case for commissioning ... [the Phase 3] facilities.”³⁴⁰ Furthermore, we are aware that even funding to keep the facilities ticking over in “care and maintenance” mode may be withdrawn from April 2012 if a business case cannot be found, meaning that the facilities will be “moth-balled”.³⁴¹
180. All stakeholders, including the Government, agree that access to facilities that can handle highly active materials is needed to train the next generation of researchers and that lack of access is a constraint on research. It is also widely acknowledged that their existence would benefit the UK in terms of providing a resource for international research collaboration. We find it perplexing therefore that NNL has not been able to take into account these wider benefits when formulating a business case to commission the facilities.
181. **We recommend that the proposed Nuclear R&D Board should work with DECC, NNL, the NDA, BIS, the research councils and relevant industry groups to develop a business case to commission the Phase 3 laboratory at NNL as a national research facility for studying irradiated materials, taking into account its wider value to the nuclear sector and to the research community for research and, in particular, its contribution to training the next generation of experts and increasing the attractiveness of the UK as a destination for international research collaboration.**

Research reactor facilities

182. Several witnesses drew our attention to the need for better access to research reactor or test reactor facilities in the UK (see paragraphs 231 to 234) and the need to establish a programme to develop a small-scale research reactor to provide “practical experience for graduate and post-graduate work in nuclear technology, allow ongoing research into ... nuclear [materials], allow the production of radio-isotopes and provide a general research capability for irradiation”.³⁴² It is not however clear whether access to these sorts of facilities abroad might be adequate to meet UK needs or, alternatively,

³³⁸ The Windscale Laboratory at Sellafield is also a post-irradiation examination facility (see Appendix 5).

³³⁹ Q 347

³⁴⁰ NRD 23

³⁴¹ See Appendix 5.

³⁴² NRD 43

whether the UK should invest in the development of UK-based facilities.³⁴³ This issue should be considered within the nuclear R&D roadmap.

183. **We welcome the current efforts by NNL to ascertain the international market for the Phase 3 laboratory. More generally, given how costly nuclear research facilities are to build and maintain, it is essential that the UK should be looking for opportunities to share UK facilities internationally and also to collaborate internationally to gain access to nuclear facilities abroad.**
184. **France is in the process of renewing its research reactors. Within the R&D roadmap, the proposed Nuclear R&D Board should investigate further the potential for access to research reactor and other nuclear research facilities abroad, within a globally co-ordinated programme of research collaborations.**

Legacy and existing systems waste

185. The NDA is a significant funder of research into decommissioning and waste management and maintains R&D capabilities and associated expertise primarily by “plac[ing] work into the technical community”.³⁴⁴ They also fund PhD studentships, bursaries and sponsorship and work with the National Skills Academy for Nuclear to “ensure a broader approach to skills maintenance”. Additional R&D is needed however to underpin work on the disposition of the UK’s plutonium stocks and to pave the way for a geological repository (see paragraphs 103 to 104).
186. At present the NDA commissions NNL to carry out work on the storage of plutonium and NNL also carries out some of its own work on plutonium disposition. However, NNL told us that, although there were “plans to actively commission alpha R&D laboratories to support programmes covering plutonium management in the UK”, there were only “limited R&D programmes” in the areas of the disposition of civil plutonium and uranium, the management of irradiated nuclear fuel and deep geological disposal of radioactive waste.³⁴⁵
187. The NDA acknowledged that “as the geological disposal programme evolves a number of UK specific capabilities will need to be developed”.³⁴⁶ Both Professor MacKay and the NDA assured us that the NDA has set aside adequate funds to cover this future work.³⁴⁷ We were given no information however about how such R&D capabilities and associated expertise would be maintained through a long-term R&D programme.
188. The research councils also fund fundamental research on radioactive waste to underpin their activities. The NDA told us that whilst they support the R&D “necessary for delivering [their] mission much of it depends on the results of previous fundamental nuclear research”. They argued that little fundamental nuclear research had been carried out in the UK in recent times and that there was a risk that the capability to carry out such research would

³⁴³ NRD 22, 31, 36, 39, 43, 44, 50

³⁴⁴ Q 263

³⁴⁵ NRD 07

³⁴⁶ NRD 19

³⁴⁷ QQ 92, 267

be lost.³⁴⁸ Professor Lee of CoRWM agreed: “A lot of what is being done with the research councils at the moment is guided by linking with the NDA on managed calls. Much less is fundamental and independent R&D”.³⁴⁹ Professor Peter Styles, Professor in Applied and Environmental Geophysics at Keele University, told us that very little NERC funding was going into this area.³⁵⁰ NERC’s current research spend appears to be fairly limited: £4 million over 2009–2013.³⁵¹ A recent programme will extend this by £5 million. We note, however, that the focus of the programme will be effects on the environment rather than the direct challenges of developing a geological disposal site (see paragraph 28).³⁵²

189. Whilst we are, to some extent, reassured that the NDA has made provision in its forward programme for the future research needs relating to radioactive waste disposal, we are concerned by the evidence which suggests that there is a lack of longer-term research programmes focused on addressing the disposal of radioactive waste and the plutonium stockpile and also by the apparent lack of fundamental research on the management of radioactive waste. **We recommend that the NDA, NERC and other relevant funders ensure that sufficient R&D capabilities and associated expertise are maintained over the longer term to manage legacy and existing systems waste.**

190. **As part of these efforts, we suggest that:**

- **the NDA develops a long-term research programme outlining how they will ensure that there are adequate R&D capabilities and associated expertise to meet their future needs for geological disposal and the disposition of the UK’s plutonium stockpile;**
- **the research councils, particularly NERC, works with the NDA to ensure that sufficient fundamental research on radioactive waste management and disposal is commissioned to maintain R&D capabilities and associated expertise in this field and to ensure that research efforts are effectively co-ordinated across the research councils; and**
- **RCUK commissions an independent review of the UK’s R&D capabilities and associated expertise in radioactive waste management and disposal.**

Nuclear safety research capabilities

191. The UK has internationally recognised expertise in nuclear safety. This expertise was called upon when Dr Weightman was invited to lead the IAEA’s fact finding mission to Japan. Post-Fukushima, there will be a growing demand to increase efforts on health and safety research. This is therefore an area where the UK could provide international leadership. The Secretary of State acknowledged this: a “key part of our objectives [is] ... to be in a position where our nuclear inspections and our nuclear safety are

³⁴⁸ NRD 19

³⁴⁹ Q 275

³⁵⁰ QQ 263, 270, 273, 282

³⁵¹ NRD 66

³⁵² NRD 66

absolutely world class”.³⁵³ In Dr Weightman’s view, such expertise would be invaluable for providing expert advice to the new nations that want to get involved in nuclear power.³⁵⁴

192. However, a number of concerns have been raised about current arrangements within the ONR with regard to the co-ordination of safety research and, in particular, about a lack of independent advice to guide the work of the ONR. Professor Williams, the Government Chief Nuclear Inspector from 1998 to 2005, explained:

“In the United Kingdom, we have a strong nuclear safety research capability. It was initially managed by the United Kingdom Atomic Energy Authority and was handed over to the Health and Safety Commission when the authority changed. The Health and Safety Commission had its own research committee and there was a subgroup of the Advisory Committee on the Safety of Nuclear Installations, which later became NuSAC [the Nuclear Safety Advisory Committee], which oversaw nuclear safety research and how it related to the needs of the industry. It also worked with the industry ... This committee, reporting through to the Health and Safety Commission, and working with the industry, ensured that throughout the United Kingdom there was a sufficient research programme to underpin safety—for the industry and the regulator. Sadly, over the years, that has declined. Now there is not a nuclear safety advisory committee and as far as I know there is therefore no research committee. Therefore, we are at risk of losing our capability of being able to understand our nuclear safety research and to commission that research.”³⁵⁵

The Nuclear Research Index

193. Formerly, NuSAC contributed to the development of the Nuclear Research Index (NRI) which helped to identify research needs and co-ordinate research activities across industry and the regulator as required, placing a levy on industry to commission work of generic need that was not covered by industry activities. We asked the ONR about the NRI. They said that it was still “produced annually by the [ONR] to support the UK reactor nuclear safety research programme” and involved consultation with nuclear site licensees on the content of the “technical area strategies” and the “addition of new issues requiring research”. Publication of the 2011 NRI (in September 2011) had been delayed because of a review by ONR of the process by which it was produced.³⁵⁶ The 2011 ONR had not however taken on the lessons from the review.
194. When we asked Dr Weightman about this issue, he told us that he hoped to “take a strategic overview of the totality of research and capability across the UK from a safety regulatory point of view to ensure that we in the UK are able not only to respond to the needs directly from the UK industry but also to provide advice to the UK Government in circumstances where there are significant incidents overseas”.³⁵⁷ We were reassured to hear that this

³⁵³ Q 457

³⁵⁴ Q 486

³⁵⁵ Q 398

³⁵⁶ NRD 67

³⁵⁷ Q 469

strategic view would encompass research of relevance to Sellafield and any future new build programme, which is excluded from the current NRI and that such an approach would be taken in the formulation of the 2012 NRI.³⁵⁸ Dr Weightman went on to say that “one issue that we need as regulators to get a better grip on is how much the industry in the UK spends, the way in which it looks at the areas that it looks at and whether there are any gaps from our perspective”. He said that this would be covered within the planned strategic overview.³⁵⁹

195. The UK has an excellent record and international reputation in nuclear safety and security. Given international recognition that safety and security are key areas of research activity in the future, post-Fukushima, this presents a significant opportunity for the UK to re-establish its reputation for nuclear research excellence internationally. We look forward to the publication of the revised 2012 NRI which will outline a more strategic view of the UK’s research needs in this area. **This research strategy should be integrated into the national nuclear R&D roadmap which should set out how the UK will maintain its international reputation for nuclear safety expertise.**

The Nuclear Safety Advisory Committee

196. NuSAC was set up to “advise the HSE on matters, regarding nuclear safety policy and its implementation at nuclear installations” and “on the adequacy and balance of HSE’s nuclear safety research programme”. Its term of office expired on 31 October 2008³⁶⁰ however and the HSE Board has deferred its decision on future arrangements for independent technical advice on nuclear safety pending various reviews on the future of nuclear regulation. Future advisory committees would, we were told by the ONR, take into consideration the new structure of the organisation following the creation of the ONR as an independent body and the appointment of the ONR’s new Board.³⁶¹
197. We asked Dr Weightman about NuSAC. He said that once the ONR was set up as a statutory corporation, he would seek to reinstate an advisory committee similar to the group which was established to advise him on the interim and final reports on the implications of Fukushima for the UK.³⁶² This model would involve openness and transparency and the ability to take a strategic approach, with people who would challenge and provide the best technical advice.³⁶³ Whilst we were reassured to hear that this was the case, we are troubled that NuSAC has been in abeyance for four years. The ONR subsequently told us also that it was not necessary to wait for them to be set up as a statutory corporation “to establish such advisory machinery it considers appropriate”.³⁶⁴ Given the already lengthy delay, **we recommend that the ONR should not wait until it has been set up as a statutory**

³⁵⁸ Q 470

³⁵⁹ Q 483

³⁶⁰ HSE website: <http://www.hse.gov.uk/aboutus/meetings/iacs/nusac/>

³⁶¹ NRD 67

³⁶² *Japanese Earthquake and Tsunami: the Implications for the UK Nuclear Industry: Interim Report*, HM Chief Inspector of Nuclear Installations, ONR, (May 2011), and *Final Report* (October 2011).

³⁶³ Q 493

³⁶⁴ NRD 69

corporation to establish a reformulated NuSAC, but should do so as soon as possible. The advisory committee should provide independent and transparent advice and external challenge to the ONR's work for both the Chief Nuclear Inspector and the Secretary of State.

198. As we have noted (see paragraph 130), the Government are seeking to change the status of the ONR to a statutory corporation. The earliest this will take effect is April 2013. The decision to make the ONR an independent body had already been delayed by a number of years and we fear that any further delay could be detrimental to the current nuclear new build programme if, as a result, the public do not have confidence in the independence of the regulator's advice. For this reason also **we urge the Government to ensure that there is no further delay in converting the ONR to a statutory corporation and that in the meantime it is able to continue under the existing arrangements that are in place** (for example the interim arrangements on pay discussed in paragraph 130).

Research requirements post-Fukushima

199. Whilst we do not have a full analysis of the impact of the Fukushima incident on UK research needs or how the UK should contribute to the large international research challenges that it presents, a number of issues were raised of relevance to this inquiry.
200. As a result of the nuclear incident at Fukushima, Professor Tatsujiro Suzuki, Vice-Chair of the Japanese Atomic Energy Commission, said that Japan was facing "many technical challenges" and was shifting its R&D towards meeting the needs of the clean-up.³⁶⁵ Inevitably, the incident has had significant implications for the international nuclear community. We asked witnesses how the international research community could contribute to meeting the challenges posed by Fukushima to improve the safety of nuclear facilities worldwide. Mr Flory of the IAEA said that there was "a need to understand better the behaviour of fuel under severe accident conditions" and that internationally "we still know quite little" about these problems which, he said, would require "dedicated research reactors ... [and] in-depth research programmes". There was also a need for in-depth research programmes on how to decontaminate land.³⁶⁶
201. In terms of the national safety research programme, Professor Williams said that in the UK "there is a need for a better understanding of the external hazards that our plants are designed to respond to and the combination of effects ... to look at whether we understand the robustness of our emergency core-cooling and residual heat-removal systems, especially in relation to fuel ponds". In his view, "the whole issue of spent-fuel management needs to be looked at, especially in relation to how much fuel you can store on-site," and emergency planning in extreme situations of severe accident management.³⁶⁷ Horizon Power also suggested that there was a gap in regard to generic research into seismic hazards in the UK.³⁶⁸

³⁶⁵ Q 393

³⁶⁶ Q 394

³⁶⁷ Q 395

³⁶⁸ NRD 02

202. Dr Weightman told us that in Japan “the extent of a tsunami associated with an earthquake was underestimated, which meant that the research basis for that particular hazard was not solid”. In his view, the UK had a better view of the possible consequences of natural hazards, although he recognised that it was important to keep abreast of certain issues such as understanding the impacts that climate change may have on events such as flooding.³⁶⁹ He also recognised that there were other areas where further research was required to understand the phenomena better in terms of the way that certain reactors would respond to severe conditions. This was not just about reactor technology but also about spent fuel safety and the safety of the fuel cycle, how we can deal with legacy issues and how we keep abreast of new technologies.³⁷⁰ When we asked Dr Weightman if the research needs identified post-Fukushima would be incorporated into the 2012 NRI, we were reassured to hear that the ONR would be considering how to “expand into these other areas as well”.³⁷¹ We look forward to seeing how the ONR will take the R&D needs identified as a result of the Fukushima incident (including those identified in Dr Weightman’s interim and final reports)³⁷² into consideration and how the UK’s contribution to meeting them will be reflected in the 2012 NRI.

Social science research

203. The social dimensions of nuclear power should, in our view, be a key component of an R&D roadmap. Professor Nick Pidgeon of the Understanding Risk Research Group at Cardiff University told us: “Given the history of this industry it would be a mistake to overlook the very many social science questions which will bear upon any new build nuclear programme and associated nuclear waste issues”.³⁷³ Professor Pidgeon noted that although “the UK is recognised as a world leader in the social studies of science and technology,”³⁷⁴ for the past 10 years, there has been relatively little detailed focus on the question of nuclear energy.³⁷⁵ He acknowledged that work had progressed with research programmes to “understand the politics and dynamics of nuclear waste”³⁷⁶ and that a major RCUK Energy Programme network (InCLUSEV)³⁷⁷ was also “building capacity in equity and energy issues, with a work-stream dedicated to equity in the nuclear fuel cycle”. He was critical however of the research councils’ past and present energy research programmes for “not mapping out more clearly the roles that the social sciences might play”, calling for a “more considered approach in drawing the full range of social science challenges into the emerging nuclear energy research landscape”.³⁷⁸ Professor Sherry also told us that, in the UK, research on nuclear has “not been strong on ... public understanding and

³⁶⁹ Q 466

³⁷⁰ QQ 466, 467

³⁷¹ Q 469

³⁷² *Japanese Earthquake and Tsunami: the Implications for the UK Nuclear Industry, Interim Report, HM Chief Inspector of Nuclear Installations, ONR, May 2011, and final report October 2011.*

³⁷³ NRD 55

³⁷⁴ Ibid.

³⁷⁵ Ibid.

³⁷⁶ <http://www.thewasteoftheworld.org/>

³⁷⁷ <http://inclusev.kcl.ac.uk/>

³⁷⁸ NRD 55

public appreciation of the risks associated with nuclear.” He went on: “The whole area of social science ... around introducing nuclear power or the recycle of fuel ... is one where I would urge for more focus to come in. Given public opinion following the Fukushima incident, a number of us were involved in telephone phone-ins where very basic questions were causing very high anxiety”.³⁷⁹

204. **We recommend that research on the societal and ethical dimensions of the use of nuclear energy in the UK should be an integral part of the nuclear R&D roadmap.**

CHAPTER 7: ROLES AND RESPONSIBILITIES

205. A range of bodies are involved in nuclear R&D, each with different responsibilities. In this chapter we consider whether the distribution of responsibilities is effective—or could be improved.

Departmental responsibilities for nuclear R&D

206. There appears to us to be some confusion within Government about the different responsibilities of BIS and DECC with regard to UK nuclear R&D capabilities and associated expertise. David Willetts MP, Minister for Universities and Science in BIS, told us that “DECC is ... the lead on ensuring that we get the civil nuclear capacity that we have identified the country needs”³⁸⁰ and that “it also has responsibilities for nuclear decommissioning and Gen IV’s role in future energy policy”;³⁸¹ whereas “BIS ... leads on maximising the opportunity of industry in the UK to benefit from a resurgent global civil nuclear market” and has “overall responsibility for research and the industrial policy at the end of research, notably through the TSB”.³⁸² Professor Sir John Beddington, GCSA, told us that the responsibilities for ensuring there were adequate R&D capabilities and associated expertise were spread across Government, including himself: “I have responsibility for ensuring the research capability is adequate to meet long-term policy demands. Obviously, those responsibilities are distributed across DECC, BIS arguably, and the research councils”.³⁸³
207. This diffusion of responsibilities has, in our view, led to BIS and DECC tending to look to the other to tackle gaps in R&D capabilities and associated expertise. We note, for example, that both departments identified the problem of lack of hot facilities but that neither proposed any action to address this issue. Given the evidence of the apparent confusion about the role of DECC, for the avoidance of doubt, **we recommend that DECC should be designated as the lead department in developing a national nuclear policy and R&D roadmap, outlining what R&D capabilities and associated expertise are necessary to support its policies.**

Responsibilities for advanced fuel recycling and reprocessing

208. Although the UK is currently considered to have world leading capabilities in reprocessing and advanced fuel recycling (based mainly at the Sellafield site), they are not adequate to keep the nuclear options open for the future (see paragraphs 116 to 117).
209. Dame Sue Ion highlighted the immediacy of the risk that the UK might lose these capabilities, stressing that it was important to understand that “within the next year decisions will be made [by the NDA] about nuclear infrastructure and investment particularly at Sellafield on reprocessing” and it was, she said, “vital these decisions are made in the context of an ongoing nuclear programme likely to involve a reprocessing scenario for the UK”.³⁸⁴

³⁸⁰ Q 383

³⁸¹ Q 375

³⁸² Q 384

³⁸³ Q 70

³⁸⁴ NRD 29

210. The NDA confirmed that at the end of the current contracts in 2018, the Thorp reprocessing plant at Sellafield will close down, reflecting the “state of the asset and the market for reprocessing”. They argued that the “significant capital investment needed to produce a new generation of reprocessing plants” was “not justified on commercial grounds” given their remit.³⁸⁵ In August 2011, the NDA also reached a decision to close their Sellafield MOX Fuel Plant (SMP) at the earliest practical opportunity, in light of the impact of the Fukushima incident on their sole Japanese client’s immediate requirements for MOX fuel.
211. In these circumstances, it appears unlikely that the limited support that the NDA currently gives to NNL and others to maintain some R&D capabilities in reprocessing will continue.³⁸⁶ It is also not clear what will happen to the expertise maintained within the Thorp and SMP sites at NDA. This is, we believe, a particular concern, given that the Government is currently consulting on the policy options for dealing with the UK plutonium stockpile, including possible re-use as MOX fuel. According to the NDA, fast reactor capability and advanced separation technology for reprocessing spent fuel were areas where the UK had previously maintained strong R&D capability and associated expertise but that, due to the NDA’s remit, they no longer maintained this in line with its mission.³⁸⁷ This raises the question: who is maintaining these capabilities?
212. There is currently no single body with responsibility for maintaining R&D capabilities and associated expertise in advanced fuel recycling or reprocessing. Given the importance of maintaining these capabilities if nuclear energy options are to remain available in the future we find this unacceptable. (We discuss this in paragraphs 213 to 222 below.)

The role of the NDA

213. The NDA is a Non-Departmental Public Body. It was created under the Energy Act 2004 (“the 2004 Act”). Its objective is “to ensure that the historic civil public sector nuclear legacy sites are decommissioned safely, securely, cost effectively and in ways that protect the environment” and “to scrutinise the site decommissioning plans of EDF Energy for their existing UK nuclear fleet”. It is also the body “responsible for implementing geological disposal of higher activity radioactive waste ... [and] for delivering the Low Level Radioactive Waste Strategy for the whole of the UK’s nuclear industry”.³⁸⁸ As regards R&D capabilities and associated expertise, the NDA said: “we are required [under the 2004 Act] to promote and, where necessary, carry out research in relation to our primary function of decommissioning and clean-up”, and “as part of this, we are required to operate existing commercial activities and meet current contracts, using revenues generated to offset spend on decommissioning”.³⁸⁹ The NDA’s MOX plant contract, for example, contributed to offsetting spend on decommissioning. The NDA is not however responsible for seeking wider commercial opportunities for the UK.

³⁸⁵ Q 257

³⁸⁶ NRD 19

³⁸⁷ NRD 19

³⁸⁸ NRD 19

³⁸⁹ Ibid.

214. Some witnesses suggested that, given the long-term need to maintain capabilities in fuel recycling and reprocessing, the NDA's remit should be changed to reflect the UK's wider nuclear energy policy.³⁹⁰ Dame Sue Ion, for example, said that the NDA "ought to be looking at how to maintain recycling expertise and facilities to undertake an ongoing recycling mission; at how to accommodate a much increased inventory of spent fuel in a 38+ GW nuclear energy park and at the possibility of Generation IV systems being deployed before 2050".³⁹¹ Professor MacKay pointed out that the NDA's remit was "coupled" to that of NNL: "If the NDA's remit were expanded from just cleaning up the nuclear legacy to maintaining recycling expertise, preparing for possible future recycling challenges arising from a new nuclear fleet, then maybe they would start commissioning NNL to do a load of work with their excellent facilities".³⁹² Others, including AMEC, went further and suggested that the NDA's remit should be extended to provide commercial services worldwide for decommissioning, spent fuel storage and geological disposal.³⁹³
215. Other witnesses suggested that the NDA's remit should be narrowed to exclude responsibilities for handling spent fuel.³⁹⁴ According to the Cambridge Nuclear Energy Centre, "DECC should reconsider whether the management of special nuclear materials over-complicates the responsibilities of the NDA. This includes commercial reprocessing of spent fuel, MOX fuel fabrication and management of the plutonium fuel stocks". In their view, "DECC should consider whether a more focused organisation could better provide focus and leadership in fuel management while operating through contracts with Sellafield Ltd and others".³⁹⁵ The University of Central Lancashire was also of the view that "The use of the nation's plutonium stockpile, and the depleted and reprocessed uranium are clearly part of the wider debate on reactor types and fuel specification, and outside the remit of the NDA".³⁹⁶
216. The NDA and many others, including the Government, believed that their current focus on dealing with legacy waste was appropriate and should not be extended.³⁹⁷ We do not find this surprising given the considerable challenges that dealing with the legacy waste will involve. Dr Simper, Director of Strategy at the NDA, told us that

"whatever you believe about the future of nuclear power, I think there is general agreement that cleaning up the legacy is a good and responsible thing to do. Because of that focus, we do not believe that a wholesale broadening of our accountabilities is appropriate ... There are a number of things that the evidence submitted posits should be done. In many cases, the NDA clearly has the ability to do those things, but it does not necessarily follow that because they should be done and the NDA could

³⁹⁰ NRD 09, 29, 50

³⁹¹ NRD 29

³⁹² Q 86

³⁹³ NRD 13, 41

³⁹⁴ NRD 16, 30, 31

³⁹⁵ NRD 31

³⁹⁶ NRD 30

³⁹⁷ NRD 32, 27, 16, 33, 02, 30, 34, 21, 39

do them, that NDA should in fact do them. There may be other ways of meeting those needs.”³⁹⁸

217. Professor Sir David King, of the Smith School of Enterprise and the Environment, thought that the issue was not about changing the remit of the NDA (which would still have to deal with the proportion of the plutonium stockpile considered to be “waste”) but about the need for “an overarching body that takes the big view” on whether the plutonium was waste or fuel before it was sent to NDA: “the important thing is not to simply say that this is all waste”.³⁹⁹ As it stands however the NDA owns significant amounts of uranium and plutonium and is accountable for its “safe management” regardless of whether it is waste.⁴⁰⁰
218. There is an urgent need to deal with the clean-up of legacy waste. In these circumstances we have come to the conclusion that the NDA’s remit should not be changed. But the difficult decision remains as to who should be responsible for maintaining R&D capabilities and associated expertise in the areas of advanced fuel recycling and reprocessing (that would support a long-term energy policy), given that the NDA currently owns the majority of relevant assets and nuclear infrastructure but the NDA’s remit constrains their use by the wider research community (see paragraphs 233 to 234).
219. **We recommend that the Government, in consultation with the proposed Nuclear R&D Board, should consider which body should be given responsibility for maintaining R&D capabilities and associated expertise in advanced fuel recycling and reprocessing and, if none of the current bodies is considered to be appropriate, they should consider whether a new one should be established.** The Government should also work with the NDA to improve access to its facilities and expertise for research. (We discuss this further in paragraphs 233 to 234.)

New build wastes

220. Some witnesses suggested that the NDA’s remit should be reviewed so as to ensure full alignment with the current new build programme (given, for example, the shared need for disposal facilities for both new build and legacy waste and the need to maintain the skills base in order to deliver the disposal programme).⁴⁰¹
221. The evidence we received indicated some confusion about the NDA’s responsibilities for research on new build waste. Professor Lee, for example, told us that:

“from a CoRWM perspective, we feel that the responsibility for new build waste should fall with the NDA. We do not think it is appropriate for the Government to rely so heavily on the NDA and the potential new build operators to make arrangements between themselves to do the R&D on long-term management of new build spent fuels. As we know, the Government has responsibility to ensure that effective arrangements are in place for management of new build waste. Part of this

³⁹⁸ Q 257

³⁹⁹ Q 311

⁴⁰⁰ Q 257

⁴⁰¹ NRD 02, 23, 32, 34, 47

responsibility is to ensure that the NDA and the potential new build operators must do sufficient R&D.”⁴⁰²

222. EDF Energy argued that “the UK strategy should recognise that it is not sensible to develop separate R&D strategies for ‘legacy’ and ‘new build’ since in many areas the same work will be relevant to both”.⁴⁰³ The Environment Agency suggested that the NDA’s Radioactive Waste Management Directorate (RWMD) R&D programme should “take account of spent fuel from any new nuclear power stations, following on from the disposability advice that NDA RWMD is currently providing for station designs”.⁴⁰⁴ The NDA acknowledged that its responsibilities for new build waste were unclear: “there are ... a number of areas where NDA does feel a little constrained for example in regard to the arrangements for the provision of ... spent fuel management services for new nuclear build, where opportunities probably exist, but the NDA operating model makes these a little harder to access”.⁴⁰⁵ **We recommend therefore that the Government should clarify the NDA’s responsibilities for dealing with new build waste and for commissioning and co-ordinating research and maintaining R&D capabilities and associated expertise in respect of new build waste.**

Providing a national lead for nuclear research

223. Several witnesses, including EDF Energy, told us that many countries with successful nuclear programmes had one or more centres of excellence to lead their nuclear programme both nationally and internationally (see paragraph 160).⁴⁰⁶
224. The Dalton Institute argued that centres of excellence were necessary because “nuclear R&D facilities require tremendous infrastructure costs to build, commission and operate”.⁴⁰⁷ Globally, there has been a trend to reduce the number of facilities and focus collaborative programmes into fewer facilities. For this reason, in their view, “the UK nuclear R&D capability should be grown around centres of excellence that demonstrate the capability to establish key skills and facilities, enable facilities access, and provide clear pathways to impact”.⁴⁰⁸ They also suggested that “there is a growing awareness that to maximise research impact a clear link needs to be established between fundamental research, technology development, and the launch of new technologies. Without this link, universities [were] unlikely to ‘push’ research through to deployment, and industry [was] unlikely to invest to ‘pull’ technology forward”.⁴⁰⁹ Dr Daryl Landeg, the Chief Scientist at the Atomic Weapons Establishment, agreed.⁴¹⁰ Mr Allen from the TSB also noted the need for “support and connectivity across the whole R&D supply

⁴⁰² Q 259

⁴⁰³ NRD 49

⁴⁰⁴ NRD 34

⁴⁰⁵ NRD 57

⁴⁰⁶ NRD 49,32

⁴⁰⁷ NRD 09

⁴⁰⁸ NRD 09

⁴⁰⁹ NRD 09

⁴¹⁰ NRD 54

- chain, from basic to applied into commercialisation” to support the translation of research.⁴¹¹
225. RCUK said that at present “research council funding is centred around centres of excellence with support from a wider group of universities. Almost all of the research council portfolio is made up of projects involving more than one institution and the university sector collaborates on a range of training activities.” This “networking” was considered, in their view, to be a “key strength of the UK” as it “will build an internationally recognised UK research capability”.⁴¹²
226. The Dalton Institute agreed that the nuclear capability in some key UK universities had been strengthened over the last decade through initiatives including the BNFL University Research Alliances, the EDF Energy University research partnerships and the more recent Rolls-Royce Nuclear University Technology Centres. They also noted that “the EPSRC Keeping the Nuclear Option Open consortium provided the opportunity for a wider engagement of UK academia in nuclear research through collaboration with these recognised centres of excellence”. However, they and others took the view that, because of the weak international perception of the UK’s nuclear R&D, this was not enough to provide the necessary international leadership.⁴¹³
227. Professor Cowley from the CCFE agreed. He commented that, at present, there was a need for a lead centre, such as the previous UKAEA⁴¹⁴ with the “mandate to be the repository of the technical knowledge and the supplier of advice ... It cannot just exist in multiple places simultaneously.”⁴¹⁵ Mr Allen agreed that “historically, the UK did have a reputation of being able to [join up the research through to market] in the days of the UKAEA and CEGB. Now it is only partially realised in the areas where we still have strengths”. But in terms of new build out to 2050 this was not “in place at the moment”.⁴¹⁶
228. It was suggested by a number of witnesses, including Professor Sir John Beddington, that a consortium approach would be most appropriate to provide such a lead, combining both the applied capabilities within NNL with the expertise within universities:
- “The way that we had originally envisaged the Nuclear Centre of Excellence, which was going to be co-hosted by NNL but would involve university partnerships—in particular, Imperial College and Manchester—was an excellent idea⁴¹⁷... We now need to think about how we substitute that.”⁴¹⁸

⁴¹¹ Q 105

⁴¹² NRD 33

⁴¹³ NRD 09, 32, 44

⁴¹⁴ See footnote 3.

⁴¹⁵ Q 60

⁴¹⁶ Q 105

⁴¹⁷ The National Nuclear Centre of Excellence was disbanded following the change in Government.

⁴¹⁸ Q 86

NNL

229. Professor Cowley and many others suggested that NNL could fulfil this leading role, given that it has internationally recognised facilities for nuclear research and expertise in many areas, as well as connections to both academia and industry.⁴¹⁹ Professor Howarth, Chief Executive of NNL, told us:

“the National Nuclear Laboratory can take a lead role, effectively, in co-ordinating that work. We would bring the universities with us and we would also bring with us the industrial supply chain within the UK in this area as well and support those. We would effectively be in a position where we could spearhead and you would have this push-pull relationship between Government and the National Laboratory. That is what happens in other countries.”⁴²⁰

230. Mr Bigot explained to us that the national lead on nuclear research was often the national nuclear laboratory because, of their “expertise and capability to have in the long term a longstanding relationship with ... other countr[ies]” which extends beyond short-term political cycles.⁴²¹ He suggested that the UK should set up an “agency” to work on the Government’s nuclear policy. It would provide a mechanism for capitalising on the experience and expertise in the UK and enable discussions with similar agencies abroad (such as CEA) about ways of sharing experience and reducing costs.⁴²² Professor Howarth supported this proposal on the grounds that:

“in other countries, where, for example, the Government wish to take a strong international position associated with a low-carbon economy ... [their] credibility on the international stage comes from the research and work that it is doing, ... and is backed up by the national laboratory. ... internationally, the other national laboratories are seen as very strong centres of excellence within the countries and internationally.”⁴²³

231. In these cases, however, the laboratory, as Westinghouse told us, often “have a remit more focused on fundamental science, supported by government funding” and therefore acts as a recognised national centre of excellence for nuclear research in both basic and applied research. When we asked NNL whether they intended to develop a programme of basic research, they told us that they did not. In their view, basic research “needs to live within academia” with NNL being responsible for applied R&D and the translation of research (see paragraph 242). It would appear therefore that the national laboratory model may not be directly applicable to the UK at the present time as the NNL is not directly comparable to other national laboratories that fulfil this role. If NNL were to become a national lead, it would have to have extensive collaborations with the academic community. We have a number of concerns however about the difficulties involved in collaborating with NNL or gaining access to its facilities.

⁴¹⁹ Q 60

⁴²⁰ Q 330

⁴²¹ Q 352

⁴²² Q 357

⁴²³ Q 326

232. Whereas the CEA has 1,400 PhD students across their portfolio of work,⁴²⁴ when we visited NNL we were disappointed to find very few students or academics (about 20–30) working at the facilities.⁴²⁵ Several witnesses, including Professor Fitzpatrick, also felt that NNL activities did not compare well to other national laboratories “in terms of scale or scope of activity” even though it has unique and leading capability and competence in certain fields, and that it had a poor profile in terms of published work.⁴²⁶ Professor Fitzpatrick told us that, for this reason, “in its present form [NNL] cannot provide the research support for the development of future nuclear technologies nor act as a focus for such activity. As a research facility, it serves the existing nuclear industry, but it is not a national facility, such as those operated by the Science and Technology Facilities Council, that is easily accessible by University researchers”.⁴²⁷ (We discuss the constraints on NNL’s remit further in paragraphs 239 to 253.)
233. The Universities of Bristol and Oxford and others said that access to facilities at NNL for handling active materials was difficult and prohibitively expensive for academics.⁴²⁸ Professor Roger Cashmore, Chair of the CCFE, also said that there was a need to move away from full economic costing to encourage the use of NNL’s expertise and facilities.⁴²⁹ Several witnesses, including CoRWM, argued that “NNL remains at a commercial disadvantage compared with its overseas competitors”.⁴³⁰ It is far easier for researchers from the UK to access overseas facilities than it is to access those at NNL, for a fraction of the cost. Sellafield Ltd told us that:
- “US funding arrangements allow academics to use the national laboratory HA [higher active] facilities at virtually no cost to their university, and this leads to spin off developments which can be launched to market. This mix of Government, academia and industry working together maximises networking and learning across the whole sector, leading to innovation benefits for US Government projects”.⁴³¹
234. NNL and the University of Manchester have developed processes to ensure academic access to these facilities.⁴³² However, for other universities, it is still very difficult and there is a need, in our view, for NNL to improve access further to encourage collaborations with academia. NNL’s remit also restricts its ability to carry out work collaboratively with academia that is not of direct commercial value. (We discuss this further in paragraphs 239 to 253.)

The Culham Centre for Fusion Energy (CCFE)

235. Several witnesses, including Professor Sir David King, of the Smith School of Enterprise and the Environment, suggested that the CCFE may be a better lead, given that it is an internationally recognised centre of excellence for

⁴²⁴ Q 361

⁴²⁵ See Appendix 5.

⁴²⁶ NRD 22, 39, 44

⁴²⁷ NRD 44

⁴²⁸ NRD 36 and 10, 17, 44, 50

⁴²⁹ NRD 13

⁴³⁰ NRD 17, 38

⁴³¹ NRD 23

⁴³² NRD 33

nuclear research and has capabilities of relevance to the development of Generation IV technologies.⁴³³ The CEA, for example, is responsible for both fusion and fission research, given the significant cross-over in research in these areas or relevance to advanced nuclear technologies. Professor Keith Mason, Chief Executive of the STFC told us that “there is a lot of capability that is being developed around the fusion programme, but [it] is equally applicable to Gen IV”.⁴³⁴ Dr Taylor of ISIS also suggested that, because of the UK’s internationally recognised expertise in fusion, “we would be a very attractive partner in those areas where we have been pursuing research on the fusion agenda”.⁴³⁵

236. The UK Atomic Energy Authority also noted the significant cross-over in expertise: “CCFE is a repository of knowledge, research expertise, and nuclear skills. This capital has been nurtured for the fusion programme but also offers crucial capabilities for the UK to grow an advanced Generation IV fission programme, as we think it should.” They explained: “Engineering synergies between fusion and fission include materials, structural integrity, heat transfer and the remote handling needed to maintain and refurbish reactors” and “fusion development would benefit from the training of a new generation of nuclear engineers. And in turn, fission could benefit from engineering expertise nurtured in the UK fusion programme. This expertise will be required in the design of both future fusion and fission power plants”.⁴³⁶ The CCFE also currently collaborates with Oxford University and French experts in fission materials research.⁴³⁷
237. Culham does not however have a remit to undertake work to meet the UK’s national nuclear fission energy R&D needs and it is not clear from the evidence we received if it has sufficient facilities links with the main universities, with nuclear fission expertise in the UK or with industry.
238. Although the weight of evidence favoured a national centre of excellence to act as a national lead for research, it appears that, at present, there is no single body with the necessary breadth of capabilities to fulfil this role. It is for this reason that we have proposed (in paragraph 143) that many of the functions of a national centre of excellence should be subsumed into the remit for the proposed Nuclear R&D Board. As the major nuclear research organisations in the UK will be represented on the Board, collectively they will have available to them the expertise and capabilities to carry out many of these functions. For those functions that it is not able to fulfil, it will also be able to advise Government on how to take them forward—in particular, to examine mechanisms to ensure that the UK is able to take a central role in international nuclear research collaborations and signal to the international research community that the UK is a credible and willing partner for such collaborations.

The role of NNL

239. Given our conclusion above, and the key role that NNL will play within the Board, we considered whether the role of NNL should be reviewed.

⁴³³ QQ 312, 317, 213–215

⁴³⁴ Q 213

⁴³⁵ Q 214

⁴³⁶ NRD 35

⁴³⁷ NRD 21

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See Appendix 1

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Current role

240. The Government describes the objective of NNL as follows: “to become a centre of expertise in applied nuclear research and development, serving primarily the needs of legacy nuclear waste clean-up, and to play a key role as a world class provider of science based technology solutions and research services”. They acknowledged that “there is a need to safeguard the skills and capabilities within NNL that are fundamental to the NDA’s mission and on a demand basis support wider government nuclear policy development and implementation”.⁴³⁸
241. NNL is a private limited company in which DECC holds all the shares through a holding company, NNL Holdings Ltd run by the Management Contractor SBM, a consortium consisting of Serco, Battelle and the University of Manchester. NNL competes with private sector providers for research contracts, charged on a full commercial basis, with no government support or subsidy.
242. According to the Government, NNL fulfils its R&D remit appropriately.⁴³⁹ Mr Higson of the OND told us that NNL had “a very important role in maintaining the skills base in the United Kingdom” and that, in the Government’s opinion, “that is best maintained, particularly for the longer term, by NNL operating in effect on a commercial-based model”.⁴⁴⁰ NNL however disagreed. In their view, their remit was too heavily focused on the legacy waste management programme and should be broadened to include the following:
- (1) appropriate stewardship of the UK’s strategic nuclear skills, capabilities and knowledge especially in nuclear fuel cycle technology:
 - to meet R&D needs on legacy clean-up;
 - to support current nuclear operations; and
 - to meet the UK’s climate change commitments and energy supply security;
 - (2) acting as technical advisor to the Government on civil nuclear fission energy and subsequently lead national strategic R&D programmes and activities;
 - (3) becoming a world class centre of expertise in applied R&D supporting public and private sector customers in the UK and internationally across the nuclear fuel cycle; and
 - (4) maintaining NNL’s sound financial footing with income from commercial and other sources as appropriate, developing its customer base and optimising the use of its facilities.⁴⁴¹
243. Several witnesses were critical of NNL’s solely commercial status and lack of government funding. They commented, in particular, that as a result, its work was too focused on the short-term needs of customers rather than conducting research of national need.⁴⁴² Many of the revised objectives

⁴³⁸ NRD 21

⁴³⁹ NRD 21

⁴⁴⁰ Q 38

⁴⁴¹ NRD 60

⁴⁴² NRD 04, 05, 23, 24, 29, 30, 37,39, 44

would, in our view, enable NNL to broaden its remit to provide a valuable contribution to the Nuclear R&D Board.

244. NNL told us that they have “the technical capabilities to undertake R&D across all areas in the nuclear fuel cycle”, but that maintaining these capabilities in the future would require “longer term R&D programmes across the technology chain with NNL leading Technology Readiness Levels (TRL) 3–6 but integrating academic research and industry longer-term needs” (see Figure 3 and 4 on pages 19 and 20). They envisaged that the programmes should cover strategic areas such as “plutonium disposition and fuel cycle options” and would need to “utilise the world class radioactive facilities at its laboratories that have yet to be fully commissioned”.⁴⁴³
245. At present, although NNL has a remit to maintain R&D capabilities and associated expertise in these strategic areas of relevance to the NDA’s remit, it has not been given a block grant to do so⁴⁴⁴ and does not have “an R&D remit on behalf of Government” to carry out a programme of research of national need to maintain such capabilities.⁴⁴⁵ NNL, and many others, took the view that NNL was best placed to take the lead on translational research for the UK.⁴⁴⁶ Commenting on this Professor Howarth said:
- “the key aspect here is that we as a country require a cadre of subject matter experts in a whole range of disciplines to support all our nuclear activities ... [with] a close link between academia and industry. They need to understand working in an academic sense and the fundamental principles associated with a bottom-up understanding of nuclear operations. They also need to have a proper understanding of the industrial context of those operations. That translation happens through a national laboratory. That is a role that the National Laboratory plays, joining those two ends together, and in the facilities that we operate—unique, critical, state-of-the-art facilities—that help to translate that research through” (see paragraphs 229 to 232).⁴⁴⁷
246. Dame Sue Ion said that she failed to see “how you can maintain a skills base in advanced systems and even in today’s systems unless you have money to help you to do that”.⁴⁴⁸ She advocated giving NNL “some form of funding to particularly maintain a skills base in systems work”.⁴⁴⁹ At present NNL uses its own funding for a minimal (£1 million) internal R&D programme for long-term research of national importance (including plutonium disposition). The rest of its profit is returned to the HM Treasury to offset losses incurred by the business prior to April 2009⁴⁵⁰ (save that an arrangement was reached recently to use some of this money to fund the commissioning of part of the Phase 2 laboratory and the Windscale laboratory).⁴⁵¹

⁴⁴³ NRD 07

⁴⁴⁴ NRD 10

⁴⁴⁵ NRD 07

⁴⁴⁶ NRD 05, 07, 23, 27, 30, 32, 37 41; QQ 241, 328, 330

⁴⁴⁷ Q 328

⁴⁴⁸ Q 54

⁴⁴⁹ Q 55

⁴⁵⁰ NRD 07, 09

⁴⁵¹ NRD 60

247. When we asked Professor MacKay if he thought that DECC should be giving funding to NNL, he said that the arguments for doing so were “strong”.⁴⁵² Providing NNL with a modest sum of money to fund strategic research of national need not, in our view interfere with its ability to generate money through commercial contracts, as other national laboratories do. It would, however, allow it to carry out R&D of national strategic need that is not commercially viable, which at present it is not able to do.

Comparisons with other national laboratories

248. The role of NNL is in stark contrast to the role of national laboratories in other countries.⁴⁵³ NNL told us that “all international national laboratories have some direct funding to undertake strategic R&D programmes of national interest often with a remit to supplement government funding through third-party contracts for R&D ... Most national laboratories are advisers to their governments and other national stakeholders and provide a degree of R&D co-ordination. ... the nature of NNL’s funding means that the focus is on addressing short-term customer needs rather than longer-term strategic requirements.”⁴⁵⁴ At present NNL provides advice to Government on an ad hoc basis, recently providing staff to advise Government on the Fukushima incident. However it does not receive funding in recognition of this important role.⁴⁵⁵

249. It would seem therefore that, despite its best efforts, excellent facilities and expertise in a number of areas, constraints on its remit and funding mechanisms mean that NNL is a national laboratory in name only.

250. **We recommend that the Government extend the remit of NNL to enable it to carry out a programme of applied long-term R&D of national strategic need, under the direction of the proposed nuclear R&D Board, in order to maintain capabilities in vulnerable areas for which no body currently has responsibility for (such as advanced fuel recycling and reprocessing and deep geological disposal) and to maintain the breadth of R&D capabilities and associated expertise needed to meet the UK’s future energy policies.**

Contractual arrangement

251. NNL’s current contract is for “three plus one plus one” years. They are now in year three of that period with no clear plan of what will happen in the coming years. According to Professor Howarth, this contrasts with “other national laboratories in the UK, like the National Physical Laboratory” which “have long-term time horizons of 10 years plus”.⁴⁵⁶ This short-term contractual arrangement impacts on the ability of NNL to attract the sort of investment which would enable it to maintain important national capabilities which are not of immediate commercial value. For example, the University of Central Lancashire told us that industry was reluctant to invest in the

⁴⁵² Q 86

⁴⁵³ NRD 16, 20, 30, 41

⁴⁵⁴ NRD 07

⁴⁵⁵ NRD 60

⁴⁵⁶ Q 335

facilities for Phase 3 partly because of the absence of a Government policy or strategy on nuclear.⁴⁵⁷

252. Speaking on behalf of NNL's managing contractors, Professor Howarth told us that the companies would themselves invest in the Phase 3 facilities if NNL's contract were extended to allow it to consider longer-term assets. In order to do this, the contractors would like to see:

“a long-term time horizon for the NNL ... to attract the best individuals to work at the National Nuclear Laboratory to keep this UK capability alive ... [and] in order to support the UK national strategy in nuclear”.⁴⁵⁸

253. **The Government should extend the length of NNL's contract to allow it to invest, and attract investment, in the infrastructure and expertise required to support longer-term research objectives.**

⁴⁵⁷ NRD 30

⁴⁵⁸ Q 332

CHAPTER 8: THE NEED FOR AN INTEGRATED POLICY APPROACH TO MAINTAINING NUCLEAR R&D CAPABILITIES AND ASSOCIATED EXPERTISE

254. A number of witnesses highlighted the need for Government energy policy to be based on an holistic view of the nuclear fuel cycle, taking into account not only priorities to meet the low-carbon economy targets and energy security objectives (including decommissioning and waste management and disposal) but also the commercial opportunities that the fuel cycle provide, as well as security and non-proliferation and defence policies.⁴⁵⁹ Post-Fukushima, there have also been calls for the better integration of nuclear safety with nuclear security policies.⁴⁶⁰ Professor Sir David King, of the Smith School of Enterprise and the Environment, for example, referred to the need for a “fully integrated policy” to address the questions:

“What does the long-term pathway for civil nuclear power generation in the UK look like and what are the drivers going to be? ... What are the commercial ways of optimising Britain’s nuclear assets? ... How can we address non-proliferation issues regarding the fuel cycle and the risk of fissile material being diverted for nuclear weapons? [and] What are the environmental impacts and opportunities for developing a long-term approach to nuclear, particularly in terms of reducing carbon dioxide emissions ... ?”⁴⁶¹

255. Responsibilities for nuclear energy production and decommissioning and waste management, nuclear safety, non-proliferation and security, and for exploiting the commercial potential from the nuclear R&D capabilities and associated expertise in the UK are split between DECC, the Department for Work and Pensions (DWP), MoD and BIS respectively. Whilst we have not been able to examine the need for an integrated policy approach in detail or the impact that such an approach would have on assessing R&D capabilities, we would like to draw attention to two examples that emerged from the evidence which suggest that at present there is insufficient cross-departmental working or integrated thinking in the development of policy areas of relevance to nuclear or consideration of the overlapping R&D requirements for these policies. The first is the decision, subsequently reversed, to withdraw from membership of the NEA; and the second is the Government’s failure to adopt an integrated approach to considering the value of the UK’s reprocessing and advanced fuel recycling capabilities at Sellafield (as discussed in paragraphs 208 to 219).

The Nuclear Energy Agency (NEA)

256. The NEA assists member countries in “maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes”.⁴⁶² In 2010, the Government signalled

⁴⁵⁹ Q 319

⁴⁶⁰ *Time for an Integrated Approach to Nuclear Risk Management, Governance and Safety/Security/Emergency Arrangements*, The World Institute for Nuclear Security, May 2011.

⁴⁶¹ Q 307

⁴⁶² NRD 47

an intention to withdraw from membership of the NEA at the end of 2011.⁴⁶³ This decision was reportedly viewed with “incredulity”⁴⁶⁴ by other countries, given the UK’s commitment to nuclear safety and non-proliferation on the international stage. We asked some of our witnesses about the decision. Serco Energy told us that membership of the NEA was important “to provide access to modelling codes ... and nuclear data”,⁴⁶⁵ for which, Dame Sue Ion told us, “there are multiple users and beneficiaries”.⁴⁶⁶ Dame Sue said that “when the decision was taken there was insufficient understanding as to the value of membership of NEA ... and the extent to which the database was used across multiple sectors in the UK”.⁴⁶⁷ We were reassured to hear therefore that the Government has now come to an arrangement to continue the UK’s membership of the NEA.⁴⁶⁸

Reprocessing and advanced fuel recycling

257. The UK is considered to have “internationally competitive resources” in reprocessing and advanced recycling capabilities.⁴⁶⁹ In March 2011, the Smith Institute of Enterprise and the Environment at the University of Oxford produced a report entitled *A low carbon nuclear future*. The report suggested that the commercial opportunities for the UK in pursuing nuclear fuel recycling alongside the new build programme were potentially significant—(£10 billion)—and could also lead to the creation of 45,000 new high-tech jobs over the next 20–30 years.⁴⁷⁰ Doing so would also reduce the UK’s volume of radioactive waste and significantly reduce the risk of proliferation. Although there are differences in opinion about the commercial viability of providing reprocessing and fuel recycling services globally, it is generally agreed that reusing the UK’s plutonium stockpile would be a cheaper option than treating it as waste.⁴⁷¹

258. Professor Sir David King said that:

“there is a massive legacy for the Government to deal with. A Government investment programme is required to manage that properly and in good time. ... whereas we could treat the plutonium as an £8 billion legacy waste problem, the alternative is to treat the plutonium as a fuel and minimise the cost to the public purse going forward ... We ... have a very big stockpile up in Cumbria, so it is the biggest opportunity for us. But we also have 60,000 tonnes of uranium. There is 100 tonnes of plutonium and a good amount of uranium. We need to optimise how we use that as we move forward.”⁴⁷²

259. At present, the Government is consulting on options to deal with the UK’s plutonium stockpile. The preferred option is to continue recycling spent fuel

⁴⁶³ NRD 70

⁴⁶⁴ NRD 43, Q 61

⁴⁶⁵ NRD 22

⁴⁶⁶ NRD 29

⁴⁶⁷ Q 61

⁴⁶⁸ NRD 70

⁴⁶⁹ NRD 13, 05, 39, 50; *A Review of the UK’s Nuclear R&D Capability* op. cit.

⁴⁷⁰ NRD 14, 29

⁴⁷¹ Q 144

⁴⁷² Q 302

and to procure a MOX plant to convert it into MOX fuel and to burn it in nuclear reactors, as Sir David suggests (although there are other fuel-based options). But, as already mentioned, because of the NDA's remit for decommissioning and waste management of legacy waste, and of the absence of a global market for the UK's uranium or plutonium, NDA have decided to cease operating the UK's only reprocessing plant, Thorp, in 2018. In August 2011, they also announced that they would cease operations at SMP immediately (see paragraphs 208 to 219 above).

260. Given that these capabilities may be required to deal with the plutonium stockpile in the future, are required to keep the option of a significantly increased nuclear contribution open and may be of significant commercial value to the UK, this seems to be a short-sighted approach to dealing with these capabilities. We would also question whether, in the long term, the Government's continued support for once-through fuel cycle technologies is compatible with their commitment to reduce the proliferation risk from nuclear material and to reduce waste in the long-term.
261. **We recommend that responsibility for co-ordinating overlapping nuclear R&D capability requirements across Government should be assigned to the proposed Nuclear R&D Board to ensure that the UK's nuclear R&D capabilities and associated expertise match the UK's requirements across different policy areas in the long term.**

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

262. The UK's energy policy aims to achieve the following objectives. (I) Energy security, protecting consumers against fluctuations in the supply of fossil fuels from outside the UK. (II) Reductions in greenhouse gas emissions to meet the legally binding commitments of the Climate Change Act (2008). (III) Affordability, ensuring that consumers are not obliged to pay more than necessary. (IV) Safety of supply. The Government have said that it will deploy a portfolio of energy sources including nuclear, renewable and fossil fuels with carbon capture and storage (CCS)⁴⁷³. There are a range of scenarios with different proportions of these three sources, but it is widely agreed that nuclear energy will play a significant role in the portfolio. (paragraph 1)
263. The Government plans to give the go ahead to start building new nuclear capacity in the UK in the next few years, which will generate 16 GW of power. Some experts suggest that 12 GW of energy generation is the minimum contribution that nuclear could make to the energy portfolio up to 2050. However, the weight of evidence indicates that a significantly higher contribution of around 22–38 GW is likely to be required to enable early decarbonisation of the sector before 2030 and to meet the UK's long-term greenhouse gas emission targets up to 2050 and beyond. (paragraph 44)
264. The Government should now put in place plans which provide for a range of contributions from nuclear energy to the overall energy portfolio—from low to high—to meet the UK's future energy needs up to 2050 and beyond. These plans should ensure that the UK has adequate R&D capabilities and associated expertise to keep the option of a higher nuclear energy contribution to the energy portfolio open and recognise that maintaining sufficient capabilities and suitably trained people will require a long lead time. (paragraph 45)
265. We do not believe that the UK has sufficient R&D capabilities and associated expertise to be able to cope with the current nuclear programme up to 2050, let alone a significantly extended programme. This is because the UK's current R&D capability is, to a significant extent, based upon an ageing pool of experts built on past investments in R&D. This means that in a few years' time, there will be crucial gaps in capabilities. A new stream of experts will need to be generated in the near future if the UK is to retain sufficient capabilities to be an intelligent customer and regulator in the future up to 2050. It takes years to develop a significant cadre of suitably trained experts with industry experience and the sector is reliant on the research base to train these experts. Sufficient investment in the research base will therefore be necessary in order to make up for the lack of investment in the last two decades. (paragraphs 99 and 100)
266. The evidence we received demonstrates a significant difference of opinion between, on the one hand, the Secretary of State and some senior Government officials who appear to believe that no action is required to sustain the nuclear research base and, on the other hand, other stakeholders, including the GCSA and DECC CSA, who argue that serious action is required. The Government's view that the need for R&D capabilities and

⁴⁷³ As well as increasing energy efficiency and reducing demand.

associated expertise in the future will be met without Government intervention is troublingly complacent. (paragraph 101)

Long-term policy planning to encourage low-carbon technologies

267. We recommend that the Government should set out a long-term strategy for nuclear energy, outlining:

- how they intend to keep the options open to ensure that, if required, nuclear can contribute more to the energy portfolio beyond the current plans for new build up to 2025; and
- how R&D capabilities and the associated expertise will be maintained to keep the different nuclear energy options open;
- how they intend to support the exploitation of the UK's strengths in the research base for the commercial benefit of the UK; and
- the role they envisage the UK playing in the global nuclear market over the period to 2050 and beyond. This should cover both the development of the supply chain for Generation III technologies and the UK's involvement in the development of new nuclear technologies in the future.

The strategy should extend up to and beyond 2050. (paragraphs 63 and 79)(**Recommendation 1**)

Energy Security

268. The Government have made a commitment to improve the UK's energy security by reducing reliance on fossil fuels. But in oral evidence the Secretary of State indicated that he could envisage a future in which fossil fuels will dominate. This apparent inconsistency causes us to question whether the current policy framework is sufficient to encourage more secure, low-carbon sources such as nuclear energy and renewables. (paragraph 86)

R&D Roadmap

269. We recommend that, as part of its long-term nuclear energy strategy, DECC should lead the development and implementation of a long-term R&D roadmap in collaboration with industry, academia, the CCFE and NNL to ensure that the UK has adequate R&D capabilities and the associated expertise to keep a range of nuclear energy options open up to 2050 and beyond. (paragraph 142)(**Recommendation 2**)

270. The roadmap will:

- improve co-ordination of R&D and associated expertise and ensure that research on strategically important and vulnerable areas, such as Generation IV technologies and advanced fuel recycling and reprocessing, is covered within a national R&D nuclear programme;
- ensure that the UK maintains a healthy research base to attract people into the field to maintain capabilities for the future;
- provide clarity and attract potential international collaborators (this issue is discussed further in paragraphs 148 to 155 below); and
- provide industry with sufficient clarity to encourage them to invest in R&D and associated expertise in the UK. (paragraph 141)

271. Without the roadmap there is a danger that the UK will lose its capabilities to act as an intelligent customer and regulator in the next 10–20 years.

Nuclear R&D Board

272. We recommend that the Government should establish a body (which we suggest may be called the Nuclear R&D Board: “the Board”) with both advisory and executive functions.

(a) Composition

The Board should be made up of experts drawn from the Government, industry and academia. It should have an independent, expert, authoritative chairman who commands the respect of the public and industry, and members which include non-executive members. The members should be appointed through the Appointments Commission.

(b) Status

The Board should, at the earliest opportunity, be established as a statutory Non-Departmental Public Body accountable to the Secretary of State for Energy and Climate Change. Pending the legislation needed to bring this recommendation into effect, the Government should, as an interim measure and without delay, establish the Board as an Executive Agency within DECC.

(c) Purpose

The purpose of the Board would be to:

- advise DECC on the development and implementation of the nuclear R&D roadmap and the Government’s nuclear energy strategy;
- monitor, and report on, progress by DECC with regard to the development and implementation of the roadmap and the strategy;
- advise the Government, industry and academia on involving UK researchers in national and international collaborations and, where appropriate, facilitating such involvement;
- examine what mechanisms are needed to signal to the international research community that the UK is a credible and willing partner for international collaborations;
- maintain a strategic overview of nuclear R&D (including research facilities) and related training, and where appropriate, facilitate the co-ordination of activities within the research community;
- establish a clear link between fundamental and applied research through to commercial exploitation for the benefit of the UK;
- identify R&D areas of strategic importance that are either missing or vulnerable and, where necessary, commission research to complement the current R&D activities; and
- facilitate public engagement activities on the use of nuclear technologies.

(d) Reporting

The Board should report annually to the Secretary of State on its assessment of DECC's progress with regard to the development and implementation of the roadmap and the strategy, and other activities. The Secretary of State should be required to lay the Board's annual report before Parliament.

(e) Funding

The Board should be given a modest amount of new funding (not drawn from BIS's science and research budget) to carry out its activities. It should also have the power to attract money from industry and elsewhere. (paragraph 143)(**Recommendation 3**)

Funding

273. We are very aware of the current climate of financial stringency. But if the Government's programme for nuclear energy is to have credibility, it must be backed up by adequate funding provision. We recommend that the Government should discuss with the relevant stakeholders what additional funding is required to implement the R&D roadmap. This funding might come from a combination of stakeholder contributions or the reallocation of funding from other sources (for example, reallocation of around 1% of the £2.8 billion allocated to decommissioning and clean up each year). (paragraph 152)(**Recommendation 4**)

What should be in such a roadmap?

274. Further to Recommendation 2, within the R&D Roadmap the proposed nuclear R&D Board should:
- outline a strategic approach to the UK's involvement in international collaborations (through programmes such as Euratom) to ensure that the UK has sufficient expertise, national programmes and facilities to be seen as an attractive and credible partner for research collaborations; (paragraph 161)
 - consider what level of engagement in future technologies is necessary at both the national and international level to enable the UK to maintain sufficient capabilities within this area of research, focusing on strategic areas of UK strength; (paragraph 171)
 - investigate further the potential for access to research reactor and other nuclear research facilities abroad, within a globally co-ordinated programme of research collaborations; (paragraph 176)
 - integrate the ONR strategy into the roadmap which should set out how the UK will maintain its international reputation for nuclear safety expertise; (paragraph 195) and
 - include research on the societal and ethical dimensions of the use of nuclear energy in the UK as an integral part. (paragraph 204)
275. We recommend also that the Government reinstates UK active membership of GIF at the earliest opportunity. (paragraph 172)(**Recommendation 5**)

Research Facilities

276. We recommend that the proposed Nuclear R&D Board should work with DECC, NNL, the NDA, BIS, the research councils and relevant industry groups to develop a business case to commission the Phase 3 laboratory at NNL as a national research facility for studying irradiated materials, taking into account its wider value to the nuclear sector and to the research community for research and, in particular, its contribution to training the next generation of experts and increasing the attractiveness of the UK as a destination for international research collaboration. (paragraph 181)(**Recommendation 6**)

Legacy and existing systems waste

277. We recommend that the NDA, NERC and other relevant funders ensure that sufficient R&D capabilities and associated expertise are maintained over the longer term to manage legacy and existing systems waste. (paragraph 189) (**Recommendation 7**)
278. As part of these efforts, we suggest that:
- the NDA develops a long-term research programme outlining how it will ensure that there are adequate R&D capabilities and associated expertise to meet its future needs for geological disposal and the disposition of the UK's plutonium stockpile;
 - the research councils, particularly NERC, works with the NDA to ensure that sufficient fundamental research on radioactive waste management and disposal is commissioned to maintain R&D capabilities and associated expertise in this field and to ensure that research efforts are effectively co-ordinated across the research councils; and
 - RCUK commissions an independent review of the UK's R&D capabilities and associated expertise in radioactive waste management and disposal. (paragraph 190)

Nuclear Safety Research

279. We recommend that the ONR should not wait until it has been set up as a statutory corporation to establish a reformulated NuSAC, but should do so as soon as possible. The advisory committee should provide independent and transparent advice and external challenge to the ONR's work for both the Chief Nuclear Inspector and the Secretary of State. (paragraph 197)(**Recommendation 8**)
280. We would also urge the Government to ensure that there is no further delay in converting the ONR to a statutory corporation and that in the meantime it is able to continue with the existing arrangements that are in place (for example the interim arrangements on pay discussed in paragraph 130). (paragraph 198)

Skills

281. We recommend that Cogent should conduct a comprehensive assessment of the current provision of undergraduate, Masters and PhD courses relevant to the nuclear sector to determine whether they are sufficient to meet the future needs of the research community, the regulator and industry for both the

current plans for new build and an extended programme up to 2050. (paragraph 127) (**Recommendation 9**)

Roles and responsibilities

282. Given the evidence of the apparent confusion about the role of DECC, for the avoidance of doubt, we recommend that DECC should be designated as the lead department in developing a national nuclear policy and R&D roadmap, outlining what R&D capabilities and associated expertise are necessary to support its policies. (paragraph 200) (**Recommendation 10**)

Responsibilities for advanced fuel recycling and reprocessing

283. We recommend that the Government, in consultation with the proposed Nuclear R&D Board, should consider which body should be given responsibility for maintaining R&D capabilities and associated expertise in advanced fuel recycling and reprocessing and, if none of the current bodies is considered to be appropriate, they should consider whether a new one should be established. (paragraph 219) (**Recommendation 11**)

The role of the NDA

284. We recommend that the Government should clarify the NDA's responsibilities for dealing with new build waste and for commissioning and co-ordinating research and maintaining R&D capabilities and associated expertise in respect of new build waste. (paragraph 222) (**Recommendation 12**)

The role of NNL

285. We recommend that the Government extend the remit of NNL to enable it to carry out a programme of applied long-term R&D of national strategic need, under the direction of the proposed nuclear R&D Board, in order to maintain capabilities in vulnerable areas for which no body currently has responsibility for (such as advanced fuel recycling and reprocessing and deep geological disposal) and to maintain the breadth of R&D capabilities and associated expertise needed to meet the UK's future energy policies. (paragraph 250) (**Recommendation 13**)
286. The Government should extend the length of NNL's contract to allow it to invest, and attract investment, in the infrastructure and expertise required to support longer-term research objectives. (paragraph 253)

The need for an integrated policy approach

287. We recommend that responsibility for co-ordinating overlapping nuclear R&D capability requirements across Government should be assigned to the proposed Nuclear R&D Board to ensure that the UK's nuclear R&D capabilities and associated expertise match the UK's requirements across different policy areas in the long term. (paragraph 261) (**Recommendation 14**)

APPENDIX 1: MEMBERS AND DECLARATIONS OF INTEREST

Members:

- Lord Broers
- Lord Crickhowell
- Lord Cunningham of Felling
- * Lord Jenkin of Roding
- Baroness Hilton of Eggardon
- Lord Krebs (Chairman)
- Baroness Neuberger
- * Lord Oxburgh
- Lord Patel
- Baroness Perry of Southwark
- Lord Rees of Ludlow
- Earl of Selborne
- Lord Wade of Chorlton
- Lord Warner
- Lord Willis of Knaresborough
- Lord Winston
- * Co-opted member

Specialist Adviser:

Dr Robin Grimes, Director of the Centre for Nuclear Engineering and Professor of Materials Physics, Imperial College London

Declared Interests

Members declared the following interests relevant to the inquiry:

- Lord Broers
 - Fellow, Royal Society*
 - Fellow, Royal Academy of Engineering*
- Lord Crickhowell
 - None*
- Lord Cunningham of Felling
 - None*
- Baroness Hilton of Eggardon
 - None*
- Lord Jenkin of Roding
 - Patron and Honorary Fellow, The Nuclear Institute*
 - Honorary President, The National Skills Academy Nuclear*
 - Honorary President, The Energy Industries Council*
 - President, Foundation for Science and Technology*
- Lord Krebs
 - Fellow, Royal Society*
 - Fellow, Academy of Medical Sciences*
- Baroness Neuberger
 - None*
- Lord Oxburgh
 - Fellow, Royal Society*

Royal Academy of Engineering

Lord Patel

*Chancellor, University of Dundee**Fellow, Royal Society Edinburgh**Fellow, Academy of Medical Sciences*

Baroness Perry of Southwark

None

Lord Rees of Ludlow

*Fellow, Royal Society**Fellow, Royal Academy of Engineering*

Earl of Selborne

*Chair, Advisory Committee for Centre for Ecology & Hydrology**Fellow, Royal Society*

Lord Wade of Chorlton

None

Lord Warner

None

Lord Willis of Knaresborough

None

Lord Winston

*Faculty member, Imperial College London**Member Engineering and Physical Sciences Research Council**Fellow, Royal Academy of Engineering**Fellow, Academy of Medical Sciences**Member, Scottish Scientific Advisory Committee**Director, Atazoa Ltd (a biotech company)*

A full list of Members' interests can be found in the Register of Lords Interests:
<http://www.parliament.uk/mps-lords-and-offices/standards-and-interests/register-of-lords-interests>

Dr Robin Grimes, Professor of Materials Physics, Imperial College

Member of the Scientific Advisory Group for Emergencies (SAGE) chaired by the Government Chief Scientific Adviser, Sir John Beddington, to address advice to UK nationals in Japan following the earthquake and tsunami.

(Committee now stood down.)

Director of the Rolls Royce University Technology Centre in Nuclear Engineering at Imperial College.

Holder of a number of research grants from RCUK and the EPSRC that support PhD students and Postdoctoral Research Fellows in areas related to nuclear energy and nuclear waste. In particular, principal investigator of the multi-university nuclear research coordination initiative.

Member of the Royal Society Working Group on Nuclear Non-proliferation.

Member of the NDA's research advisory board.

Member of the Technical Advisory Panel to the ONR's Report on the implications for the UK nuclear industry of the Fukushima nuclear accident.

Visiting Scientist at Los Alamos National Laboratory (unpaid).

APPENDIX 2: LIST OF WITNESSES

Evidence is published online at www.parliament.uk/hlscience and available for inspection at the Parliamentary Archives (020 7219 5314)

Evidence received by the Committee is listed below in chronological order of oral evidence session and in chronological and alphabetical order of written evidence. Those witnesses marked with * gave both oral evidence and written evidence. Those marked with ** gave oral evidence and did not submit any written evidence. All other witnesses submitted written evidence only.

Oral Evidence

- | | | |
|----|-----------|--|
| * | Q 1- 21 | Department of Energy and Climate Change, Committee on Climate Change, UK Energy Research Centre |
| * | | Energy Technologies Institute |
| ** | | Doug Parr, Chief Scientist, Greenpeace |
| * | Q 22-40 | Department of Energy and Climate Change, Office for Nuclear Development |
| * | Q 41-67 | Dame Sue Ion, Chair of the EURATOM Science and Technology Committee for the European Commission |
| * | | Professor Andrew Sherry, Director of the Dalton Nuclear Institute, Manchester |
| * | | Professor Steven Cowley, Chief Executive Officer, UK Atomic Energy Authority and Head of EURATOM/CCFE Fusion Association, Culham Centre for Fusion Research |
| * | | Professor Mike Fitzpatrick, The Open University, Materials Engineering, Head of Department, Chair of the Lloyd's Register Educational Trust Chair in Materials Fabrication and Engineering |
| * | Q 68-103 | Professor Sir John Beddington, Government Chief Scientific Adviser |
| * | | Professor David MacKay, Chief Scientific Adviser to the Department for Energy and Climate Change |
| ** | Q 104-146 | Nuclear Advanced Manufacturing Research Centre |
| * | | Rolls Royce |
| * | | Technology Strategy Board |
| * | Q 147-174 | Mr Simon Webster, Head of Unit Fission, DG Research, European Commission |
| * | | OECD Nuclear Energy Agency |
| * | Q 175-229 | Engineering and Physical Sciences Research Council, Science and Technology Facilities Council |
| ** | | Dr Andrew Taylor, Director, ISIS |
| ** | | Professor Sir Adrian Smith, Director General, Knowledge and Innovation, Department for Business, Innovation and Skills |

- * Q 230-255 Nuclear Industry Association
- * AMEC
- * EDF Energy
- ** Professor Sir Adrian Smith, Director General, Knowledge and Innovation, Department for Business, Innovation and Skills
- * Q 256-293 Nuclear Decommissioning Authority
- ** Professor Peter Style, Professor in Applied and Environmental Geophysics, Keele University
- * Professor William Lee, Deputy Chair, Committee on Radioactive Waste Management (CoRWM)
- * Environment Agency
- ** Q 294-317 Sir David King, Director, Smith School of Enterprise and the Environment, University of Oxford
- * Q 318-350 National Nuclear Laboratory
- * Q 351-362 Mr Bernard Bigot, Chairman, Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA).
- ** Q 363-391 Mr David Willetts MP, Minister of State for Universities and Science, Department for Business, Innovation and Skills
- ** Q 392-419 Mr Denis Flory, Deputy Director General and Head of Nuclear Safety and Security Department, International Atomic Energy Agency (IAEA)
- * Professor Tatsujiro Suzuki, Vice-Chair, Japanese Atomic Energy Commission
- * Professor Laurence Williams, Professor of Nuclear Safety, John Tyndall Institute for Nuclear Research, University of Central Lancashire
- * Q 420-440 Professor Nick Pidgeon, Understanding Risk Research Group, School of Psychology, Cardiff University
- ** Mr Michael Hanlon, Daily Mail Science Correspondent
- ** Mr Richard Black, BBC Environment Correspondent
- * Q 441-464 Mr Chris Huhne MP, Secretary of State for Energy and Climate Change
- * Q465-497 Dr Mike Weightman, Her Majesty's Chief Inspector of Nuclear Installations and Executive Head of the Office for Nuclear Regulation, Health and Safety Executive

Written Evidence in Numerical Order

- NRD 01 Lord Julian Hunt
- NRD 02 Horizon Nuclear Power
- NRD 03 British Geological Survey
- NRD 04 Professor R A Ainsworth, University of Manchester

	NRD 05	Prospect
	NRD 06	Mr Ernest Woodruff
*	NRD 07	National Nuclear Laboratory
*	NRD 08	Energy Technologies Institute LLP
*	NRD 09	Dalton Nuclear Institute, University of Manchester
	NRD 10	Professor Simon Biggs, University of Leeds
	NRD 11	Office for Nuclear Regulation
	NRD 12	National Physical Laboratory
	NRD 13	Professor Roger Cashmore, University of Oxford
	NRD 14	Royal Society of Chemistry
	NRD 15	Nuclear Physics Group, University of Manchester
	NRD 16	British Pugwash
*	NRD 17	Committee on Radioactive Waste Management (CoRWM)
	NRD 18	Institute of Ergonomics and Human Factors
*	NRD 19	Nuclear Decommissioning Authority
*	NRD 20	Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA)
*	NRD 21	Department of Energy and Climate Change
	NRD 22	Serco Technical Consulting Services
	NRD 23	Sellafield Ltd
	NRD 24	Nuclear Waste Research Forum
	NRD 25	Tokamak Solutions UK Ltd
	NRD 26	UK Research Centre in NDE, Imperial College London
*	NRD 27	Technology Strategy Board
*	NRD 28	Nuclear Industry Association
*	NRD 29	Dame Sue Ion
	NRD 30	University of Central Lancashire,
	NRD 31	Cambridge Nuclear Energy Centre, University Cambridge
	NRD 32	Westinghouse Electric Company
*	NRD 33	Research Councils UK
*	NRD 34	Environment Agency
*	NRD 35	United Kingdom Atomic Energy Authority and Culham Centre for Fusion Energy
	NRD 36	Bristol-Oxford Nuclear Research Centre
*	NRD 37	Rolls-Royce plc
	NRD 38	Institute of Physics
	NRD 39	Professor Malcolm Joyce, Lancaster University

	NRD 40	Professor James Marrow, Professor Steve Roberts and Professor Sir Chris Llewellyn-Smith, University of Oxford
*	NRD 41	AMEC
	NRD 42	Nuclear Waste Advisory Associates
*	NRD 43	Dr Adrian M Simper, Professor Graham Fairhall, Mr Peter Wylie, Professor Richard Clegg and Dr Bob Page
*	NRD 44	Professor Michael Fitzpatrick, Open University
	NRD 45	Dr Georges Van Goethem
	NRD 46	Mr Colin Megson
*	NRD 47	OECD Nuclear Energy Agency
	NRD 48	Professor Neil Hyatt, University of Sheffield
*	NRD 49	EDF Energy
	NRD 50	Engineering the Future Alliance
	NRD 51	Geological Society
	NRD 52	National Skills Academy for Nuclear
*	NRD 53	Mr Simon Webster
	NRD 54	Dr Daryl Landeg
*	NRD 55	Professor Nick Pidgeon, Cardiff University
*	NRD 56	Committee on Radioactive Waste Management (CoRWM) supplementary
*	NRD 57	Nuclear Decommissioning Authority supplementary
*	NRD 58	Dr Tatsujiro Suzuki
*	NRD 59	Nuclear Industry Association supplementary
*	NRD 60	National Nuclear Laboratory supplementary
*	NRD 61	Research Councils (EPSRC) supplementary
*	NRD 62	Professor Laurence Williams supplementary
*	NRD 63	Nuclear Industry Association further supplementary
	NRD 64	Horizon Nuclear Power supplementary
	NRD 65	Rolls-Royce plc supplementary
	NRD 66	Natural Environment Research Council
	NRD 67	Office for Nuclear Regulation supplementary
*	NRD 68	EDF Energy supplementary
	NRD 69	Office for Nuclear Regulation further supplementary
*	NRD 70	Department of Energy and Climate Change supplementary

Written Evidence in Alphabetical Order

Professor R A Ainsworth, University of Manchester (NRD 04)

* AMEC (NRD 41)

Professor Simon Biggs, University of Leeds (NRD 10)

Bristol-Oxford Nuclear Research Centre (NRD 36)

British Geological Survey (NRD 03)

British Pugwash (NRD 16)

Cambridge Nuclear Energy Centre, University of Cambridge (NRD 31)

Professor Roger Cashmore, University of Oxford (NRD 13)

* Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA) (NRD 20)

* Committee on Radioactive Waste Management (CoRWM) (NRD 17) (NRD 56)

* Dalton Nuclear Institute, University of Manchester (NRD 09)

* Department of Energy and Climate Change (NRD 21) (NRD 70)

* EDF Energy (NRD 49) (NRD 68)

* Energy Technologies Institute LLP (NRD 08)

Engineering the Future Alliance (NRD 50)

* Environment Agency (NRD 34)

* Professor Michael Fitzpatrick, Open University (NRD 44)

Geological Society (NRD 51)

Horizon Nuclear Power (NRD 02) (NRD 64)

Lord Julian Hunt (NRD 01)

Professor Neil Hyatt, University of Sheffield (NRD 48)

Institute of Ergonomics and Human Factors (NRD 18)

Institute of Physics (NRD 38)

* Dame Sue Ion (NRD 29)

Professor Malcolm Joyce, Lancaster University (NRD 39)

Dr Daryl Landeg (NRD 54)

Professor James Marrow, Professor Steve Roberts and Professor Sir Chris Llewellyn-Smith, University of Oxford (NRD 40)

Mr Colin Megson (NRD 46)

* National Nuclear Laboratory (NRD 07) (NRD 60)

National Physical Laboratory (NRD 12)

National Skills Academy for Nuclear (NRD 52)

Natural Environment Research Council (NRD 66)

* Nuclear Decommissioning Authority (NRD 19) (NRD 57)

* Nuclear Industry Association (NRD 28) (NRD 59) (NRD 63)

- Nuclear Physics Group (NRD 15)
- Nuclear Waste Advisory Associates (NRD 42)
- Nuclear Waste Research Forum (NRD 24)
- * OECD Nuclear Energy Agency (NRD 47)
- Office for Nuclear Regulation (NRD 11) (NRD 67) (NRD 69)
- * Professor Nick Pidgeon, Cardiff University (NRD 55)
- Prospect (NRD 05)
- * Research Councils UK (NRD 33) (NRD 61)
- * Rolls-Royce plc (NRD 37) (NRD 65)
- Royal Society of Chemistry (NRD 14)
- Sellafield Ltd (NRD 23)
- Serco Technical Consulting Services (NRD 22)
- * Dr Adrian M Simper, Professor Graham Fairhall, Mr Peter Wylie, Professor Richard Clegg and Dr Bob Page (NRD 43)
- * Dr Tatsujiro Suzuki (NRD 58)
- * Technology Strategy Board (NRD 27)
- Tokamak Solutions UK Ltd (NRD 25)
- UK Research Centre in NDE, Imperial College London (NRD 26)
- * United Kingdom Atomic Energy Authority and Culham Centre for Fusion Energy (NRD 35)
- University of Central Lancashire (NRD 30)
- Dr Georges Van Goethem (NRD 45)
- * Mr Simon Webster (NRD 53)
- Westinghouse Electric Company (NRD 32)
- * Professor Laurence Williams supplementary (NRD 62)
- Mr Ernest Woodruff (NRD 06)

APPENDIX 3: CALL FOR EVIDENCE

The Science and Technology Committee, under the Chairmanship of Lord Krebs, has launched a short inquiry to investigate whether the UK's nuclear research and development (R&D) capabilities are sufficient to meet its future nuclear energy requirements to 2050.

Background

The Government's finalised Energy National Policy Statements will be presented to Parliament for ratification in the spring and regulatory approval of nuclear reactor designs for new build plants is expected to be given later this year.

In recent months, a number of reports, including a report on nuclear fission by the Energy Research Partnership in September 2010, have highlighted the need for Government to look beyond current plans for nuclear new build and, looking ahead to 2050, to consider whether the UK satisfies the R&D requirements necessary to meet the country's demand for nuclear energy in the future.

A range of scenarios and roadmaps estimate that between 12 to 38 GW of nuclear capacity will be required if a secure, reliable and low carbon energy system is to be in place in the UK by 2050. Attempts have been made to assess the R&D capabilities that will be needed, now and in the future, to meet these future scenarios. Conclusions from this work indicate that, within the 2050 timeframe, deployment of a new generation of nuclear technology (Generation IV) is likely. If this is the case, a significant global R&D programme will be needed over the next few years to ensure successful delivery of Generation IV. Added to this, increasing demand for uranium, coupled with concerns about nuclear proliferation, will require consideration of the development of technologies associated with recycling of fuel and reprocessing plutonium. Assessment of the adequacy of the UK's nuclear R&D capabilities will need also therefore to include our being able to ensure a safe and secure supply of fuel and, when the time comes, its safe and secure disposal.

In these circumstances, the Committee has decided that it is timely to consider what role the UK should be playing in the coming years to develop these future technologies and what domestic R&D capabilities are needed to contribute to, and benefit from, international research programmes in order to meet our future nuclear energy needs.

The Committee decided to undertake this inquiry before the recent events in Japan concerning the Fukushima Daiichi nuclear plant. Consideration of health and safety R&D capabilities is inherent within the scope of this inquiry. These events confirm the importance of ensuring that the UK has adequate R&D capabilities to meet current and potential future needs for nuclear energy safely and securely.

The Committee is aware that the UK's nuclear interests extend beyond the UK's borders to international non-proliferation and security policies. The Committee fully acknowledges the critical importance of these policy areas. However, for the purposes of this present inquiry, our intention is to focus principally on UK nuclear R&D and our ability to meet future nuclear energy requirements, touching on other related policy areas only where they have implications relevant to this inquiry topic.

Questions

The Committee invites evidence on the following questions. Submissions are not required to cover all questions. **The deadline for written evidence submissions is Thursday 28 April 2011.**

The implications of future scenarios

- What are the research and capability requirements of nuclear energy policy options, roadmaps and scenarios up to 2050?
- What consideration is the Government giving to the UK's R&D requirements to meet the policy objectives for nuclear energy both in the near term and longer term (to 2050)? Does more need to be done?
- What research capabilities and commitments are required now to meet these future nuclear energy policies?

The research base

- Does the UK have adequate R&D capabilities, including infrastructure, to meet its current and future needs for a safe and secure supply of nuclear energy?
- Are there sufficient opportunities and avenues to conduct translational nuclear research in the UK to develop future technologies? Which bodies should be funding this work?

Competing in the global market

- What are the research areas in which the UK is recognised internationally as having strengths?
- What are the costs and benefits to the UK of a more or less active R&D capability within the country?

Strategic oversight and co-ordination

- Is there sufficient co-ordination between the bodies involved in nuclear research and, if not, how should it be improved? Who has oversight of the whole nuclear R&D landscape, including international activities?
- What role should the Government play in identifying gaps in research, providing oversight of the whole landscape and encouraging co-ordination between funders and deliverers? Are they fulfilling that role? Should more be done?

International and European research activities and comparisons

- Should the UK be involved in international and European research activities on nuclear? If so, how and what are the benefits and costs of doing so?
- What can the UK learn from how other countries presently organise and deliver R&D provision for nuclear? To what extent are other countries increasing or decreasing their research capacity in order to deliver future nuclear policies?

Roles and responsibilities

- Are the bodies involved in funding research and setting research agendas adequately fulfilling their roles and responsibilities? Should anything change?

- In particular:
 - (1) what is the role of the Research Council's cross-council Energy Programme? Is it giving sufficient attention to the UK's current and future nuclear energy research requirements?
 - (2) is the National Nuclear Laboratory fulfilling its R&D remit appropriately? Can it deliver the required research to support the UK's future nuclear energy policies? How does it compare to NNL's in other countries?
 - (3) is the Nuclear Decommissioning Authority's R&D remit still appropriate, given the UK's current and potential future nuclear policies?

The Committee would also be interested to hear about any other issues not already covered by this call for evidence that are relevant to the scope of the inquiry.

APPENDIX 4: SEMINAR HELD AT THE HOUSE OF LORDS

5 April 2011

Members of the Committee present were Lord Broers (acting Chairman), Lord Crickhowell, Baroness Hilton of Eggardon, Baroness Neuberger, Lord Patel, Baroness Perry of Southwark, Lord Rees of Ludlow, Earl of Selborne, Lord Wade of Chorlton, Lord Warner, Lord Willis of Knaresborough and Lord Winston.

Presentations were heard from:

- Professor Robin Grimes (Specialist Adviser to the Committee and Professor of Material Physics, Director of the Imperial Centre for Nuclear Engineering, Director of the Imperial College Rolls Royce University Technology Centre in Nuclear Engineering, Imperial College, London): introduction to the nuclear research and development landscape.
- (1) Mark Higson (CEO of the OND, DECC) and Katherine Randall (2050 Team Leader, DECC) and (2) Richard Heap, Executive Analyst, ERP): energy scenario analysis and implications for research and development capabilities.
- Dr Stephen Elsby (Senior Sector Manager, Energy Programme Portfolio Manager, EPSRC): an introduction to the Research Council's nuclear research and development activities.
- Les Philpott (Deputy Director, Office for Nuclear Regulation) and Andy Hall (Deputy Chief Inspector, ONR): an introduction to the ONR's research and development activities.
- Dr Melanie Brownridge (Head of R&D, NDA): an introduction to the NDA's research activities.

APPENDIX 5: VISIT TO THE NATIONAL NUCLEAR LABORATORY (NNL), NUCLEAR DECOMMISSIONING AUTHORITY (NDA) AND SELLAFIELD LTD

18 July 2011

Members visiting: Lord Krebs (Chairman), Lord Broers, Lord Crickhowell and Lord Willis of Knaresborough. In attendance: Elisa Rubio (Clerk) and Rachel Newton (Policy Analyst). A second visit by Lord Wade of Chorlton and Lord Jenkin of Roding took place in September 2011.

National Nuclear Laboratory

Presentation by Professor Paul Howarth, Managing Director

Professor Howarth described the operation of NNL. NNL was created in July 2008 and in April 2009 became a GoCo. The duration of the contract was three years with the possibility of extending the contract by one year and then another year. NNL employs approximately 780 staff over six sites and has a turnover of approximately £80 million. As a GoCo, NNL's operational model was unique internationally in that it had no baseline funding and therefore had to compete for all of its work. Vital work was carried out at NNL to support safety cases for continued operation of Magnox and AGR reactors, fuel processing facilities, waste plants and transportation. NNL's main customers were Sellafield UK, EDF Energy, the NDA, Magnox, MoD, Westinghouse, other Government departments and agencies, and regulators.

Professor Howarth gave an overview of the R&D roadmap work on which they were leading (on behalf of the ERP) and NNL's proposed revised remit⁴⁷⁴ to carry out more applied research of strategic need in the TRLs between universities and industry. He described French plans for advanced reactor deployment to 2060 and the timeline for deployment of Generation III and IV reactors. France's first demonstrator fast reactor was expected to become operational by 2021. Under current plans, France would be self-sufficient in plutonium by the end of the century due to their deployment of fast-breeder reactors. French plans contrasted with UK plans which went only up to 2025. The UK was one of the few countries that had demonstrated a fast breeder reactor but we were not working on this technology at present.

The question was raised as to why the UK industry was not funding more R&D work. It was suggested those the UK lacked a long-term strategy and vision for nuclear energy and that industry would not make investments when the future of nuclear energy in this country was unclear. Most companies involved in the nuclear industry were international companies which could invest in other countries that had better plans and visions.

Professor Howarth explained that a relatively small annual investment of £20–£30 million a year in nuclear R&D would position the UK on the world stage as a key player. The investment could see a return on that investment by a factor of 10 or 20 through leverage of international R&D programmes.

⁴⁷⁴ NRD 60

He also explained that NNL was in discussions with the CEA in France and laboratories in the United States about working in partnership and gaining access to their facilities for research. NNL was currently conducting an internal review which would look at whether there was sufficient demand to enable the Phase 3 laboratory to be commissioned as part of the overall requirements for highly active R&D facilities in the UK, including the use of the Windscale Laboratory.

Professor Howarth said that, at present, two PhD students from Manchester University were carrying out research at the Central Laboratory. Each summer they hosted a dozen students at NNL facilities, but agreeing access arrangements could be complicated because of site licence requirements. They also had their own intake of graduates each year and were currently sponsoring around 20 case award students. NNL had a number of formal visiting roles at universities including 12 visiting professors and six teaching fellows.

Presentation by Leigh Wakefield, Facilities and Safety Director

Mr Wakefield gave an overview of the Windscale Laboratory facility, a unique strategic asset in the UK, capable of handling irradiated nuclear fuel for post-irradiation examination. The facility had applications for all ongoing operational safety programmes. Windscale Laboratory consisted of a network of interlinked caves installed in the 1970s, as part of the Windscale Piles infrastructure. The NDA owned the facility with Sellafield Ltd as landlord and site license holder. NNL was the tenant and operator of the facility. The facility had suffered from a lack of investment for over 10 years which had resulted in a reduction in reliability of the facility. The combined long-term investment from NNL, Sellafield Ltd and the NDA would return the facility to full operational capability in five years. The operational cost of the facility was £10 million a year.

Tour of NNL

The facilities at NNL Central Laboratory were divided into three categories or 'Phases' according to their capabilities: Phase 1 to carry out desk-based assessments, non-active experimental work and low and medium radioactive R&D including work with plutonium; Phase 2, alpha generating radioactive materials and larger quantities (kilogrammes) of plutonium; and Phase 3, to handle high alpha and gamma material including spent fuel and higher active nuclear waste in various forms.

Phase 1 facilities

Most of the work undertaken within Phase 1 laboratories and offices was non-active experimental work, low-level radioactive R&D and desk-based research. Manchester University had an agreement to bring in students to work at NNL but the complexity of the ownership of NNL made the laboratories difficult to access. At present the laboratories were being used about 40% of the time although, on average, use tended to be about 55% of the time.

Phase 2 facilities

Phase 2 is currently being commissioned and was designed to undertake research on advanced fuel manufacturing and work related to the MOX plant. The facility will be used initially to carry out research on plutonium storage, treatment of residues and to study the behaviour of material currently in a poor condition.

An example was also given of how americium decay products removed from plutonium could be used by the European Space Agency to produce fuel for the space programme.

Phase 3 facilities

The Phase 3 facility could handle higher radioactive materials in significant quantities as well as providing the necessary environment to carry out advanced fuel cycle R&D. The facility is unique internationally because the five boxes in which experiments were carried out were retractable. Once an experiment had been completed, the box could be removed to be cleaned, and a new one put in. It was also a facility which could allow technical underpinning work to be carried out to support the programme on the deep geological disposal of radioactive waste.

The Phase 3 facility have been in “care and maintenance” mode for five years. NNL were currently discussing with other companies in the UK and internationally the possibility of forming a consortium to commission and use the facilities. If the discussions were successful, this consortium would not be formed until the later part of 2012 and there were concerns about the funding for the “care and maintenance” of the facility until then. Commissioning the Phase 3 facilities would take three to five years in order to allow testing to be carried out. If, after 12–18 months, a consortium could not be formed, “care and maintenance” work would cease and the facility would be “mothballed”.

Nuclear Decommissioning Authority

Presentation by Stephen Henwood, Chairman

Mr Henwood gave an overview of the NDA. He described its mission and preferred Government efforts to deliver risk and hazard reduction and to accelerate the decommissioning programme and clean-up (particularly for high hazard material). £1.5 billion a year was spent by the NDA at Sellafield. This was over 50% of total NDA spend. As a result of cutbacks in the Spending Review, NDA had scaled down the magnox programme, reducing staffing levels by 10%.

The research commissioned by NDA was “needs driven”. The NDA now had sufficient knowledge to make progress with the Managing Radioactive Waste Programme. They were currently supporting the Phase 2 facilities which was, in their view, necessary to carry out research to meet their needs. Their need for the Phase 3 facilities was unclear, given that the Windscale Laboratory could handle higher active wastes if necessary.

Mr Henwood told the Committee that NDA had sufficient research capacity available to them, within the UK and internationally, to deliver decommissioning and clean up activities.

Sellafield Ltd

Tour of MOX Plant (SMP)

Since SMP had become operational in 2001, the plant had produced a total of 15 tonnes of MOX fuel instead of the 70 tonnes a year which it was designed to

produce. New working processes were being introduced to increase capacity to 15 tonnes a year.⁴⁷⁵

Tour of Thermal Oxide Reprocessing Plant (THORP)

THORP reprocessed around 450 tonnes a year of nuclear fuel from AGRs and LWRs from around the world. Their current commercial contracts extended to 2018.

Spent fuel had a life of five years inside a reactor. The spent fuel was cooled on site for 100 days and then transported to Sellafield. There it would be cooled for five years and reprocessed. For new plants, under a once-through fuel cycle, the fuel would not need to be reprocessed before long-term disposal.

⁴⁷⁵ In August 2011, the NDA announced that the MOX plant would be closed down at the earliest practical opportunity following a decline in orders from their sole Japanese client after the Fukushima incident.

APPENDIX 6: ABBREVIATIONS AND ACROYNMS

AMEC	An engineering, project management and consultancy company
AGR	Advanced Gas-Cooled Reactors
BGS	British Geological Society
BIS	Department for Business, Innovation and Skills
BNFL	British Nuclear Fuels Ltd
BWR	Boiling Water Reactor
CCA	Climate Change Act
CCC	Climate Change Committee
CCFE	Culham Centre for Fusion Energy
CCS	Carbon Capture and Storage
CEA	Commissariat à l'énergie atomique et aux énergies alternatives
CEGB	Central Electricity Generating Board
CoRWM	Committee on Radioactive Waste Management
CSR	Comprehensive Spending Review
DECC	Department for Energy and Climate Change
DIAMOND	Decommissioning, Immobilisation and Management of Nuclear Wastes for Disposal (an EPSRC consortium grant)
DWP	Department for Work and Pensions
EDF Energy	An energy company
ERM	Electricity Market Reform
EPSRC	Engineering and Physical Sciences Research Council
ERP	Energy Research Partnership
ETI	Energy Technologies Institute
Euratom	European Atomic Energy Community
GCSA	Government Chief Scientific Adviser
GIF	Generation IV Forum
GoCo	Government-owned contractor-operated body
GW	Gigawatt (an energy unit)
g/(kW.h)	grams per kilowatt hour
HSE	Health and Safety Executive
IEA	International Energy Association
IAEA	International Atomic Energy Agency
ISIS	The pulsed neutron and muon source at the Rutherford Appleton Laboratory in Oxfordshire. Owned and operated by the STFC.
KNOO	Keeping the Nuclear Option Open (An RCUK consortium grant)
LWR	Light Water Reactor

M/yr	Millions a year
MoD	Ministry of Defence
MOX	Mixed Oxide Fuel (a nuclear fuel type)
NDE	Non-Destructive Evaluation
NDA	Nuclear Decommissioning Association
NDT	Non-Destructive Testing
NEA	Nuclear Energy Agency
NERC	Natural Environment Research Council
NIA	Nuclear Industries Association
NAMRC	Nuclear Advanced Manufacturing Research Centre
NNL	National Nuclear Laboratory
NRI	Nuclear Research Index
NuSAC	Nuclear Safety Advisory Committee
OECD	Organisation for Economic Co-operation and Development
OND	Office for Nuclear Development
ONR	Office for Nuclear Regulation
PWR	Pressurised Water Reactor
R&D	Research and Development
RDA	Regional Development Agency
RCUK	Research Councils UK
RWMD	Radioactive Waste Management Division
SME	Small and Medium-Sized Enterprise
SMP	Sellafield MOX plant
SQEP	Suitably qualified and experienced personnel
STEM	Science, Technology, Engineering and Maths
STFC	Science and Technology Facilities Council
THORP	Thermal Oxide Reprocessing Plant
TIC	Technology Innovation Centre
TINA	Technology Innovation Needs Assessment
TRL	Technology Readiness Level
TSB	Technology Strategy Board
UKERC	UK Energy Research Centre

APPENDIX 7: RECENT REPORTS FROM THE HOUSE OF LORDS SCIENCE AND TECHNOLOGY COMMITTEE

Session 2006–07

- 1st Report Ageing: Scientific Aspects—Second Follow-up
- 2nd Report Water Management: Follow-up
- 3rd Report Annual Report for 2006
- 4th Report Radioactive Waste Management: an Update
- 5th Report Personal Internet Security
- 6th Report Allergy
- 7th Report Science Teaching in Schools: Follow-up
- 8th Report Science and Heritage: an Update

Session 2007–08

- 1st Report Air Travel and Health: an Update
- 2nd Report Radioactive Waste Management Update: Government Response
- 3rd Report Air Travel and Health Update: Government Response
- 4th Report Personal Internet Security: Follow-up
- 5th Report Systematics and Taxonomy: Follow-up
- 6th Report Waste Reduction
- 7th Report Waste Reduction: Government Response

Session 2008–09

- 1st Report Systematics and Taxonomy Follow-up: Government Response
- 2nd Report Genomic Medicine
- 3rd Report Pandemic Influenza: Follow-up

Session 2009–10

- 1st Report Nanotechnologies and Food
- 2nd Report Radioactive Waste Management: a further update
- 3rd Report Setting priorities for publicly funded research

Session 2010–12

- 1st Report Public procurement as a tool to stimulate innovation
- 2nd Report Behaviour Change