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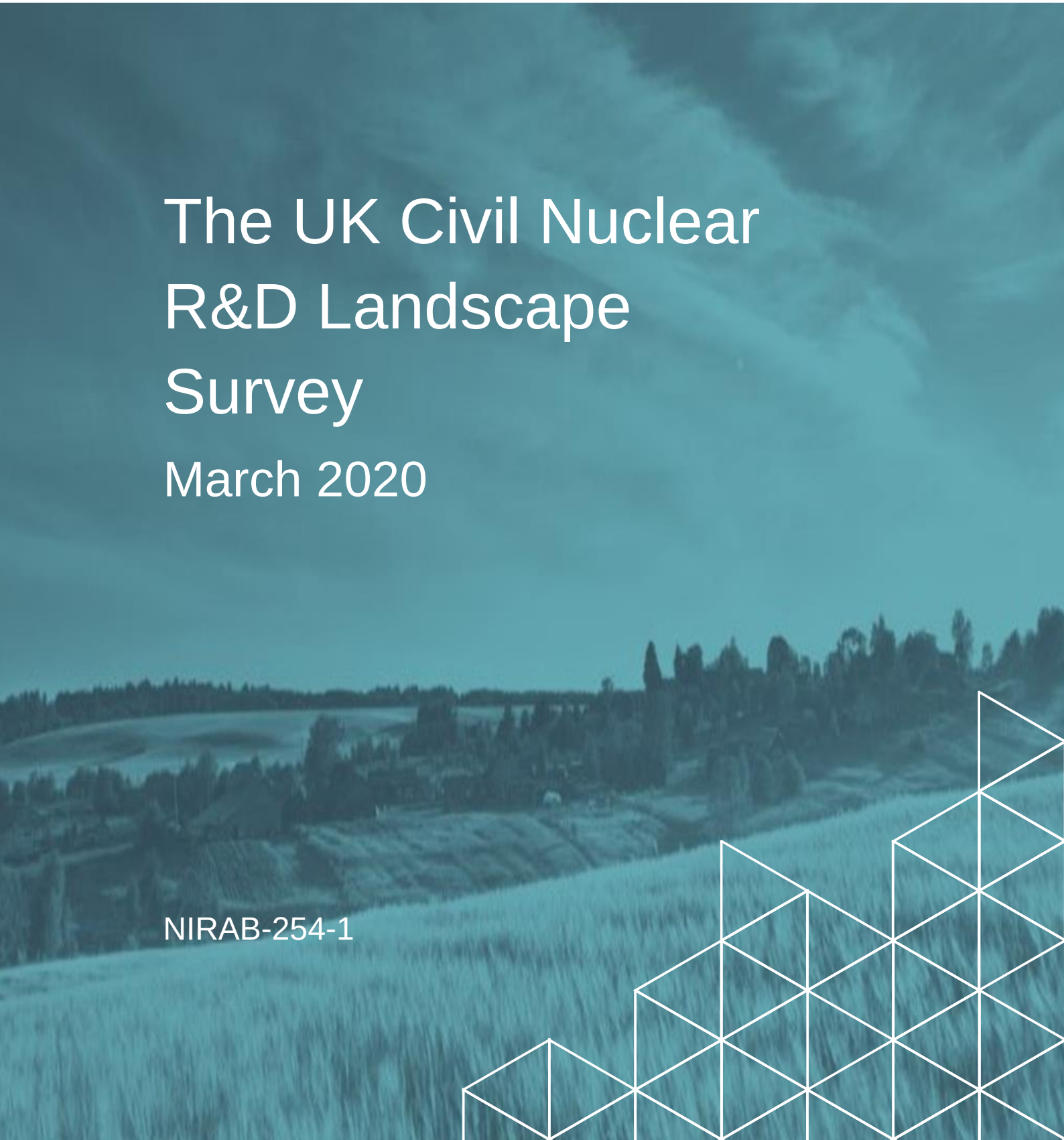

The UK Civil Nuclear R&D Landscape Survey

March 2020

NIRAB-254-1

Executive Summary

This document presents the results of a survey of the UK civil nuclear research and development (R&D) landscape in the 2018/19 financial year (April to March). It provides information on the Government policy landscape, funding sources, magnitude, location and focus of R&D being undertaken in the UK and the level of experience of the R&D community currently engaged in civil nuclear research. It is an update to the landscape reviews published by NIRAB in 2017 and by Government in 2013.

This survey presents data comparable with both previous reviews so that Government can identify trends and assess the impact of interventions. The survey also seeks to present a useful overview for the UK's community of researchers of the funding sources for nuclear R&D, detailing where research is being undertaken and the focus of that research.

The Civil Nuclear Landscape - Funding

Total funding for civil nuclear R&D in the UK has been collected as part of this survey; it includes public sector contributions and an estimate of private and overseas funding for nuclear fission and fusion research. The figure for total funding for 2018/19 was around £331million. This represents an increase of around 39% relative to 2015/16. This increase in funding is distributed across public, private and overseas sources. Direct funding from the Department for Business, Energy and Industrial Strategy (BEIS) for 2018/19 is £43.5m, more than double the direct funding from BIS & DECC in 2015/16. Overseas funding has grown by 48% to £80.8m, Nuclear Decommissioning Authority (NDA) funding in 2018/19 is £91m, £26m higher than 2015/16 and private funding is now £56m, £11m higher than in 2015/16. Proportionally, the most marked changes in funding have been the tripling of overseas funding from non European Union (EU) sources and the fivefold growth in private funding of fusion R&D now representing half of all privately funded civil nuclear R&D.

The rate of public spending in the period since 2015/16 has varied, but overall public sector funding for civil nuclear R&D in 2018/19 has increased and is now around 40% higher than in 2015/16, totalling £194.4million.

The NDA and its SLCs account for around half of all public sector civil nuclear R&D funding. Research funded by the NDA is needs driven, focussing on waste management and decommissioning, with a funding level of £91million in 2018/19. This is 40% higher than in 2015/16, however NDA R&D funding during 2015/16 was lower than in any other year between 2010/11 and 2018/19. NDA R&D funding during 2018/19 was 10% higher than the mean annual funding during the period 2010/11 to 2017/18.

In the fusion sector, the largest component of funding continues to be from the European Union (EU), the bulk directly related to UKAEA's operation of the Joint European Torus (JET). However there have been significant increases in both public and private sector funding of fusion. The result is that EU funding now accounts for 38% of fusion R&D funding in the UK.

Funding for research into advanced nuclear fission technologies remains low; this was also a key conclusion in both the 2017 survey and the 2013 review.

The growth in the UK's annual public expenditure on nuclear R&D compares favourably with other major nuclear nations in the Organisation for Economic Co-operation and Development (OECD). The UK expenditure on nuclear R&D is still low relative to the USA, Japan & France.

The Civil Nuclear Landscape - Capability

Overall it is estimated that there has been an underlying 3% increase in the number of researchers engaged in civil nuclear research in the UK compared to 2015/16. The number of civil nuclear researchers recorded in 2018/19 is 16% higher than the 2015/16 figure reported in the 2017 survey, however it is believed that this change is dominated by changes of assumptions used by the organisations reporting and inclusion of organisations for the first time that were active in 2015/16. The NDA Estate and the Nuclear Advanced Manufacturing Research Centre (NAMRC) report that the number of their researchers working on civil nuclear R&D is approximately the same in 2018/19 as in 2015/16. NDA Estate have used a wider definition of research when counting their researchers for 2018/19 than used for 2015/16, this accounts for around 11% of the apparent 16% increase. NAMRC researchers weren't captured in the 2015/16 figures reported in the 2017 survey, they account for around 2% of the apparent increase.

Stripping out the NDA and NAMRC increases: The number of researchers engaged in civil nuclear research in UK industry has increased by 13%. In our national laboratories there has been an 11% increase in the number of researchers. There has been a significant loss of more experienced staff (individuals with greater than 15 years' experience), in our national laboratories, this is particularly marked in UKAEA.

There has been a reduction in recorded academic activity in civil nuclear R&D. In particular, the number of PhD students carrying out civil nuclear R&D has dropped by 14% and is now lower than reported in the 2013 review. As in 2015/16 the University of Manchester, the University of Sheffield and Imperial College London remain the most intensive centres of research activity and account for over half of the university researchers. There are distinct regional variations with the reduction in academic activity concentrated in Southern England, whilst activity has increased in all other regions.

The number of people (in industry, national laboratories and universities) working on research into fuel fabrication remains very low. The modest increase in activity related to advanced reactors reported in 2017 has continued, although researchers in this area still account for less than 5% of civil nuclear researchers. The number of researchers working on fusion has increased sharply, now making up almost a third of all researchers engaged in civil nuclear R&D.

Objectives for nuclear R&D

This survey highlights that there are several Government departments with policies relating to civil nuclear energy, and each has its own objectives which are underpinned by R&D. The resulting institutional landscape is complex, with each department enacting its research objectives through a range of different non-departmental public bodies or agencies. The majority of civil nuclear energy policy resides within BEIS.

Coordination of R&D

Mechanisms are in place within Government to coordinate public funding of research. The Energy Innovation Board provides strategic oversight, challenge and recommendations to Ministers, whilst the Energy Innovation Programme Board (EIPB) acts as a programme board for the delivery of the BEIS Energy Innovation Programme. Under the EIPB the Nuclear Thematic Committee provides governance of the BEIS Nuclear Innovation Programme and sharing information across its membership. Recently efforts have been stepped up to enhance coordination between the key public sector funders of nuclear research, development & deployment, with a new co-ordination group meeting to explore opportunities for greater collaboration and programme synergies in the upcoming spending review period

The Nuclear Innovation and Research Advisory Board (NIRAB) continues to provide a forum to aid coordination across public and private sector research. NIRAB will publish its further findings in April 2020. In addition to NIRAB, nuclear R&D is coordinated through the activities of individual funders, e.g. the NDA Research Board. Also, there are a number of cross sector bodies such as the National Nuclear User Facility (NNUF) steering group and the Nuclear Waste and Decommissioning Research Forum (NWDRF) that coordinate specific aspects of the nuclear R&D programmes.

Research facilities

Government has committed to over £200M to civil nuclear facilities across fission and fusion since the last landscape review, and has announced significant funds for future enhancement of the facility base. In doing so Government should largely address the paucity of facilities for handling radioactive materials identified in the 2013 review.

International collaboration

The UK has significantly increased its engagement in international collaborative research programmes. The UK re-joined the Generation IV International Forum in 2019, signed the UK/US Fission R&D Action Plan in 2018, and has a number of bilateral agreements with leading nuclear nations. Research from the BEIS Nuclear Innovation Programme is being leveraged into these new engagements.

There is now an overarching strategy to coordinate UK engagement with both the IAEA and the OECD. Coordination with NEA is managed through BEIS. Work is also underway to secure a strong cooperative working relationship with the Euratom Fission Research and Training programme following UK exit from the EU. The UK has also signed new bilateral Nuclear Cooperation Agreements (NCA) with Canada, Australia and the USA. Furthermore, the operability of the existing UK-Japan NCA to ensure that civil nuclear trade can continue following the end of the transition period has been confirmed.

Contents

Figures

1 Introduction

1.1 Background

The Nuclear Innovation and Research Office (NIRO) was tasked by Government to undertake a survey of the civil nuclear research and development (R&D) landscape. This comprises an update to the survey published by the Nuclear Innovation and Research Advisory Board (NIRAB) in 2017[1]. This in turn was commissioned as an update to the review published by Government and overseen by the Government's Chief Scientific Advisor in 2013[2]. These previous reviews provided Government with a comprehensive view of the landscape of organisations that fund and conduct civil nuclear research. They provided a useful picture of the policy landscape, funding sources, magnitude, location and focus of R&D being undertaken in the UK and the level of experience of the R&D community.

1.2 Purpose

This survey presents data which is, as far as possible, comparable with the 2017 survey and the 2013 review[3] so that Government can identify trends and assess the impact of interventions. As well as providing data for Government, the survey seeks to present a useful overview for the UK's community of researchers of the funding sources for nuclear R&D, detailing where research is being undertaken and the focus of that research.

1.3 Scope

This survey is limited in scope to the civil nuclear energy sector in the UK. Whilst many of the organisations involved in civil nuclear R&D in the UK also perform research in the nuclear defence sector, defence R&D is excluded from the data presented here. The survey includes both civil nuclear fission and fusion research.

Source information has been gathered using both a 'top down' approach, where Government departments and agencies have provided data on their R&D expenditure, as well as a 'bottom up' approach with UK companies, universities and national laboratories providing information through a questionnaire. The questions sought to elicit the number and experience levels of researchers, the focus of the research and the value and sources of funding in the 2018/19 financial year (April to March). This survey includes responses from: 30 industrial organisations (compared to 25 in the previous survey), 4 national laboratories and 28 universities (compared to 32 in the previous survey). The data has been compiled by NIRO on behalf of the BEIS.

When presenting funding data, the emphasis is on taking a one-year snapshot for 2018/19 as a basis for comparison with the previous snapshots. Data has also been gathered on the level of public funding for each of the intervening years since the previous review.

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[1] http://www.nirab.org.uk/media/10671/nirab-123-4.pdf

[2] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/168039/13-631-a-review-of-the-civil-nuclear-r-and-d-landscape-review.pdf

[3] The 2013 landscape review *A Review of the Civil Nuclear R&D Landscape in the UK (BIS/13/631)* was published in 2013; the UK Government expenditure data presented in the 2013 report was for the 2010/11 financial year. The number of FTEs undertaking research reported in the 2013 report was for 2011/12. Hence, throughout this survey the reader should note that when 2010/11 funding or 2011/12 FTE data are discussed they both relate to data from the 2013 published report.

The data is presented, and commentary made where there are significant changes from the 2017 survey. This report, however, does not attempt to analyse any underlying causes for changes, or attempt to assess the impact of Government interventions or policy decisions.

1.4 Structure of document

This survey is structured in six sections (Chapter 2 to Chapter 7), with the first of these sections focussing on presenting the data collated from this survey. This data is compared to that presented in the previous 2017 landscape survey and 2013 landscape review, where appropriate, and comment is made on changes and trends observed in the data. The six sections are:

The UK's Civil Nuclear R&D Landscape

Chapter 2 presents data on funding for civil nuclear R&D in the UK. Annual expenditure by Government departments and agencies is summarised for each year from 2012/13 to 2018/19. The extent of industry and overseas funding is also presented to indicate the balance of source funding. A comparison to other countries is also made using data from the Organisation for Economic Co-operation and Development (OECD).

Chapter 2 then presents data on civil nuclear R&D capability for 2018/19. The number of full time equivalent (FTE) researchers per research theme, level of experience and geographical location in the UK is quantified.

Objectives for civil nuclear R&D in the UK

Chapter 3 outlines Government and private sector objectives for nuclear energy, with a focus on where R&D is required to meet those objectives.

Institutional landscape of nuclear R&D in the UK

Chapter 4 describes the structure of the civil nuclear sector in the UK and the institutional landscape for R&D, including Government departments and agencies responsible for nuclear energy, waste management and decommissioning.

Coordination of nuclear R&D in the UK

Chapter 5 describes the mechanisms currently in place in the UK to coordinate research activity.

International collaboration in nuclear R&D

Chapter 6 summarises developments in UK involvement in international collaborations.

Facilities for civil nuclear R&D in the UK

Chapter 7 gives an overview of the additions to the research facility base in the UK, focussing on where there has been Government investment over the past three years. This is not intended to be a comprehensive record of the UK's civil nuclear research infrastructure, but to highlight those new additions to the research base to assist in assessing the impact of Government interventions.

The UK's Civil Nuclear R&D Landscape

This survey presents data so that Government can identify trends and assess the impact of interventions.

2 The UK's Civil Nuclear R&D Landscape

This section of the document presents the data collected on the level of funding for, and the capability deployed on, civil nuclear research during 2018/19. The data is presented graphically with commentary to highlight key points. There is a significant amount of data presented but there are a few key messages that arise from assessment of the data. For clarity, a summary of the key messages is presented up-front:

Funding:

- The figure for total funding (public, private and overseas) for civil nuclear R&D in the UK in 2018/19 was £331.2million this is around 39% higher than in 2015/16.
- Public sector funding for civil nuclear R&D has varied throughout the intervening period, but overall public sector funding for civil nuclear R&D has increased and in 2018/19 was around 40% higher than in 2015/16, totalling £194.4million.
- Public funding for nuclear fission and fusion R&D programmes, provided by the NDA (direct), Innovate UK and the Research Councils, have increased during the 2017/18 and 2018/19 financial years.
- In the fission sector, research funding was dominated by the NDA and its SLCs and focussed on waste management and decommissioning. There has been a 40% increase in expenditure through NDA when compared to 2015/16 as reported in the previous landscape survey, however NDA R&D funding during 2015/16 was lower than in any other year between 2010/11 and 2018/19. NDA R&D funding during 2018/19 was 10% higher than the mean annual funding during the period 2010/11 to 2017/18.
- In the fusion sector, around 38% of the funding is from the EU, however there has been substantial growth in all other source of funding for fusion R&D, with public sector now also accounting for around 38% of funding and private sector providing around 19%.
- Growth in the UK's annual public expenditure on nuclear R&D since 2011 is the highest in the OECD. However, UK expenditure on nuclear R&D is still low relative to the USA, Japan & France.

Capability – FTEs and experience:

- Overall it is estimated that there has been a 3% increase in the number of researchers engaged in civil nuclear research in the UK compared to 2015/16. The number of civil nuclear researchers recorded in 2018/19 is 3179, 16% higher than the 2015/16 figure reported in the 2017 survey, however it is believed that this change is dominated by changes of assumptions used by organisations reporting and inclusion of organisations for the first time that were active in 2015/16. NDA Estate and NAMRC report that the number of their researchers working on civil nuclear R&D is approximately the same in 2018/19 as in 2015/16. NDA Estate have used a wider definition of research when counting their researchers for 2018/19 than used for 2015/16, this accounts for around 11% of the apparent 16% increase. NAMRC researchers weren't captured in the 2015/16 figures reported in the 2017 survey, they account for around 2% of the apparent increase.
- The number of researchers conducting research related to fusion has risen by 310 since 2015/16 an increase of 36%, the greatest increase of any research theme.
- The total FTEs working on R&D related to fuel fabrication (99) remains very low. The low level of research activity in this area was highlighted as a concern in both the 2013 landscape review and the 2017 landscape survey.
- The modest increase in activity related to advanced reactors in 2015/16 has continued, although researchers in this area (159) still account for less than 5% of civil nuclear researchers.
- Excluding NDA increases the number of researchers engaged in civil nuclear research in UK Industry has increased by 13% since 2015/16.
- Excluding NAMRC, there has been an 11% increase in the number of researchers in our national laboratories. There has been a significant loss of more experienced staff (individuals with greater than 15 years' experience), in our national laboratories, this is particularly marked in UKAEA.
- There has been a reduction in recorded academic activity in civil nuclear R&D. In particular the number of PhD students carrying out civil nuclear R&D (583) has dropped by 14% since 2015/16 and is now lower than reported in the 2013 review.
- As in 2015/16 the University of Manchester, the University of Sheffield and Imperial College London remain the most intensive centres of research activity and account for over half of the university researchers. There are distinct regional variations with the reduction in academic activity concentrated in Southern England, whilst activity has increased in all other regions.

The following pages present a summary of the funding and capability data collated as part of this survey and provided by industry, national laboratories and universities. A comparison is made, where appropriate, to the data presented in the previous landscape survey published in 2017 and the landscape review published in 2013. Figure 1 to Figure 5 present the funding data with accompanying commentary, the data included in each of the figures is as follows:

Figure 6 to Figure 17 present the capability data with accompanying commentary, the data included in each of the figures is as follows:

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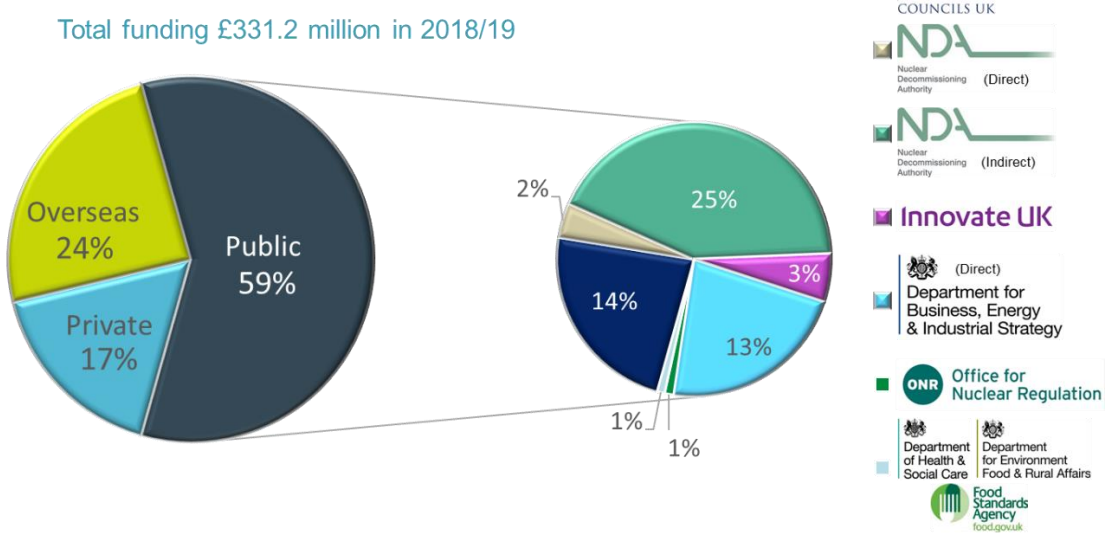
The UK's Civil Nuclear R&D Landscape: Funding

Total funding for civil nuclear R&D in the UK for 2018/19 was around £331 million.

Figure 1. Sources of funding for the total UK civil nuclear R&D portfolio



- The data collected as part of this landscape survey suggests the total funding for nuclear R&D in the UK for 2018/19 was around £331.2m. This represents an increase of around 39% relative to 2015/16. Private and overseas funding data has been collated from responses to this survey. Public funding data has been provided by the relevant Government department.
- 24% (around £80.8m) of funding for civil nuclear R&D in the UK is from overseas sources.
- 59% (around £194.4m) of funding for UK civil nuclear R&D is public funding. The largest component of public funding comes from the NDA estate (either through NDA directly supporting R&D or through NDA SLC's which account for the majority of the funding), including SLCs[4] with the Research Councils UK (RCUK) and direct funding from BEIS also providing significant contributions.
- 17% (around £56m) of funding for civil nuclear R&D in the UK is from private sources a rise of 25% relative to 2015/16. Private funding includes industry and self-funding from universities and national laboratories. Notably private funding of fusion has grown fivefold from £5m in 2015/16 to £27m in 2018/19, whilst private funding across all other research themes has fallen from £40m in 2015/16 to £29m in 2018/19

[4] NDA SLCs includes Radioactive Waste Management Ltd (RWM), Sellafield Ltd, Low Level Waste Repository Ltd (LLWR), Magnox Ltd and Dounreay Site Restoration Ltd (DSRL).

Figure 2. UK Government expenditure on civil nuclear R&D in 2018/19 and comparison to 2015/16 and 2010/11 funding

UK Government expenditure on nuclear R&D in financial year 2018/19

Total fission (£139m)[a]	Total BEIS (£136.9m)[b]	EPSRC (£13.2m)
		STFC (£0.5m)
		Innovate UK (£11m)
		BEIS Direct (£21.2m)
		NDA Direct (£8m)
		NDA Indirect (£83m)
	Total DWP (£2.1m)	ONR (£2.1m)
Total fusion (£53.7m)[a]	Total BEIS (£53.7m)[b]	EPSRC (£31.4m)
		BEIS Direct (£22.3m)
Total other (£1.7m)	Total DHSC (£0.3m)	PHE (£0.25m)
	Total FSA (£1.4m)	FSA (£1.4m)
	Total Defra (£0.1m)	EA (£0.08m)

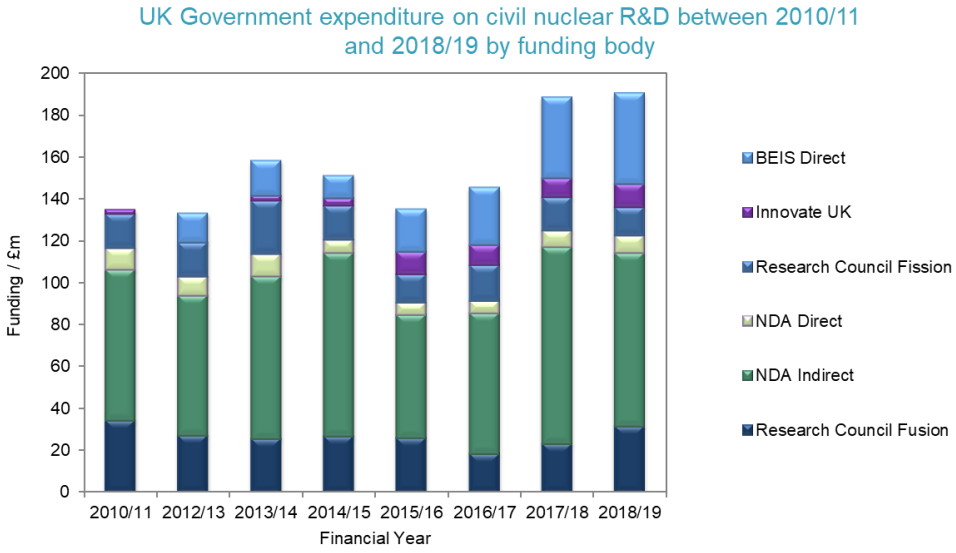
UK Government Expenditure on Nuclear R&D in 2010/11 to 2018/19

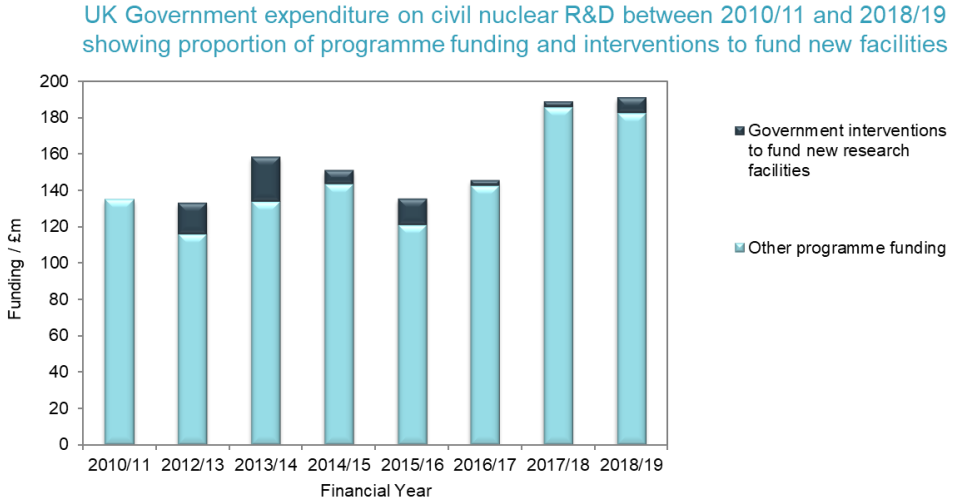
	2010/11	2015/16	2018/19
Fission NDA Estate	£82.5m	£64.7m	£91m
Fission Other	£18.1m	£38.8m[c]	£48m
Fusion	£33m	£33m[d]	£53.7m
Other	£4m	£1.9m	£1.7m
Annual Total	£137.6m	£138.4m	£194.4m

[a] The Government also funds nuclear R&D in the UK indirectly through its contribution to the EU budget and therefore to the Euratom programme and other nuclear-related elements of Horizon 2020 Programme (these indirect contributions are excluded from the table).
[b] BEIS also provided research funding to universities through Research England. The total amount (for all areas of research and all universities) was £2,078m in 2018/2019. It is not possible to disaggregate this figure to provide data on nuclear R&D. The same situation applies to the funding councils of devolved administrations.
[c] The 2017 civil nuclear R&D landscape survey reported a Fission Other R&D spend of £31m, this omitted Innovate UK funding of NAMRC (£8m), which has now been included.
[d] The 2017 civil nuclear R&D landscape survey reported a Fusion R&D spend of £24.6m, this omitted BEIS capital funding of new UKAEA facilities (£7.5m) and under-reported programmatic spend by £0.9m, these have now been included.

- The annual level of publicly funded nuclear R&D in 2018/19 (£194.4m) is around 40% higher than Government funding on civil nuclear in 2015/16 (£138.4m). This increase is distributed across the public sector funders. Fission funding has gone up by 34%, an increase of £35.5m, fusion funding has risen by 63%, up £20.7m.
- Public funding for NDA Estate R&D, was £26.3m greater in 2018/19 than in 2015/16, up 40%. However, NDA R&D funding during 2015/16 was lower than in any other year between 2010/11 and 2018/19. NDA R&D funding during 2018/19 was 10% higher than the mean annual funding during the period 2010/11 to 2017/18. NDA R&D varies year on year, driven by the overall decommissioning schedule across the different organisations in the NDA Estate.
- Public funding for fission research, excluding NDA Estate, was £9.2m greater in 2018/19 than 2015/16. This funding is dominated by the ramp up of spending on the BEIS Nuclear Innovation Programme
- Public funding of fusion research has increased by £20.7m between 2015/16 and 2018/19. This is made up of both increases in programme funding and funding of capital projects (£8.3m).

Figure 3. Annual UK Government expenditure on civil nuclear R&D between 2010/11 and 2018/19



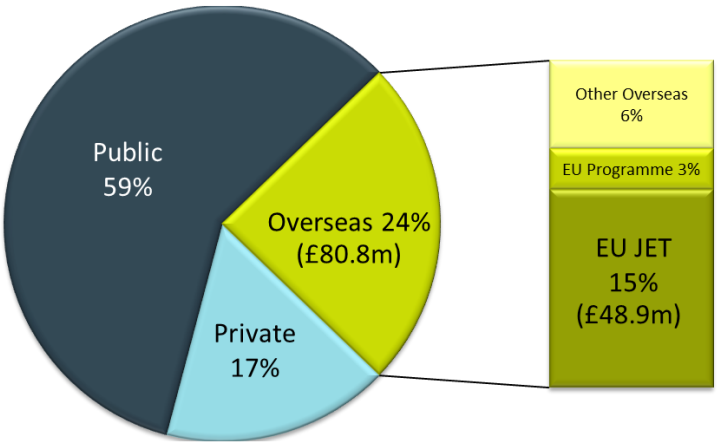


Note: data in the charts excludes Department of Health and Social Care, Department of Work and Pensions, Food Standards Agency and Defra funding

- NDA funding consistently makes up around half of the total UK Government funding for civil nuclear R&D between 2010/11 and 2018/19. It has fluctuated between £64.7m and £102m over this period.
- Programme funding from UKRI has fluctuated but has remained relatively consistent between 2010/11 and 2018/19.
- Between 2015/16 and 2018/19 the direct spend from BEIS on civil nuclear R&D has steadily increased. Direct BEIS funding stood at £43.5m in 2018/19, more than double the figure for 2015/16. BEIS was formed in 2016 and funding to then came either through DECC or BIS.
- Between 2015/16 and 2018/19 Government made interventions (through BEIS and UKRI) and invested approximately £23m in total in new nuclear fusion research facilities (see Chapter 7).

Figure 4. Overseas funding for civil nuclear R&D in the UK

Origin of overseas funding for nuclear R&D in the UK



UK Participation in Euratom Research Projects

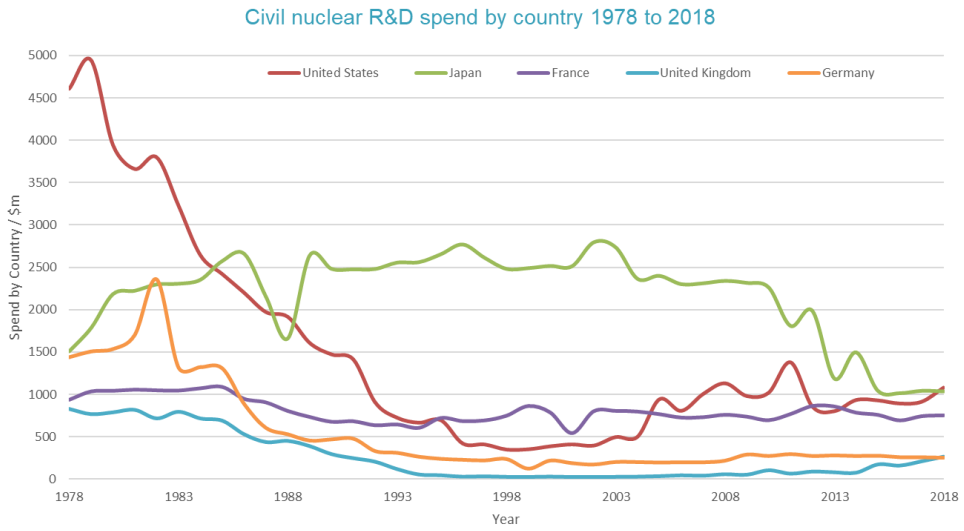
Number of Projects with UK Participants[a]	Approx. Combined Value of Projects per Annum[b]	Approx. Total EU Contribution to Projects per Annum[b]	Approx. Total EU Contribution to UK for Projects per Annum[b]
33	€174m	€104m	€11m

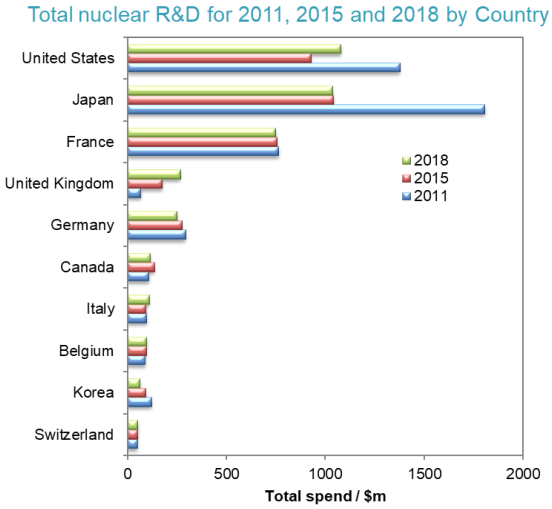
[a] H2020-Euratom projects live between 1st April 2018 and 31st March 2019.
[b] Live projects have start dates from 2014 to 2017 and a range of project durations. The longest project duration is seven years with an average project length of around four years. The annual value is calculated taking the total value for the duration of the project and assuming a linear spend profile. The total value presented in the table is the sum of the annual value per project for all live projects.

- Overseas funding totals around £80.8m. The majority of this funding originates from the EU and is dominated by the €55.4m (£48.9m[5]) per year paid to the United Kingdom Atomic Energy Authority (UKAEA) in relation to the Joint European Torus (JET) project.
- EU funded nuclear research in the UK, in addition to JET, is primarily through involvement in Euratom programmes. Data presented was obtained from the European Commission (EC) Community Research and Development Information Service (CORDIS) database for projects that were live between 1st April 2018 and 31st March 2019 and which had at least one UK participant.
- A total of 33 projects with UK involvement were identified. The available data shows that the UK participates in projects with an approximate total annual value of €174m, around €104m of this coming from the EU and of that €104m EU contribution approximately €11m in total per year is paid to UK participants.
- The annual EU project funding received by the UK is dominated by the EUROfusion project (EUROfusion started in 2014 and will complete at the end of 2020 with a total project value of €857m); the project has an approximate total annual value of €122m, around €67m of this annual value comes from the EU and of the €67m EU contribution approximately €6.8m in total per year is paid to UK participants (UKAEA) – this is in addition to the €55.4m per year paid to the UK for the JET contract.

[5] An average rate of exchange of 1.13 euros per £1 has been used for the 2018/19 financial year taken from: *HMRC foreign exchange rates:yearly averages* (https://www.gov.uk/government/publications/exchange-rates-for-customs-and-vat-yearly)

Figure 5. A comparison of UK public funding for civil nuclear R&D with other OECD countries





Data extracted March 2020 from OECD iLibrary: IEA (2020), "RD&D Budget", IEA Energy Technology RD&D Statistics (database). DOI: https://doi.org/10.1787/data-00488-en

- Assessment of (Government) funding data, submitted to the OECD International Energy Agency (IEA) database, from 1978 to 2018 shows a continuous decline in UK nuclear R&D funding from the early 1980s to the mid-1990s, it then stabilised around $30m per annum. From the mid-2000s there was a gradual increase in funding. Since 2015 this increase has become more marked, as of 2018 (latest data available from the IEA) funding has now returned to a level comparable with the early 1990s, although this is still only a third of the level spent in 1978.
- This initial decline is also seen in the historic spend profile of other leading nuclear nations e.g. the United States of America (USA), France and Germany. In Japan funding remained high until the early 2010's but has subsequently reduced.
- The UK expenditure on nuclear R&D is still low relative to the USA, Japan & France. Compared to other OECD nuclear nations developing future nuclear reactor technologies the UK growth in R&D spend since 2011 is proportionally the highest. In 2018, the UK had the 4th largest total nuclear R&D budget of the OECD countries (note the data above does not include non-OECD nations Russia, China and India, all of which have significant nuclear research budgets.)

The UK's Civil Nuclear R&D Landscape:

Capability – FTEs, Research Focus, Experience and Geographical Spread

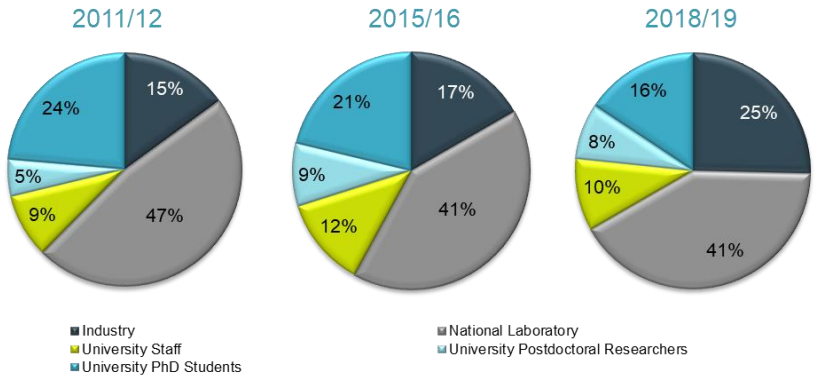
Overall there has been an increase in the number of researchers engaged in civil nuclear research in the UK since 2015/16.

Total

Figure 6. A comparison of the total number of FTEs involved in civil nuclear R&D in the UK in 2011/12, 2015/16 and 2018/19

FTE nuclear R&D personnel in the UK in 2011/12, 2015/16 & 2018/19

		2011/12 FTEs	2015/16 FTEs	2018/19 FTEs	Difference[b]
	Industry	397[a]	534[a]	944	+410
	National Laboratory	1260	1317	1538	+221
	University	1000	1344	1237	-107
UK University breakdown	Staff	238	391	369	-22
	Postdoctoral Researchers	134	274	285	+11
	PhD Students	628	679	583	-96
	Total	2657	3195	3719	+524

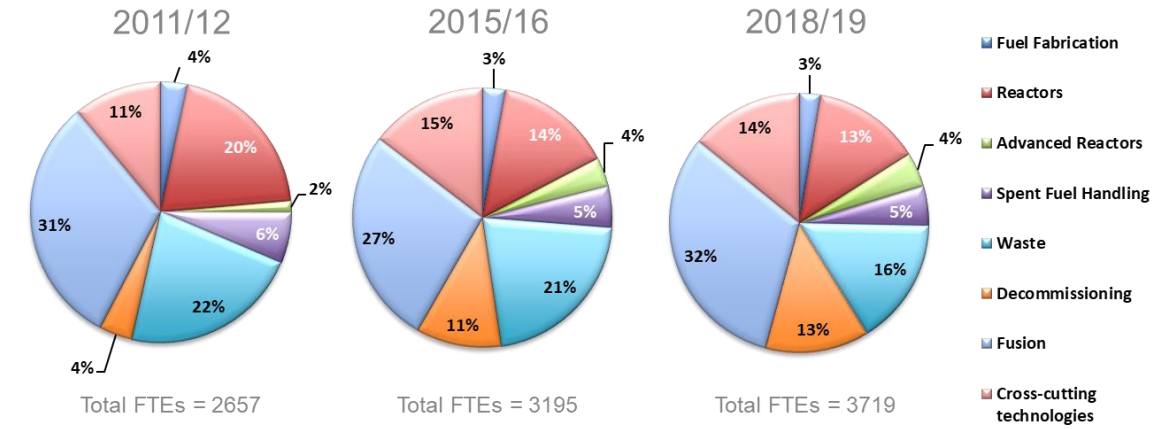


[a] The 2018/19 survey received responses from Tokamak Energy & First Light Fusion, these organisations were not represented in the 2017 civil nuclear R&D landscape survey. Both organisations were asked for FTE nuclear R&D figures for 2011/12 & 2015/16, these figures have been added to the Industry figures presented in the 2017 Survey, this has increased the 2011/12 & 2015/16 Industry FTEs by 3 and 25 respectively.
[b] The Difference is the change between 2015/16 and 2018/19.

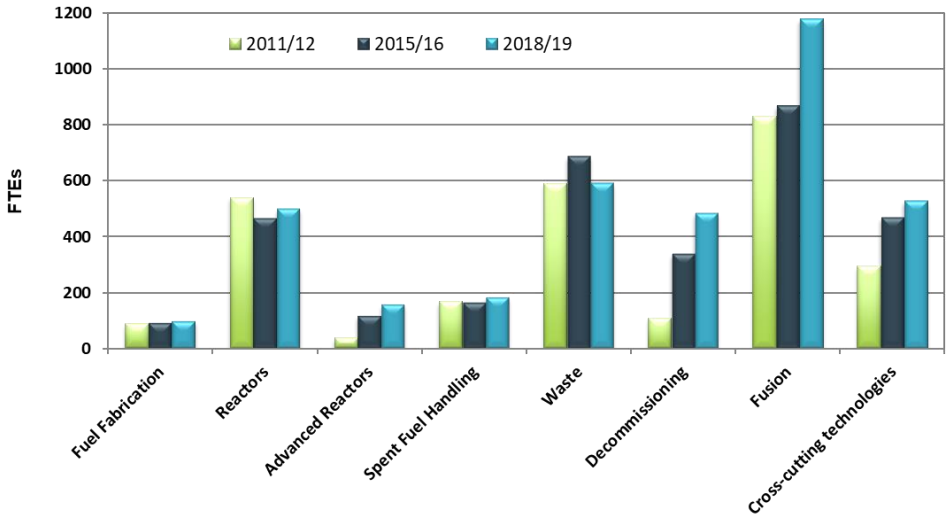
- Overall it is estimated that there has been a 3% increase in the number of researchers engaged in civil nuclear research in the UK compared to 2015/16. The number of civil nuclear researchers recorded in 2018/19 is 3179, 16% higher than the 2015/16 figure reported in the 2017 survey, however it is believed that this change is dominated by changes of assumptions used by organisations reporting and inclusion of organisations for the first time that were active in 2015/16. NDA Estate and NAMRC report that the number of their researchers working on civil nuclear R&D is approximately the same in 2018/19 as in 2015/16. NDA Estate have used a wider definition of research when counting their researchers for 2018/19 than those used for 2015/16, this accounts for around 11% of the apparent 16% increase. NAMRC researchers weren't captured in the 2015/16 figures reported in the 2017 survey, they account for around 2% of the apparent increase.
- Excluding NDA increases, the number of researchers engaged in civil nuclear research in UK Industry has increased by 13% since 2015/16.
- Excluding NAMRC, there has been an 11% increase in the number of researchers in our national laboratories, this increase is dominated by fusion researchers.
- The number of FTEs carrying out civil nuclear research in academia has reduced by 8%, including university staff (down 5%), postdoctoral researchers (up 4%) and PhD students (down 14%). There were fewer academic responses to the survey than in 2017, so the true fall in academic FTEs may be less than 8%.

Total

Figure 7. A comparison of the research focus of FTEs involved in civil nuclear R&D in the UK in 2011/12, 2015/16 and 2018/19

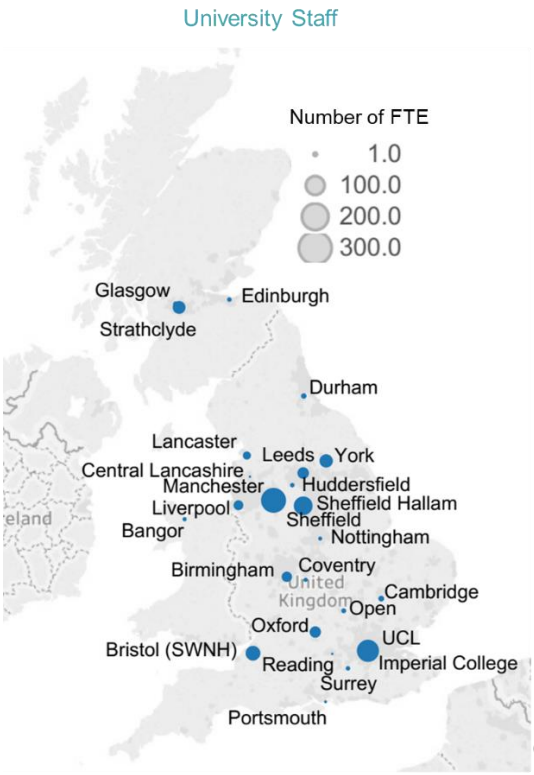


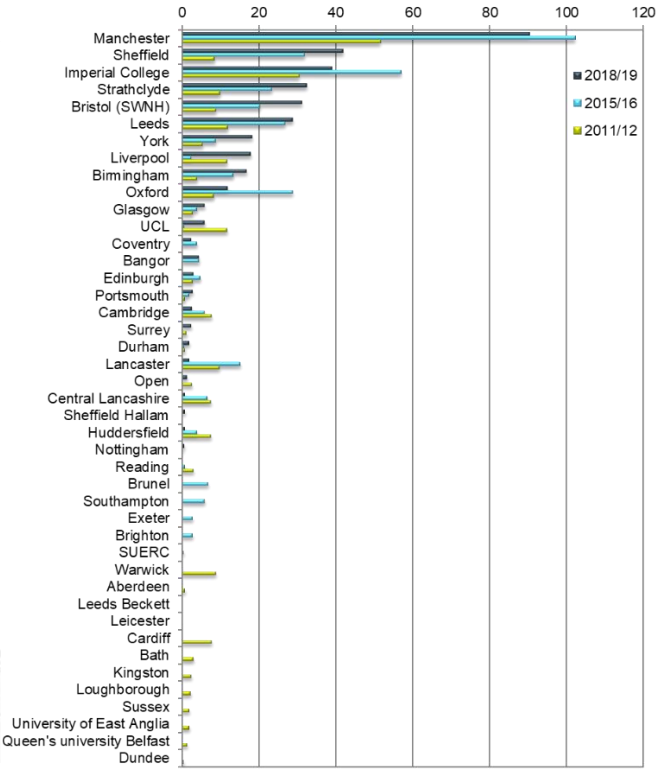
Note: Total FTEs include PhD and postdoctoral researchers



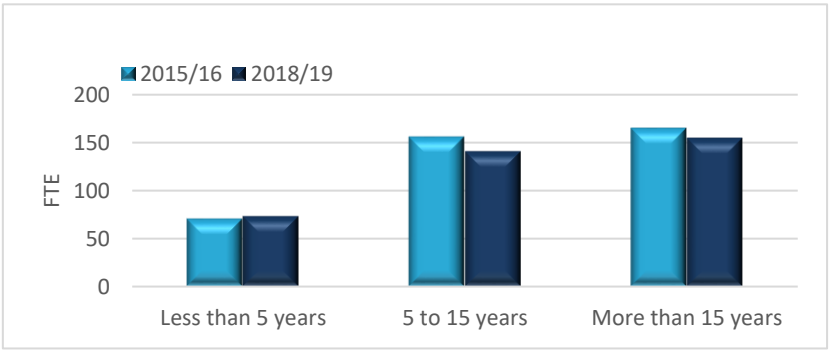
- The total FTEs working on R&D related to fuel fabrication (99) remains very low. The low level of research activity in this area was highlighted as a concern in both the 2013 landscape review and the 2017 landscape survey.
- The modest increase in activity related to advanced reactors reported in 2015/16 has continued, although researchers in this area (159) still account for less than 5% of civil nuclear researchers.
- The greatest increase in FTE research focus is related to fusion, which has grown by 310 FTEs compared to 2015/16 and is now double the next largest theme (waste).
- Growth of research FTEs focussed on decommissioning is dominated by NDA Estate's wider definition of research. Outside NDA research in this area has decreased.
- The increase in FTEs engaged in cross-cutting technology research has continued, now approaching double the number in 2011/12, these activities include robotics, modelling and simulation and energy system modelling. These are not unique to the nuclear sector.
- FTEs researching waste have dropped by 93 (14%) and are now back to the 2011/12 level.

University	Figure 8. FTEs and geographical spread of UK university staff involved in civil nuclear R&D





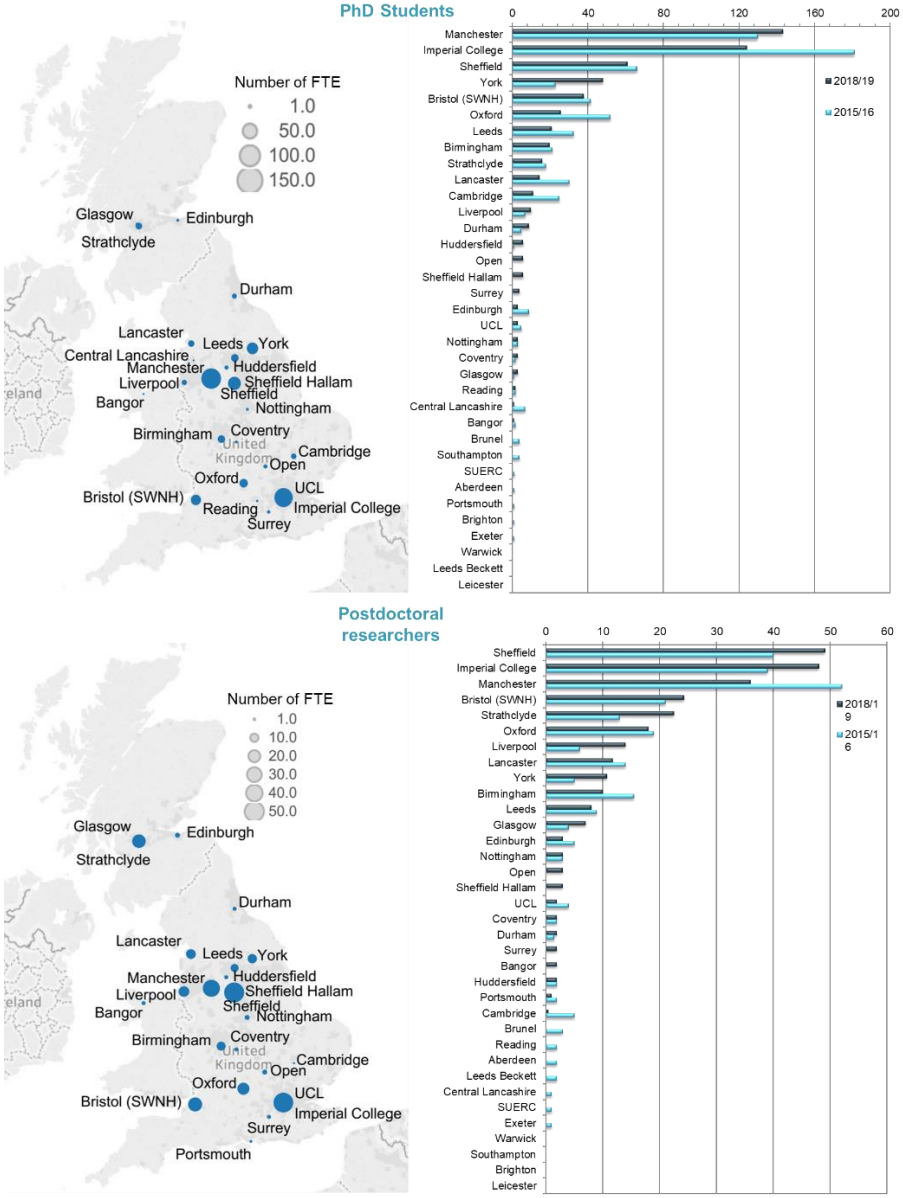
Note: Universities with multiple sites are shown at their primary location only



- There has been a 5% reduction in academic staff (391 to 369 FTEs) engaged in civil nuclear R&D between 2015/16 and 2018/19, although the number remains well above the 2011/12 figure.
- It is a mixed picture with growth in academic numbers at some universities offset by reductions in others.
- Fewer universities have reported as being actively engaged in nuclear research than in 2015/16. 7 universities, accounting for 5% of university staff, responded for 2015/16 but did not this time. A further university provided a nil return.
- Whilst there are still many universities engaged in nuclear research (28 respondents), almost 90% of the academic staff (FTEs) are in 10 universities.
- Three universities that did not report activity in 2015/16 responded this time. These universities accounted for 1% of the total university staff FTEs, the majority of who are believed to have been active in 2015/16.
- There are regional differences with modest growth in academic staff numbers doing civil nuclear R&D in all regions other than southern England, which saw a 28% drop. This is a combination of fewer FTEs in the responses received, down 19% and 3 fewer universities in this area responding than in 2015/16.

University

Figure 9. PhD students and postdoctoral researchers involved in civil nuclear R&D in the UK, FTEs and geographical spread

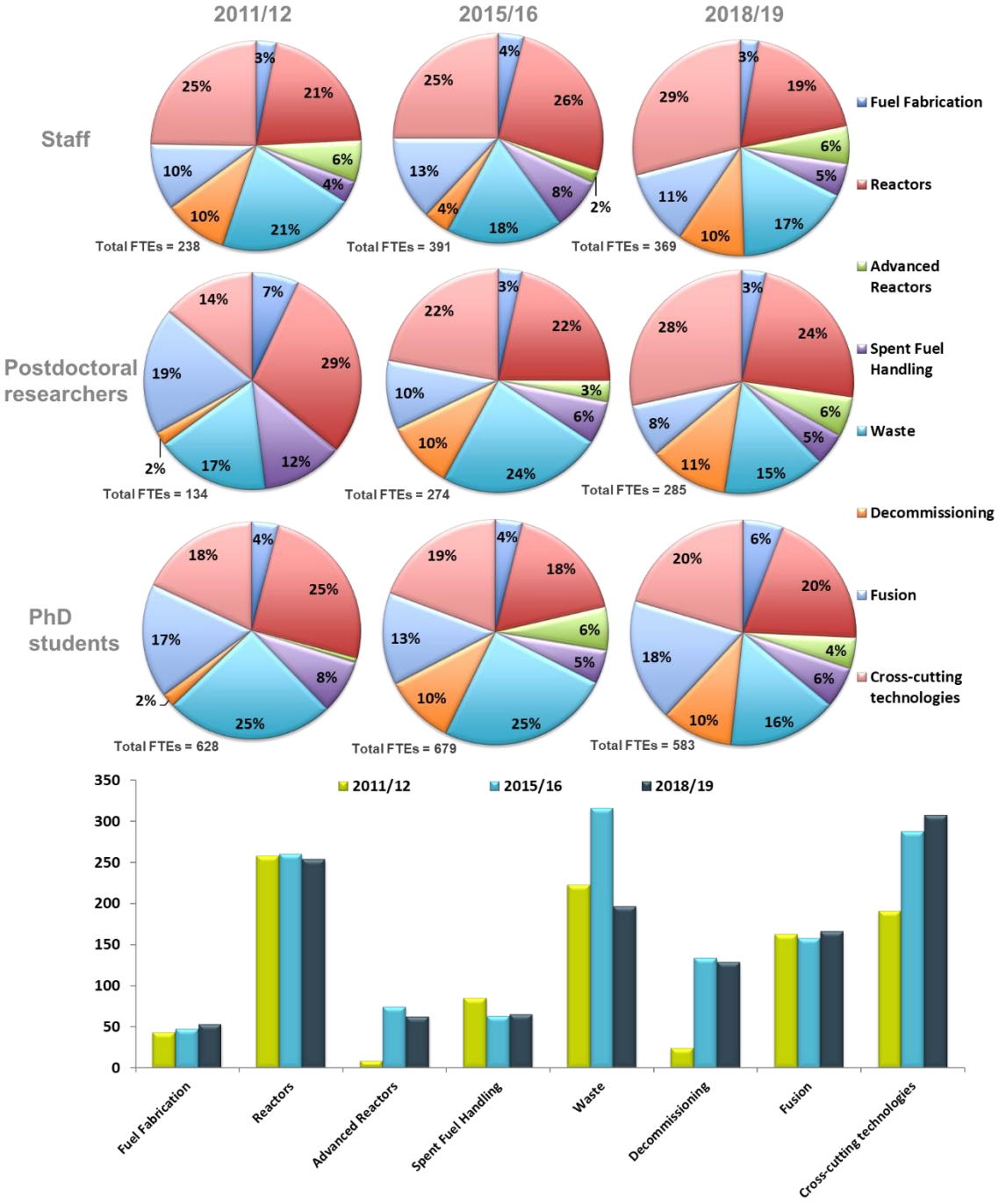


Note: Universities with multiple sites are shown at their primary location only

- There has been a significant reduction in the number of PhD students engaged in civil nuclear R&D between 2015/16 and 2018/19. The number of PhD students has dropped by 96 (14%) and is now 45 lower than recorded in 2011/12.
- There was a 4% increase in the number of postdoctoral researchers engaged in civil nuclear R&D between 2015/16 and 2018/19. This builds on the doubling between 2011/12 and 2015/16.
- PhD students and postdoctoral researchers are concentrated in a few universities, over 70% of PhD students are in 5 universities and 86% of postdoctoral researchers are in 10 universities.
- There are regional differences in the changes in the number of PhD students engaged in civil nuclear R&D, with modest growth in northern England, Wales and the midlands, whilst in southern England and Scotland numbers have dropped by around a third since 2015/16.

University

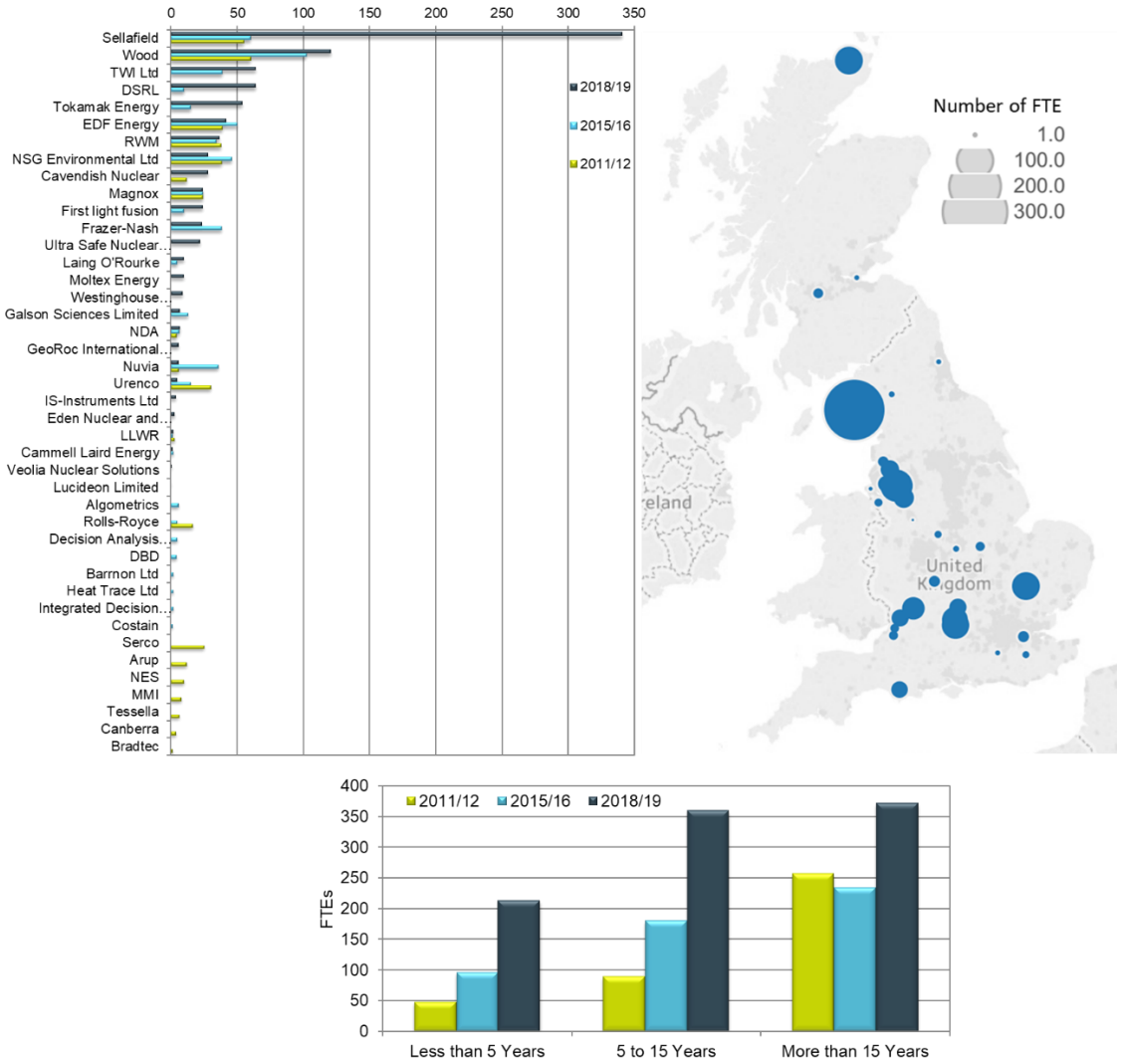
Figure 10. A comparison of UK university civil nuclear R&D research focus (FTEs) in 2011/12, 2015/16 and 2018/19



- Whilst the total FTEs in universities has reduced, the distribution of research activity by theme remains broadly similar to 2011/12 and 2015/16.
- Most research areas have seen little change since 2015/16. There has been a noticeable reduction in the number of FTEs engaged in waste research, more than cancelling out the rise seen between 2011/12 and 2015/16.
- The total number of Staff, PhDs and postdoctoral researchers working on fuel fabrication, spent fuel handling and advanced reactors remains low.

Industry

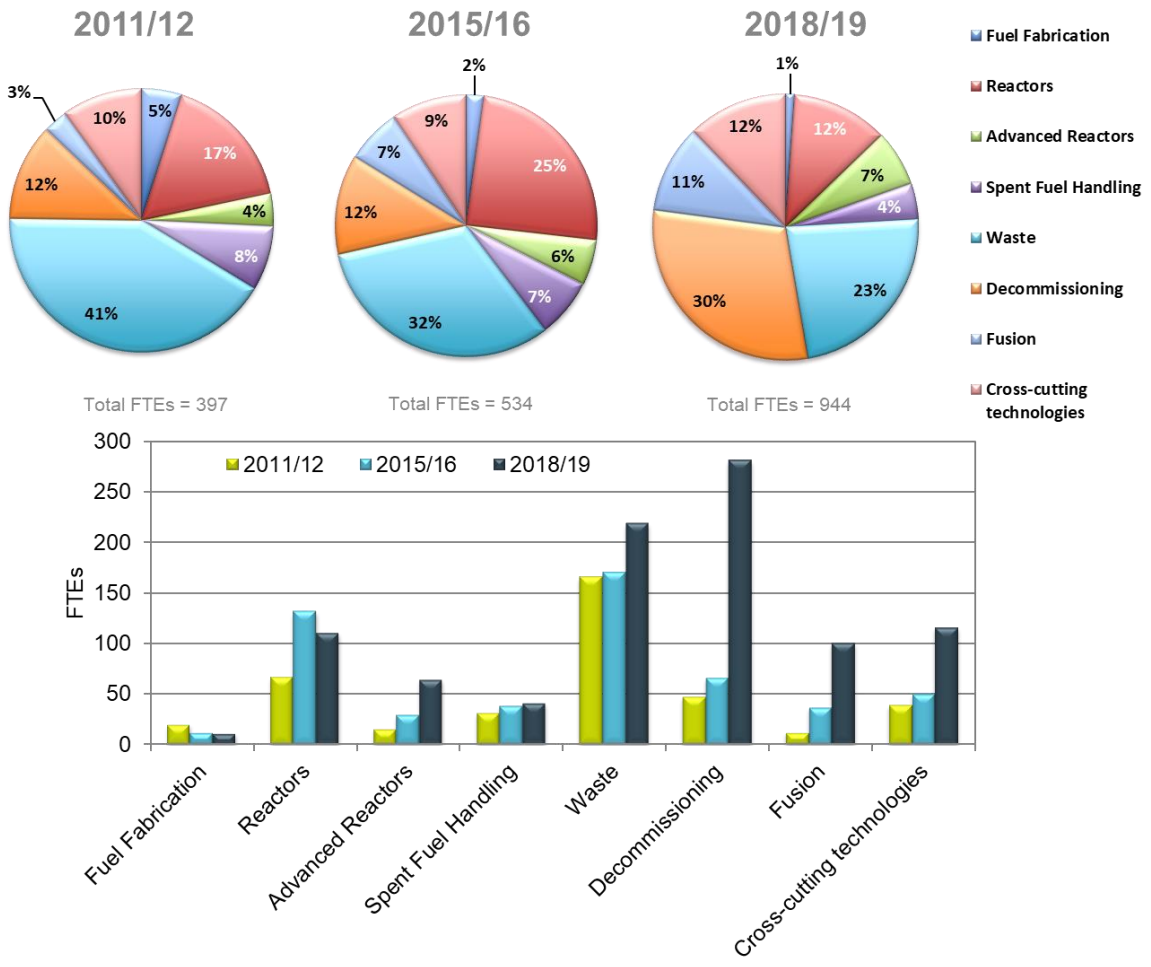
Figure 11. Total FTEs, geographical spread and experience of UK industry involved in civil nuclear R&D



- Overall it is estimated that there has been a 13% increase in the number of researchers engaged in civil nuclear research in UK industry compared to 2015/16. The number of industry civil nuclear researchers recorded in 2018/19 is 944, 85% higher than the 2015/16 figure reported in the 2017 survey. A large proportion of this increase is seen in the figures from Sellafield and DSRL, however, NDA Estate report that the number of their researchers working on civil nuclear R&D is approximately the same in 2018/19 as in 2015/16. NDA Estate have used a wider definition of research when counting their researchers for 2018/19 than for 2015/16, this accounts for the majority of the apparent increase.
- There are two more organisations (27) recorded as carrying out civil nuclear R&D than in 2015/16, however 85% of researchers are found in the leading 10 organisations.
- The distribution of experience shows growth in all categories; however, growth is more pronounced in the less than five years (+123%) and the five to 15 years (+100%) categories.
- The organisations reporting that they are carrying out civil nuclear R&D has changed since 2015/16, with 10 new respondents; and 8 active in 2015/16 not reporting activity this time, including 6 organisations who didn't respond but may still be active and 2 nil returns.

Industry

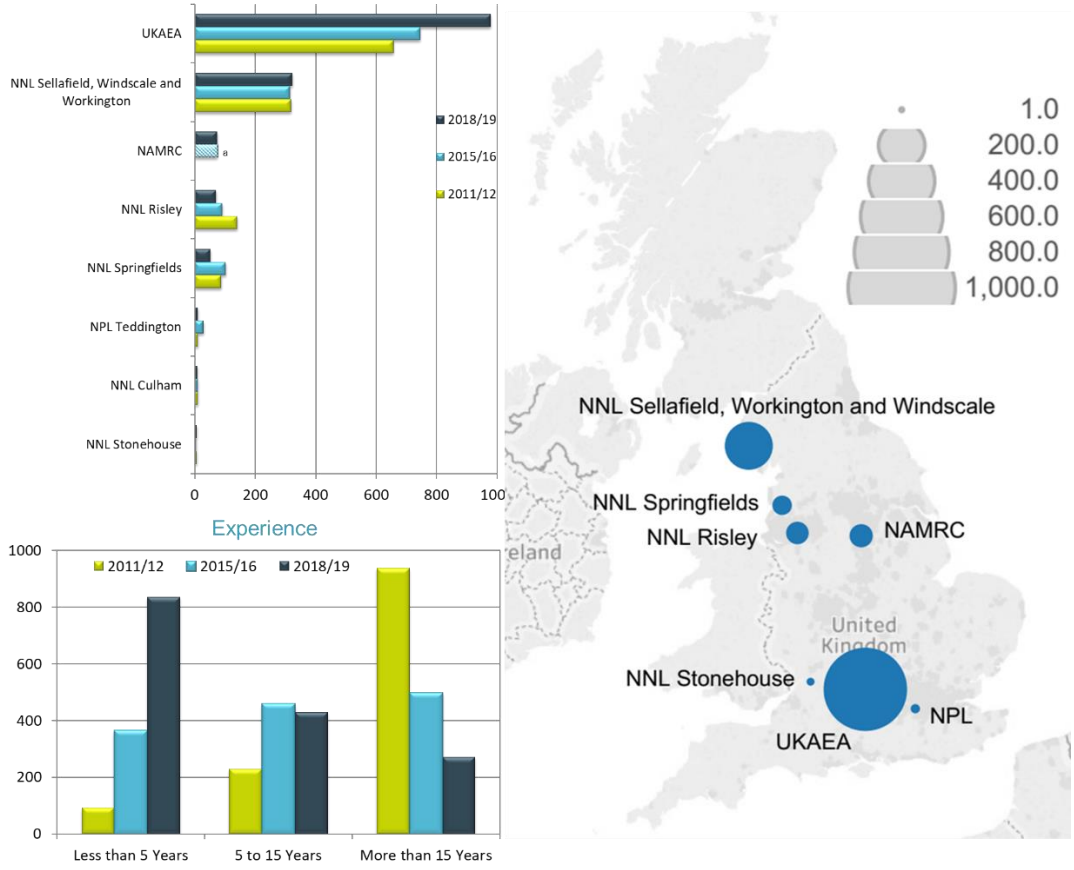
Figure 12. A comparison of UK industry civil nuclear R&D research focus (FTEs) in 2011/12, 2015/16 and 2018/19



- Advanced reactors, Waste, Decommissioning, Fusion & Cross-cutting technologies have all seen significant increases in reported industry R&D FTEs between 2015/16 and 2018/19. However the increases in Waste & Decommissioning FTEs correlate directly to the increase in the figures recorded from Sellafield, DSRL as already noted.
- FTEs researching fuel fabrication and spent fuel handling remain very low with very ittle change since 2015/16.
- Industry FTE researchers involved in current reactor research have declined compared to 2015/16 but remain well above the 2011/12 level.
- Industry FTEs researching advanced reactors remains a small proportion of overall activity (6%, 30 FTEs).

National Labs

Figure 13. Total FTEs, geographical spread and experience in UK national laboratories involved in civil nuclear R&D

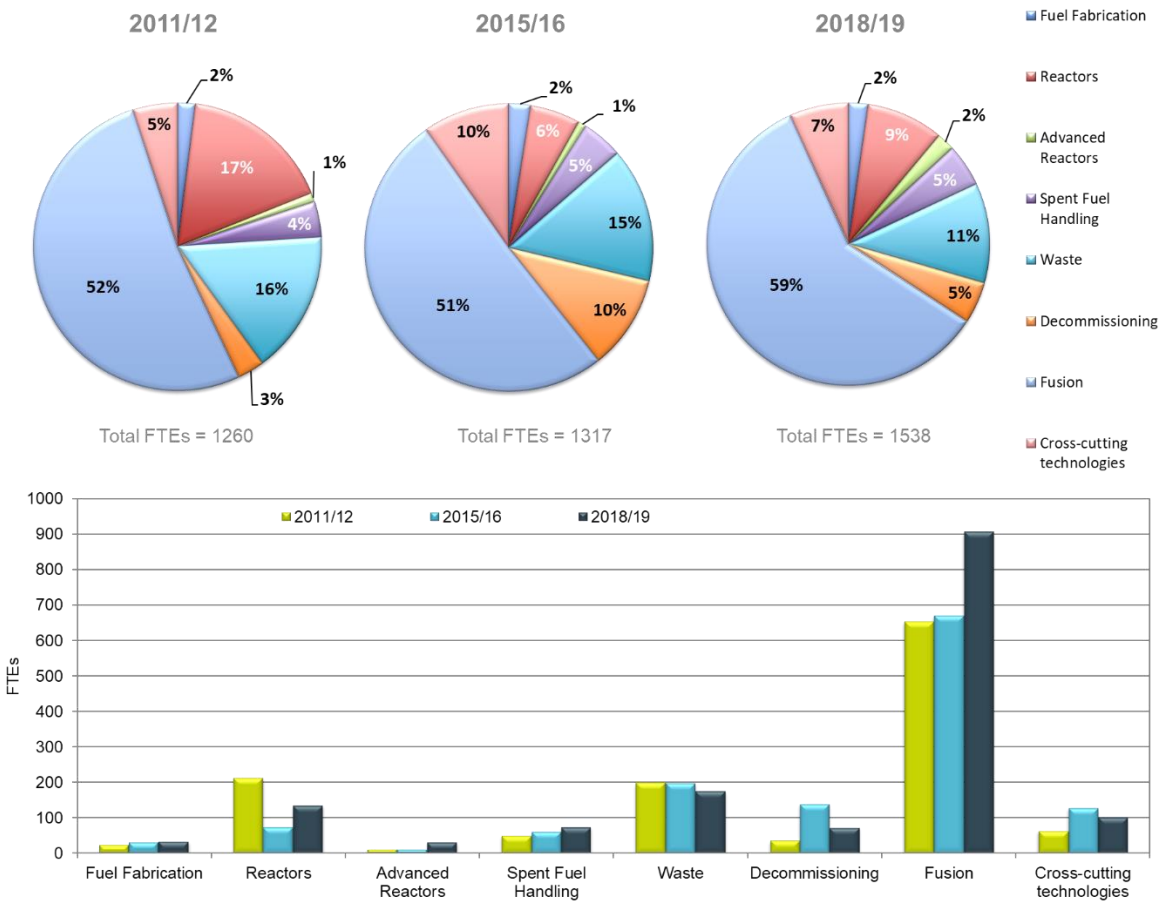


[a] NAMRC are included in national laboratory figures for the first time in 2018/19, NAMRC report that in 2015/16 their number of civil nuclear R&D researchers was approximately the same as in 2018/19.

- National laboratory FTEs are mainly within the National Nuclear Laboratory (NNL) for fission related research, and UKAEA for fusion research. The majority of NNL researchers are based across 3 sites in the North West of England, and the entirety of UKAEA researchers based at the Culham site in the south of England.
- NAMRC in Yorkshire are included alongside national laboratories, for the first time. Researchers at NAMRC account for 5% of national laboratory civil nuclear R&D FTEs (76).
- The data suggests a 12% decrease in fission (NNL) national laboratories FTEs carrying out civil nuclear R&D since 2015/16. This continues the decrease noted in the 2017 survey. Since 2011/12 the overall reduction observed across NNL is 18%.
- Conversely there has been a 31% increase in fusion (UKAEA) national laboratory FTEs carrying out civil nuclear R&D since 2015/16. This also continues the upward trend seen in the 2017 survey. Since 2011/12 the total increase within UKAEA is 49%.
- National Physical Laboratory (NPL) report that the number of researchers working on civil nuclear R&D there has dropped by 59%, returning to approximately the level seen in 2011/12.
- In both fission and especially fusion national laboratories the significant loss of more experienced staff, predominantly through retirement, has continued. At the fusion national laboratory this is countered by a threefold increase in FTEs with less than 5 years' experience. The effect of these changes is a complete reversal of the distribution of experience compared to 2011/12.

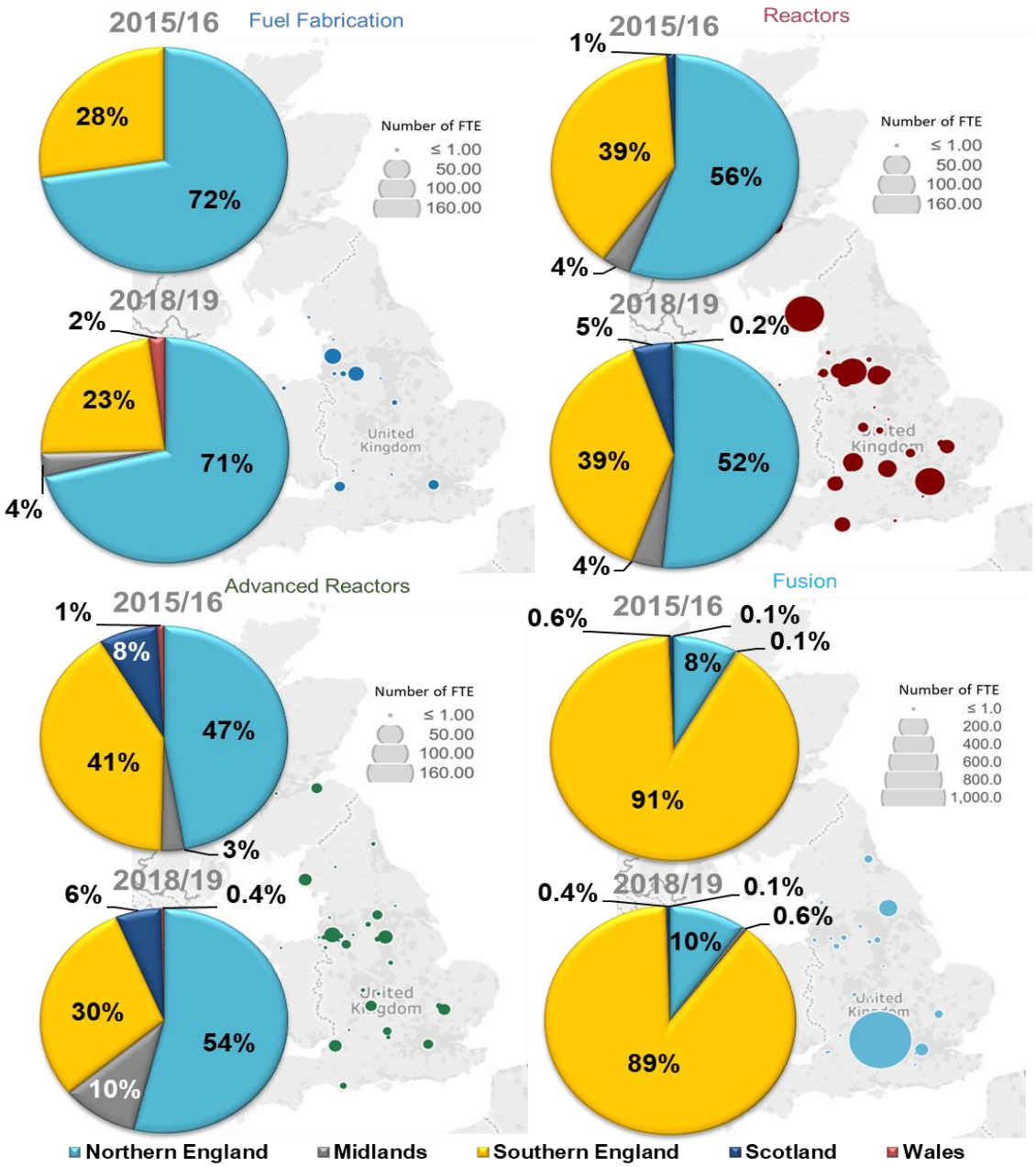
National Labs

Figure 14. A comparison of UK national laboratory civil nuclear R&D research focus (FTEs) in 2011/12, 2015/16 and 2018/19



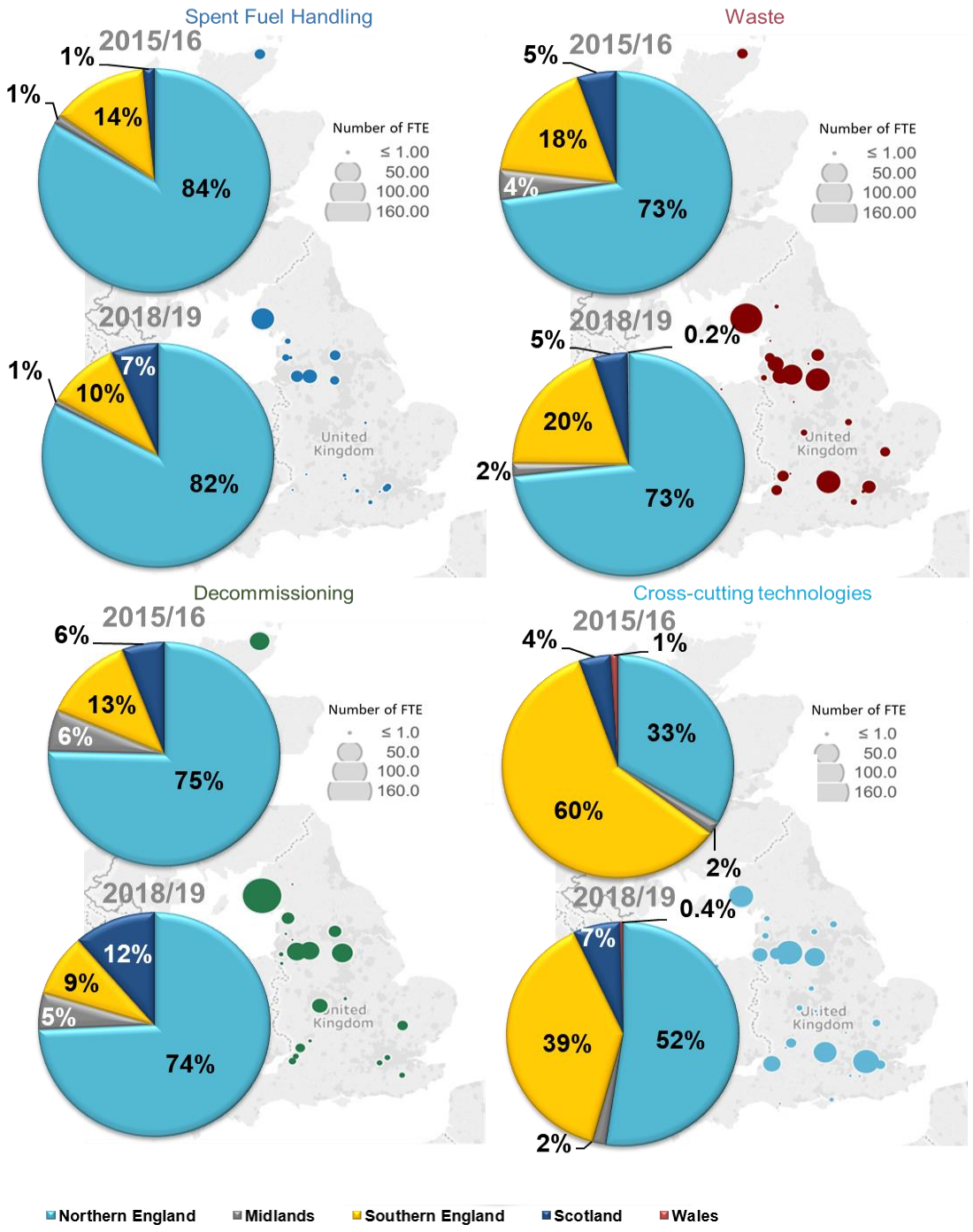
- Activity in fusion research has increased by around a third since 2015/16, and now accounts for 59% of national laboratory research.
- The number of fuel fabrication researchers (34 FTEs) has increased slightly but remains very low.
- Activity related to advanced reactors (32 FTEs) has grown by 163%, predominantly due to the inclusion of research at NAMRC, but also remains very low.
- The increase in decommissioning research observed in 2015/16 has reversed with a halving in the numbers of researchers working in this area relative to 2015/16.
- Current reactor research has increased compared to 2015/16, however the number of researchers remains below the level observed in 2011/12.
- The steady increase in researchers working on spent fuel handling seen in 2015/16 has continued, with 50% more FTE in 2018/19 than 2011/12.

Figure 15. Geographical distribution of the total UK civil nuclear workforce by research theme (a)



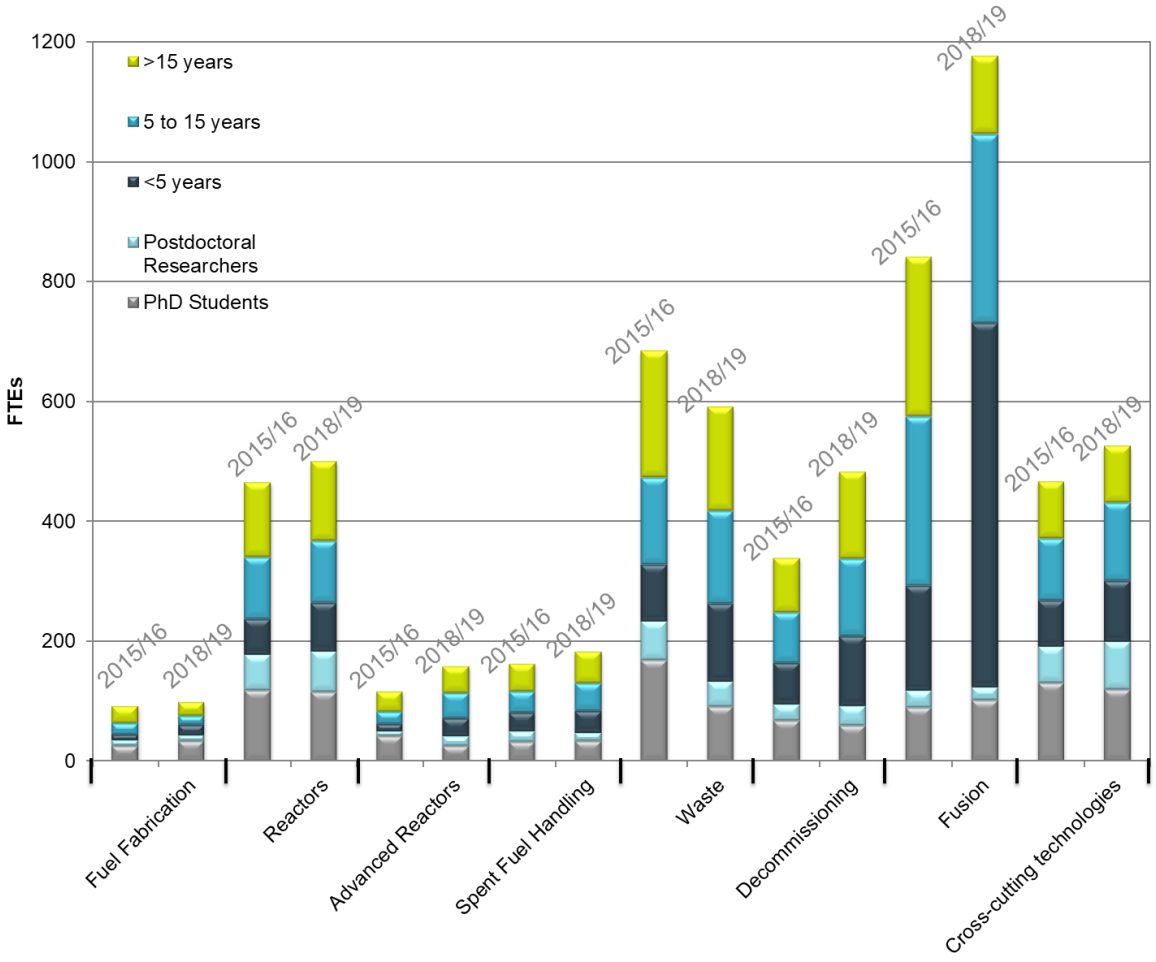
- Northern England & southern England combined account for over 90% of researchers in all themes except for advanced reactors and decommissioning (see Figure 16 below).
- Fusion continues to be the least distributed theme with 89% of researchers in southern England. NB Fusion FTE numbers presented on a different scale.
- Advanced reactors are the most distributed research theme, although effort has become more focussed in northern England since 2015/16.

Figure 16. Geographical distribution of the total UK civil nuclear workforce by research theme (b)



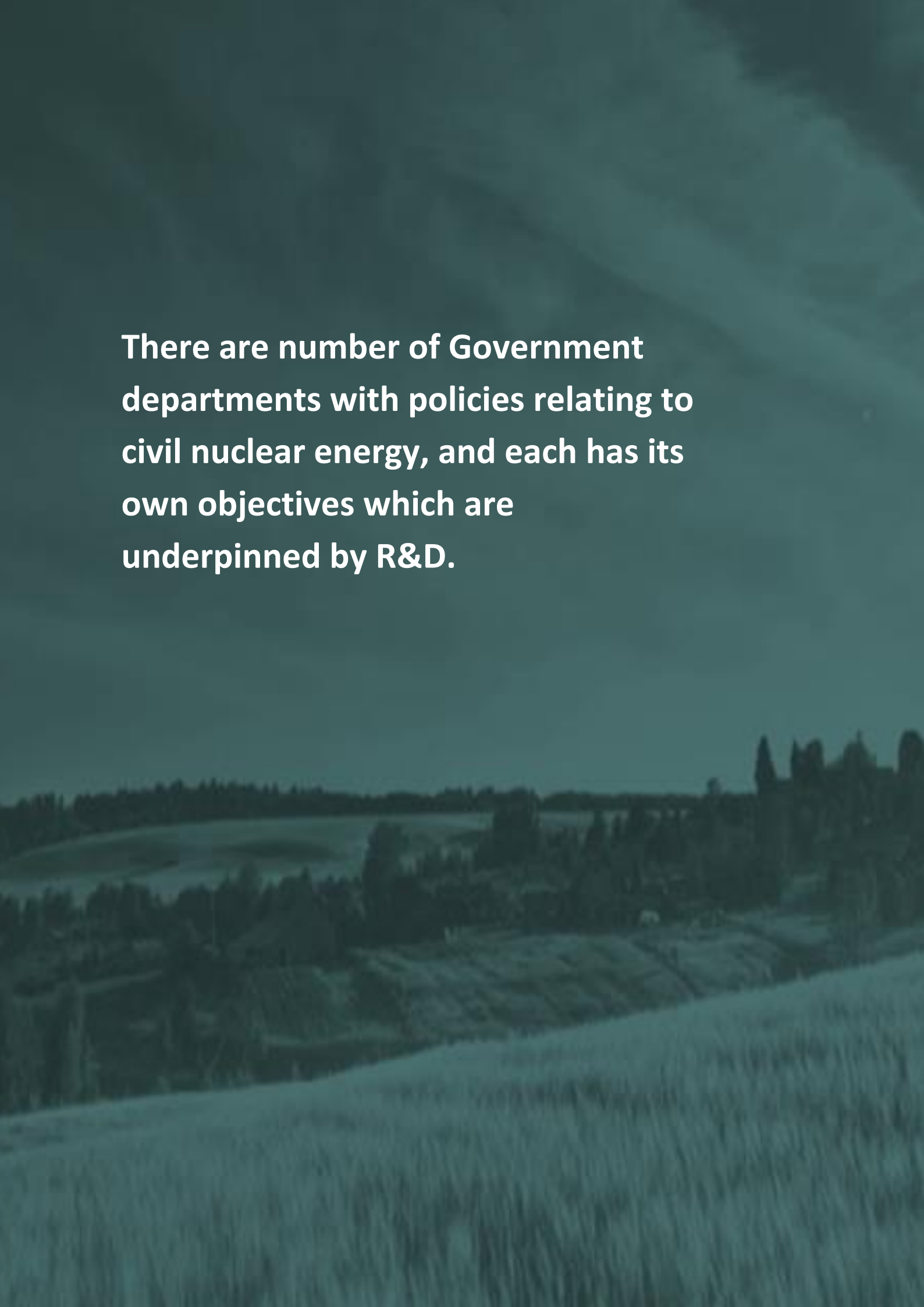
- The number of researchers has increased in all regions, Scotland saw the largest increase (70%), increases in other regions ranged from 12% (Midlands) to 17% (Wales).
- Over 70% of research into fuel fabrication, spent fuel handling, waste and decommissioning takes place in northern England, the distribution of these themes has changed little since 2015/16.
- Since 2015/16 research into cross-cutting technologies has shifted from being 60% carried out in southern England to being more evenly distributed, with 52% in northern England.

Figure 17. A comparison of the experience of the total UK civil nuclear R&D workforce in 2015/16 and 2018/19, broken down by research theme



- In both 2015/16 and 2018/19 all the research themes had FTEs in each of the five experience categories.
- The number of researchers with less than five years experience has grown significantly for all research themes, overall the number of researchers with less than five years experience doubled between 2015/16 and 2018/19.
- Fusion has seen the most dramatic change in profile with 247% growth in researchers with less than 5 years experience and 51% drop in those with more than 15 years experience.
- The overall reduction in research into waste between 2015/16 and 2018/19 is dominated by a 46% reduction in PhD students and a 35% reduction in postdoctoral researchers.
- PhD students researching advanced reactors have dropped by 38% since 2015/16, however all other experience categories researching this theme have increased (Postdoctoral researchers +94%, <5 years +155%, 5-15 years +97%, >15 years +34%).

Objectives for Civil Nuclear R&D in the UK



There are number of Government departments with policies relating to civil nuclear energy, and each has its own objectives which are underpinned by R&D.

3 Objectives for Civil Nuclear R&D in the UK

3.1 Public sector objectives for nuclear R&D

A number of Government departments have policies that relate to civil nuclear energy, and each has its own objectives which are underpinned by R&D.

The majority of policies relating to civil nuclear power belong to the BEIS. Whilst the Government's overall strategy on nuclear energy has not changed significantly, the position on low carbon targets has. In 2019, the Committee on Climate Change (CCC) published its recommendations to limit emissions of greenhouse gases over the next 30 years with a target of net-zero emissions by 2050[6]. Whilst net-zero is significantly more ambitious than previous targets, upon reviewing the latest scientific evidence on climate change, the CCC concluded that net-zero is necessary, feasible and cost-effective. Government accepted the main conclusions of the CCC report and the UK adopted a net-zero emissions target for 2050 through the Climate Change Act 2008[7], the first country to do so. Since the CCC report, a number of further studies have been conducted. These more stringent carbon targets are placing a greater focus on the cost-effective implementation of nuclear energy.

The Government's most recent statement of vision for nuclear energy[8] is to have a nuclear sector that:

- has safety and security as its highest priorities, with the UK leading the world in safe and secure operations across the whole fuel cycle.
- continues to contribute to a low carbon and secure energy future, with nuclear energy being deployed efficiently and effectively, competing successfully with other low carbon technologies.
- leads the way in successfully decommissioning redundant nuclear facilities, including the environmentally safe disposal of nuclear waste.
- contributes to employment and prosperity in the UK including by exporting to overseas markets, respecting the imperative of not proliferating nuclear weapons.
- continues to command public confidence, by operating safely, securely, sustainably and transparently.

[6] https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

[7] https://commonslibrary.parliament.uk/research-briefings/cbp-8590/

[8] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/168047/bis-13-630-long-term-nuclear-energy-strategy.pdf

The most recent statement of Government nuclear research and development objectives[9] are:

- To have the right level of nuclear research and innovation to ensure near-term as well as long-term commercial success in domestic and global markets.
- For the research base to be underpinned by world-leading facilities which are fully utilised by both national and international customers and which conduct a programme of fission-related research whose scale is consistent with the UK's nuclear aspirations.
- To be a respected partner contributing significantly to appropriate international research programmes undertaken with selected international collaborators.
- To have a joined-up approach to nuclear research and innovation across government, industry and academia, which serves to benefit the UK economy and ensure security of supply.

Other Government departments with policies relating to civil nuclear energy are:

Foreign and Commonwealth Office (FCO) – objectives to enhance prosperity through promoting UK economic interests overseas. FCO also has responsibility for safeguarding the UK's national security by countering terrorism and weapons proliferation.

Department of Health (DoH) – objectives to understand the risk to health of the effects of radiation, supported by its agency Public Health England (PHE).

The Food Standards Agency (FSA) – objectives to understand the impact of radiological discharges in the UK on foodstuffs, and the safety and detection of irradiated food**.**

Department for Environment, Food & Rural Affairs (Defra) – objectives related to the regulation and management of radioactive and nuclear substances and waste. This is actioned through the Environment Agency (EA).

Department for Work and Pensions (DWP) – objectives related to health and safety, enacted through the Office for Nuclear Regulation (ONR).

3.2 Private sector objectives for nuclear R&D

The private sector shares Government's long-term vision for nuclear energy to play a significant role in the UK's energy mix by the middle of the century and beyond. From a commercial perspective the nuclear sector offers significant potential reward, and so R&D objectives in the private sector underpin business objectives.

[9] https://www.gov.uk/government/publications/nuclear-industrial-strategy-the-uks-nuclear-future

Institutional Landscape of Nuclear R&D in the UK

The civil nuclear sector in the UK is complex, with a combination of public and private ownership and responsibilities for different aspects across the nuclear fuel cycle.

4 Institutional Landscape of Nuclear R&D in the UK

The civil nuclear sector in the UK is complex, with a combination of public and private ownership and responsibilities for different aspects of R&D across the nuclear fuel cycle.

4.1 Sectors of the civil nuclear industry

Waste Management and Decommissioning

Waste management and decommissioning responsibility for the UK's nuclear legacy which includes retired first-generation power stations, fuel reprocessing facilities and some aspects of the UK's early defence programme is held by the NDA, an executive non-departmental public body (NDPB) sponsored by BEIS.

Research is commissioned directly by the NDA in order to deliver potential improvements across the estate, and through its SLCs to support projects at individual sites.

Current Generation

Following the shutdown of the final first-generation Magnox reactor at Wylfa in 2015, there are currently eight operational nuclear power stations in the UK (seven stations operating Advanced Gas Cooled Reactors and one station operating a Pressurised Water Reactor). EDF Energy operates all the UK's nuclear power stations and is part owned by the French Government. The operator is responsible for ensuring there is sufficient R&D to underpin safe performance and, where possible, extend the lifetime of its power stations.

Uranium Enrichment and Fuel Manufacturing

Enrichment activities in the UK are undertaken by URENCO, a company which is one third owned by UK Government and the remainder equally by the Dutch Government and two German utilities. Fuel manufacturing is undertaken by Westinghouse, a US company which is owned by Brookfield Asset Management, a Canadian company. Research activity related to enrichment and fuel manufacture is predominantly done overseas within these organisations.

New Nuclear Build

Hinkley Point C is the first new nuclear power station to be built in the UK in over 20 years. Based in Somerset, it will provide low-carbon electricity for around 6 million homes, create thousands of jobs and bring lasting benefits to the UK economy. Construction and operation of Hinkley Point C will create 25,000 employment opportunities, up to 1,000 apprenticeships and 64% of the project's construction value is predicted to go to UK companies. There are currently over 4,500 workers on the site. Marking a significant milestone in the revitalisation of our nuclear power industry, Hinkley Point C will make a major contribution to the UK's move to reduce carbon emissions. The electricity generated by its two EPR reactors will offset 9 million tonnes of carbon dioxide emissions a year, or 600 million tonnes over its 60-year lifespan. This is a market led approach, with Government undertaking a number of facilitative actions to promote private investment, including delivery of national policy statements, regulatory justification, establishment of the Generic Design Assessment (GDA) process and waste and decommissioning financing arrangements.

Whilst further investment in other large-scale nuclear projects has proven difficult to move forward, a number remain under consideration.

Responsibility for the R&D to support the new third generation nuclear power stations to be built in the UK is held by the private sector organisations that are developing the sites but is not expected to be a significant element of these programmes as mature technology options are generally the product proposed. These organisations are consortia of non-UK companies that have access to significant experience in their native countries, specifically France, China and Japan. Their responsibilities cover all stages of the project from construction, commissioning, operations and decommissioning.

Future Nuclear Energy Technologies

The UK Government and industry have stated their vision for nuclear to continue to play a significant and increased role in the UK's energy mix by the middle of the century, which may require the development and deployment of advanced reactor systems different to those currently being built around the world. The UK Government policy for any future technologies is for the market to provide the technologies that can competitively be deployed. However, given the long development time and high upfront investment required to commercialise new reactor systems and related fuel cycle infrastructure, Government has recognised it can play a role in supporting early stages of research.

The Nuclear Innovation Programme (NIP) commenced in 2016 and is a £180m commitment by Government. The NIP was established with input from the original NIRAB and NIRO with the initial objective of maintaining the key nuclear capabilities required to innovate, improve and deploy future reactor systems. A framework for projects was established which covered a wide spectrum of activities:

- Digital Nuclear Reactor Design
- Advanced Nuclear Manufacturing and Materials
- Nuclear Safety and Security Engineering
- Nuclear Facilities and Strategic Toolkit
- AMR Feasibility and Development Study
- Advanced Fuel Cycle Programme

In addition to the Nuclear Innovation Programme, Government is supporting higher maturity nuclear but novel activities such as the Low Cost Nuclear Programme.

Standardised Small Modular Reactors (SMRs) promise to provide the UK a versatile option that can be built quickly as we move towards a net-zero economy. The Low-cost nuclear challenge proposed by a Rolls-Royce led consortium aims to develop a SMR designed and manufactured in the UK capable of producing cost effective low carbon electricity and creating significant export opportunities for UK businesses. An initial £36 million joint public and private investment, with £18m of the investment from the Industrial Strategy Challenge Fund, will enable the consortium to further develop their design. This is part of a greater bid into the Industrial Strategy Challenge Fund worth £500 million (joint investment with the private sector), subject to future approvals and a final decision to make public investment.

4.2 Government agencies and public bodies commissioning civil nuclear R&D

Several Government departments have policy objectives related to nuclear energy and are therefore involved in commissioning or are interested in the output of associated research activity, as outlined in Chapter 2. Departments enact their research needs directly or through a number of different agencies and public bodies, as shown in Figure 18. This section briefly describes the various Government bodies commissioning research; details of funding levels are given in Chapter 2.

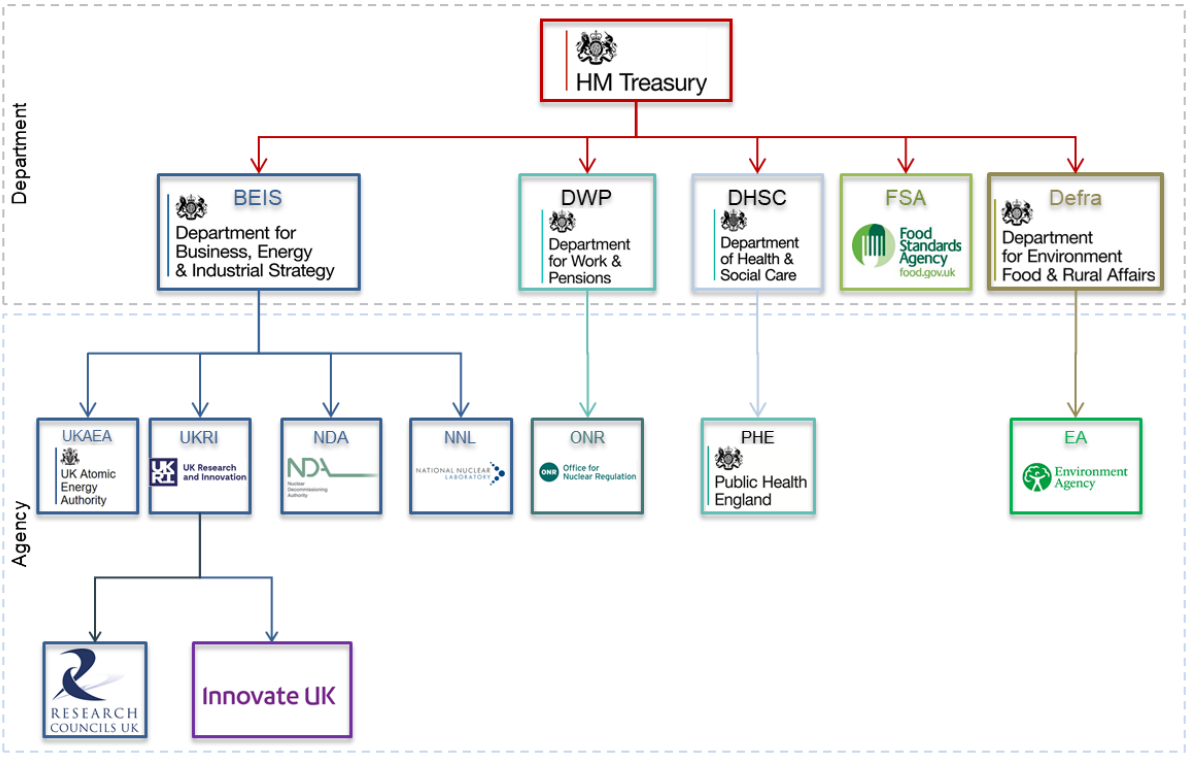


Figure 18. Government agencies and public bodies commissioning civil nuclear R&D

Department for Business, Energy and Industrial Strategy (BEIS)

BEIS is the Government department responsible for much of the UK's public spend on research and innovation. This is primarily done through agencies, but BEIS also commissions nuclear research directly through its Science and Innovation directorate's Energy and Innovation budget.

UK Research and Innovation (UKRI)

UKRI works in partnership with universities, research organisations, businesses, charities, and Government to create the best possible environment for research and innovation to flourish. We aim to maximise the contribution of each of our component parts, working individually and collectively. We work with our many partners to benefit everyone through knowledge, talent and ideas. Operating across the whole of the UK with a combined budget of more than £7 billion, UKRI brings together the seven Research Councils, Innovate UK and Research England.

Innovate UK

Innovate UK is an executive NDPB, sponsored by BEIS and managed through UKRI. It was formerly known as the Technology Strategy Board until the trading name Innovate UK was adopted in 2014.

The approach of Innovate UK has shifted to target funding at non-sector specific areas, allowing for a more open competition, mainly through the Industrial Strategy Challenge Fund (ISCF). Thus, it has no overarching programme directed at the nuclear sector. However, it does provide funding to fission through its various programmes, where nuclear based proposals compete with those from other sectors. The first nuclear specific challenge to gain funding under the ISCF (£18m) is the Low Cost Nuclear challenge, focussed on the development of Small Modular Reactors (SMRs). Innovate UK also funds the High Value Manufacturing Catapult (HVMC) which in turn provides core funding to NAMRC.

Innovate UK has supported projects with a total value of around £30m over the last three years. It has helped to develop the UK supply chain and primarily supported Small and Medium Enterprises (SME) in relation to the NDA estate, life extension of existing plants and nuclear new build.

Research Councils

There are seven Research Councils classified as NDPBs who receive funding as part of the Science Budget administered through BEIS under the overarching structure of UKRI. They have a strategic partnership which aligns them under one non-department government body Research Councils UK (RCUK) which seeks to enhance the collective impact of a number of benefits including research.

The Research Councils' objectives are to:

- fund basic, strategic and applied research.
- support postgraduate training (PhDs and masters students and fellows).
- advance knowledge and technology and provide services and trained scientists and engineers to contribute to the economic competitiveness, the effectiveness of public services and policy, and quality of life.
- support science in society activities.

These organisations support academic level research through open and targeted calls for proposals. These projects of cutting-edge science and commissioning world class facilities are funded through an open peer review process.

Several Research Councils fund activities related to civil nuclear energy, with the majority of funding flowing through the Engineering and Physical Sciences Research Council (EPSRC) led Energy Programme[10], which also includes research commissioned by the Natural Environment Research Council (NERC), and the Science and Technology Facilities Council (STFC). The Energy Programme includes both nuclear fusion and fission research.

[10] http://www.rcuk.ac.uk/research/xrcprogrammes/energy/

Nuclear Decommissioning Authority (NDA)

NDA is an executive NDPB sponsored by BEIS, responsible for the safe and efficient clean-up of the UK's nuclear legacy. NDA owns 17 UK nuclear sites including their assets and liabilities. NDA primarily delivers its mission through SLCs and their supply chains, although the NDA does commission research directly where there is a cross-site benefit or need to do so. The budget for the NDA is formed from a combination of public funding and income from commercial contracts.

National Nuclear Laboratory (NNL)

NNL is the UK's national laboratory for fission covering the whole of the nuclear fuel cycle. It is a Government owned and operated public corporation and operates on a commercial basis, receiving no direct grant funding. By agreement with Government, NNL invests in areas of strategic national importance from its operating profits including into facilities, critical skills, innovation and R&D.

NNL is one of the host organisations for the National Nuclear User Facility (NNUF) at its central laboratory.

United Kingdom Atomic Energy Authority (UKAEA) and Culham Centre for Fusion Energy (CCFE)

CCFE is the UK's national laboratory for fusion research. CCFE is owned and operated by the UKAEA. UKAEA is an executive NDPB, sponsored by BEIS.

Fusion research at CCFE is funded jointly by Euratom, BEIS and EPSRC.

UKAEA is one of the host organisations for the National Nuclear User Facility (NNUF) and hosts the Materials Research Facility (MRF) which was established to analyse material properties and is utilised on both Fission and Fusion programmes. MRF provides academic and industrial users with the resources to carry out micro-characterisation of neutron-irradiated materials. UKAEA also hosts the Remote Applications in Challenging Environments (RACE) facility and has seen significant developments in the past 3 years.

Department for Work and Pensions (DWP)

Office for Nuclear Regulation (ONR)

ONR is responsible for regulation of nuclear safety and security across the UK. Its mission is to provide efficient and effective regulation of the nuclear industry, holding it to account on behalf of the public.

At the time of publication of the previous Landscape, ONR was an agency of the Health and Safety Executive (HSE), an NDPB sponsored by the Department for Work and Pensions. ONR was established as a statutory Public Corporation on 1 April 2014 under the Energy Act 2013. The Secretary of State for Work and Pensions has principal responsibility for ONR.

ONR uses research to support its independent regulatory decision making. Where necessary it commissions research to support this function.

Department for Environment, Food and Rural Affairs (Defra)

Environment Agency (EA)

The EA is an executive NDPB, sponsored by Defra. It works to create better places for people, wildlife and to support sustainable development. EA is responsible for regulating major industry and waste management and the treatment of contaminated land. It is therefore responsible for granting site permits to operators, ensuring compliance with radioactive waste disposal regulations. It has limited funds for commissioning its own research, but as a key user of research output, it publishes its research priorities to inform external researchers and research funders[11].

Department of Health and Social Care (DHSC)

Public Health England (PHE)

PHE is an executive agency, sponsored by the Department of Health and Social Care. It aims to protect and improve the nation's health and wellbeing, and reduce health inequalities. It is a research-informed organisation that is driving forwards the provision and use of evidence for decision-making across the UK's public health system. PHE contributes to research into radiation protection issues.

The Health Protection Agency, which was listed as funding civil nuclear research in the 2013 Landscape review, became part of PHE in 2013.

Food Standards Agency

The Food Standards Agency is a non-ministerial Government department responsible for food safety and food hygiene in England, Wales and Northern Ireland. Part of its research portfolio investigates the impact of radiological discharges in the UK on foodstuffs, and the safety and detection of irradiated food. The majority of its 2018/19 radiological research funding was spent on food sampling and analysis with the remainder on research related to developing capability for assessing the impact to the public from radioactivity in food.

[11] https://www.gov.uk/government/publications/collaborative-research-priorities-for-the-environment-agency-2015-to-2019

Coordination of Civil Nuclear R&D in the UK

NIRAB's remit includes fostering greater cooperation and coordination across the whole of the UK's nuclear research and innovation capability.

5 Coordination of Civil Nuclear R&D in the UK

Coordination between public sector research funders

At the time of publishing the last landscape survey in 2017 the Government had recently announced the formation of the Energy Innovation Board (EIB) to provide strategic oversight of all energy innovation programmes and coordination of energy innovation activity. This was to replace the Low Carbon Innovation Coordination Group (LCICG).

The current situation is that the role previously carried out by LCICG has been split between the Energy Innovation Board (EIB) and the Energy Innovation Programme Board (EIPB):

- The EIB provides strategic oversight, challenge and recommendations to Ministers
- The EIPB acts as a programme board for the delivery of the BEIS Energy Innovation Programme.

Under the EIPB there are a number of thematic committees including the Nuclear Thematic Committee (NTC). The NTC is the successor to the LCICG Nuclear Sub-group, it consists of members of BEIS, UKRI, NDA, MoD, FCO and is chaired by the BEIS Science and Innovation for Climate and Energy. The key functions of the NTC are governance of the BEIS Nuclear Innovation Programme and sharing information across its membership.

Recently efforts have been stepped up enhance coordination between the key public sector funders of nuclear research, development & deployment, with a new co-ordination group meeting to explore opportunities for greater collaboration and programme synergies in the upcoming spending review period.

The Government established the Nuclear Innovation and Research Advisory Board (NIRAB) in January 2014 to advise Ministers, Government Departments and Agencies on issues related to nuclear research and innovation in the UK. NIRAB was established as a temporary advisory board for a period of up to three years and concluded at the end of December 2016. Following consideration, the output of the NIRAB report this body was then reconvened for a further 3 years and will publish its further findings in April 2020. Part of the role of NIRAB was to foster greater cooperation and coordination across the whole of the UK's nuclear research and innovation capability, portfolio and capacity.

NIRAB has, in part, fostered cooperation and coordination by providing a forum at which Government Departments and Agencies have been able to discuss priorities and share plans for funding research. The Nuclear Innovation and Research Office (NIRO) has also supported NIRAB in attending other coordinating bodies such as the NDA Research Board, the National Nuclear User Facility (NNUF) steering group and the Nuclear Waste and Decommissioning Research Forum (NWDRF).

Coordination between research performers

There are a number of mechanisms, bodies and groups which act to facilitate coordination between research performers in the nuclear field. Some have a specific nuclear focus and others include nuclear as part of a more extensive portfolio. These include:

- The Nuclear Waste and Decommissioning Research Forum (NWDRF) is a cross industry group that aims to enhance coordination of R&D and technical programmes across UK Site Restoration and Integrated Waste Management activities. Its membership includes representatives from NDA, Radioactive Waste Management (RWM), Site Licence Companies, regulators and organisations with significant nuclear decommissioning liabilities.
- The Nuclear Universities Consortium for Learning, Engagement and Research (NUCLEAR) is funded by the EPSRC to widen academic and industrial collaboration and enhance knowledge transfer. The NUCLEAR group is responsible for organising national meetings to support the nuclear universities in the UK.
- The NNUF steering committee, which coordinates access to NNUF equipment suitable for conducting research on radioactive or activated materials. This committee reports to BEIS on usage of the NNUF facilities.

Coordination between public and privately funded research

There are no formal mechanisms for coordination of public and privately funded research.

NIRAB's remit includes fostering greater cooperation and coordination across the whole of the UK's nuclear research and innovation capability, including members and observers from the public and private sector.

Nuclear Industry Council

The Nuclear Industry Council (NIC) is a joint forum between the nuclear industry and Government and its primary role is to provide strategic leadership to the nuclear industry. Originally set up to deliver the 2013 Nuclear Industrial Strategy, the previous NIC delivered valuable work in key areas including cost reduction, skills and public understanding of nuclear energy. The NIC was reformed in 2017, following a review in consultation with its members. It was reduced in size to ensure more focused discussions on the key strategic issues for the sector.

Nuclear Sector Deal

The NIC developed the Nuclear Sector Deal which was launched on 28 June 2018 as part of the Government's modern Industrial Strategy. The NIC is responsible for overseeing the delivery of the Nuclear Sector Deal. Five working groups are leading the detailed work to implement the Sector Deal, focusing on:

1. New build cost reduction
2. Legacy cost reduction
3. Winning UK business
4. Skills and diversity
5. Innovation and R&D

The Nuclear Sector Deal was developed by industry and Government, based on proposals set out by the NIC:

Chair and structure

The Council is currently co-chaired by Tim Stone, Chairman of the Nuclear Industry Association (NIA) and Nadhim Zahawi, Parliamentary Under Secretary of State for Business and Industry. The secretariat is provided by the Department for Business, Energy & Industrial Strategy and the NIA. The Council aims to meet quarterly; minutes of meetings are published on its website, along with reports and publications produced by the Council. The NIC is comprised of executive-level members from across the nuclear industry, as well as senior representatives from Government and regulators. Members have been selected to provide a breadth of knowledge and experience and will be expected to speak for their areas of expertise, rather than their companies or organisations. Membership is refreshed every 2 years.

NIRAB and NIRO have worked closely with the NIC since 2014; NIRO, for example, has collaborated with the relevant NIC sub-groups and work streams on innovation to coordinate specific R&D activities across the two organisations.

There are good examples of coordination in some areas; for example, RCUK and industry have come together to fund collaborative programmes:

- The Henry Royce Institute – The Royce provides a unique capability to design, make and test advanced materials for nuclear applications. Its primary funding is from the Engineering and Physical Sciences Research Council. Through its partnership model, the Royce enables industry to use state-of-the-art facilities and draw on expertise of over 900 academics from across the UK. The founding partners of the Royce are the universities of Manchester, Sheffield, Leeds, Liverpool, Cambridge, Oxford and Imperial College London, as well as UKAEA and NNL.
- Robotics for Nuclear Environments (RNE) - RNE is a five-year collaborative research programme that brings together robotic and nuclear engineering experts to make the step changes in robotics and autonomous systems capability that are needed to overcome the challenges facing the UK and international nuclear industries. RNE is led by the University of Manchester in partnership with NNL, Bristol robotics laboratory, University of Birmingham, NDA, NPL, EDF and a range of other industrial partners. The programme is being funded by The Engineering and Physical Sciences Research Council, industrial partners and the Italian Institute of Technology.

International Collaboration in Civil Nuclear R&D


The UK is active and visible on the international stage with an ambitious nuclear innovation programme.

6 International Collaboration in Civil Nuclear R&D

International collaboration is the main route for developing nuclear technologies, such as advanced reactors, due to the substantial investment required by such programmes. International engagement and collaboration are important and afford a number of benefits:

- Access to international best practice to challenge and benchmark the UK's research capability.
- Access to facilities to enable the UK to meet its research objectives, for example, research reactors and irradiation facilities.
- Leverage on investment in nuclear R&D.
- Access for UK industry to overseas markets.
- Improved understanding of political and legislative developments.

The UK is active and visible on the international stage with an ambitious nuclear innovation programme and investment in new research facilities and equipment, ambitions for deploying a small modular reactor (SMR) and developing an advanced modular reactor (AMR). The UK are now more effectively coordinated and represented on various international fora (OECD.NEA, IAEA etc) through UK Government departments and wider nuclear sector organisations. The provision of research facilities, for example, provides credibility and a basis for finding mutual benefit in international research collaborations.

A more coherent and overarching international collaboration strategy is under development for nuclear research in the UK. Since publication of the first landscape review in 2013, a number of Government sponsored Memoranda of Understanding, Nuclear Cooperation Agreements and other declarations have been made that state the UK's intent to collaborate with international partners in the field of nuclear energy, for example:

- The UK and South Korea signed two Memorandums of Understanding in November 2013 to develop closer cooperation in the fields of commercial civil nuclear energy and nuclear decommissioning[12].
- UK and France have signed a number of declarations and Memorandums of Understanding on nuclear energy and fission research over the last 10 years.
- In June 2015 the UK and Canada signed a Memorandum of Understanding concerning enhancing cooperation in the field of civil nuclear energy[12].
- UK and China signed a Statement of Cooperation in the field of civil nuclear energy in October 2015[13]. This was followed by a signing of a Heads of Terms Agreement for a

12 https://www.gov.uk/guidance/guidance-for-operators-of-new-nuclear-power-stations#history

13 https://www.gov.uk/government/publications/statement-of-cooperation-in-the-field-of-civil-nuclear-energy-2015

UK–China Joint Research and Innovation Centre (JRIC). NNL and China National Nuclear Power Co Ltd (CNNP) are the lead organisations for the UK and China.

- In December 2016 the UK and Japanese governments signed a Memorandum of Cooperation across a range of civil nuclear activities, including decommissioning, research and development and new nuclear. The Memorandum stimulated creation of the EPSRC sponsored network for Japan – UK Nuclear Opportunities (JUNO) which is forging new and deeper collaboration between academic researchers in the nuclear fission landscape.
- The UK/US Nuclear Fission R&D Action Plan was signed in September 2018 by BEIS for the UK and USDOE covering 6 areas of Nuclear Fission research linked to the SICE Nuclear Innovation Programme.

There are good examples of where the UK is working as a respected partner and contributing to international research programmes, for example, EU funded projects (such as EUROfusion, THERAMIN, CONCERT, GENIORS, MIND and CHANCE). There is also international academic engagement through Research Councils UK funding of programmes supporting collaboration with Japan, India, South Korea and the US.

The UK actively engages in International Atomic Energy Agency (IAEA) Coordinated Research Projects (CRPs). UK organisations are currently participating in over 20 active CRPs which include research in the areas of Food and Agriculture, Human Health, Nuclear Power, Nuclear Security and Nuclear Fuel Cycle and Materials Technologies and Climate Science. The following are a selection of active CRPs with UK involvement:

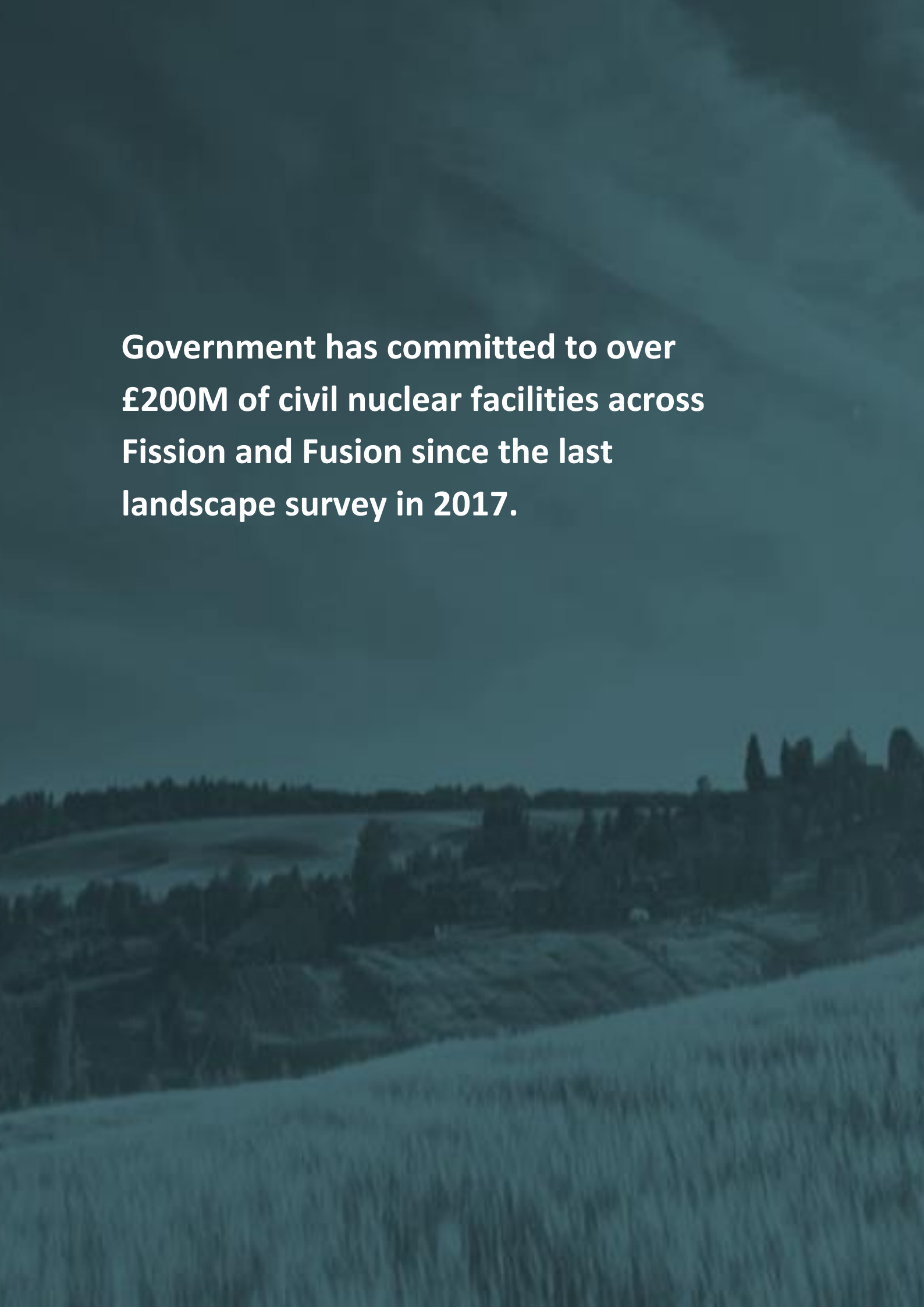
- Development of Steady-State Compact Fusion Neutron Sources
- Neutronics Benchmark of China Experimental Fast Reactor (CEFR) Start-Up Tests
- Spent Fuel Performance Assessment and Research
- Ion Beam Irradiation for High Level Nuclear Waste Form Development (INWARD)
- Accelerator Simulation and Theoretical Modelling of Radiation Effects - SMoRE-II

The UK became an active member of the Generation IV Forum (GIF) in 2019. Additionally, the UK is a member of the Jules Horowitz Reactor (JHR) project being built in France and continues to be a member of the OECD Nuclear Energy Agency (NEA) Halden reactor project in Norway, however the reactor closed in 2019 with plans to transfer much of the experimental work to the JHR project once this project is up and running.

The UK has left the EU, and Euratom, and negotiations are underway to mitigate the impact on the UK's nuclear R&D activity and international collaboration. The UK Government hope to develop a close partnership with the Euratom R&T programme during the ongoing negotiations.

There has been significant progress since the recommendations in the 2017 landscape survey, for the UK to develop and implement a comprehensive and coordinated international collaboration strategy for nuclear research and innovation and there is growing evidence that this is starting to enable research to be implemented and UK investment leveraged to the greatest effect.

Facilities for Civil Nuclear R&D in the UK



Government has committed to over £200M of civil nuclear facilities across Fission and Fusion since the last landscape survey in 2017.

7 Facilities for Civil Nuclear R&D in the UK

As the UK aspires to progress its technology development programmes from blue skies, lab-based work, through the technology development cycle to commercialisation, so investment in UK facilities continues. This chapter focusses on the Government investment in R&D infrastructure since the last R&D Landscape survey published in 2017 while also acknowledging the comprehensive baseline of infrastructure that is already in existence.

Highlights of recent funding announcements include:

£74m in the National Nuclear Users Facility Phase 2 (£61m for Capital Equipment and £12M for support).

£42m (£11.2m HMG and £32m from other sources) invested in the National Centre for Nuclear Robotics.

£40m to be invested in a National Thermal Hydraulics Facility.

£86m to be invested in the UKAEA Hydrogen-3 Advanced Technology (H3AT) Centre and the Fusion Technologies Facility.

£22m in a Fusion Energy Research Centre in Rotherham[14].

These announcements cover facilities and infrastructure that will take many years to develop and can be seen as infrastructure as opposed to facilities. Notwithstanding this, the scale of these announcements are significant and represent a real increase in the investment in civil nuclear technologies by the UK as the decarbonisation agenda starts to take effect.

However, whilst investment has been made in capital equipment, there is a comparative lack of the corresponding investment in programmes to enable effective use of the facilities.

7.1 Details of selected Government funded research facilities

The following section identifies the details of some of the funding announcements made above.

Host	Facility	Description	Funding
University of Bristol, NNL, Dalton Cumbria Facility and RACE	Hot Robotics Facility	A new robotics facility to prove remote robotics technology in active environments. This facility should help provide site operators with the confidence to allow deployment of new and novel equipment on site.	EPSRC - NNUF 2

[14] Fusion Energy Research Centre

Host	Facility	Description	Funding
University of Birmingham	High Flux Accelerator Driven Neutron Irradiation Facility.	Neutron accelerator facility to be constructed at the University of Birmingham for the development of next generation nuclear materials for fission and fusion applications. Design spec includes: - Accelerator maximum proton current and energy: >30mA DC / 2.6 MeV. - 100kW beam dump for tuning at full beam current. - Designed for continuous operation aiming for uptime > 95% between service intervals - Initial guaranteed neutron yield > 2.5e13 primary neutrons - Neutron target performance maintained for >250 hours at full power with <10% yield loss.	EPSRC - NNUF 2
University of Bristol	Active Nano Mapping Facility	High Speed Atomic Force Microscopy facility to be hosted with the University of Bristol Department of Physics. This equipment should allow the measurement of sample nano and micro structures with the accuracy (spatial and temporal) required for modelling nuclear relevant materials, including fuels.	EPSRC - NNUF 2
UKAEA, NNL and the University of Bristol	Irradiated Materials Archive Option Study	An options study review with the objective of proposing a pragmatic archive facility for historic irradiated sources in the UK.	EPSRC - NNUF 2
University of Southampton and University of Bristol	Radio-chemistry Labs	The University of Southampton has been awarded funding for facilities focussing on radiochemistry. The facilities will be provided via the GAU institute, a commercial organisation with a renowned reputation in radiochemistry analysis.	EPSRC - NNUF 2
Lancaster University	Trace Analysis System	UKAEA has been awarded funding to develop a UK trace analysis system for remote identification of environmental contamination. The grant includes funding for an accelerator mass spectrometer.	EPSRC - NNUF 2

Host	Facility	Description	Funding
Consortia of 8 Universities including University of Bristol and University of Birmingham	National Centre for Advanced Robotics	Research centre/facilities investigating and applying robotics and advanced nuclear characterisation techniques in remote/hazardous environments.	EPSRC
UKAEA	National Thermal Hydraulics Facility	The National Thermal Hydraulics Facility was announced in 2018. Since then a feasibility exercise has been ongoing to scope such a facility against an array of different reactor types which could potentially be deployed in the UK. The main spend will be in future years once the scope of the facility is agreed.	BEIS - Nuclear Innovation Programme for scoping
UKAEA	Hydrogen-3 Advanced Technology (H3AT) Centre	The H3AT facility is proposed to research and develop the tritium systems and infrastructure which will be required to operate future fusion infrastructure. To date contracts are being tendered and let for the design, supply and installation/construction of the facility which is due to be commissioned in 2021.	BEIS
UKAEA	Fusion Research Technology Centre	UKAEA and the Nuclear Advanced Manufacturing Research Centre are to create a Fusion Research Technology Centre in Rotherham. The facility will focus on the development of materials, e.g. ceramics and metals, for use in fusion reactors and their testing under simulated operational environments. Design and construction of the facility is yet to commence.	BEIS and Sheffield City Region
UKAEA	Fusion Technology Facility	The Fusion Technology Facility will be a thermal hydraulics focussed facility focussing on the design and testing of components needed for a fusion reactor. Characteristics of importance for a fusion reactor include being under a vacuum, high thermal flux and strong magnetic fields although as the facility is yet to be designed, the specifics of the intended facility are still to be confirmed.	BEIS

It is noted that with respect to the NNUF 2 funding, the EPSRC included a list of indicative facilities and equipment within their grant call[15]. The items included in the list above are only those with confirmed funding as of March 2020.

7.2 Facility Longevity

The investment in fusion facilities is predominantly driven by the announcement of £220m to develop STEP. This is considered separately here as STEP could be considered construction of a large demonstrator facility or a programme.

For STEP to be achieved, the fusion facilities identified in this section all have a role. This clarity of purpose gives the facilities and the capital investment made by the Government a long-term future of programme funding.

While acknowledging that there will be crossover for some of the fission facilities, a similar long-term programme would also be beneficial in attracting the best researchers, supervisors and academics to fission. It has already been identified that the skilled personnel are integral to any facility, and as such, the fission community also require a long-term vision beyond the UK SMR which requires only limited research facilities to meet its goal.

7.3 Access to Neutrons

Attention should be drawn to the challenge of access to neutrons which are essential for future materials and fuel development.

It is noted that the UK continues to monitor its investment in the Jules Horowitz Reactor which is currently under construction in France. Yet this is the only research reactor for civil nuclear purposes in which the UK has an ownership stake.

It is further noted that during the period since the last report the Halden Reactor in Norway has closed. The UK was an active member in this programme with historical results underpinning operational safety cases for reactors in the UK and further afield. The loss of this facility means that civil reactor operators and researchers have lost access to one of the major neutron sources for fission research.

As the UK looks to decarbonise our economy and develop new civil nuclear technology, the challenge of access to appropriate neutron sources is going to be a challenge as irradiation of sample materials and fuels will become an increasing requirement. It is noted that a new accelerator facility has been identified and that UK researchers have been working internationally, including with the US national labs, to gain access to irradiation facilities. Yet the issue of access to neutrons for research and technology development has the potential to become an increasingly important facility need.

[15] Included at:
https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=2ahUKEwjXjcb3tKToAhWZQUEAHTB7DVMQFjABegQIAhAB&url=https%3A%2F%2Fepsrc.ukri.org%2Ffiles%2Ffunding%2Fcalls%2F2019%2Fnational-nuclear-user-facility-phase-2-invitation-for-proposals%2F&usg=AOvVaw3AtMI0JYzVGE0Y8aQNHaCu

The UK's Civil Nuclear R&D Landscape 2020:

Appendices and Glossary

Appendix 1 Methodology for Data Collection

The national laboratory, industry and academic R&D data presented in this report has been acquired using a data collection process using a questionnaire agreed by NIRAB. This questionnaire was designed to collect data which could be compared directly to that collected in 2016 and 2012 and used in the previous reviews of the civil nuclear landscape published by NIRAB in 2017 and by Government in 2013.

A questionnaire was sent to national laboratories, industrial organisations carrying out research and universities engaged in civil nuclear research. The number of national laboratories is limited, and these were contacted directly. Questionnaires were sent to all the industrial organisations that responded in 2012 and 2016, all organisations that have received research funding from Innovate UK and all of the organisations holding research contracts with NDA and RWM. Finally, questionnaires were sent to all universities with academics belonging to the nuclear academics meeting, a total of approximately 300 people.

The academic questionnaire is replicated in Appendix 2. The industrial and national laboratory questionnaires were almost identical to the academic questionnaire. The only difference was that they did not seek information on numbers of PhD students and postdoctoral researchers.

In common with the previous reviews the list of organisations responding to the request for data is significant, but not definitive. There are almost certainly organisations engaged with civil nuclear R&D that have not responded.

Appendix 2 Civil Nuclear R&D Landscape Survey Questionnaire 2019 - Universities

About Your Organisation

1. Organisation Name
2. Organisation point of contact and contact details

R&D Funding

3. Complete the table for R&D Projects which your organisation undertook in FY18/19 (Add more rows as required).

Project Title	*Total 2018/19 Project Value*	*Funding source*				Research Theme (See Guidance)
		Internal funding	*UK industry funding*	*Public funding*	*Overseas funding*	

Guidance - The research themes include the following programme areas:

Themes

Fuel Fabrication
Uranium conversion and enrichment, fuel development, fuel manufacture, fuel cycle assessment

Reactors
Reactor technology/design, reactor component manufacture, reactor operation including materials degradation and structural integrity, activation and structural integrity

Advanced Reactors
Advanced reactor systems (GEN IV), fuel recycle / reprocessing for advanced systems

Spent Fuel Handling
Spent fuel storage, fuel recycle / reprocessing for current operations, nuclear materials management

Waste
Waste retrieval, legacy clean-up, effluent management, geo-science, earth science

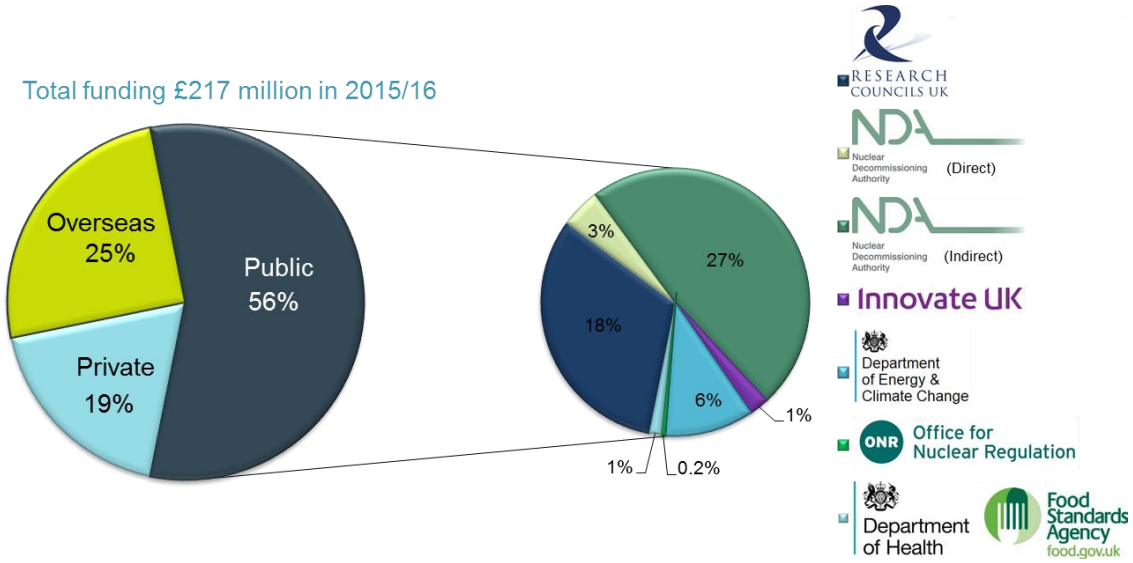
Decommissioning
Decontamination, structure demolition, asset management, post operation clean out

Fusion
Plasma, advanced materials for fusion, tritium handling in fusion, activation studies for fusion, nuclear data for fusion, remote handling for fusion

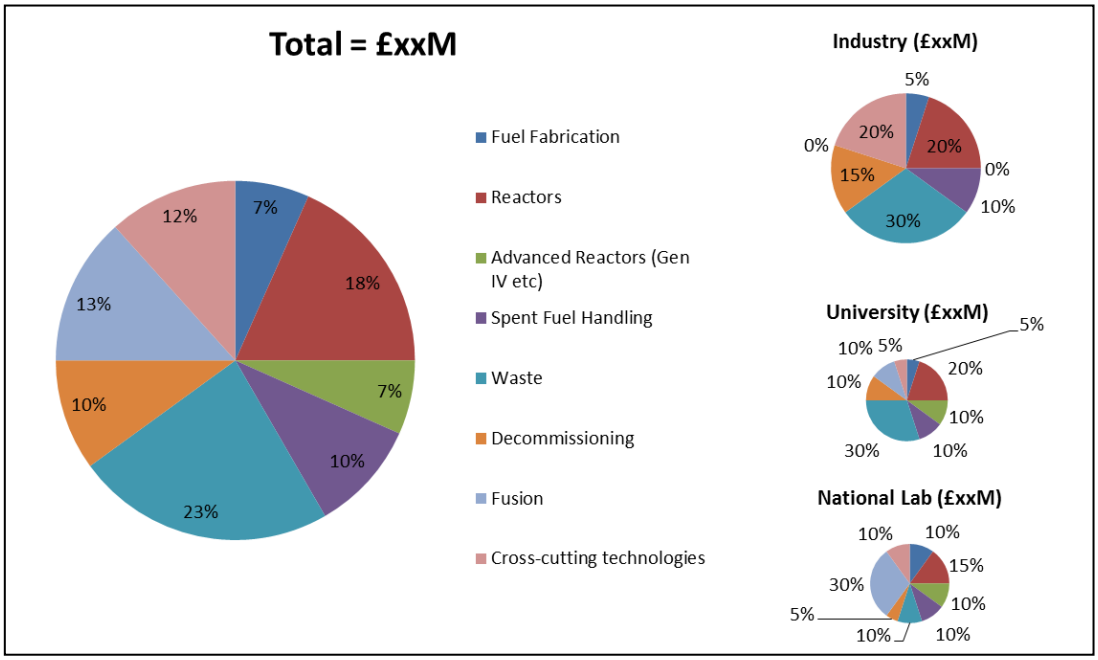
Cross-cutting technologies
Advanced computational methods, neutronics, safety, security, social studies, public engagement, regulatory, economic

Guidance - The R&D funding data received will be used to generate a series of figures showing the breakdown of funding per source for research done in academia, industry and national labs, and the breakdown of funding per research theme as shown in the figures below.

Example chart (2017 Review) - Breakdown of funding per source:



Example chart - Breakdown of funding per research theme:



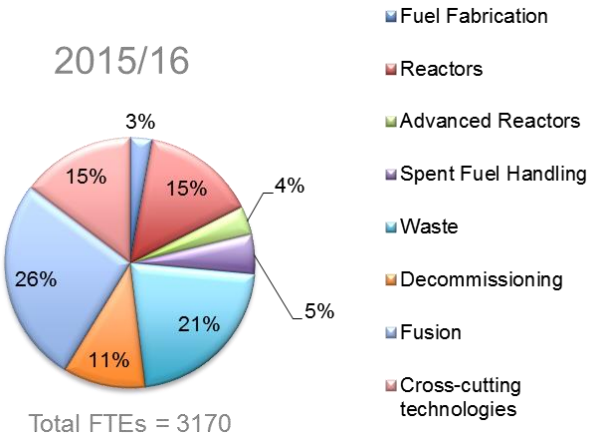
Research Capacity and Focus

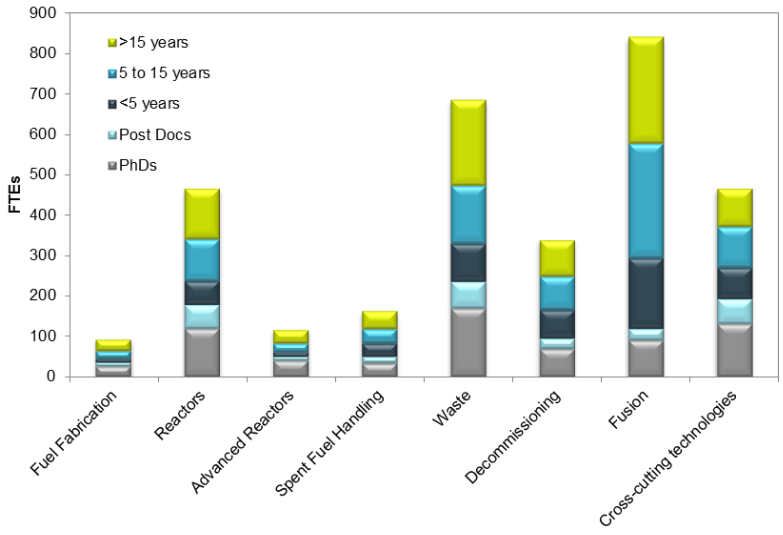
4. **Please complete the table for the number of Full Time Equivalents (FTE) in your organisation that were deployed on nuclear R&D projects in FY2018/19, their area of expertise and number of years experience. Please note that an FTE can be split across a number of themes if applicable.**

If you have more than one location, please estimate the number of researchers based at each site.

Themes	PhD Students	Post Doc Researchers	Academic staff with less than 5 years experience	Academic staff with 5 to 15 years experience	Academic staff with more than 15 years experience
Fuel Fabrication					
Reactors					
Advanced Reactors (Gen IV etc)					
Spent Fuel Handling					
Waste					
Decommissioning					
Fusion					
Cross-cutting technologies					

Guidance - It is intended that the data will be used to generate figures illustrating the distribution of research across the research themes for each sector (academia, industry and national labs). It is not intended to publish data on the distribution of research themes on an organisation by organisation basis. The figure to the right is taken from the 2017 Review and illustrates the distribution of research effort in civil nuclear R&D in the UK.





Guidance - The data may be used to compile figures illustrating the varying distributions of experience of researchers working on different research themes as illustrated in the figure to the left, taken from the 2017 review.

Guidance - The data received will be used to generate a series of figures showing the distribution of experience across the country for researchers in academia, industry and national labs. The academia data from the 2017 Review is reproduced on the right.

Have Your Say

5. Please provide any additional comments you have on strategic issues facing the UK's civil nuclear R&D landscape. Your comments will not be attributed in the summary report but will help inform the qualitative analysis.

Thank you for completing the Civil Nuclear R&D Landscape Survey Questionnaire 2019. Please return to info@niro.org.uk

Glossary

AWE	Atomic Weapons Establishment
BEIS	Department for Business, Energy and Industrial Strategy
BIS	Department for Business, Innovation and Skills
CCFE	Culham Centre for Fusion Research
CNNP	China National Nuclear Power Co Ltd
CORDIS	Community Research and Development Information Service
DCF	Dalton Cumbria Facility
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food & Rural Affairs
DoH	Department of Health
DWP	Department for Work and Pensions
DISTINCTIVE	Decommissioning, Immobilisation and Storage Solutions for Nuclear Waste Inventories
DSRL	Dounreay Site Restoration Ltd
EA	Environment Agency
EC	European Commission
EPSRC	Engineering and Physical Sciences Research Council
EU	European Union
FCO	Foreign and Commonwealth Office
FSA	Food Standards Agency
FTE	Full Time Equivalent
GDA	Generic Design Assessment
GIF	Generation IV Forum
HEFCE	Higher Education Funding Council for England
HMRC	HM Revenue and Customs
HSE	Health and Safety Executive
HTF	High Temperature Facility
IEA	International Energy Agency
JET	Joint European Torus
JHR	Jules Horowitz Reactor
JRIC	Joint Research and Innovation Centre
LCICG	Low Carbon Innovation Coordination Group
LLWR	Low Level Waste Repository Ltd
MIDAS	Materials for Innovative Dispositions from Advanced Separations
MoD	Ministry of Defence
MRF	Materials Research Facility
NAMRC	Nuclear Advanced Manufacturing Research Centre
NDA	Nuclear Decommissioning Authority
NDPB	Non-Departmental Public Body
NERC	Natural Environment Research Council
NFCE	Nuclear Fuel Centre of Excellence
NIC	Nuclear Industry Council
NIRAB	Nuclear Innovation and Research Advisory Board
NIRO	Nuclear Innovation and Research Office

NNL	National Nuclear Laboratory
NNUF	National Nuclear Users Facility
NNUMAN	New Nuclear Manufacturing
NPL	National Physical Laboratory
NUCLEAR	Nuclear Universities Consortium for Learning, Engagement and Research
NWDRF	Nuclear Waste Decommissioning Research Forum
OECD-NEA	Organisation for Economic Co-operation and Development – Nuclear Energy Agency
ONR	Office for Nuclear Regulation
PHE	Public Health England
PRL	Pyrochemical Reprocessing Laboratory
R&D	Research and Development
RACE	Remote Applications in Challenging Environments
RCUK	Research Councils UK
RWM	Radioactive Waste Management Ltd
SLC	Site Licence Company
SMR	Small Modular Reactor
STEP	Spherical Tokamak for Energy Production
STFC	Science and Technology Facilities Council
UKAEA	United Kingdom Atomic Energy Authority
UKRI	UK Research and Innovation
USA	United States of America
UTGARD	U/Th/beta-Gamma Active process chemistry R&D

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