HM Government

Nuclear Industrial Vision Statement

Executive Summary

In this Nuclear Industrial Vision Statement, UK industry presents its ambitions over the next 40 years to ensure the development of a vibrant UK nuclear industry, and position the UK as a strong player in the expanding global nuclear market, yielding long-term economic growth. UK industry believes that the nuclear industry can be an area of economic and strategic national strength, and provide the UK with a safe, reliable, affordable supply of low-carbon electricity.

The Vision has been produced by representatives of the UK's nuclear industry as part of Government's response to the House of Lord's Science & Technology Select Committee report on the UK's nuclear R&D facilities. It forms the start of a commitment for the UK nuclear industry to work more collaboratively with Government in pursuit of a vibrant and globally respected UK industry.

The aims that are outlined will, if properly supported, see the UK regain its credibility as a 'top table' nuclear nation, with significant capability and an international role to play across all stages of the nuclear lifecycle. In its early phases, the Vision supports the re-establishment and strengthening of the industry, through relevant policy decisions, investments, and partnering mechanisms for knowledge transfer into UK organisations. The experience and knowledge this approach develops will be used to create significant export opportunities for UK organisations as part of the global nuclear market. The UK nuclear industry's clear and ambitious Vision for its future can be summarised as follows:

- **New Nuclear**: to maximise its stake of the UK's new build programme, achieving excellent delivery performance, and so secure a significant share in overseas new build programmes, becoming a key partner in commercialising Generation III, IV and Small Modular Reactor (SMR) technologies worldwide.
- **Operations & Maintenance (O&M):** to safely operate and achieve full service capability for domestic Light Water Reactors (LWR) and overseas Generation III plants, and provide packaged life-cycle management solutions for Generation IV and SMR reactors domestically and globally.
- **Waste Management & Decommissioning (WM&D):** to establish the UK industry as a global leader, securing a significant share of high value WM&D contracts globally, successfully deliver the UK's Geological Disposal Facility (GDF) and advance in safe decommissioning of UK sites, including land remediation.
- **Fuel Cycle Services:** to capitalise on and expand its current significant share of the overseas enrichment market, expand domestic and global supply of LWR fuel, safely deliver wet and dry spent fuel storage solutions at home and abroad and exploit opportunities in advanced fuel cycle technologies through a significant stake in emerging Generation IV designs.

For the Vision to become reality, UK industry believes four key enablers need to be understood clearly:

i. Successful delivery of the first wave of new UK nuclear power stations is a critical requirement to enable the Vision and secure the enormous strategic national benefits that can flow from it.

ii. UK industry must strive to be competitive, and make significant and growing contributions to domestic programme delivery across the entire nuclear sector.

iii. The UK needs to make demonstrable progress on safely managing its historic nuclear facilities, including decommissioning, waste management and disposal, displaying a joined-up approach to the way all aspects of the nuclear energy sector are tackled.

iv. Government must demonstrate that it recognises the long-term importance of nuclear to the UK's future energy and economic security. It can do this by:

    a. Working with industry to provide the required infrastructure solutions to underpin successful domestic nuclear energy generation that is commercially competitive and strategically secure.

    b. Identifying the long-term strategic international relationships/alliances needed to provide political stability and grow UK's influence and reputation.

    c. Investing where necessary in education, skills and long-term research and development (R&D).

The mature status of the UK nuclear industry and the structures that already exist must be taken into account when considering how best to ensure the Vision is realised. Industry believes that the remits of specific existing bodies, including the Nuclear Decommissioning Authority (NDA) and the National Nuclear Laboratory (NNL), require review to ensure that the UK nuclear sector is best positioned to meet the UK's strategic energy needs and realise its commercial ambitions.

The privatisation of the nuclear sector in the UK has led to fragmentation of R&D capability over time; there are currently few centralised bodies or national objectives around which the supply chain can coalesce and invest confidently for the long-term. Appropriate leadership across Government, industry and academia will be vital in rebuilding this area to support the industrial aims outlined through the establishment of a strategic coordinating R&D body and adaptation of the remits of existing industry and academic research bodies. UK industry has identified a number of specific R&D areas that will support the development of the UK nuclear industry over time, both strategic and commercial in their focus.

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1. Introduction

Background

In its response[1] to the House of Lords Science and Technology Select Committee report[2] on the UK's nuclear R&D capabilities, Government undertook to work with industry to produce a vision statement outlining the commercial role industry wants to play in the global nuclear market, and to identify how the research base could support it in its aims. This 'Vision' has been produced by a 'Nuclear Industry Group', whose membership (Appendix B) covers a broad cross-section of UK industry, and through extensive consultation with Government and relevant bodies.

The Vision has been developed by industry and shared with Government and its agencies for consideration in its decision-making which will shape the future of the UK's nuclear landscape. The content of the Vision has not been bound by current policy and seeks to be realistic yet also ambitious about the opportunities for economic growth and high value job creation in the UK.

The evolution of the nuclear market has meant that the number of multinational commercial entities has increased across the entire nuclear sector over time and there is now significant overseas involvement at many UK nuclear sites. International companies operating in the UK create significant benefit within our borders through creation of capability, jobs and strengthening the overall vibrancy of the UK sector, and the Vision has sought to consolidate and build on all activity undertaken in this country. Therefore, in addition to consulting UK-owned companies, this Vision for the UK has involved valuable contributions from overseas companies who invest in UK sites, facilities and capability and whose activities in the UK make them a valuable component of the UK nuclear industry.

The significance of the nuclear industry in providing a safe means of meeting the UK's energy needs as well as its massive potential for generating economic growth and job creation explains its inclusion as a priority in Government's industrial strategy this year. Agreement and delivery of the ambitions set out here in the Vision will contribute to the development of the nuclear industrial strategy; UK industry looks forward to closer collaborative working with Government as part of this process.

Report Structure

The Vision extends over the next 40 years and presents a view on each of the four major civil nuclear business sectors: New Nuclear, Operations & Maintenance

[1] Government Response to 2 (see http://www.parliament.uk/business/committees/committees-a-z/lords-select/science-and-technology-committee/news/nuclear-government-response/)
[2] House of Lords Select Committee on Science and Technology, 3rd Report of Session 2010-2012, Nuclear Research and Development Capabilities. ISBN 978 0 10 847395 1

(O&M), Waste Management & Decommissioning (WM&D) and Fuel Cycle Services, noting the extensive cross-over between them. Commercial opportunities develop over time and it is impossible to foresee them all in absolute clarity now but, for the purposes of this document, we can anticipate particular phases unfolding in the domestic and global markets:

Phase 1 - Current phase:	Now and over the next 5 years
Phase 2 - Expanding market phase:	Expanding global market share from 5-20 years' time
Phase 3 - New technology phase:	Developing and exploiting new technologies from 20-40 years' time

In each phase, the necessary 'building blocks' in developing UK industry's credentials are laid out. These activities (be they establishment of collaborations, research activity or technical achievements) progressively and realistically develop UK industry over time. In this way, the sequential and time-sensitive nature of many of the dependencies upon which the goal of a vibrant and globally-respected nuclear industry rests are highlighted.

The main audiences for the Vision, and rationale for their interest in it, are summarised below:

- **UK industry:** The Vision, together with the recent Nuclear Industry Association (NIA) report on the capability of the UK nuclear supply chain[3], describes where the UK nuclear industry is collectively operating and provides a view of where industry, with Government, aims to develop in the future. The Vision aims to stimulate a more unified approach from the UK nuclear industry, result in clearer thoughts on current and future market opportunities and what enablers must be put in place, or barriers removed, over time. The recent formation of a new Nuclear Industry Council (NIC) is welcomed by UK industry as a means of achieving that. The Vision should be seen as a live document: realising the commercial opportunities detailed within it will require industry to hold both itself and Government to account on making progress.
- **Government:** The Vision provides a clear steer to Government on how the UK nuclear industry wishes to develop in the future and what steps are needed to get there. Realising current and future commercial opportunities in this sector, both domestic and global, is dependent upon support from Government. The Vision sets out what these main requirements are and, once agreed, Government will enter into a partnership with industry to see these delivered, looking to industry to hold both itself and Government to account on making progress.
- **Overseas customers:** The collective UK nuclear industry has a long track record and already delivers in a competitive environment to the highest levels of quality and safety both domestically and globally. The Vision (together with the NIA report on the

[3] NIA Capability Report, 2012

capability of the UK nuclear supply chain[3]), provides a view to overseas customers of what the UK nuclear industry already has to offer and its long-term commitment to a high-achieving future. The UK nuclear industry welcomes interaction from overseas industries on the Vision, both as potential clients and collaborators. The NIA, UK overseas trade posts and United Kingdom Trade & Investment (UKTI) are all able to assist with more detailed information on the capabilities and services the UK nuclear industry can provide.

- **Prospective international investors:** The Vision offers prospective domestic investors a clear statement of the UK nuclear industry's aspirations for the future. The collaborative pursuit of future goals is something that the UK nuclear industry and Government would welcome discussing with prospective investors.

Current Landscape

The Domestic Nuclear Market

The UK industry we see today is mature and has a long heritage. It has evolved from state-owned roots in the 1950s into a predominantly market-led sector. For the past two decades, the focus of the industry has been on operating and extending the life of existing first generation (Magnox) and second generation (Advanced Gas-Cooled Reactors (AGR)) reactors, supplying enrichment and new fuel, reprocessing of spent fuel, and cleaning up the sites and facilities associated with the UK's nuclear history. The forthcoming domestic new build programme has changed the direction of the nuclear industry in the UK from one entirely focussed on gradual run-down and closure to one that aims at long-term growth. Government and UK industry are together actively making preparations to enable nuclear energy to make a significant contribution to the country's future prosperity.

New Nuclear

The UK is set to embark on a significant programme of new nuclear build.

- Current new nuclear activity in the UK is being progressed by three consortia (NNB Genco, Horizon and NuGen) that between them have set out proposals to develop approximately 16 GW of new nuclear power in the UK by 2030[4]. The new build programme will utilise third generation technologies, which are already widely deployed and being constructed internationally.
- Having not built a domestic reactor since 1995, the UK industry overall lacks recent new build experience. However, it does have a nuclear experienced workforce and mature nuclear industrial capability that is qualified to take on new build activities or extend existing missions in areas such as fuel fabrication, pumps, valves, as well as design and safety assessment. It is also important to note that sections of the industry have remained very active in supporting the delivery of recent international new build programmes across Europe, Asia and the Middle East.
- Government is clear that nuclear power has a role to play in the UK's future energy mix, but without public subsidy. A number of facilitative actions have been undertaken to promote private investment in this sector, including delivery of national policy statements, regulatory justification, establishment of the Generic Design Assessment (GDA) process and waste and decommissioning financing arrangements.

Operations & Maintenance

Nuclear generation in the UK has a distinguished safety record and is currently undertaken by EDF Energy, which owns and operates 15 out of the 16 remaining electricity generating reactors. The UK's 16 operating reactors (14 AGRs, 1

[4] World Nuclear Association (WNA) website (http://www.world-nuclear.org/info/inf84.html)

Pressurised Water Reactor (PWR) and 1 remaining Magnox reactor) generate 19% of its electrical needs (~10 GW capacity)[5].

- EDF Energy has a total annual supply chain spend of approximately £650m on its generating fleet in the UK, the vast majority of the associated work being delivered by UK suppliers. A £200m programme of post-Fukushima work is also underway across the EDF Energy UK fleet to enhance the existing robust safety systems[6]. In addition to this, specific work in the area of lifetime extensions is underway, with an average life extension of 7 years across the AGR fleet and 20 years for Sizewell B expected, subject to the necessary approvals.
- As a result of its 60 year history of safe power generation, the UK's existing nuclear O&M industry has technical expertise, established integrated relationships between regulator, operator, academia and supporting industries that place it at the forefront of global operational excellence.

Waste Management & Decommissioning

The UK decommissioning sector is overseen by the NDA, a non-departmental public body created under the Energy Act of 2004. It is responsible for implementing Government policy on the long-term management of nuclear waste through the decommissioning and clean-up of 19 sites built in the early days of the UK's original nuclear programme (including all the Magnox stations, several research sites and Sellafield). It also has a role in scrutinising the decommissioning plans of generator EDF Energy and in overseeing the implementation of the Geological Disposal Programme through its subsidiary the Radioactive Waste Management Directorate (RWMD).

NDA do not directly manage the facilities they own, and instead contract out the delivery of site programmes through management and operation contracts with licensed operators, Site Licence Companies (SLCs). SLCs manage sites, including preparing site plans, performing and sub-contracting work. Parent Body Organisations (PBOs) own shares in SLCs for the duration of their contract with the NDA, which are periodically competed. The PBO is responsible for managing the delivery of site programmes.

- Annual spending since the NDA commenced full operation has been approximately £3 billion, with up to £1 billion per year of this offset by operational revenue from generation and reprocessing[7]. This represents the most significant funding source in the UK's decommissioning sector.
- The UK has significant and developing nuclear WM&D expertise at legacy facilities as well as in nuclear material storage. Notable UK WM&D accomplishments include:

[5] WNA website (http://www.world-nuclear.org/info/inf84.html)
[6] EDF Energy has provided these figures from its own records
[7] NDA Business Plan 2012-2015

  - Full decommissioning of the Windscale Advanced Gas-cooled Reactor (WAGR);
  - The first fuel retrieval from an open aired pond in 50 years;
  - World's largest asbestos removal project at Chapelcross;
  - Safe destruction of sodium liquid metal primary coolant at Dounreay, one of the most hazardous legacies of the UK's early nuclear research.

- Commercial Magnox reactor decommissioning is presently being undertaken at 11 sites in the UK, with 25 reactors either in the process of being defuelled, or in the care and maintenance preparation stage having already been defuelled. In addition, several early experimental reactors have been fully decommissioned.
- The UK is progressing the design, safety and environmental assessment of a final geological disposal solution for its historic and future radioactive waste. Site selection is on a volunteerism based approach. The programme is led by NDA RWMD and supported by an industry that has gained extensive knowledge of, through a large programme of innovative R&D, the technologies required to deliver the solution to safe long-term waste disposal.
- Internationally, the UK via NDA has numerous bilateral agreements in place through which R&D collaborations are occurring, including:
  - International Atomic Energy Agency (IAEA)
  - Organisation for Economic Cooperation and Development Nuclear Energy Agency (OECD-NEA)
  - United States Department of Energy (US DOE)
  - Atomic Energy and Alternative Energies Commission (CEA)
  - EDF Energy
  - Japan Atomic Energy Agency (JAEA)
  - Nuclear Waste Management Organisation of Japan (NUMO).

Fuel Cycle

The UK is one of only a handful of countries with capability across the full fuel cycle (excluding mining).

- It has world-leading expertise and facilities for uranium enrichment, with 10% of global supply produced within the UK at the Capenhurst site[8]. Government owns a one-third share of the associated company, and at the time of writing is considering the sale of its share.
- The UK has a vast and diverse experience in fuel fabrication, ranging from novel fuels and cladding for early test reactors to commercial Magnox, AGR and the initial series of fuel for the Sizewell PWR. Fuel provision for LWRs is now an international

[8] Urenco has provided these figures from its own records

business dominated by multinational suppliers with sites in more than one country. For example, fuel for Sizewell B is supplied by such a business and utilises services from locations in more than one country. The Springfields site, which is currently managed by an international company on a long-term lease from the NDA, produces the unique design of fuel required by all the UK AGR reactors, and the site's capability for LWR fuel production is currently being revived.

- Commercial reprocessing has been performed in the UK since the 1960s. The currently operating Magnox and THORP plants at Sellafield are scheduled for closure by 2017[9] and 2018[10] respectively, with the view that reprocessing is not the most cost-effective means of managing spent fuel from the UK's existing AGR and PWR nuclear fleet. MOX fuel production at the Sellafield site ceased in 2011. The UK strategy for managing spent fuel now involves long-term wet and dry storage, fuel conditioning and disposal.
- The UK was a pioneer of advanced reactor systems. Current indigenous capability in this area is limited to a few organisations and individuals, and involvement in R&D on the international stage is below that of other leading nuclear nations.

Research and Development

- The UK nuclear R&D landscape benefits from having a diverse range of companies and organisations providing expertise, knowledge and direction. However at present there is no single body holding the mandate or capability to determine how well this meets the UK's national requirements, especially in the area of future fuel cycles. Industry welcomes the current review of this situation by Government, who have recognised the need for change in this area.
- NDA currently are the prime UK funding body for UK WM&D R&D and coordinate other related R&D areas through their Research Board with representation from AWE, MoD, EDF Energy and regulators as well as internationally from CEA and EU. This model has been recognised as good practice. The NDA spends approximately £10.9m[11] each year on R&D supporting its mission.
- EDF Energy carries out significant R&D activity in support of its generating fleet and life extension work.
- NNL and universities house much of the additional R&D capability, but there are limited facilities to handle radioactive materials for R&D purposes. Government is currently reviewing the UK's R&D facility base, with the view to ensuring the right R&D infrastructure is in place as set out in this year's nuclear industrial strategy.

[9] The Magnox Operating Programme (MOP 9), NDA July 2012, ISBN number: 978-1-905985-29-6
[10] Oxide Fuels, Preferred Option, NDA June 2012, SMS/TS/C2-OF/001/Preferred Option
[11] NDA also funds nuclear R&D in the UK indirectly through the overall budgets provided to site licence companies who may undertake R&D in order to meet their contractual obligations to NDA. The collated estimates for R&D spend by the site licence companies in 2010/2011, as reported to the House of Lords in June 2012 was £121.3m

The Global Nuclear Market

Globally, there are 435 reactors currently operating around the world[12]. The majority of these reactors are operated within established nuclear nations with their own supply chains. Rising fossil fuel prices and climate change concerns mean many countries with existing nuclear power programmes have plans to or are already expanding their domestic programmes, meaning that in some cases their resources may be stretched. In addition, 31 new entrant countries are considering or making active preparations for the introduction of a nuclear power programme, with six planning commissioning by 2020 and half by 2030[13].

None of these new entrant countries have an established supply chain, and many are seeking 'turnkey' solutions presenting strong export opportunities. However, it is a competitive market with a total of 9 consolidated vendors offering their technology and services[13].

UK involvement in the first stages of international new build programmes must be seen as the 'gateway' for subsequent opportunities in the fuel cycle services and O&M sectors as the programmes become fully established.

[12] WNA reactor database as of 1/1/13 (http://world-nuclear.org/info/reactors.html)
[13] The World Nuclear Supply Chain: Outlook 2030, WNA, Sep 2012, ISBN: 978-0-9550784-6-0

Future Landscape

UK industry envisions delivery of a fleet of reactors within the UK that not only replaces but extends the level of current generation, to potentially deliver up to 75 GW by 2050. Whilst clearly fulfilling an important role in ensuring the security of the future UK energy supply, the timing of the programme also creates a significant (and early) opportunity for UK industry to gain international credibility in the efficient and safe delivery of major nuclear construction projects.

The UK's commitment to a stronger nuclear future that is market-led will require that the existing structures and remits of some UK bodies (including the NDA and NNL) change in support. In line with global trends, it is likely that there will be a continuation of the trend for the industry to comprise multinational companies operating internationally and the UK nuclear industry must adapt to this.

The international market will continue to expand as more new entrant countries enter the nuclear market. UK industry's vision is to capitalise on the planned UK new build programme to position the UK as a trusted deliverer of major nuclear construction projects throughout the world. There will need to be a strategic and phased approach to developing UK capability to maximise involvement on the domestic programme, as well as comprehensive involvement in international programmes, including further development of partnerships on the delivery of new reactor technology with vendors.

The trend towards 'turnkey' procurement in these new markets is likely to continue increasing the significance that the vendor, with its established supply chain, will have for new build, operations and maintenance and fuel supply. The UK must become established in the supply chains for existing reactor types to ensure growing market share capture.

Newer evolutionary technologies such as SMRs together with Generation IV reactors will become commercially available over the coming decades. The increasing globalisation of the market coupled with the cost of developing new reactor designs means that development of the next generation of reactor designs will be an internationally collaborative affair.

The economic rewards to the UK as a whole of returning to the status of a 'top table' nuclear country are potentially enormous over the timeframe of this Vision:

- WNA projections shows at least 600 GW of global nuclear capacity by 2030 and 1140 GW by 2060, with upper projections up to 1350 GW by 2030 and 3700 GW by 2060[14]. This is compared with 374 GW today[15].
- The WNA also estimate that on current plans the value of investment in new reactor build is of the order US$1.5 trillion (£0.93 trillion), with significant international procurement expected to be approximately US$530 billion (£330 billion), US$40 billion (£25 billion) per year to 2025. Approximately $500 billion (£310 billion) will be

[14] WNA Nuclear Century Outlook, 2012 (http://www.world-nuclear.org/outlook/nuclear_century_outlook.html)
[15] WNA reactor database as of 1/11/12 (http://world-nuclear.org/info/reactors.html)

for equipment purchases, with the balance consisting of design, engineering, project management, commissioning, and other professional consulting services[16].

- The anticipated industry investment of approximately 16 GW of new build capacity in the UK before 2030 equates to around £60bn[17], which is equivalent to five new multiple-reactor nuclear power stations each with on average capital investment requirements of around £12.0 billion. This compares to an overall cost of around £9bn for the construction of the London 2012 Olympics venues. Such a programme delivered in the UK could result in between 43000 and 60000 gross jobs in 2020[17].
- Not only will all reactors built require manufactured components but also O&M support over their 40 plus year lifespan. Ongoing support to existing reactors will also continue (with respective global markets thought to be worth in the region of £17 billion for new build and £13 billion for existing reactor O&M by 2030).
- WM&D in the UK is already a significant market (~£3bn annually). Globally, decommissioning market revenues are estimated to be over £300bn in the next 30-40 years. It will develop into a strong international market driven by an increasing global shortage of capability and expertise to safely manage nuclear waste and provide site clean-up and restoration.
- Globally, reactor decommissioning plans will have to be accelerated in line with the plans of countries such as Germany, Switzerland and Belgium that intend to end nuclear generation by 2030. Over 200 nuclear power plants are estimated to close worldwide by 2030. The European commercial reactor decommissioning market is estimated at £53bn (Notably: UK £12.4bn, France £13.78bn, Russia £8.6bn). The Asian-Pacific region market is estimated at £13bn and North America at £5.2bn[18].

The realisation of the aims laid out in this Vision will only be delivered through an effective, commercially-based and long-term partnership between industry, academia and Government. There must be recognition on all sides that the sector is global in nature in terms of companies, sources of investment, markets and R&D collaborations. These aims will, if properly supported, see the UK regain its credibility as a 'top table' nuclear nation, with significant capability and an international role to play across all stages of the nuclear lifecycle in the future.

[16] The World Nuclear Supply Chain: Outlook 2030, WNA, Sep 2012, ISBN: 978-0-9550784-6-0
[17] "The Economic Benefit of Improving the UK's Nuclear Supply Chain Capabilities", Oxford Economics, 2012
[18] GlobalData, Nuclear Reactor Decommissioning Industry-Global Market Size and Competitive Landscape Analysis to 2030

2. New Nuclear

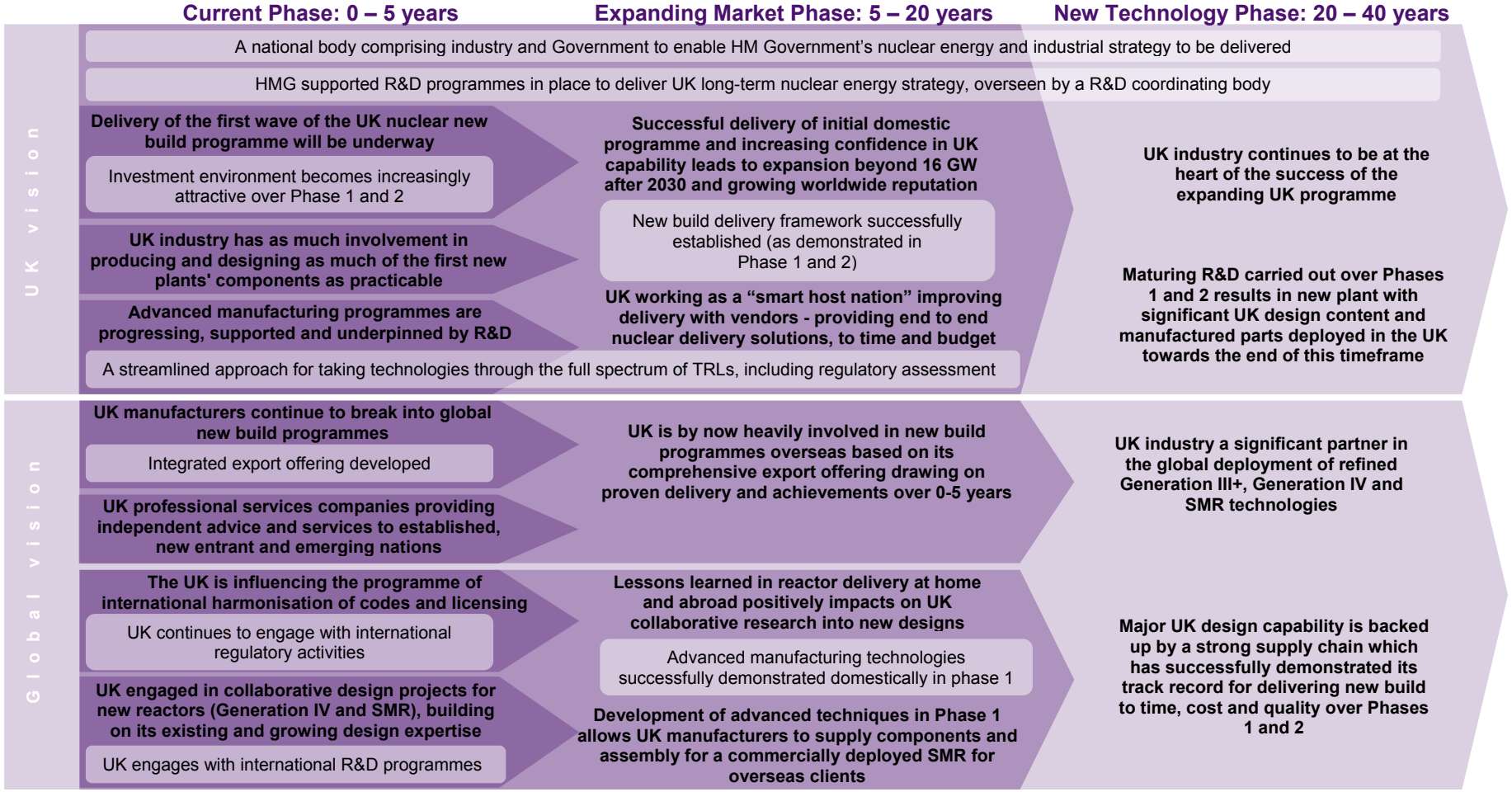

Figure 1: The vision for new nuclear

(Key: Pale boxes denote the dependencies (see Section 6) upon which UK industry's achievements (in bold) in each phase rest)

Current Phase (now – 5 years)

Reactor Delivery

Delivery of the first wave of the UK nuclear new build programme will be underway

Successful delivery of the first wave of the UK nuclear new build programme is an essential part of achieving the Vision of a nuclear energy industry providing major energy security and economic benefits and long-term high quality jobs for the country. UK industry, alongside Government, is looking to do its part in delivering this, through investment in skills and capabilities to maximise the design, assessment, manufacturing (including enhanced manufacturing techniques) and construction capability and developing partnerships with international organisations who bring recent experience on major nuclear programmes. Government's Nuclear Supply Chain Action Plan[19] outlines the work that is currently underway in more detail.

As part of this approach to capability development, the UK's Nuclear Industry Association has updated their 2006 report detailing the UK industry's capability and specifically details individual companies and the services and components they offer[20].

Capability in the UK new build sector can be summarised as follows:

Support to Owners	UK has strong capability in this area but some niche expertise may be sourced overseas.
Enabling Works	UK has sufficient capability in this area.
Civil Engineering & Construction	The UK has sufficient capability overall, but some workforce training for the requirements of working on nuclear sites will be needed.
Mechanical Equipment	The UK has sufficient capability in all but the largest of items. Particular strength resides in pumps and valves, pipes, tanks, heat exchangers, structural fabrications and systems integration packages. To support this, the UK also has good capable sub-tier supply chain companies who are able to deliver on sub-assembly and process activities.
Electrical, Control & Instrumentation	The UK generally has sufficient capability in EC&I. However there is limited capability and capacity for high safety grade nuclear element, so this is an opportunity for expansion.
Large safety-related nuclear equipment	The UK cannot supply the major elements of the nuclear island and turbine generator, but there is some capability in component supply.

From this snapshot it can be seen that the UK has capability across a significant proportion of required areas. Capacity, however, is predicated on commercial orders and will take a period of time and certainty to build. Because of this, industry is calling for a domestic new build programme that is assured and consistent. UK input should develop and play an increasing part in Phase 2 as domestic and international programmes expand and gather pace.

[19] The Nuclear Supply Chain Action Plan, Government, December 2012
[20] NIA Capability Report, 2012

Manufacturing

UK industry has the capability and appetite to deliver a significant proportion of the manufactured components needed for the first wave of the UK new build programme. There are a small number of items which can be manufactured by only a few companies in the world and for which there is no current UK capability. These are the reactor pressure vessel, main turbo-generator, steam generator, reactor coolant pumps, associated ultra-large forgings and large diesel engines. Although they are critical, these items represent a relatively small portion (around 10-15%) of the total requirement for a new nuclear plant[21].

UK industry has as much involvement in producing and designing as much of the first new plants' components as practicable

The UK does however have the capability to supply most of the remaining 85-90% of the manufactured components across the Balance of Plant, including pumps and valves, pipework, vessels, tanks, heat exchangers, HVAC (heating, ventilation, and air conditioning), radwaste plant, control, instrumentation and electrical equipment and forgings.

Many of the UK companies that are capable of manufacturing these items are already supplying similar equipment to the global new build market, as well as to the existing nuclear industry in the UK and to other regulated sectors such as the oil and gas, chemical and other process industries. Building on the strengths of those numerous manufacturing areas where the UK has been continuously involved domestically and internationally, the key opportunity during Phase 1 will be to demonstrate to vendors and the wider international market the UK's comprehensive current manufacturing capability on the first plants of the UK domestic programme.

UK manufacturers will continue to break into global new build programmes

Exporting to international new build markets represents a key building block in developing the necessary capability and capacity to gain a foothold in supplying components to the new domestic fleet. Over this period, UK industry will continue to look for entry points in other nations in advance of the UK programme getting fully underway, and will need to be supported by a unified approach from Government, the Foreign and Commonwealth Office (FCO) and UKTI. A coordinated industrial approach to identify international commercial collaborations and partnerships will be needed to bring stronger buying power, stronger manufacturing ability and show UK commitment to nuclear development on a world stage (see also the Operations & Maintenance section).

Advanced manufacturing programmes are progressing, properly supported and underpinned by R&D

UK industry wishes to build on its current areas of manufacturing strength and develop into a trusted partner of choice delivering key advanced manufactured components for domestic and international new build programmes deploying reactor technologies with additional manufactured scope. This aim can only be achieved if long-term investment in the relevant R&D (throughout the full spectrum of Technology Readiness Levels (TRLs)) is maintained in the near-term through initiatives such as the Nuclear Advanced Manufacturing Research Centre (NAMRC).

[21] NIA Capability Report, 2012

Specific advanced manufacturing techniques which industry itself wishes to be brought to commercial deployment as soon as possible include Electron Beam Welding, Laser Arc Welding and Hot Isostatic Pressing (HIP). Effective utilisation of organisations like the NAMRC will lead to continued support to UK suppliers at the leading edge - developing new techniques to raise quality, durability, reliability and safety whilst at the same time driving down costs. Deployment of these techniques (even if in a small way) during the first wave of the UK's new plants is a crucial first step in enabling UK industry to carve a significant role in upcoming global new build programmes, as a supplier of components as well as ultimately a partner in delivery or co-vendor of a design in Phases 2 and 3.

Professional and Technical Services

The UK has huge experience and knowledge of a range of nuclear technologies and their associated infrastructure. During the current phase the UK therefore has the opportunity for growth either through offering independent advice and service to utilities and regulators both in the UK and abroad, or through partnering with international technology suppliers.

By virtue of its considerable experience, there are a wide range of areas where UK companies already support domestic and international new build projects that are being delivered by a multi-package contracting strategy. These include:

- Project management
- Construction management and supervision
- Licensing support
- Safety assessment
- Component product delivery
- Legal services
- Financial services

UK professional services companies providing independent advice and services to established, new entrant and emerging nations

It is widely recognised that strong project and programme management capability will be critical to the successful delivery of any new build programme. An integrator role in the form of Architect Engineer will be a common requirement of new build projects both domestically and internationally with greater involvement of Engineering, Procurement and Construction (EPC) contractors employed to project manage, sometimes on a turnkey basis[22]. Building on the existing capability outlined above, UK companies aim to fulfil this role within Phase 1, whether independently or as part of an international consortium.

UK industry already has significant civil engineering and complex programme management capability, delivering major domestic and international projects, including the Olympics, Heathrow Terminal 5, Channel Tunnel Rail Link (stage 2) and Crossrail. UK industry therefore has the capability to carry out much of the design, management and most of the construction work for the UK's new nuclear programme. Much of this work will be delivered through joint ventures involving both UK and international

[22] The World Nuclear Supply Chain: Outlook 2030, WNA, Sep 2012, ISBN: 978-0-9550784-6-0

companies, as is common international practice, and these partnerships are already being developed. The opportunity to transfer on-site construction experience to international projects is somewhat limited because construction typically relies on local labour. However, incorporating the lessons learned from construction in the UK to the programme management of other Generation III projects will represent a major commercial opportunity for UK industry internationally. Successful programme and construction management of UK new build is a key dependency for UK industry to become embedded in international supply chains.

New regulatory bodies also need considerable support – the set up of the regulatory system is the first step on the road to delivering new nuclear build. The UK nuclear industry is rigorously regulated by a world-leading system and has comprehensive skills, understanding and compliance prevalent at all layers across the industry. The UK already offers other nations services to assist with the regulatory and infrastructure set-up: an integrated support offering recognising the needs of other countries and their current level of skill and knowledge should be developed. It is unlikely that the entire UK system will be sought as a product, though much of the UK's knowledge can be made available to other countries, especially new entrant countries, and there will undoubtedly be scope for the UK to assist others in enhancing safety through constant improvement and delivery of safety cases, both now and in the future.

UK skills in all the areas highlighted above are particularly beneficial to new entrant nuclear countries at the very start of programme set-up; in this 0-5 year phase, a number of countries are considering nuclear programmes and the early aspects of these services will increasingly be required. As an established nuclear nation, the UK is in a position to offer a range of nuclear and technical training as well as advice on education system set-up. The UK is currently developing a Nuclear Skills Provider Directory detailing specific provision and UKTI can advise nations on how the UK can offer training suited to their needs.

Regulatory Developments

New nuclear in the UK and worldwide will be based on standardised designs of plant that are adapted at the margins to suit differing physical and regulatory environments. This is a break with the past for the UK when many of our nuclear reactors were unique projects in themselves.

The UK is influencing the programme of international harmonisation of codes and licensing

The move towards a smaller number of standard blueprint designs with local design modifications is intended to help reduce the cost of nuclear build and enable global supply chains to deliver. To aid this process and to increase safety, collaborative programmes are underway which aim to deliver mutual recognition of international regulatory decisions as well as harmonisation of nuclear codes and standards. Specific programmes include:

- The Multinational Design Evaluation Programme (MDEP), involving regulators from twelve countries;
- The Cooperation in Reactor Design Evaluation and Licensing (CORDEL) project, involving Standards Development Organisations from six countries.

Active engagement with this work is necessary if the UK is to be at the forefront of understanding international requirements and realise its ambitions in exporting services to programmes in other countries (especially from Phase 2 onwards), as well as demonstrating our commitment to developing new reactor designs ourselves.

New Reactor Designs

If the UK is to be considered a 'top table' nuclear player in the years ahead it is vital that the UK develop its design contribution to the domestic and international marketplace. With its significant nuclear pedigree and experience, the UK civil nuclear industry retains design capabilities across a number of areas including components, maritime propulsion systems, fuel design, high performance computer modelling, control and instrumentation and licensing. Over Phase 1, industry wishes to build on this capability and begin to develop the UK's reactor design capabilities once again, with Government support within an environment of international collaboration.

UK engaged in collaborative design projects for new reactors (Generation IV and SMR), building on its existing and growing design expertise

There would be limited commercial benefit in pursuing a new Generation III design and the likely economics of developing a Generation IV design unilaterally during the current phase are not attractive. The Generation IV International Forum (GIF) is well-established and is considering six designs, featuring thermal and fast neutron spectra, closed and open fuel cycles, thorium fuels and a wide range of reactor sizes. Re-engagement with GIF at a national level is essential in the near-term to begin the journey to a new UK design. Failure to do so will signal the UK's disengagement from an entire technology area with future commercial opportunities.

The importance of continued research into future fuel cycles (including thorium and closed cycles) for energy security needs is outlined in the Fuel Cycle Services section. UK industry also believes that pursuit of Generation IV research can capitalise on the UK's existing industrial and research design base and bring near-term benefits, including cross-over with other areas of research.

The UK's knowledge of AGR systems and a proportion of the associated R&D will be relevant to certain Generation IV high temperature gas-cooled reactor (HTGR) designs. Generation IV developments may also support AGR life extension which will be ongoing throughout Phase 1 and the start of Phase 2.

Commercial SMRs represent an additional area in which UK companies could develop or have significant contribution to a design which builds on existing UK strengths. Smaller proliferation-proof designs could be of considerable interest internationally, particularly in emerging nuclear nations with smaller economies and electricity grid systems. SMRs could also be of interest to energy intensive industry as well as potentially to maritime transport over the phases ahead. The UK's existing design capability (enhanced by our naval propulsion reactor systems design and delivery experience) brings relevant expertise on which to base domestic research programmes and engage with international partners. The UK also has a significant amount of relevant experience in 'production line' modular construction of similarly-sized components (from the aviation and shipping industries). Industry regards it as a

priority to engage in discussions with potential international research partners within Phase 1.

Expanding Market Phase (5 – 20 years)

Reactor Delivery

The global nuclear energy output is expected to reach ~600 GW during this phase[23]. Worldwide, projections suggest that by 2025 global nuclear new build sales will be worth over £25bn per year[24]. Competition to provide services will continue to rise as newer nuclear nations develop indigenous capability, but the trend towards new entrant nations engaging EPC services (sometimes on a turnkey basis) will also grow.

Successful delivery of initial domestic programme and increasing confidence in UK capability leads to expansion beyond 16 GW after 2030 and growing worldwide reputation

UK industry aims to become a trusted partner in the delivery of Generation III reactors at home and globally, through the development of collaborative relationships with vendors. Reactors built with UK industry during this timeframe will be delivered better, faster and more cheaply, through a progressive increase in the UK design content and adoption of UK-developed advanced manufacturing processes including increased modularisation, enhanced materials and enhanced techniques.

The necessity of driving down cost in the supply chain in the delivery of new plants means the incorporation of lessons learned across all aspects of reactor delivery will be vital. This again highlights the strategic importance of UK industry involvement (including knowledge transfer from international partners) in the very first build of new UK reactors if increasing market share (both in the UK and abroad) is to be realised over this timeframe.

Manufacturing

Export of manufactured components to new build markets in other countries will continue during this phase. This in turn will continue to strengthen the necessary capability and capacity of UK industry to supply components to the new domestic fleet as the programme gathers pace.

UK working as a "smart host nation" improving delivery with vendors - providing end to end nuclear delivery solutions, to time and to budget

Techniques deployed in non-nuclear manufacturing industries (e.g. oil, gas, automotive, aerospace, ship and submarine construction) will continue to be brought into advanced nuclear manufacturing processes where beneficial. Advances first deployed in Phase 1, such as Electron Beam Welding, will increase in maturity and be more widely deployed, underlying the importance of developing such technologies in the next few years.

[23] WNA Nuclear Century Outlook, 2012 (http://www.world-nuclear.org/outlook/nuclear_century_outlook.html)
[24] The World Nuclear Supply Chain: Outlook 2030, WNA, Sep 2012, ISBN: 978-0-9550784-6-0

There is strong ambition amongst UK component manufacturers to create UK 'centres of excellence' for specific product offerings in which world class capability has been retained in the global market, including pumps and valves. Over Phase 2, UK component suppliers will be working to implement this approach across a wider component portfolio to facilitate the provision of packaged offerings (including complete reactor modules where appropriate) to utilities and vendors. This will build upon the collaborative partnerships that were initiated during Phase 1. Vendors and their key suppliers should be encouraged to invest in and make use of such facilities in the UK (particularly the NAMRC) in order for closer collaboration in component delivery to be achieved and maximum export opportunity realised.

Thus, in capitalising on strategically important contributions to the domestic programme during the current market phase, underpinned by targeted R&D, UK industry can continue to introduce innovations in advanced manufacturing process technology and design during this phase to reduce costs across the expanding domestic fleet. The "UK nuclear manufacturing brand" in support of new build will be one of efficiency, reliability and safety. From this basis, UK industry will capture a growing global new build market share.

Professional and Technical Services

UK is by now heavily involved in new build programmes overseas based on its comprehensive export offering drawing on proven delivery and achievements over 0-5 years

Utilities and government agencies from countries with little or no experience in constructing new nuclear plants will continue to buy in the capability from an EPC contractor. Based on export successes in Phase 1, and the establishment of a more unified UK export front, the UK civil nuclear industry will have positioned itself to take an increasingly cohesive approach to the provision of nuclear professional services to customers worldwide. This will take the form of mature industrial partnerships that feed in lessons learned to subsequent builds. The UK's comprehensive export offering will vary by the procurement philosophy of the customer but will include:

- Established suppliers building on their success in helping to drive down costs in the delivery of popular Generation III plants at home and that are now an integral part of the global delivery of one or more reactor technologies;
- An export finance offering aligned (upfront) with the industry offering for the needs of each customer country;
- Additional professional services and advice (as developed in Phase 1).

With the UK now established as a trusted delivery partner for Generation III programmes worldwide, and active in the development of harmonised codes and standards, there will be a strong commercial opportunity in the deployment of an education and skills package. This will draw on our global position, wide-ranging capability and global language. To achieve this, industry and the skills bodies must work to bring together the relevant knowledge currently retained across industry, education and skills organisations and academic institutions.

Regulatory Developments

In construction, the harmonisation of codes and standards between countries will be progressing with the benefits seen in reduced construction times. The UK's involvement in this work area in Phase 1 will directly benefit our own industry's activities in Phase 2 as construction of the domestic fleet expands.

New Reactor Designs

Lessons learned in reactor delivery at home and abroad positively impacts on UK collaborative research into new designs

Large (>1 GW) LWRs will continue to be built around the world during this period. These designs are likely to be evolutionary, developed from existing Generation III technology, and incorporating lessons learned in construction, manufacture and detailed design experience. With UK industry now established in the global supply chain's delivery of LWR designs, industry will contribute to the refinement of these designs through the main activity areas identified above. UK industry's key role in the successful delivery of a fleet of Generation III also means that the next generation reactor R&D which the UK is involved in during this time will benefit from a range of lessons learned across design, manufacture, construction and operations and maintenance to decrease production costs.

Potential vendors that are already involved in Generation IV R&D activity will begin to select the most commercially viable Generation IV designs to continue the development needed to bring to them to the market during this phase. The decision for the UK (and its collaborative partners) to fully commit to developing a commercial reactor design will require a significant commitment from the UK R&D community along with substantial, far-sighted backing from Government during this phase which may tie in with any potential change in the UK position on future fuel cycles. The associated R&D programmes (with international collaboration) will also continue to develop during this period and will focus on advanced manufacturing implications, construction and operating cost reduction issues as well as fuel cycle scenarios (see the Fuel Cycle Services section). Since no one can predict what Generation IV technology will ultimately come to the fore, it would be sensible for UK to cover more than one by forming judicious multinational R&D partnerships; the UK must be present in such programmes if it is serious about input into Generation IV.

Industrial R&D activity will also continue into the design of SMRs, building upon the international relationships forged during the pre-commercial R&D phase. Activity will include:

- Developing an understanding of international market requirements;
- Advanced, low-cost manufacturing;
- Modular build design;
- Addressing regulatory issues;
- Developing low cost operating models;

Development of advanced techniques in Phase 1 allows UK manufacturers to supply components and assembly for a commercially deployed SMR for overseas clients

- Addressing potential siting issues.

The commercial deployment of SMRs would be expected to emerge sometime between the middle and end of this period in certain markets. The advanced manufacturing initiatives and industrial collaboration initiated in Phase 1 will ensure that manufacturing capability in this area is enhanced, with UK suppliers positioned to supply a large proportion of the components and assembly services.

New Technology Phase (20 – 40 years)

UK industry continues to be at the heart of the success of the expanding UK programme

Based on the successes as outlined in previous phases, UK industry will by now have played a significant role in domestic new build, together with overseas clients' projects. In the process of delivering these orders UK industry, in partnership with Government, will have developed and deployed manufacturing process innovations which will be paying dividends in this period by reducing the cost of nuclear build and helping ensure timely delivery.

With the development of a strong UK track record of new build delivery, investment confidence will have increased, such that by 2050 the UK market will be sized between 40 to 75 GW (equivalent to up to 50 reactors). By that time, there will be a fully developed and streamlined UK new build industry led by strong partnerships between key organisations to deliver this. The most appropriate reactor technologies available that align with the UK position on an open or closed fuel cycle will also be deployed (see the Fuel Cycle Services section).

Major UK design capability is backed up by a strong supply chain which has successfully demonstrated its track record for delivering new build to time, cost and quality over Phases 1 and 2

The market opportunities by this time will be significant. Global population growth in combination with industrial development will lead to a quadrupling of electricity generation need from 2011 levels by 2050, despite increasing energy efficiency. With evolving electricity needs (i.e. increasing electric transportation), the global nuclear market is expected to grow to ~1200 GW during this period[25] and will continue to shift into traditionally non-nuclear nations that will require full service provision. The successes achieved by UK industry in the domestic and international new build programmes in Phases 1 and 2 will have led to the UK nuclear industry establishing itself as one of the world leaders in nuclear new build, trading on its experience and expertise in acting as a significant partner in deploying at least one (and probably more) reactor Generation III types globally. Its proven advanced manufacturing techniques and reputation as a centre of excellence in some areas of component manufacture will provide a powerful commercial and technical edge in winning overseas orders.

UK R&D activity will by now focus on the refinement of SMR and Generation IV technologies (refinement of Generation III designs will also continue as life extensions come into force). There will be the potential for increased international

[25] IAEA Energy, Electricity and Nuclear Power Estimates for the Period to 2050, 2012

SMR deployment depending on investment attractiveness. With the foundations laid down in Phases 1 and 2, industrial capacity for components and equipment will be extended so that the UK is able to supply an entire modular reactor design as part of a packaged offering.

Maturing R&D carried out over Phases 1 and 2 results in new plant with significant UK design content and manufactured parts deployed in the UK towards the end of this timeframe

Dependent upon the extent of Government backing in Phase 2, a UK-backed Generation IV reactor may be deployed in the UK by the middle of this period as part of a closed fuel cycle strategy and providing demonstration of the technology to potential global customers (N.B. This will also be dependent upon the right commercial environment).

Within this timeframe, the nuclear industry may also be looking more closely at fusion development. Results from the continued research into nuclear fusion, including experiments planned at the new International Thermonuclear Experimental Reactor (ITER) facility in Cadarache should become clear within this period. As is well understood, ITER does not represent an end in itself and will lead onto additional development projects, including the Demonstration Power Plant (DEMO). Conceptual design for such a machine is pencilled for completion by the early 2020s, and with operations commencing in the early 2030s, fusion power on the grid could happen around 2040[26].

With DEMO leading fusion towards its commercial era during this phase, it represents the opportunity for more substantive industry input into fusion reactor technology. The capability built up in the UK industry through previous phases in refinement and delivery of existing reactor types along with the development of modular and Generation IV designs will mean UK companies will be strongly positioned to compete for this opportunity. There will also be significant opportunity associated with lead through into a commercial fleet deployment of any subsequent fusion reactor design. The long-term nature of this opportunity for wider industry does not diminish the size of the potential benefits: UK industry is keen that UK involvement in the ITER project be sustained throughout the timeframe of this Vision such that any long-term future move of the nuclear power industry toward nuclear fusion creates significant opportunity for UK industry.

[26] ITER 'Beyond ITER' 2012 http://www.iter.org/proj/iterandbeyond

3. Operations and Maintenance

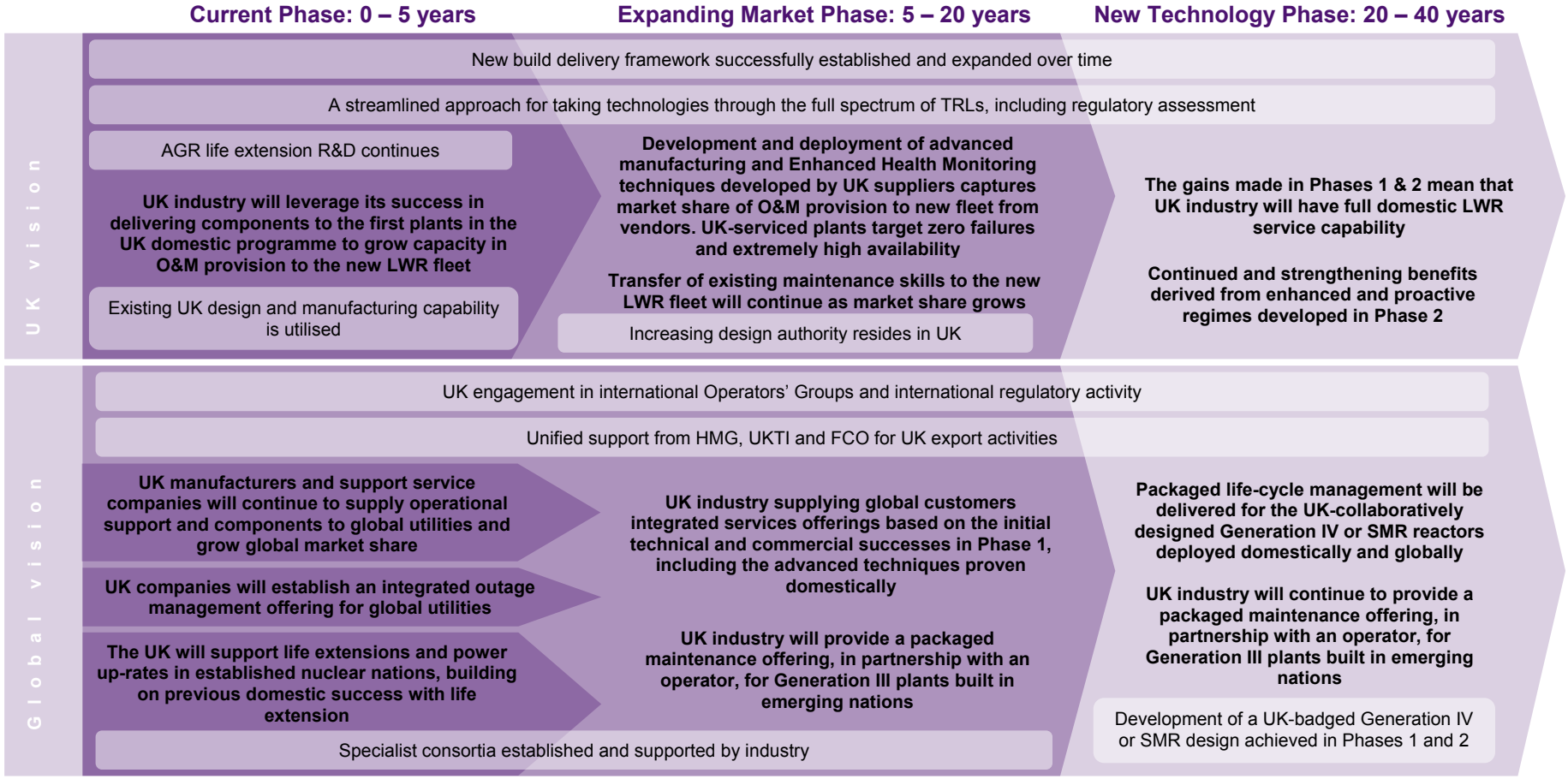

Figure 2: The vision for operations and maintenance

(Key: Pale boxes denote the dependencies (see Section 6) upon which UK industry's achievements (in bold) in each phase rest)

Current Phase (now – 5 years)

UK industry will leverage its success in delivering components to the first plants in the UK domestic programme to grow capacity in O&M provision to the new LWR fleet

The commercial success of companies supplying manufactured components and ongoing services is to a large extent bound up with their degree of involvement at the earliest stage of any new build. A supplier of new parts is naturally well-placed to supply the associated maintenance and replacement, thus providing an unrivalled opportunity to develop and secure business going forward for the 40 year plus life cycle of the plant. To ensure the long-term success of UK providers of O&M components and services and continued investment in capability, it is therefore essential that (where it already exists) proven manufacturing and design capability is extensively utilised on the first phase of new nuclear development in the UK. Involvement in the UK programme will also be invaluable to UK suppliers in expanding their export offering by underlining their LWR credentials.

UK manufacturers and support service companies will continue to supply operational support and components to global utilities and grow global market share

Since the new build technology delivered in the UK towards the end of Phase 1 will be supplied by international companies and will be operated by utilities that are owned by multinational companies, the UK needs to recognise that achievement of this objective may require UK businesses to consider forming alliances, collaborations or joint ventures with other international players. This will open up opportunities not only within the UK but also position UK businesses or consortia to capture opportunities from the potential growth of fleets worldwide operating the same international designs. The New Nuclear section gives more detail on the necessary steps and progressive development UK industry envisions in this area.

UK components and service providers are already exporting their services globally to established nuclear nations. During Phase 1, UK industry will continue to grow export capability, building on those established markets where it is already actively supplying components and services, trading on the strength of UK industry's heritage and its commitment to safety, quality and innovation. This is dependent upon continued access to research facilities and initiatives supporting advanced manufacturing.

The UK will support life extensions and power up-rates in established nuclear nations, building on previous domestic success with life extension

UK industry has already successfully supported the first life extensions of the AGR fleet. Many other established nuclear nations are at this time embarking on life extension and power up-rate programmes, which can also play an important role if new build programmes falter or delay. These programmes are happening in countries where resource is often already stretched due to decommissioning challenges, new build activity or even upgrades in response to the Fukushima incident (although it should be noted that this work will be focused on stations employing LWR technology).

There may however be areas where UK companies that have supported AGR life extensions have an opportunity to export their proven domestic capabilities to new markets within this phase, either alone or in collaboration. Similarly, those companies that have had involvement in upgrades in the UK may be able to take advantage of this experience in other existing nuclear markets in the near-term.

UK companies will establish an integrated outage management offering for global utilities

The UK has a well developed and pro-active approach to planning and implementing domestic outage maintenance programmes which has been enhanced over many years of close collaborative working between operator and suppliers. This experience offers an excellent platform on which to expand into the export market in assisting new operators improve their activities in this area. UK industry already has a promising basis upon which to build in this area: programmes that stand out in highlighting this capability include the UK's involvement in the CANDU Bruce Power Restart project in Canada and the Technical Assistance to the Commonwealth of Independent States (TACIS) program.

Existing O&M experience should be used by the UK nuclear industry as the basis to develop stronger appropriate commercial models to take advantage of the large (and growing) export market for O&M services. In the case of outage management, the model would most likely be in the form of provision of management teams with the operational and technical product know-how to oversee the program and supervise local labour resources. Over time this knowledge can be transferred to local markets and the strong relationships used as a conduit for sharing of information and implementation of the latest technological development and operational techniques. This will also pave the way for a more comprehensive suite of O&M service offerings spanning management, technical services and component supply (see Phases 2 and 3). In addition, there is the opportunity to leverage the current UK operator training capability (especially that for the PWR at Sizewell B) by offering this to overseas utilities seeking high quality training from an English-speaking provider. This could become increasingly important in later phases.

To ensure strong involvement and continued growth in the global nuclear O&M market the UK also needs to become an established presence at the global nuclear operator user groups. These groups explore current and potential future operations issues as well as pro-active approaches they can adopt. A joint body of Government and industry representatives should be established to work collaboratively with owner groups. This will ensure commercial opportunities are sighted and understood and that UK industry can realise commercial benefit through developing appropriate service offerings and contribute to maintaining the highest safety performance of overseas plants.

Expanding Market Phase (5 – 20 years)

Transfer of existing maintenance skills to the new LWR fleet will continue as market share grows

As the domestic fleet expands during this phase, UK industry will be positioned to contribute more strongly to domestic LWR maintenance regimes. International vendors will become stretched due to an uptake in the

global new build market, whilst supply of components to the first tranche of new build plants in Phase 1 will position UK companies strongly to provide ongoing maintenance services.

The commitment to safety, quality and innovation employed by UK suppliers, underpinned by the development of advanced manufacturing processes, will pay dividends to operators through improved performance of components, again leading to increased market share during this phase.

Development and deployment of advanced manufacturing and Enhanced Health Monitoring techniques developed by UK suppliers captures market share of O&M provision to new fleet from vendors. UK-serviced plants target zero failures and extremely high availability

Over this period, safety and performance of Generation III reactors will improve not just through design, but also through new technologies brought out of R&D investment in operational efficiency. One such area in which UK industry wishes to develop its capability and position itself as a market leader is in the area of Enhanced Health Monitoring (EHM). More advanced remote condition monitoring utilising fibre sensors, guided ultrasound, and digital control and instrumentation will improve data capture and signal processing that can replace periodic inspections with continuous monitoring. Early development and deployment of these Enhanced Health Monitoring techniques relative to other international competitors will influence pro-active maintenance regimes and act as strong leverage for utilisation of UK companies.

UK industry supplying global customers integrated services offerings based on the initial technical and commercial successes in Phase 1, including the advanced techniques proven domestically

UK industry will by now be able to consolidate experience gained through supporting the current AGR fleet in the UK and initial experience supporting LWR programmes both in the UK and globally. These developments will mean that UK nuclear companies with an existing O&M capability and proven advanced manufactured products will be established and looking for further growth. Export markets will by now be in a position to provide this - opportunities to service a growing global reactor base out of the UK will be significant.

This general increase in demand for components and services as new build increases will coincide with opportunities to capitalise on the periodic maintenance and upgrade regimes of existing plants with targeted offerings including performance upgrades and technology replacements. One such upcoming opportunity is the replacement of analogue control systems with digital technologies across the existing global nuclear fleet to which UK industry will seek to contribute.

Companies already active in exporting fabricated components (new reactors and replacement parts), plant maintenance (including major repairs) and services independently should consider coming together in specialist consortia, international partnerships or joint ventures to benefit from shared knowledge, synergistic offerings and increased market power. The experience of the commercial models employed in offering outage management services in Phase 1 will be incorporated to strengthen this more comprehensive range of service offerings.

Technical areas where UK companies should develop collaborative offerings based on existing capability and new developments from Phase 1 include (amongst others):

- LWR operational support (building on the expanding capability of UK industry in servicing its home fleet);
- Planning and implementing outage maintenance programmes;
- EHM (building upon the development programmes undertaken domestically);
- Provision of a diagnostics package (combining the practical experience of the UK's long operational history, linked to an established network of universities and research laboratories);
- Component supply (building on existing export capability and advanced manufacturing techniques now proven and deployed at home);
- Operational excellence (exporting well regarded UK nuclear professionalism programmes encompassing such elements as nuclear safety culture, human performance, a structured approach to training, and nuclear leadership development);
- Engineering support services (utilising the problem solving approach supported by the UK's regulatory approach).

UK industry will provide a packaged maintenance offering, in partnership with an operator, for Generation III plants built in emerging nations

As a result of the demonstration that the UK plants delivered at the start of Phase 2 have been efficiently built and operated, along with the initial successes of service and components consortia established, increasing market share will be realised in global markets for components and services. Over time, the individual service combinations can also be rolled up into a single packaged maintenance service, offered in partnership with an international operator. This will be attractive for those emerging new build nations embarking on small domestic programmes that have no desire to invest in building up domestic operations capability.

Over time, the market will also incorporate UK first implemented and co-developed technologies including refined Generation III designs, closed fuel cycle reactors and even UK-led Generation IV or SMR (towards the end of this phase, see the New Nuclear section). The developing collaborative offerings outlined above will form the foundations for a comprehensive lifecycle management offering for any UK-developed reactor design, which will be fully realised in Phase 3.

New Technology Phase (20 – 40 years)

The UK sector will see continued and strengthening benefits from increased efficiency delivered through the adoption of advanced O&M techniques first

The gains made in Phases 1 & 2 mean that UK industry will have full domestic LWR service capability

Continued and strengthening benefits derived from enhanced and proactive regimes developed in Phase 2

deployed in Phase 2, with the UK now an established global leader in this area. The UK's involvement in the development of Generation IV reactor designs (see the New Nuclear section) will now also be expected to yield technology and understanding that can positively feedback into improving the existing Generation III fleet. Through the effective delivery of these programmes and initiatives it will be realistic for plants serviced by UK companies to target zero failures and extremely high availability, both in the UK and abroad.

Packaged life-cycle management will be delivered for the UK-collaboratively designed Generation IV or SMR reactors deployed domestically and globally

By the end of this timeframe, the UK will potentially be a vendor of emerging reactor technologies (Generation IV or SMR), developed through collaborative international partnership, and which will be deployed commercially (see the New Nuclear section). Full capability for the reactors' O&M requirements when constructed in the UK will be provided by domestic industry. Building on the now well-established packaged maintenance service offered for Generation III plants as described above, a packaged lifecycle management for any UK design deployed internationally will also be offered (particularly as a component of a packaged EPC service for emerging nations seeking a full partner in deploying SMR).

UK industry will continue to provide a packaged maintenance offering, in partnership with an operator, for Generation III plants built in emerging nations

Regardless of the reactor technologies that are popularly adopted during the latter part of Phase 2 and the start of Phase 3 and the 'nuclear maturity' of the countries who adopt them, the UK's key exportable O&M activities and developments will continue to be relevant. The strength of the UK's offering will be the flexible and tailored approach that can be offered to the needs of different customers, depending on the maturity of their nuclear sector, the technology adopted, and either direct to utilities or as part of a technology-based consortium.

4. Waste Management and Decommissioning

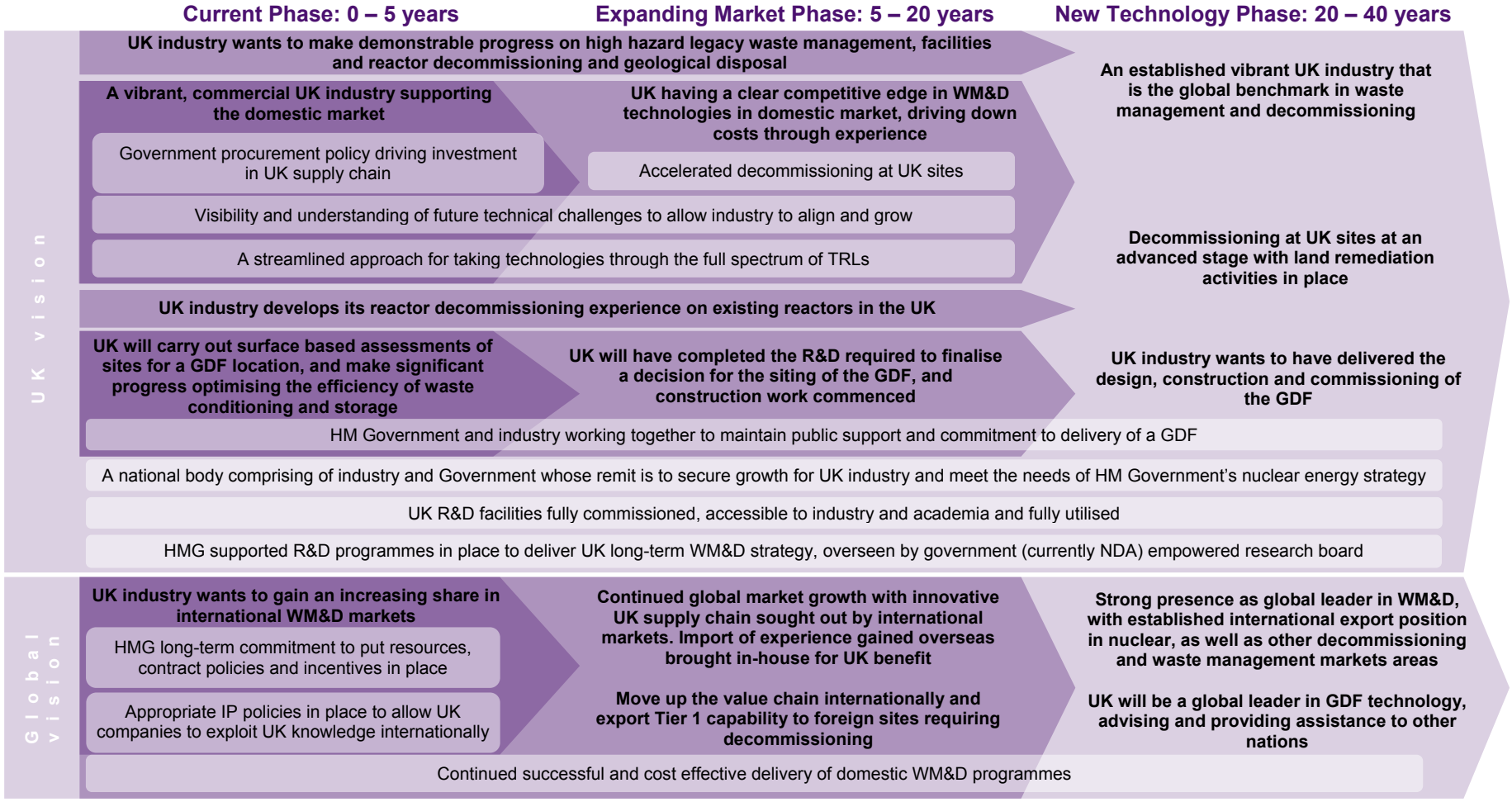

Figure 3: The vision for waste management and decommissioning
(Key: Pale boxes denote the dependencies (see Section 6) upon which UK industry's achievements (in bold) in each phase rest)

Current Phase (now – 5 years)

UK industry's vision during this phase is to make demonstrable progress against a number of WM&D activities, including high hazard legacy waste management, facilities and reactor decommissioning and geological disposal. Successful delivery of a domestic programme, with UK companies at its heart, will create a vibrant, commercial industry, which is able to expand into international markets.

A vibrant, commercial UK industry supporting the domestic market

UK Legacy Waste

Over the next five years, UK industry will continue to develop and deploy innovative solutions to reduce the risks and hazards associated with UK legacy waste at Sellafield, Harwell, Dounreay, Winfrith, Low Level Waste Repository (LLWR) and Magnox facilities. UK industry will build expertise from these types of challenging projects and will advance in its capability to characterise and retrieve waste.

Decommissioning

The decommissioning industry is established across the civil nuclear industry addressing the challenging and diverse demands from 60 years of nuclear activities.

UK's industry WM&D competencies are extensive and include:

- Nuclear construction, project and facility management
- Consultancy, safety case services and regulatory expertise
- Equipment design and manufacturing
- Characterisation
- Decontamination
- Remote decommissioning
- Retrieval, handling, conditioning, transport, storage and disposal of radioactive materials
- Recycling and reuse
- Effluent treatment
- Advanced computational modelling and simulation
- R&D programmes and facilities

UK industry wants to gain an increasing share in international WM&D markets

UK industry's focus during this phase will be on advancing its capabilities, becoming more efficient, and delivering cost effective solutions, with the goal of gaining a clear competitive edge in WM&D technologies for domestic and international markets. Acquiring an increasing share of international decommissioning markets will require technical community support in obtaining knowledge of commercially available technologies and their applications, as well as the state of on-going research in WM&D. An increasing presence on the international market will, conversely, also enable UK industry to gain experience in deploying technologies that could later be used within the UK.

Future WM&D projects in the UK will require the design and construction of new facilities. Successful delivery of these major projects will demonstrate UK industry's ability to deliver complex work on UK sites safely and with environmental stewardship.

A streamlined approach for taking technologies through the full spectrum of TRLs, as well as encouraging a broader public/private interest in delivering WM&D R&D is needed. Relationships between industry and research entities (both domestic and international) during this phase will be crucial for successful technology-based economic growth. In the UK this will be accomplished through networks, partnerships and alliances with such entities as Britain's Energy Coast (BEC), Universities, NAMRC, NNL and the National Physical Laboratory (NPL). Government needs an international engagement strategy that ensures collaboration and implementation support of UK nuclear goals.

Identification, development and expansion of current facilities for non-active or low activity rig work and trialling of new processes will be required, and potential for new facilities will be realised as clean up progresses. NAMRC's current activities on waste container development is an example of how these facilities can provide UK companies, who enter into a commercial partnership arrangement, with the capability to optimise design and manufacturing for successful product commercialisation.

Access to facilities (domestic and international) that could act as radioactive test bed environments would enable further technology development. Having a facility with accurate field conditions would allow the acceleration of trialling, selection, demonstration, regulatory acceptance and deployment of a variety of decommissioning technologies for use in the commercial sector. The creation of these types of facilities will need the support of the site owner organisations and key regulatory authorities in partnership with public and private organisations, academia, and research collaborators.

Industry believes that to encourage companies to invest in capability and capacity, Government contract strategies will need to address longer term scope commitments that encourage investment in skills development and new Intellectual Property (IP) creation. This would be in conjunction with Government access to enabling support services in these areas resulting in a broader public /private interest in delivering R&D.

Nuclear Reactor Decommissioning

UK industry will develop its reactor decommissioning experience on existing reactors in the UK

Over the next 5 years, UK industry will expand on its current capability of reactor decommissioning through de-fuelling operations and care and maintenance of UK facilities. Provided it makes sense in terms of both economics and waste management, UK industry would welcome an accelerated programme of reactor decommissioning that would enable it to demonstrate progress to the UK, acting as a catalyst for the rest of the industry, and serve as a showcase to the rest of the world. A key UK challenge for this phase is to determine a way forward for graphite waste management and disposal, which may best be realised through international collaborations with countries such as France who have similar issues.

UK expertise with research reactors, the prototype AGR at Windscale and Magnox stations provides an opportunity during this phase for exporting services for project

management and decommissioning operations to other countries with similar reactor designs such as France, Italy, Spain and Japan.

Geological Disposal

UK will carry out surface based assessments of sites for a GDF location, and make significant progress optimising the efficiency of waste conditioning and storage

Measurable progress to achieving a final disposal route for higher activity wastes is of fundamental importance to the ongoing success of nuclear in the UK. Within the next five years, the UK supply chain will continue to support R&D fundamental to delivery, and NDA RWMD will progress surface based assessments of volunteer sites. Over this period, focus will be on optimising the efficiency of decommissioning waste conditioning and storage for a significant number of waste streams across the lifecycle of the waste products. In addition to technical underpinning, R&D should be directed towards ensuring public confidence in the safety of a GDF, and this can only be done if the research is undertaken objectively.

The UK is presently not the most advanced nation in developing a geological disposal solution, and therefore it is recognised that international collaboration in R&D is key, with the UK potentially benefiting from existing mature overseas technology. Countries that have not finalised site plans or are still debating all waste disposition options may have an interest in learning from the UK's investigative methods and volunteerism approach.

Expanding Market Phase (5 – 20 years)

The UK industry will continue to use the domestic WM&D market during this phase as a platform to achieve its ultimate vision of being a global provider of world-leading site management technical solutions and professional services.

Innovative UK companies sought out by international markets

Opportunities to develop capabilities domestically will continue as Sellafield moves into broad front decommissioning and waste treatment, and other UK sites continue their clean-up activities. As the UK WM&D industry gains in experience and reputation, it will be capable of dealing with more complex challenges whilst driving down the costs of decommissioning. Innovative UK companies will be sought out by international markets.

Decommissioning in other sectors
UK industry can capitalise on its nuclear WM&D expertise in other decommissioning sectors such as North Sea oil and gas, navy nuclear submarines and ships, military installations and coal-fired facilities.

With significant progress made on the decommissioning of facilities in the UK, the role of the NDA in developing integrated waste management strategies in support of the UK new build programme will become increasingly important, underpinning investment decisions of international nuclear utilities in the UK market.

UK Legacy Waste

Industry's vision is to see significant progress and completion of waste retrieval from many of the legacy waste plants in the UK during Phase 2. To achieve this, UK industry will have expanded its knowledge base, attracting new entrants to the industry through the innovative technology used to overcome challenging issues. Solutions to the processing of waste in preparation for interim and long-term storage will have been demonstrated through R&D at UK facilities, and the programme of work commenced to put the solutions into practice. The facilities required to safely process and store the waste, such as the Silos Direct Encapsulation Plant (SDP) at Sellafield, will be constructed and commissioned successfully using UK industry, which needs to have strategically developed over time to provide the necessary capacity.

Decommissioning

Skills and training initiatives for sustaining the core competency in decommissioning will be in place to support the growing needs of NDA's missions, and the commercial nuclear sector, as well as providing support services to overseas markets. It will be important in this phase to recognise the planning need for parallel projects in new reactor build that will utilise the same manufacturing and construction skills needed to support WM&D activities.

UK having a clear competitive edge in WM&D technologies in domestic market, driving down costs through experience

The manufacturing sector will continue to grow, using advanced manufacturing techniques developed through partnerships such as NAMRC, and applying technology innovation and knowledge from academia and research organisations.

Technologies deployed in this phase will be exportable, and UK industry capable of providing world-leading solutions competitively on the global stage. Export opportunities in WM&D will include technologies and tooling in numerous categories, such as characterisation, decontamination, remote handling, size reduction, instrumentation and sensors, waste reduction and treatment, and non-destructive examination. Export opportunities will also be available for processes, procedures, software/virtual systems for decommissioning operations, project management, and cost estimating (including decommissioning costs for inclusion in new build life cycle cost estimates).

Nuclear Reactor Decommissioning

The domestic and global demand for reactor decommissioning services will increase significantly during this phase as currently operating reactors are brought off-line after their life extensions end. As Magnox reactor care and maintenance activities end and active deconstruction commences, UK knowledge gained through forensic examination of the graphite structures could be invaluable in feeding into the development of some future Generation IV designs.

Move up the value chain internationally and export Tier 1 capability to foreign decommissioning sites

Using programme management skills and experience developed and proven primarily domestically, UK companies want to exploit opportunities to move up the value chain internationally and export out Tier 1 capability to foreign sites requiring decommissioning. This in turn will provide a route into foreign markets for UK companies who have well established links with Tier 1 companies, and a coordinated export of UK capability is envisioned.

Geological Disposal

UK will have completed the R&D required to finalise a decision for the siting of the GDF and construction work will have commenced

Within this phase, industry would like to see continued progress and commitment from Government and NDA to delivering the GDF. To achieve this as currently planned, the safety cases and underpinning R&D required to finalise a decision for the siting of the GDF will have been developed, and industry wants this to use UK expertise and research facilities, with a focus on providing the most cost-effective technology solutions. The volunteer siting process will ideally present one or more options for location, and it is important that communities are engaged throughout the process to maintain their support.

The Government siting process, presently estimated to be concluded around 2025, will enable construction work to commence. With strategic planning in Phase 1, UK industry will be prepared and able to deliver this competitively. UK industry believes that implementing a disposal technology for a broad range of nuclear materials will provide a larger platform for the development of future nuclear energy disposal needs, and allows for wide-ranging materials knowledge to be gained for exploitation.

New Technology Phase (20 – 40 years)

Building on the successes realised in the previous phases, UK industry's ultimate vision is that the UK will be a provider of world-leading technical solutions and professional services, and be the global benchmark in waste management and decommissioning for safe, timely and cost effective operations. The UK will have firmly established a vibrant commercial industry in waste management and decommissioning, driving forward WM&D programmes delivering solutions supported by R&D.

An established vibrant UK industry that is the global benchmark in waste management and decommissioning

Spin-off technologies - Recycling
UK industry will be expanding its nuclear WM&D expertise to capitalise on opportunities in the coal, oil, gas, and military decommissioning sectors. This in turn will provide an opportunity to develop recycling as a UK industry, capitalising on the UK's facilities and competencies in the steel/construction industries to realise commercial and environmental benefits from recycling and reuse of scrap materials, exotic and precious metals, and for building materials as global demand increases in developing nations.

UK industry wants the UK's programme of legacy waste management and reactor site decommissioning to be well-advanced and progressing in an accelerated time

Decommissioning at UK sites at an advanced stage with land remediation activities in place

scale. Costs will be minimised through innovative solutions and project delivery techniques. UK industry will possess a strong portfolio of available products and services for a broad range of decommissioning activities and will be deploying these world-wide.

The UK will have a clear and fully integrated strategy to deal with the wastes generated through operating facilities, with the NDA fulfilling a key role as an implementer of government's nuclear waste policy.

International standardisation of regulatory and safety policies to address waste handling, storage and transport will also be in place. Opportunities for decommissioned land restoration and reuse in new and varied commercial capacities will be progressing in the UK and abroad.

Building on experiences from decommissioning of UK reactors, and of increasing involvement at Tier 1 level internationally, UK industry will be providing services for hands-on decommissioning construction, project management and engineering support services to the worldwide market, where decommissioning of Generation III nuclear facilities will steadily continue as life extensions expire and countries phase out of their nuclear energy and weapons programmes.

UK industry want to have delivered the design, construction and commissioning of the GDF

The UK nuclear industry wants to have developed the capability and capacity to complete the design, construction and commissioning of a GDF. The R&D required to understand and monitor the long-term behaviour of materials and waste emplaced in packages will have been performed at UK facilities, with consideration of all legacy and future new build wastes. Towards the end of this phase, UK industry wants to be in a position to transport waste packages from interim stores at sites around the country to the GDF, and be operating the facility safely.

The lessons learned from successful implementation of a GDF will be immensely valuable to nations who are progressing down this route. The UK will be one of only a few pioneers of much of the technology involved in geological disposal, and at a scale not deployed elsewhere in the world. UK industry would look to exploit these opportunities and take the lead internationally in assisting entrant countries to prepare, transport and dispose of and monitor their nuclear waste safely.

UK industry wants to be a global leader in GDF technology, advising and providing assistance to other nations

5. Fuel Cycle Services

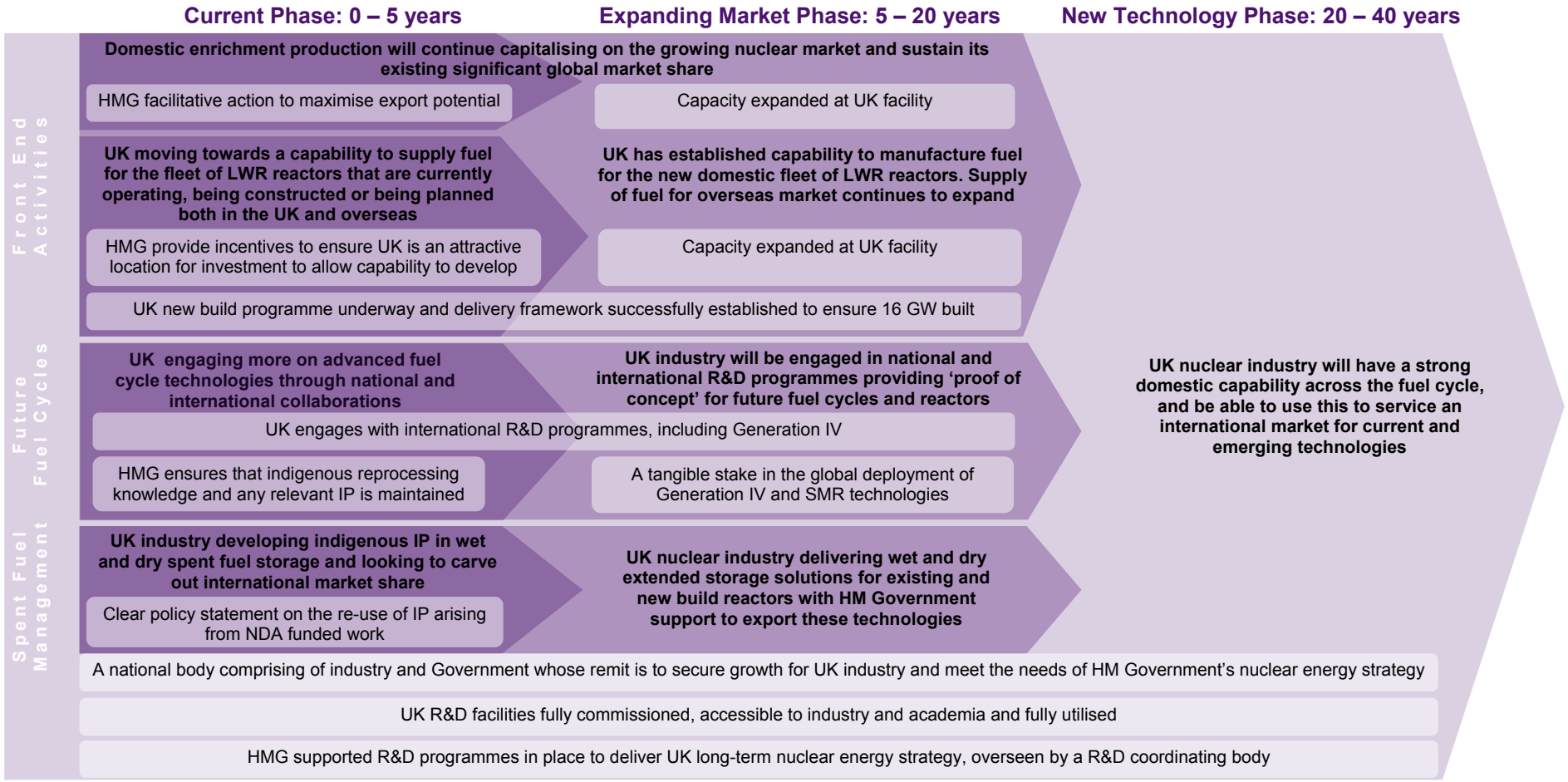

Figure 4: The vision for fuel cycle services

(Key: Pale boxes denote the dependencies (see Section 6) upon which UK industry's achievements (in bold) in each phase rest)

Current Phase (now – 5 years)

Front End Activities

Domestic enrichment production will continue capitalising on the growing nuclear market and sustain its existing significant global market share

The UK Capenhurst site provides world-leading enrichment technology, already producing 10%[27] of global annual uranium enrichment requirement, and is well placed to capitalise on an expanding global market. With the investment that has already been made to build on and advance this position at the Capenhurst site, the longer term vision is to retain UK's pre-eminent market position over the duration of this Vision period.

Countries who lead in enrichment have the opportunity to supply services to established, developing and emerging nuclear countries. UK industry would look to maximise the commercial benefit associated with assisting ambitious developing nuclear countries with their domestic programmes within our non-proliferation obligations. In support of this, industry believes strong Government facilitative action is required in the short term, both in maintaining an active interest in the ownership of the Capenhurst site and in developing overseas export streams for enrichment services.

Uranium stewardship is also an area in which the UK industry would look to build upon existing activities to carve a prominent global position, including 'tails management' and 'proof of concept' investigation of disposition of depleted uranium in mines from which original natural material came. Avoiding the consignment of such material to a highly engineered geological repository (thereby reducing its overall size and cost) represents a key R&D area with large potential commercial opportunities which could be realised by UK industry.

The UK has a vast and diverse experience in fuel fabrication. Capability for LWR fuel production is currently being revived at the UK's Springfields site, with the long-term goal of serving the domestic and global markets (both operating and planned) with intermediate fuel products and LWR fuel manufacturing (whilst continuing to provide fuel for the UK AGR fleet). Whilst recognising that fuel is purchased from companies and not individual sites, UK industry wishes to see all practical incentives put in place to ensure LWR fuel manufacture is undertaken competitively in the UK for customers around the world. Support of this aim will reinforce the UK's status as a global nuclear nation.

UK moving towards a capability to supply fuel for the fleet of LWR reactors that are currently operating, being constructed or being planned both in the UK and overseas

Nuclear fuel safety and reliability and advances in these areas are dependent on the ability to examine samples of highly radioactive fuel and fuel components after they have been removed from the reactor (termed Post-Irradiation Examination, PIE). As one of the original pioneers of nuclear power, the UK has had PIE capability for many

[27] Urenco has provided these figures from its own records

years but both the facilities and the expertise necessary for this work are being eroded such that some of this work has already had to transfer to overseas suppliers.

UK industry believes that during this phase it is important that this trend is arrested since PIE is an essential support service to nuclear generation and a key aspect in the development of any future reactor design. To achieve this aim, Government may need to consider investing in PIE facilities and a change in remit for the organisations that house and operate them.

Future Fuel Cycles

Increased UK engagement in advanced fuel cycle technologies through national and international collaborations

UK industry's vision is for the UK to have long-term security and sustainability of nuclear energy at levels up to 75 GW by 2050, as postulated in the Carbon Plan. Achieving this is likely to involve advanced reactors, with both open and closed fuel cycles a possibility. UK industry would look to work with Government in ensuring that the future fuel cycle route adopted aligns with Government objectives for non-proliferation and security of supply, whilst at the same time maximising commercial benefit to the UK where appropriate.

UK industry believes that UK must act now to develop its indigenous knowledge in credible advanced fuel cycle technologies in order that options are not closed off in the future due to lack of activity in the near-term. This includes retaining existing knowledge in advanced reactor technology, commercial reprocessing, and plutonium re-use. Action needs to be taken within the next 5 years to develop national (and engage with international) R&D programmes to a level that demonstrates to the international community the UK's commitment to play a major collaborative role.

The timescales for deployment of advanced fuel cycle technologies is sufficiently far in the future to preclude industry investment alone, and therefore long-term support from Government is required; specifically, UK effort should be centrally coordinated by an enduring R&D body that can serve national interests. In addition to underpinning the longer-term objective of securing a sustainable UK nuclear energy supply, developing advanced fuel cycle capability in the near-term will position UK industry to exploit a globally expanding market in the longer-term, as other nations adopt advanced fuel cycle technology.

In the area of advanced reactor technology, capability should be developed through the UK engaging fully with the Generation IV Forum (GIF), recognising that international collaboration is the optimum way to develop knowledge in this field.

UK industry presently has the knowledge and capability to reprocess various fuel types and performs this for domestic as well as overseas clients. All reprocessing activity is scheduled to end in the UK by 2018 since reprocessing is currently not a cost-effective approach. Consequently, the associated skills and capability are at risk of being lost in the very near-term. UK industry recognises that the decision whether to reprocess is a commercial one, and the management team of the Sellafield site has no mandate or present commercial driver to act to maintain any level of capability. However, UK industry believes that whether a future decision is taken to develop the UK's own reprocessing technology, or purchase a solution from

the international market, retention of this knowledge will be of benefit. As a result, an appropriate means of retaining this knowledge and any relevant IP within the UK needs to be identified and supported by Government, a relevant overseeing body and through national and international programmes (including R&D and collaboration) within the next 5 years.

UK industry recognises that the management of separated civil plutonium is a key Government strategy decision that is influenced by many sensitive factors. UK industry's main priority in this area is that progress continues in delivering a plutonium disposition policy that meets national needs. In support of this developing position, industry believes that the separated civil plutonium should be used for energy generation. UK industry would wish to see the ultimate choice of technology implemented with serious consideration given to UK industry involvement in its delivery, recognising that the net benefit to the UK taxpayer overall must be the overriding consideration. By considering how the technology will be deployed, this approach will allow UK industry to work with other countries that may look to develop closed fuel cycle technologies in the future.

Spent Fuel Management

Over the next 5 years UK industry will continue to actively support the transition from domestic commercial reprocessing to a programme of spent fuel management encompassing long-term storage, fuel conditioning and disposal.

UK industry developing indigenous IP in wet and dry spent fuel storage and looking to carve out international market share

Spent fuel stewardship in existing and emerging nuclear nations will continue to represent a significant global opportunity - all countries must implement some degree of extended surface storage of spent fuel including, in some cases, the transition from wet to dry storage regimes. UK industry wants to use the domestic market during this phase to develop indigenous IP and in doing so will be well placed to carve out a leadership role in this field internationally, especially considering UK experience of a wide variety of fuel types.

The current mechanisms for managing spent fuel arising from NDA, existing and new build sites are different. Development of a single coherent, cost-competitive approach to spent fuel strategy for the UK would benefit the development of indigenous expertise in this area and increase the UK's international reputation.

Expanding Market Phase (5 – 20 years)

Front End Activities

UK industry's vision during this phase is to capitalise on the growing nuclear market and to increase its global market share in front end fuel cycle activities. Capacity at the UK's enrichment facility will continue to meet target production volumes. Achievement of this target for growth will be dependent on having secured access to developing nuclear nations' markets, with the facilitative

The UK will capitalise on the growing nuclear market maintaining domestic enrichment production and global market share

measures for export established by Government in Phase 1 having enabled this.

UK has established capability to manufacture fuel for the new domestic fleet of LWR reactors. Supply of fuel for overseas market continues to expand

UK industry wants to build on the position attained within Phase 1 of re-establishing a competitive LWR fuel manufacturing capability, and to grow this capability by initially supplying fuel for UK LWR reactors, and subsequently through securing an increasing amount of the international market share. The scope for expansion at the Springfields site to meet a significantly increased proportion of projected market demand means this is a realistic aim. The successful revival of the UK LWR capability, based on secured orders to manufacture fuel for the new UK fleet of reactors, will help to ensure the UK site is seen as the most attractive to investors when deciding which of several competing sites to expand.

Looking further ahead, and in support of a clear UK sustainable strategy for nuclear energy, UK industry will in this phase also be involved in R&D in support of providing enriched uranium and fuel for future Generation IV and SMR reactor technologies.

Future Fuel Cycles

UK industry wishes for clear strategic direction to be provided in Phase 1, subsequently leading to the opportunity to provide significant support to the delivery of the following 'new' requirements:

- The design, construction and operation of domestic plutonium management facilities;
- A national domestic programme providing 'proof of concept' for future fuel cycles and reactors.

UK industry will be engaged in national and international R&D programmes providing 'proof of concept' for future fuel cycles and reactors

Through this phase UK industry would seek to continue its active role as a collaborator in global fuel cycle initiatives, such as GIF, through a range of active technology 'proof of concept' demonstrations. UK industry believes that, during this phase, securing partial UK ownership of an emerging Generation IV design to be brought to market in the subsequent stages will be of commercial benefit to the UK, extending beyond fuel cycle services to meet other industry aims for New Nuclear and Operations & Maintenance.

Integration of the capabilities and facilities of the UK's national laboratories will enhance industrial involvement in international collaboration. By this point, industry would wish to see the UK's leading-edge facilities fully commissioned along with an established mechanism for bringing in public and private financing of significant strategic projects. Nuclear R&D at this strategic level would require the leadership and direction of an enduring R&D body with the remit and ability to oversee active implementation.

Spent Fuel Management

UK nuclear industry delivering wet and dry extended storage solutions for existing and new build reactors with HM Government support to export these technologies

The spent fuel management market during this phase will continue to grow domestically and internationally as the number of operating stations increases globally and nations consider their future strategies for sustainable nuclear fuel cycles. UK industry will be at the forefront of delivering wet and dry extended storage solutions for spent fuel from existing and new build reactors in the UK, as well as exporting these services to new build markets globally to assist in developing solutions within the host nations.

New Technology Phase (20 – 40 years)

Successful achievement of the Vision within the earlier phases will result in UK industry being active in all areas of the global fuel cycle services market. UK industry would look to capitalise on the domestic and international experience developed over the earlier phases and so be well placed to lead the global supply chain for fuel cycle services for many decades.

Globally, existing and emerging nuclear nations will be undergoing significant expansion of nuclear capacity, opening up major new market areas for the UK to exploit. UK industry can realistically seek to be world leaders in providing enrichment services and fuel manufacture to support future Generation IV and SMR reactor technologies.

UK industry as a whole seeks to be offering a complete package of services for future reactor technologies, including design, build, operations and maintenance. A comprehensive fuel cycle services offering will complement and strengthen these aims.

UK nuclear industry will have a strong domestic capability across the fuel cycle, and be able to use this to service an international market for current and emerging technologies

Within this phase UK industry believes there will be a need for full scale demonstrations of emerging priority technologies, and would look for a share of these to be delivered from the UK. These are expected to include reactor technology for Generation IV technologies and fuel cycles.

UK industry believes this vision is realistic and practicably achievable provided the foundations are laid in the current phase, with particular emphasis by Government given to ensuring investment by non-UK entities in existing UK fuel cycle sites.

6. Delivery of the Vision

The UK Government has, through the actions they have taken in recent years, facilitated a return to the construction of new nuclear power stations. In doing so they have created a fantastic opportunity for the UK nuclear industry to play a major role in meeting the challenge of transforming the domestic energy sector while at the same time powering economic growth and creating high quality UK jobs. In parallel with this over the past decade, the waste management and decommissioning sector has been restructured to give a clear focus on accelerating clean up of the UK's nuclear history. UK industry now has the opportunity to build on this domestic platform and once again be recognised internationally as a 'top table' nuclear nation that is well-positioned to compete in the international market. The Nuclear Industrial Vision Statement is a response to this opportunity.

For the Vision to become reality, UK industry believes four key enablers need to be understood clearly:

i. **Successful delivery of the first wave of new UK nuclear power stations is a critical requirement to enable the Vision and secure the enormous strategic national benefits that can flow from it.**

ii. **UK industry must strive to be competitive, and make significant and growing contributions to domestic programme delivery across the entire nuclear sector.**

iii. **The UK needs to make demonstrable progress on managing its historic nuclear facilities, including decommissioning, waste management and disposal, displaying a joined-up approach to the way all aspects of the nuclear energy sector are tackled.**

iv. **HM Government must demonstrate that it recognises the long-term importance of nuclear to the UK's future energy and economic security. It can do this by:**

    a. **Working with industry to provide the required infrastructure solutions to underpin successful domestic nuclear energy generation that is commercially competitive and strategically secure.**
    b. **Identifying the long-term strategic international relationships/alliances needed to provide political stability and grow UK's influence and reputation.**
    c. **Investing where necessary in education, skills and long-term R&D.**

i. **Successful delivery of the first wave of new UK nuclear power stations is a critical requirement to enable the Vision and secure the enormous strategic national benefits that can flow from it.**

It is imperative that the UK new build programme commences as soon as possible: Government must make the financial environment in the UK attractive to investors to facilitate this, whilst ensuring nuclear energy remains competitive in the long-term.

Once underway, the new build programme must provide clarity and consistency of demand for the UK industry in order for it to have the confidence to invest in development.

ii. **UK industry must strive to be competitive, and make significant and growing contributions to domestic programme delivery across the entire nuclear sector.**

Long-term growth for the UK nuclear industry relies on a significant contribution being made by UK industry to the first phase of domestic new build, and to the ongoing waste management and decommissioning programme. Achieving this will develop capability and capacity, ensure long-term competitiveness, and provide a springboard to expand into international markets (particularly in new build) - UK industry needs strong Government support to achieve this. In the UK decommissioning sector, UK industry must continue to build up its own management strength in order to develop as a credible exporter of expertise.

Reaching the forefront of the global new nuclear build market requires the UK to extend its current component and reactor design capability and ensure design authority is transferred to the UK over time, with initial focus on securing a high proportion of the design of Balance of Plant components. As well as supplying components to a global market, having design authority will enable longer-term O&M contracts to be secured.

The procurement/tendering process for new build contracts must be fair, open and genuinely competitive to give UK capability the opportunity to be considered. UK industry may well need to rely on the establishment of international collaborations with the existing supply chain in the near-term, especially for UK companies wishing to supply manufactured components. This will ensure the necessary knowledge is transferred into UK companies

To become more competitive internationally, UK industry as a whole needs to develop a more coordinated and unified export front as appropriate. UK industry must recognise that, to increase market power and facilitate stronger, long-term links with international markets, specialist consortia or partnerships built around technical offerings or service areas need to be established in the near-term.

iii. **The UK needs to make demonstrable progress on managing its historic nuclear facilities, including decommissioning, waste management and disposal, displaying a joined-up approach to the way all aspects of the nuclear energy sector are tackled.**

Fundamental to the UK industry developing its capability and capacity, and subsequently expanding into overseas markets will be measurable and sustained progress across all sectors of the domestic industry, including decommissioning and the GDF.

In order to achieve this, UK industry (at all tier levels) needs to have visibility and clear understanding of the procurement plans and technical challenges for decommissioning, as well as realistic timing requirements for implementation. This will allow companies to position themselves for successful bidding and skills development. NDA presently provides this transparent forward view of SLC activities, but more may need to be done to ensure that this information is cascaded down the tier levels appropriately. This need could be addressed by alliances of the various stakeholders and technical community, through which uniformed consensus of needs and priorities are developed and communicated to industry.

As part of this, Government must consider the most appropriate mechanism needed to deliver an integrated waste management policy that encompasses wastes arising from decommissioning, current and future generation. This will provide confidence for investors, industry and the public that the UK's long-term nuclear strategy is viable. This is a fundamental issue which requires the appropriate level of priority afforded to it.

iv. Government must demonstrate that it recognises the long-term importance of nuclear to the UK's future energy and economic security. It can do this by:

a. Working with industry to provide the required infrastructure solutions to underpin successful domestic nuclear energy generation that is commercially competitive and strategically secure.

Leadership and coordination will be essential to successful delivery of the Vision, across Government, industry and academia. The right enabling bodies and policies must be in place to achieve this.

Nuclear Industry Council

Industry welcomes the recent formation of the Nuclear Industry Council, co-chaired by industry and Government. It believes the Council should act as an effective platform to provide leadership and direction, deliver growth for UK industry and meet the needs of Government's nuclear energy strategy.

The Council will need to be supported by bodies responsible for all aspects of the UK civil nuclear industry. These will include those with a remit to ensure delivery of a successful new build programme, delivery of the UK waste management and decommissioning programme, coordinated national strategic R&D and addressing future skills requirements (some of these areas are led by existing bodies which should be included).

R&D coordinating body

A national research body is required that can serve national interests across the full nuclear lifecycle, 'horizon scan' domestically and internationally for upstream requirements and represent the UK internationally. How best to integrate existing

research organisations and overseeing bodies and their R&D programmes, such as NNL, the Dalton Institute and the Nuclear Waste Research Forum led by the NDA, will need careful consideration.

The role of NDA

The current remit of NDA and its associated Site Licence Companies have a 'closure 'agenda only, as their formation came at a time when the UK did not have plans for new reactors. Given the recent changes in the UK nuclear sector, there needs to be consideration of whether the current remit of NDA is appropriate to account for and align with the waste management and decommissioning requirements of the new build fleet.

The NDA's current remit is solely focussed on UK clean-up, meaning that a significant part of the UK capability and knowledge in the field of WM&D cannot be made available for wider use by the UK industry. The NDA's mission must be relaxed or broadened to represent all UK WM&D interests, allowing UK industry to maximise its commercial potential in international markets. For example, the current arrangement of the PBO model and its importance in assisting UK industry in building up its decommissioning management capability also needs review. This will be fundamental in allowing UK industry to utilise the domestic market to build up UK industrial capability as a basis for export.

HMG initiatives to support technology development

Strong relationships between industry and research entities will be crucial for successful technology development and commercialisation. A streamlined approach for supporting the development of new technologies along the full spectrum of TRLs, including regulatory assessment and approval, is required. The commercial planning horizons of industry precludes investment in the middle TRLs – continued Government support in this area through existing initiatives such as the NAMRC and the TSB is needed. The regulator also needs to commit resources, recognising their role in the process of bringing new advanced manufacturing techniques to the market.

In support of technology development, a clearer communication and consistent implementation of policy on IP arising from NDA funded work is required, especially as it applies to international export opportunities. Greater clarity on IP ownership and its protection at all tier levels would encourage business growth and export activities, particularly for SMEs. Where it is still retained following the break-up of BNFL, exploitation of historic IP knowledge related to the NDA estate should be made available to UK companies to allow its value to be realised in the global market place.

UK enrichment interests

UK industry's view is that an enrichment capability is a strategically significant role in a country's nuclear energy programme. UK industry will be seeking reassurance that the prospective sale of Government's enrichment capability would be consistent with the vision for the UK to regain 'top table' status.

b. Identifying the long-term strategic international relationships/alliances needed to provide political stability and grow UK's influence and reputation.

To be recognised as a capable international player the UK must be seen as having an influential voice amongst the 'top table' of nuclear nations, many of whom have industries that are fully backed by their government. The development of strategic relationships in this environment is something that can only be effectively led by governments - UK industry requires Government's assistance to reap the benefits of such activity.

UK involvement in IAEA expert groups will also be an essential underpinning of a professional services offering in each area. Government assistance is needed to maintain this active international presence because invitations to groups such as IAEA expert committees generally come via government routes. It is important that Government re-establishes appropriate interfaces with industry to address such opportunities (the Nuclear Industry Council could offer such a route).

Specific examples of important international interaction include:

- Interaction with the IAEA to promote regulatory activities and to influence development and harmonisation of codes and standards across all nuclear sectors will ensure the UK aligns with the rest of the world, and will therefore be able to integrate with a global market. The work of the existing NIA Quality Group should be fed into this.
- A joint body of Government and industry representatives should be established to work collaboratively with international reactor 'owner groups' and ensure any commercial opportunities are captured, for example building on the approach used for Technical Assistance to the Commonwealth of Independent States (TACIS). This is vital in growing UK credibility in delivering services for reactor types which we do not currently operate.
- A marketable education and skills package that would be attractive to new entrant countries to develop their indigenous capability. In order to deliver this, the UK needs to:
    - Draw together the knowledge currently retained across industry, skills bodies and academic institutions;
    - Be at the forefront of reactor knowledge;
    - Understand codes, standards and regulatory requirements of other countries.

There needs to be continued unified activity from Government, UKTI and FCO in support of more coordinated UK nuclear industry export activities and optimisation of the UK's export mechanisms. The WNA is currently seeking to create a streamlined regime of export control and other trade-related regulations for the global nuclear industry; UK industry would wish to see FCO and Export Controls Office involved in and shaping that programme. Industry also believes that a financing option should

be developed that can be incorporated into packaged technical offerings to new entrant countries.

c. Investing where necessary in education, skills and long-term R&D.

Education

Government's commitment to nuclear energy in the UK must extend over decades (i.e. between successive governments) for the industry to have confidence to invest. Continued public support will be fundamental to this, and UK industry needs to work with Government, academia and professional institutions in a continuous concerted effort to keep the public fully informed and educated about the new build programme, as well as waste management and decommissioning activities and geological disposal.

Skills

To maintain a successful approach to domestic nuclear skills development, a strong integrator is needed; industry would like to see continued dedicated support for and coordination by the National Skills Academy for Nuclear (NSAN) and associated support networks, such as Cogent. Greater input from industry is needed in steering the skills agenda, working to ensure industry needs are met.

In committing to a long-term sustainable domestic nuclear energy supply, Government must recognise the need to keep future fuel cycle technology options open. UK industry believes it is important to maintain an indigenous skill base across the fuel cycle and, with the approaching end of reprocessing and the recent end of MOX fuel manufacture, this applies in the very near-term. Given that neither the NDA or wider industry has the mandate nor commercial driver to ensure this knowledge is retained in the UK, Government leadership is required to facilitate this. This may require a change remit of the NDA and NNL, whose facilities and resources would be necessary. Any activity initiated should involve strategic national R&D programmes and a significant UK involvement in Generation IV technology development through international fora such as GIF.

R&D

As outlined previously, a national R&D coordinating body is required to act to serve national interests and represent industry internationally. The UK's extensive and world leading nuclear R&D facilities exist across a variety of institutions and will be fundamental in the delivery of national and internationally focused R&D programmes, as well as commercial R&D for overseas clients. The R&D coordinating body would need to oversee a coordinated approach to their use, allowing access for both industry and academia to facilitate the UK in developing a commercial advantage in the domestic and global marketplace. Government will also need to support investment in existing R&D facilities with national relevance where refurbishment is necessary, and ensure new facilities are fully actively commissioned to realise their commercial potential.

The remit of the existing Government owned bodies such as the NDA and the NNL will need to be changed to enable the most strategic use of the UK's active R&D facilities. NNL is presently established as a commercial organisation, with no remit to use its facilities for national interests. Commissioning of its high active laboratory facility at Sellafield is dependent on NNL demonstrating it is commercially viable.

R&D can broadly be categorised as that commissioned by Government as part of delivering the longer term national nuclear energy strategy, and that which industry commissions in the shorter term to gain commercial advantage. The distinction between industry and Government led R&D and the extent of involvement of a national coordinating body in industry related R&D, if any, will need to be considered. The following areas of R&D have been highlighted as necessary activities to support UK industry achieving its Vision:

R&D that must be led by Government

- **Generation IV technologies** - UK programmes and international collaboration in the area of evolving and future reactor systems and fuel cycles, including demonstrations.
- **SMR technology** - Set up national and engage in international R&D programmes aimed at bringing SMR technology to the commercial market. UK industry and Government should draw upon UK design capability and naval reactor design and delivery experience and include research into advanced manufacturing, modular construction and operating cost reduction issues with cross-over to other manufacturing research. Government interaction with other governments over SMR development must occur in the very near-term (i.e. within the next 1-2 years). Some existing programmes must be widened in focus if the UK is to contribute - individual research bodies cannot achieve this strategic move alone (e.g. the existing US programme is partly US Government funded).
- **Fusion** - Continued R&D involvement in the ITER project to position UK industry for a substantial share of the future fusion economy. In addition, cross-over benefits between fusion and fission research (i.e. next generation nuclear structural materials and computer simulation capability for reactors and blankets) should be further explored. These activities will positively benefit some UK activity pursuing Generation IV technologies in the near-term.
- **Waste management and decommissioning** - Continued investment in innovation and R&D to deliver decommissioning faster, safer and more cost effectively, supporting NDA and industry's aim to deliver demonstrable progress. NDA's Research Board response to research needs identifies seven recommended areas of focus:
    - Characterisation techniques (environmental and nuclear);
    - Decontamination and decommissioning techniques (remote handling/robotics);
    - Waste treatment;
    - Waste packaging and storage;

- Management of contaminated land;
- Management of plutonium;
- Waste disposal.

As other countries enter decommissioning in the short term there are opportunities for collaboration in technology development nationally and internationally. Effort should also be directed to solving issues surrounding the dismantling of graphite-moderated reactors and subsequent management of the waste material, possibly through international collaboration with countries facing similar challenges.

- **Spent fuel management** - Undertake research necessary to facilitate long-term surface storage of spent fuel (including wet and dry options).
- **Geological disposal** - Continue the delivery of R&D fundamental to delivery of a GDF, including optimising decommissioning waste conditioning and storage for a significant number of waste streams across waste product lifecycle. This research needs to be objective in order to gain public confidence.
- **Public acceptance** - Undertake R&D in the areas of public acceptance and the perception of risk in order to support a long-term sustainable future for nuclear in the UK, for both new build and geological disposal.

R&D that must be led by UK industry

- **Depleted uranium management** - Undertake necessary research to underpin 'proof of concept' for the novel disposition of depleted uranium, including returning it to its mine origins.
- Transfer of **AGR life extension knowledge** to future reactor designs - the links between life extension of AGRs and certain types of high temperature gas-cooled Generation IV technologies should be examined. Any UK Generation IV programme should also incorporate an initiative to retain AGR operations knowledge from the existing workforce, as well as retain forensic information arising from AGR reactor decommissioning.
- **Fuel supply and servicing** - Expand the scientific basis for top quality fuel supply and servicing for O&M of LWR plants (in combination with the advanced manufacturing work that will be ongoing). This will involve the use of the PIE facilities which the UK presently has, but which will need investment and refurbishment in order to maintain this essential capability.
- **Operational efficiency** - Extend programmes supporting the development of Enhanced Health Monitoring and proactive maintenance regimes, in order to maximise opportunities for UK industry to deliver greater operational efficiency to operators.
- **Extreme natural hazards** - Carry out R&D into extreme natural hazard abatement and response, and the effect on plant operating parameters.
- **Construction and project management** - Invest in advanced construction and project management R&D to offer UK industry a valuable edge in its aim to become a

trusted delivery partner in the deployment of Generation III designs at home and globally.

- **Advanced Manufacturing** - Continued support for the development of Advanced Manufacturing techniques is essential for growing market-share in component supply for new build and the associated growth of UK industry's O&M service supply. Areas identified for focus include:
    - Electron beam welding
    - HIP (not just monolithic components)
    - Laser welding
    - Robotics
    - 3D Modelling
    - Machining and fixtures

Appendix A: Glossary

AGR	Advanced Gas-Cooled Reactor
ASME	American Society of Mechanical Engineers
AWE	Atomic Weapons Establishment
BEC	Britain's Energy Coast
BNFL	British Nuclear Fuels Ltd
CANDU	CANada Deuterium Uranium
CEA	Atomic Energy and Alternative Energies Commission
CORDEL	Cooperation in Reactor Design Evaluation and Licensing
DEMO	Demonstration Power Plant
EDF Energy	Électricité de France
EHM	Enhanced Health Monitoring
EPC	Engineering, Procurement and Construction
EU	European Union
FCO	Foreign and Commonwealth Office
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
GIF	Generation IV International Forum
HIP	Hot Isostatic Pressing
HTGR	High Temperature Gas-Cooled Reactor
HVAC	Heating, ventilation, and air conditioning
IAEA	International Atomic Energy Agency
IP	Intellectual Property
ITER	International Thermonuclear Experimental Reactor
JAEA	Japan Atomic Energy Agency
LWR	Light Water Reactor
LLWR	Low Level Waste Repository
Magnox	Magnesium non-oxidising (1st generation UK reactor)
MDEP	Multinational Design Evaluation Programme
MoD	Ministry of Defence
MOX	Mixed Oxide
NAMRC	Nuclear Advanced Manufacturing Research Centre
NAMTEC	National Metals Technology Centre
NDA	Nuclear Decommissioning Authority
NIA	Nuclear Industry Association
NIC	Nuclear Industry Council
NNL	National Nuclear Laboratory
NPL	National Physical Laboratory
NSAN	National Skills Academy for Nuclear
NUMO	Nuclear Waste Management Organisation of Japan
OECD-NEA	Organisation for Economic Cooperation and Development Nuclear Energy Agency
O&M	Operations & Maintenance
PIE	Post Irradiation Examination

PBO	Parent Body Organisation
PWR	Pressurised Water Reactor
R&D	Research and Development
RWMD	Radioactive Waste Management Directorate
SDP	Silos Direct Encapsulation Plant
SLC	Site Licence Company
SMEs	Small and Medium Enterprises
SMR	Small Modular Reactor
TACIS	Technical Assistance to the Commonwealth of Independent States
THORP	Thermal Oxide Reprocessing Plant
TRLs	Technology Readiness Levels
TSB	Technology Strategy Board
US DOE	United States Department of Energy
UKTI	United Kingdom Trade & Investment
WAGR	Windscale Advanced Gas-Cooled Reactor
WM&D	Waste Management & Decommissioning
WNA	World Nuclear Association

Appendix B: Nuclear Industry Group

The following list shows the Nuclear Industry Group members who have been instrumental in developing the Vision. Only the lead representatives from each company have been listed. It should be noted that these individuals have been given significant support by several others within their own companies; Government, on behalf of wider UK industry, would like to extend its thanks to all those involved in the production of the Vision.

Industry members:

Nawal Prinja	Amec
Robert Davies	Areva
Chris Ball	Atkins
Norman Harrison	Babcock
Colin Elcoate	Clyde Union Pumps
Don Ward	Construction Excellence
Steve Garwood	Culham
Glen Little	Doosan Babcock
Jeremy Western	EDF Energy
David Powell	GE Hitachi
Richard Clegg	Lloyds Register
Stephen Court	NAMRC
Richard Taylor	National Nuclear Laboratory
Mike Hawe	Nuclear Engineering Services Ltd
Chris Savage	Nuclear Industry Association
Dave Millington	Nuvia
Richard Swinburn	Rolls Royce
Peter Wylie	Sellafield Ltd
Graham Honeyman	Sheffield Forgemasters
Andrew Sherry	University of Manchester Dalton Institute
Paul Harding	Urenco
Ian Tough	Weir Group
Mike Tynan	Westinghouse UK

Government members:

Professor John Perkins	BIS
Andy Howarth	BIS
Rhian Jones	BIS
Dominic Scullard	BIS
Ron Gorham	NDA
Melanie Brownridge	NDA
Derek Allen	TSB
Bob Bish	UKTI

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