A report to Her Majesty's Government by the Expert Finance Working Group on Small Nuclear Reactors

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PREFACE

I was very pleased to be asked to chair the Expert Financing Working Group, particularly at such an important time for the nuclear industry in the UK. The UK has a strong heritage in nuclear energy and it continues to be recognised by HMG as an important part of the UK's diverse energy mix, recognising its impact as a low carbon technology. It plays an important role in delivering HMG's Clean Growth Strategy providing clean, green, on-demand and baseload low carbon energy.

It should be remembered that civil nuclear has a much wider role in the global market and will continue to do so in the future. Nuclear and nuclear isotopes are recognised as important to so many areas. Nuclear energy alone currently accounts for 11% of the world's electricity (with the objective of raising this to 25% by 2050) however nuclear and nuclear isotopes have a much wider application. The United Nations Sustainable Development Goals 2030 agenda sets out 17 goals and how they will be implemented to meet the United Nation's objectives around people, the planet, prosperity, peace and partnership. Nuclear and nuclear isotopes play an important role in nine of the 17 goals including: food security, improved nutrition, water and sanitation, climate change, conserving oceans and ecosystems, medical, energy for all and resilient infrastructure, industrialisation and innovation. The emergence of small nuclear as, I believe, a commercially viable technology will further contribute to delivering these goals and the UK is well placed to take a leading role in their development both in the UK and across the global energy market.

Despite the increase in global activity and interest in small nuclear there remains a market failure in getting technologies and projects to commercial delivery, and in particular in securing sufficient financing for projects from the private sector. The role of the EFWG was to explore a range of potential financial models for small nuclear, considering the market conditions that HMG could establish to give confidence to the market, and consider the private sector appetite for investment, barriers to investment and risks. The EFWG had the benefit of considerable experience and expertise across the finance markets – and crucially not just in the nuclear sector – to address these areas and I would like to thank the group itself, the observers and the Secretariat for their invaluable efforts.

The EFWG report needs to be read in the context of the trust and confidence being built in the UK nuclear market at this time. This trust and confidence has developed through HMG's support of the Hinkley Point C development, the progress now being made on the Horizon project, the Nuclear Sector Deal that was announced at the end of June 2018, together with the wider policies, work-streams and framework being developed by HMG including:

- the Advanced Modular Reactor Programme (up to £44 million to assess the feasibility of innovative reactors);
- up to £12 million funding for the Office for Nuclear Regulation and the Environment Agency to increase their capability and capacity in advanced nuclear technologies;
- the option assessment of the potential sites for small reactors;
- the potential for the advanced manufacturing initiative for small reactors;
- a report commissioned to explore public perception of small reactors; and
- exploring opportunities around international collaboration.

The special characteristics of small nuclear provide greater opportunities for global deployment and the UK has the opportunity of developing the supply chain to manufacture and supply the potential international market, and in doing so helping to deliver HMG's Industrial Strategy. To do this the UK needs to bring small reactors into commercial operation through a framework which provides for support from the private finance market. HMG's role in supporting this commercial deployment should not be focused on down-selecting a technology but should be providing the market framework to allow the market to bring forward these developments. Creating the correct market framework will build further trust and confidence in the market and provide a greater foundation for bringing small nuclear projects to market.

In developing its recommendations for a market framework the EFWG thoroughly reviewed the risks associated with small nuclear, considering who is best able to manage such risks, the consequences of the risks and how the consequences can be managed. This analysis is important for any project development company, its financiers and other stakeholders, whether nuclear or otherwise.

It is our hope that HMG and the wider sector consider this report of practical use and that it provides the basis of the framework that HMG could put in place. This framework could not only enable the establishment of the small nuclear market in the UK but it would also allow for developing an industry that can deploy in the global market to help the United Nations meet many of its Sustainable Development Goals.

Fiona Reilly
Chair of the Expert Finance Working Group

KEY RECOMMENDATIONS

The Expert Finance Working Group (EFWG) is an independent group convened by the Department for Business, Energy and Industrial Strategy (BEIS) in January 2018 to consider what was needed to attract private financing to small reactor projects. The EFWG has settled on a number of recommendations for Her Majesty's Government (HMG) to consider to assist in enabling the development of small nuclear projects in the UK.

Key recommendation:

HMG should help to de-risk (perceived and real risks) the small nuclear market in order to enable the private sector to develop and finance projects.

The EFWG concludes that, subject to the recommendations below, the UK could be well placed to develop first-of-a-kind (FOAK) small reactors projects, with overnight costs of less than £2.5 billion, by 2030.

The characteristics of small nuclear reactors and the mechanisms by which they can be delivered are such that they may be commercially viable propositions both in the UK and for an export market, however, as with any significant energy or infrastructure project, attracting private finance will be challenging for the FOAK projects.

Small nuclear projects range from micro-generation projects through to 600MW reactors. The costs of such projects range from £100 million to £2.5 billion. As such each project will have its own structure and risks.

However, the EFWG believes that the enabling recommendations in this report apply to all the different potential small reactors being considered for development by 2030. Risk allocation, management and dealing with the consequences of risks became a clear focus for the EFWG in framing the recommendations and the market framework. Without considering these elements the group could not establish a position where private finance would be attracted to small nuclear projects whether FOAK or nth-of-a-kind (NOAK). Creating the right framework is key to attracting financing and making these projects commercially viable. Reducing the risks of the projects and making the consequences of the risk manageable are fundamental to creating the best environment for the private sector to be able to invest in small nuclear.

HMG's actions could build on the momentum, trust and confidence created by large nuclear such as Hinkley Point C and now Horizon together with HMG's focus on climate change and Industrial Strategy[1] objectives to deliver a robust market framework to allow small nuclear to develop and attract private investment.

1 https://www.gov.uk/government/topical-events/the-uks-industrial-strategy

For more details on each of these recommendations please see **Section 7**.

To help attract private financing to small nuclear projects the EFWG makes the following recommendations:

General

RECOMMENDATION 1

HMG should enable the small nuclear sector through a clear Policy and a market framework, rather than down-selecting technologies.

RECOMMENDATION 2

HMG should work with stakeholders from the energy, nuclear and finance sectors to develop a common understanding of the risks associated with small nuclear projects; thereby removing perceptions of risks which have previously acted as barriers to investment to enable a level playing field with other low carbon energy projects.

Technology Development

RECOMMENDATION 3

For technologies capable of being commercially deployed by 2030, HMG should focus its resources on bringing FOAK projects to market. HMG should only provide support and grants to enhance the UK's existing capability and/or in exchange for Intellectual Property (IP) and other rights investors would expect.

Manufacturing Capability

RECOMMENDATION 4

HMG should establish an advanced manufacturing supply chain initiative (as it did with offshore wind) to bring forward existing and new manufacturing capability in the UK and to challenge the market on the requirement for nuclear specific items, particularly Balance of Plant (BOP), thereby reducing the costs of nuclear and the perceived risks associated with it.

Nuclear Power Project

RECOMMENDATION 5

HMG should work with the Office for Nuclear Regulation (ONR) and the Environment Agency (EA) to review regulatory processes to develop an optimised and flexible approach and through the Generic Design Assessment (GDA) process allow the market to down-select technologies.

RECOMMENDATION 6

HMG should makes sites available to FOAK small nuclear projects and should consider maintaining the UK's existing nuclear Site Licensee capability to de-risk the licensee role for small nuclear projects.

RECOMMENDATION 7

For technologies capable of being commercially deployed by 2030, HMG should focus its resources on bringing FOAK projects to market by reducing the cost of capital and sharing risks through:

- assisting with the financing of small nuclear through a new infrastructure fund (seed funded by HMG) and/or direct equity and/or HMG guarantees; and
- assisting with the financing of small nuclear projects through funding support mechanisms such as a Contract for Difference (CfD)/ Power Purchase Agreement (PPA) or potentially a Regulated Asset Base (RAB) model while maintaining the supply chain plans required for larger low carbon projects.

For NOAK projects the market should be self sustaining having learnt the lessons of the large nuclear plant and the small nuclear projects that will have gone before.

CONTENTS

1. INTRODUCTION

The Expert Finance Working Group (EFWG) was charged by Richard Harrington, the Minister for Business and Energy, to assess the prospect of raising private investment for small nuclear projects. In particular the EFWG was asked to:

- identify barriers and solutions to attracting private sector finance;
- identify the financing models that may be appropriate;
- provide a brief analysis of the relative merits of each financial model with, if possible the effects on costs of capital (CoC);
- identify the criteria or hurdles required to be passed to allow a reduction in CoC including an illustration of the points / evidence required to enable refinancing at some future point; and
- identify the criteria for refinancing, i.e. stage gates in a programme for nuclear power stations using small reactors.

The key underlying questions the EFWG was asked to consider are:

1. how can HMG create the right market conditions for private sector investment; current mechanisms (such as a CfD) and other mechanisms should be explored;

2. what is the private sector appetite for investing in small reactors (both FOAK and NOAK), typical investment size and approach, appetite for risk (particularly construction risk) and return requirements;

3. what are the barriers to this investment and how might these be mitigated;

4. what range of financial structures/ models / options could be applicable; and

5. what is needed to enable UK deployment (e.g. FOAK reference case)?

In addressing these questions the EFWG has considered: the market framework that it recognises needs to be established by HMG and the private sector; the risk profile of small nuclear reactors and the appropriate allocation of risk; and pros and cons of the various financial models available in the infrastructure and energy development markets. Risk appetite, the allocation of risks and the management of the consequences of the risks are all key to the question of whether private finance can be secured for innovative programmes such as small nuclear. As such risk allocation, risk management and managing the consequences of risk within a market framework (created by HMG) became a clear focus of the EFWG's discussions.

Further details on the EFWG including the members of the group and its process can be found in **Appendix A**.

2. A GLOBAL ROLE FOR SMALL NUCLEAR

Nuclear plays an important role in the world economy. Nuclear and isotope techniques contribute to nine of the 17 United Nations Sustainable Development Goals[2]. The nine are:

- end hunger, achieve food security and improved nutrition and promote sustainable agriculture;
- ensure healthy lives and promote well being for all at all ages;
- ensure availability and sustainable management of water and sanitation for all;
- take urgent action to combat climate change and its impact;
- conserve and sustainably use the ocean, seas and marine resources for sustainable development;
- protect, restore and promote sustainable use of terrestrial ecosystems, sustainable manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss;
- strengthen the means of implementation and revitalise the global partnership for sustainable development;
- ensure access to affordable, reliable, sustainable and modern energy for all; and
- build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation.

Small reactors could play an important role in achieving these goals having the ability to provide power in remote locations and where grid systems are not as developed and resilient as they could be. As such, small reactors could play an important role in the global economy and could provide a strong market for those technologies that become commercially and economically deployable.

Small reactors are well placed to become part of the energy mix in the UK, and globally, in the foreseeable future. The technical development of small reactors in the last few years has grown exponentially making them a commercial possibility by 2030.

From the evidence the EFWG has seen, small reactors will be clean, safe and have the potential to be economically attractive sources of energy for the future. As such, small reactors can help HMG in delivering its Clean Growth Strategy[3]. To meet the ambitious Clean Growth Strategy private sector investment is certainly needed. Green finance has highlighted the £180 billion already in the pipeline for clean electricity and supporting infrastructure. However with innovative projects, whether small reactors or other technology, HMG's role is to provide a framework for the market to allow the private sector to develop these projects.

Furthermore, HMG's Industrial Strategy will be a key driver and policy framework for future UK industrial and economic growth; recognising the shift to green energy. With the need for manufacturing facilities to deploy small reactors commercially, factories for small reactors and modules fit well within the Industrial Strategy. There is a real short-term opportunity for the UK as supply chains are yet to established for small nuclear projects (unlike large nuclear with

2 https://www.iaea.org/about/overview/sustainable-development-goals-sdgs

3 https://www.gov.uk/government/publications/clean-growth-strategy

established supply chains largely outside the UK); the development of these supply chains together with the Manufacturing Capability can support both Industrial Strategy and localisation objectives.

London is seen as a leading hub for green finance. However, despite HMG's key and important shift to low carbon power being green power the financial sector has been slow to follow HMG's lead; the finance sector still seems to limit green finance to renewable power. This is an unhelpful and often unrealistic narrowing of opportunity by the finance market.

The finance markets include deep and liquid capital markets as well as considerable banks and funds able to support the development of small nuclear projects. Further the professional services market in London has many experienced professionals with leading experience of bringing energy and infrastructure projects to market. The London financial and professional service markets have much to offer in facilitating the development of small nuclear within the right framework having been given confidence in the market.

There is however a current market failure in supporting nuclear projects generally. This is due to a number of reasons:

- the financing sector's potential misunderstanding of nuclear specific risks and how such risks can be mitigated, and that nuclear specific risks aside, nuclear energy projects are no different to any other energy project;
- the number of large nuclear projects that have ended up significantly over budgeted costs or delayed during construction and delivery, and the market perception associated with these past problems; and
- the disconnect in the finance sector between green energy and low carbon energy, despite HMG's policy around the need for nuclear in a low carbon energy mix.

The special characteristics of small nuclear projects (see **Section 3**) should help to address the second bullet point and build confidence in the market. Further disclosure and transparency together with earlier and easier GDA processes should help to encourage trust from the market and help to dispel some of the perceptions. However, these will remain a concern during the FOAK small nuclear projects.

Recommendations 1 and 2 seek to address bullet points one and three.

Once FOAK small reactors can be commercially developed the export potential for the market is seen as significant. Combined with the global reach of the Department for International Trade (DIT) and the Foreign and Commonwealth Office (FCO) this could create a leading export market for the UK for many years to come.

3. WHAT MAKES SMALL NUCLEAR DIFFERENT?

The Challenge with "Megaprojects"

The EFWG received input from academia summarising a number of studies which have concluded that certain key issues typically lead to budget over runs and delay in megaprojects (Appendix B). These include schedule pressure to reduce construction time and to increase the Net Present Value (NPV), poor bid management, and a drive to reduce upfront costs leading to inadequate levels of engineering definition by the time manufacturing and construction is started i.e. an incomplete design. The three major characteristics of megaprojects that drive project underperformance are size, complexity and uniqueness (both physical and organisational). The inherent bespoke nature of megaprojects, which has been particularly true of nuclear projects, is likely to see them subject to several of the above issues (where scope change is also often a key aspect).

The nature of the small nuclear delivery model, which supports repeating and frequent standardised/simpler projects, is likely to reduce the impact on the three key major issues of megaprojects: size, complexity and uniqueness.

The Benefits of Small Nuclear

Small nuclear reactors have a number of potential purposes and benefits, depending on the technology, design and delivery model employed. Some common elements to all/most include:

- the ability to deliver not only baseload but on-demand low carbon energy;
- the ability to offer additional functionality such as domestic or industrial process heat
- the modular construction and factory build;
- considerable opportunities for the UK to enhance its capability in engineering and manufacturing through innovation, advanced techniques and new facilities;
- significant regional and socio-economic benefits, including the creation of high value manufacturing and engineering jobs;
- the potential to utilise existing nuclear sites and to co-locate small nuclear with other technologies;
- lower capital costs and quicker build times;
- the ability to achieve NOAK learning earlier in a programme lifecycle;
- greater opportunities for international collaboration; and
- opportunities to deploy in remote locations.

It is worth highlighting that small nuclear designs could utilise a number of BOP components that are similar in nature and hence a single supply chain/factory could serve numerous technologies in parallel. A market environment with a number of live programmes (i.e. customers) will encourage investment and growth in the supply chain which can drive significant learning and cost reduction opportunities from standardisation, and will ultimately drive competition and efficiency into suppliers.

The benefits of small nuclear, how they reduce risk and opportunities for cost reduction are further addressed in **Section 5**

Stakeholder submissions

To explore how the characteristics and potential benefits of small nuclear may improve the private sector financing prospects, reactor vendors, developers and other interested parties (stakeholders) were invited to provide information relevant to the work of EFWG through a Request for Information (RFI) that was published on BEIS' website[4]. The EFWG received submissions from a range of stakeholders each bringing a different perspective. The stakeholders were invited to present to the EFWG, thereby giving the group the opportunity to ask questions on the commercial propositions. The key themes that emerged from the stakeholder submissions relate to the benefits of risk mitigation and improved project performance which may be realised through factory build, modular construction, standardisation, reduced lead times and lower capital costs, i.e. the typical characteristics of smaller reactor deployments.

Product Design and licensing risk mitigation

To mitigate design and licensing risks, Technology Developers are:

- proposing to use as much proven technology as possible so as not to introduce unnecessary regulatory and licensing challenges and risk; thereby reducing development costs;
- where innovation is introduced this is targeting the simplification of designs e.g. introducing passive safety techniques which eliminates the need for complex safety systems and associated infrastructure;
- approaching designs to reduce, if not eliminate, fixed costs which may proportionally be higher with smaller nuclear;
- designing to achieve cost targets considering affordability and competitiveness;
- overnight capital costs vary with technology but all are below £2.5 billion – there is sufficient liquidity in the market to potentially finance such amounts; and
- levelised cost of electricity (LCOE) for NOAK Nuclear Power Project (NPP) Development in the range of £40-80/MWh.

Project delivery/construction risk mitigation

Delivery strategies for small nuclear projects aim to reduce risks in the construction phase (cost, schedule overruns etc.) and maximise savings from market learning and economies of volume are:

- standardisation of as much of the plant as possible to minimise variations and maximise productivity during manufacture and construction, in particular adopting a commodity approach to BOP components;
- modular factory build – moving construction activities to factories thereby removing construction risk and the need for highly skilled workforce on site for a long period of time;
- road transportable modules which are easily installed on site;
- design completion prior to construction – experience shows design changes post Final Investment Decision (FID) add significantly to schedule and cost, one of the key findings from the recent Energy Technologies Institute

4 https://www.gov.uk/government/groups/expert-finance-working-group-on-small-reactors#request-for-information

(ETI) Cost Drivers study[5] (see section 5); and
- significant reduction in civil groundworks; simpler design resulting in smaller footprints and shorter site preparation and in turn lower cost.

Operational/revenue risk mitigation

To mitigate operating risks, Technology Developers are looking to use standard fuel with an established supply route.

Decommissioning risk mitigation

To mitigate decommissioning risks, Technology Developers are: using fuel/waste streams that are consistent with current UK plans for GDF; and minimising decommissioning and waste volumes per MW compared with large nuclear. Due to the modular nature of the plant, this brings with it greater opportunities for off-site decommissioning and waste management.

Finance structures

No consensus view on a financing structure has been obtained due to the variation in technology type, size and deployment time. Some common areas of agreement by the Technology Developers are:

- technology development phase and licensing up to GDA – the Technology Developers/ vendors are requesting some HMG financial support for this phase;
- FOAK project construction phase – ability to obtain debt of up to 70%; sources of debt could include Export Credit Agencies (ECA), pension funds and commercial lenders. It was recognised that equity may come from various sources including potentially HMG;
- FOAK project operational phase – possibility to refinance and obtain an increased level of debt. There was some discussion about financial exit strategies for HMG during this phase; and
- NOAK – no specific details on how the project financing structures would differ from FOAK.

Enablers

To provide trust and confidence to investors in a future market for small nuclear in the UK, the stakeholders identified the following enablers that need to be in place:

- general:
  - clarity on HMG policy;
  - a stable regulatory regime;

- for Technology Developers/ vendors:
  - direct financing support from HMG for technology development;
  - guaranteeing timely access to a GDA slot;

- for NPP Development:
  - potential direct HMG investment;
  - guaranteed off take price – e.g. CfD, (PPA)[6]; and

- guaranteed site availability.

5 The ETI Nuclear Cost Drivers Project: Summary Report, 20 April 2018 (http://www.eti.co.uk/library/the-eti-nuclear-cost-drivers-project-summary-report)

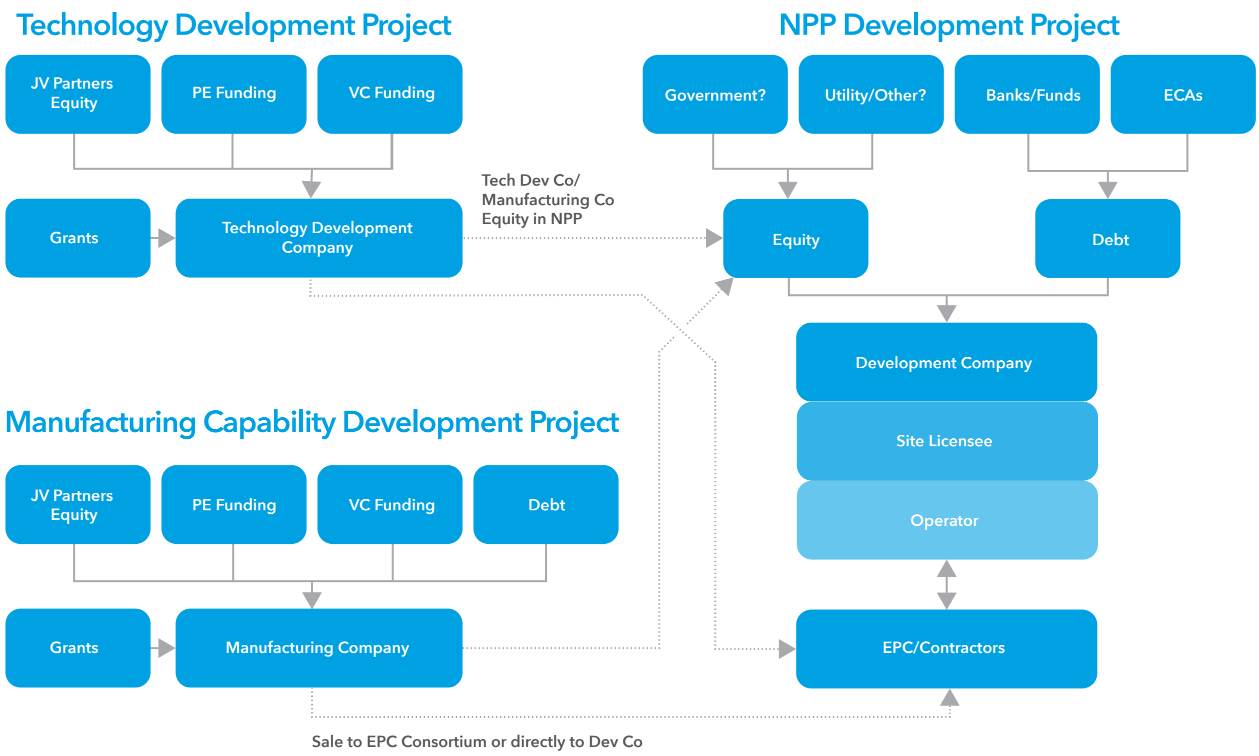
6 No stakeholders positively advocated a RAB model

4. LIFE CYCLE AND PLAYERS IN SMALL NUCLEAR PROJECTS

The life cycle of small nuclear is not dissimilar to other energy projects – even though nuclear has a longer operating life than most technologies. However over the last few years we have seen difficulties in the nuclear sector with nuclear reactor vendors being asked to be developers of nuclear power projects. For small nuclear to move ahead and to become commercially viable there needs to be clarity around the different roles of the different parties during the life-cycle.

To take a technology from a reactor development stage through to the commercial development of a nuclear power project could take three separate projects. At each stage separate corporate and/ or project financing is required.

Figure 1:
Life cycle and Players in Small Nuclear Projects



Technology Development Project

KEY PLAYERS

Technology Development Company – the company with responsibility for developing a small nuclear technology. This company is likely to take the design from a theoretical/ paper design through to feasibility studies and prototype development. This company may become the technology vendor particularly for a FOAK NPP Development. However this could depend on the relationship between the Technology Development Company and the Manufacturing Company.

FINANCING

The first project for any small reactor is for the design to be established and to be proven as a development proposition. The feasibility of the reactor technology will need to be proven (rather than being a theoretical design), which is even more important for advanced reactor types which are not based on technology currently deployed. Also the commercial viability of the reactor technology will need to be ascertained to determine whether a reactor technology has a practical and commercial application, including its ability to get through GDA.

During this stage of development financing is likely to come from venture capital funds, corporate private equity and high net-worth individuals i.e. entities that will take a higher level of risk and are content to wait a longer time for a return. There is a paucity of investors willing to take this early stage risk, particularly when the timeline to commercial deployment is often long and complex.

As such, HMG may take a role at this stage by providing grants, tax incentives etc. Technical innovation has a key role to play in delivering the Clean Growth Strategy and the Industrial Strategy – the Clean Growth Grant Challenge Fund and other funds may well be able to assist with the stage of development.

However as noted in the Accelerating Green Finance Report[7] *"The start-stop nature of Government grant funding for early stage R&D can increase the risk of the technology incubation stage and lengthen the prototype development phase."* The report also recommends an Energy Entrepreneurs Fund be established by BEIS by selecting a number of experienced private sector investors to be partners in early stage development. The EFWG agrees with these comments and believes that supporting the commercial development of nuclear power projects is more important to the UK than providing stop-start grants with no benefit to the country. **See Recommendation 3**.

Manufacturing Capability Development Project

KEY PLAYERS

Manufacturing Capability Project Company – the company or companies with responsibility for manufacturing components, modules and/or reactors. This company may be the technology vendor for the NPP Development. However this will depend on the relationship between the Technology Development Company and the Manufacturing Company.

There were various approaches proposed by the Technology Developers. Some saw themselves becoming technology vendors and owning the manufacturing facilities (at least in part). Some saw themselves as becoming a technology vendor but placing orders with manufacturing facilities. Others saw no connection between the Technology Development and becoming a reactor vendor; the EFWG does not believe that the latter is commercially viable as the risks associated with building the technology (and therefore proving the technology is constructible) are of themselves considerable.

7 https://www.gov.uk/government/publications/accelerating-green-finance-green-finance-taskforce-report

FINANCING

As identified above, one of the many benefits of small nuclear reactors is the factory/ modular build of the reactors. Establishing a manufacturing facility/ facilities is a project(s) in itself. The financing of the project may come from the same entities that have developed the reactor technology. However if the Manufacturing Company can show a business plan including a pipeline of future sales then other equity investors may become interested in participating. Equally commercial corporate debt may be available from banks and other financial institutions. As a standalone project, the commercial lending rate for these types of projects is likely to be higher than an infrastructure/ energy project finance project. Again HMG may take a role in the Manufacturing Capability Project Development by providing local authority grants, other development grants, tax incentives etc.

Nuclear Power Project Development

KEY PLAYERS

Nuclear Power Project Development Company (NPP Development Company) – the company established to develop the nuclear power project and therefore the owner of the nuclear power project. In its role as owner the NPP Development Company is also the procurer of the small nuclear technology and therefore the customer. The NPP Development Company is also likely to be holder of the generation license and the counter-party to any off-take/ revenue contracts e.g. CfD, PPAs, RAB payments.

Site Licensee – this is the entity that holds the nuclear site license in the UK. The nuclear Site Licensee has responsibility for nuclear safety, security and safeguarding on the nuclear site.

It is often difficult for new build companies with no track record to build the capability and experience to qualify as a nuclear Site Licensee. This company can however be different to the operator[8] and the owner of the nuclear power plant. The nuclear sector in the UK currently has a number of established nuclear licensees which could help a nuclear development company in becoming the nuclear licensee of a new plant. In terms of civil nuclear plant there are two groups of well established licensees:

- the Site Licensee companies for the Nuclear Decommissioning Authority (NDA) sites such as Magnox Limited and Sellafield Limited; and
- EDF Energy Nuclear Generation Limited.

These licensees have developed their qualifications and experience of being a nuclear licensee over many years (through the legacy and currently operating nuclear plant). A new build developer could reap the benefit of these many years of expertise through involving one of them as the Site Licensee for the new small reactor. This would require the Site Licensee company to learn about the small reactor design and make sure it is qualified to be the Site Licensee for the construction, operation and ultimately the decommissioning of the small reactor. Where existing nuclear sites are to be utilised for the development of small reactors there may well be an incumbent Site Licensee who could add the construction and operation of the small reactor to its nuclear safety case/ portfolio. **See Recommendation 6** below.

Operator Company – the operator is the company that operates the nuclear site during construction and operation.

If established Site Licensees are utilised for NPP Development the operator of the NPP could be a separate company allowing the NPP Development Company to bring in an established operator of existing nuclear plant rather than having to try to establish either a Site Licensee or operator from scratch; thereby de-risking the project.

8 Not the nuclear Operator who in many jurisdictions is the nuclear site licensee.

Separating the NPP Development Company, the Site Licensee Company and Operator Company allows different parties to be counter-parties to different contracts thereby allowing the owner to manage and control the financing and leaving the Site Licensee Company and the Operator Company to manage the construction and operation of the nuclear power plant. It would also allow the NPP Development Company to de-risk the project thereby making attracting private financing more possible.

FINANCING

While the NPP Development Company itself would usually be an SPV – special purpose vehicle – the equity investors need to come from those who understand the market and are happy to invest for the development and, probably, the construction phase. Equity investors could be utilities or other corporates interested in developing nuclear power projects.

Splitting the project between different companies – the NPP Development Company, the Site Licensee and the Operator Company – allows the NPP Development Company to focus on being the owner of the development. Taken together with separating out nuclear risks (including third party liability risk) to be managed by an experienced Site Licensee will make managing risks and the consequences of risks more straightforward, reduces the cost of capital and makes attracting developers in the form of utilities (UK and overseas) and others easier.

Commercial NPP Development through securing a customer, i.e. an NPP developer, should be the aim of all Technology Developers/ vendors. However it is rare for a reactor vendor to be the NPP Developer. In recent years reactor vendors taking equity in a NPPs has not always been successful.

However equity can be particularly hard to find especially for FOAK projects and there may be a role for HMB in taking an equity stake to help building trust and confidence in the market.

Debt may be able to be secured depending on the structure once the equity is secured. Export Credit Agencies may be brought in to support exports from other countries; however this is often at odds with local content. Different financial structures are delivered in more detail below.

As we have seen in other industries largely standardised contract documentation for projects reduces costs and increases market acceptance. The small nuclear market should come together with the aim to establish standard principles that would allow the financial market to quickly review and accept documents as market.

This should extend to HMG support mechanisms such as CfDs to reduce the costs for HMG and for NPP Developers. Standardisation could also, in the longer term, lead to an auction mechanism for the allocation of HMG support.

Insurance Market [9]

Small nuclear reactors are, in principle, no different from an insurance perspective than conventional, GW-scale reactors. This applies equally to conventional small nuclear based on light water moderation as well as advanced reactors. So far as is currently discernible, the risks attaching to small nuclear of any description are no different to those attaching to the conventional designs.

The risks should be thought of in two categories:

- third party risks such as the liability for emissions and damage arising from such emissions. These are essentially fixed costs and invariant to the value of the total production from the site (whether electricity, heat, hydrogen or any other output); and
- first party risks – those which are directly related to the asset value at risk – such as the

9 The EFWG would like to thank Nuclear Risk Insurers for their assistance with this section.

value of a specific piece of equipment, the value of a fuel assembly etc. damaged as a result of an insurable risk.

The real issue for small nuclear projects is that the scale of the output and therefore the value of the business is potentially smaller than conventional units.

There are a number of possible areas of insurable events for nuclear installations which include:

- third party liability;
- property damage;
- risk during construction;
- cargo risk – e.g. for the transit of advanced modules;
- cyber risk during operation; and
- cost overrun risk (this is conventionally hard).

All of these are as insurable for small nuclear as for conventional projects – cost overrun risk being potentially easier to achieve for carefully planned and managed small nuclear construction where a much larger proportion of the risk is related to manufacturing rather than construction risk.

It is equally important to be absolutely clear that the London market has more than ample capacity and appetite for all these risks. On the specific issue of third party liability the cover is dictated by the international conventions, such as the 2004 Paris Convention, and as such the London market will treat small nuclear risks no differently than conventional nuclear risks. The basis of pricing of risks will not change with the advent of small nuclear. It is, and will be, based on the specific risks of a particular licensed site and installation. Nuclear insurance is not based on some broad statistical analysis of historical claims (as there is little to no specific data) but on the fundamental risks of a particular site, installation and operating behaviour. Small nuclear will not change that in any way.

Should the advent of successful small nuclear designs lead to a significant increase in installed nuclear capacity in the UK, it is hard to imagine a scenario in which that increased scale would, in any way, remotely challenge the capacity of the London market.

5. RISKS, ALLOCATION AND CONSEQUENCES

Risk and the allocation of risks to the party best able to manage them is fundamental to contracting and to raising finance from anyone, but particularly the private sector. The EFWG concluded that the risk allocation was key to raising any form of private finance during the NPP Development, especially as it will be important to rating agencies to allow the rating of the NPP SPV to be determined. Anything below BBB+ and the SPV will be unlikely to be able to raise private finance. A higher rating helps to improve the chances of financing and the terms on which the financing can be raised (including the cost of capital).

The risk profile of a small nuclear project differs significantly from that of a GW nuclear project. The concept of smaller nuclear reactor projects offers an opportunity to attract investment and finance that is improved relative to large nuclear projects. The ability to attract financing and the potential cost of this is a function of the risk perception of the investing party and the number of investors with a capacity and appetite to invest in the market.

The relative risk profiles of a large nuclear project, FOAK smaller nuclear project and NOAK smaller nuclear project are shown in Figure 2. This illustrates the common themes and characteristics of smaller reactor projects which have been presented to the EFWG and the indicative impact that this may have on risk and hence the cost of finance during the investment life cycle. The risk profile of a large nuclear project is shown for comparative purposes.

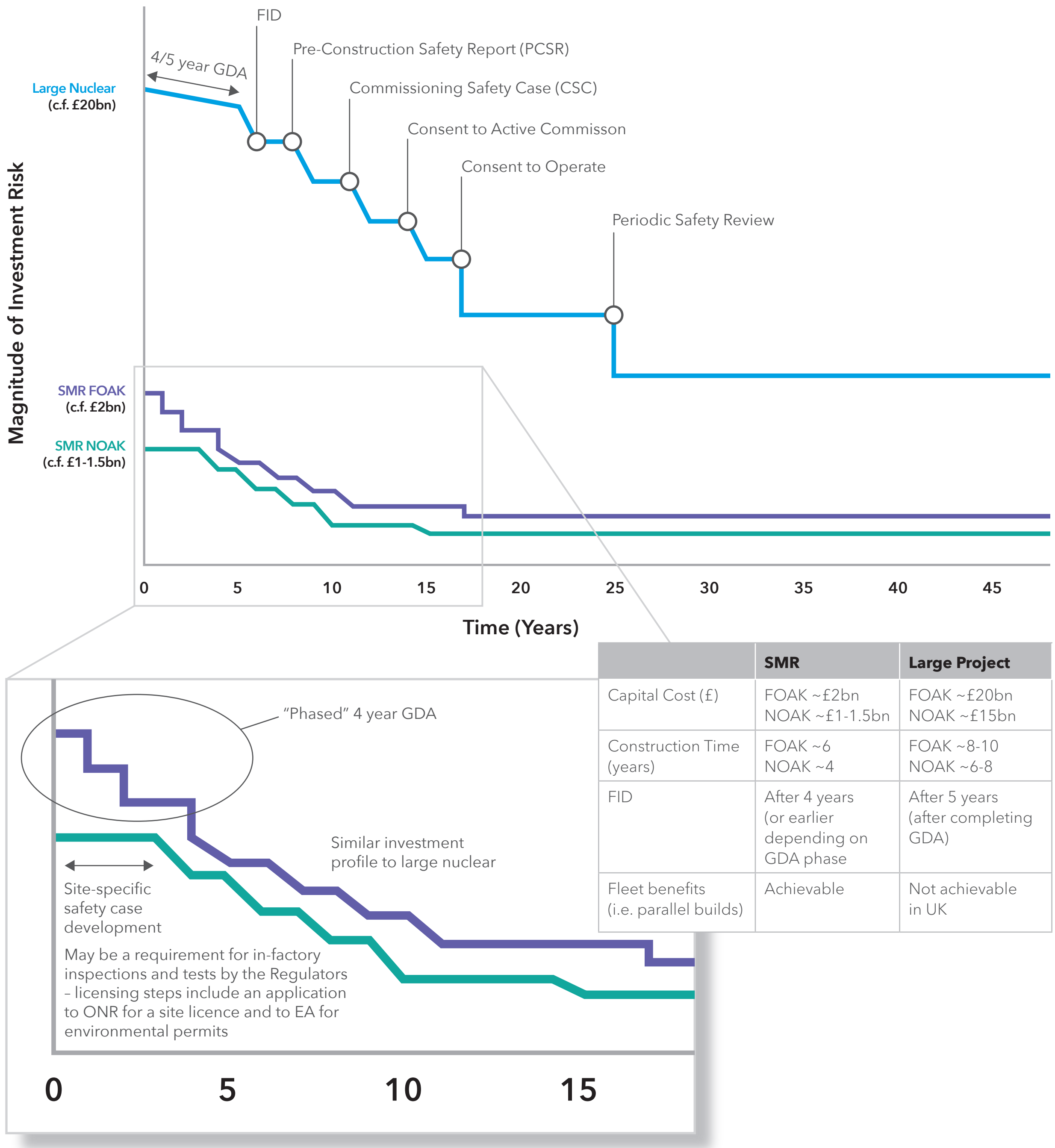
The following points are of note:

- if an existing Site Licensee is involved in a NPP Development, rather than applying for a new nuclear site license, it will need to develop a site specific safety case for the construction and operation of the small reactor. This process, subject to ONR confirmation, should be smaller and more cost efficient than applying for a new nuclear site license;
- the capital cost of a small nuclear FOAK is of the order of £2-2.5 billion for units in the range 440 – 600 MWe. This represents a scale of investment that although still large is within the range of a significantly increased number of market investors, opening the market for small nuclear to entities such as utilities, high energy industrial users and private investors, i.e. the scale of investment can be met by a wider group than traditional large nuclear projects; and
- smaller reactors are typically characterised by a significantly increased proportion of factory build in support of delivery relative to large nuclear. Physically smaller components and systems can be manufactured, assembled, tested and assured prior to arrival at site using processes that are well understood in many typical manufacturing facilities (e.g. casting, welding, machining, assembly, inspection and assurance) in the UK and beyond.

The nature of work in a factory environment is significantly different to that associated with build on a licensed site and offers mitigation to several risks that are typically associated with large projects, i.e. variable environmental conditions, control and enabling of access

Figure 2:

Investment Risk Profiles for Large and Small Nuclear Projects[10,11]



	SMR	Large Project
Capital Cost (£)	FOAK ~£2bn NOAK ~£1-1.5bn	FOAK ~£20bn NOAK ~£15bn
Construction Time (years)	FOAK ~6 NOAK ~4	FOAK ~8-10 NOAK ~6-8
FID	After 4 years (or earlier depending on GDA phase	After 5 years (after completing GDA)
Fleet benefits (i.e. parallel builds)	Achievable	Not achievable in UK

10 Timings are indicative

11 The EFWG recognises that an NPP Developer could currently choose to proceed with a Site Licensee application without the Technology Vendor having completed GDA. However as mentioned in Recommendation 5 of this report the EFWG believes that the GDA process should be used as a market-mechanism to allow the down-selection of technologies based on commercial readiness. Further proceeding to Site Licensing without GDA would be riskier for a NPP Development Company and something the financing community would be concerned with. To manage the risk it is more likely that there would be a requirement for the site licensing process to be completed prior to financial close (if GDA has been completed this provides some confidence to financiers that the technology is licensable). With a GDA process the site licensing can be in train but does not necessarily have to be completed prior to financial close – especially if the project involves an experienced and existing Site Licensee.

scaffolding, work permits, in field testing and repair, if required, all of which require high levels of resource to be compliantly executed on a licensed site when a requirement to demonstrate compliance with a Site Safety Case as required by Nuclear Installations Act[12] (NIA) 1965 is paramount. In the factory environment (assuming no fissile operations) NIA 1965 compliance is not a pre-requisite and manufacturing organisations can adopt standard Health and Safety Executive (HSE) compliance methodologies that are well understood.

As an example: traditional site build dictates that components are delivered to site, assembled in situ and then functionally tested to validate and assure this prior to any nuclear operation. The execution of this work currently requires a labour force that is experienced in commissioning and operations on a NIA compliant site. In the UK this is a scarce resource and as such is at a premium cost (i.e. the "nuclear premium"). On site work involves manual processes which are subject to variation and may suffer quality failures needing rework. Faults are often revealed after installation and remediation and assurance of correct construction and assembly is lengthy and difficult.

Low productivity associated with on site build is mitigated by an increase in available working time within a controlled factory environment, i.e. work can be reliably executed on a continuous 24 hour basis. Equipment utilising automated process control to improve the "right first time" quality of manufacture can be incorporated into the in-factory processing, and quality assurance undertaken at point of manufacture. This significantly reduces the time taken to perform manufacturing operations with benefits leveraged across multiple units.

The small nuclear delivery model which supports increased factory build content is best supported through manufacturing in purpose designed factories (i.e. production lines for major components and systems) which deliver increased productivity. The case for investment in manufacturing facilities as described is unlikely to be made in a market environment that is limited to single projects with no visibility of a future demand. However many small nuclear designs have a number of components that are similar in nature hence the case for building a high performing factory based supply chain is brought forward in a market where more than one design is likely to be deployed and there is a forecast potential for multiple units. The UK has a well-developed capability within the High Value Manufacturing Catapult[13] network which can significantly enhance the performance of the manufacturing phase of small nuclear projects.

All of the above can be expected to deliver much higher levels of productivity than a site build and as a result project durations will be reduced. The EFWG was presented with FOAK project durations (including construction) ranging from 3 to 7 years and NOAK project durations of 2.5 to 4 years – these are considered achievable and this is reflected in Figure 2.

Risk through the Stages of Development

The EFWG, in considering the question of how best to create an environment where raising private finance for small reactors is possible, considered the fundamental risks for small reactors in the difference stages of development. The full risk register can be found in Appendix C. The fundamental points for each stage of development are set out below.

TECHNOLOGY DEVELOPMENT PROJECT RISKS

At this stage the technology is not a commercial proposition and certain aspects of the feasibility of the technology may need to be proven. This is

12 https://www.legislation.gov.uk/ukpga/1965/57

13 https://hvm.catapult.org.uk/

often the riskiest time in a development and as such there is a paucity of investors willing to take this early stage risk, particularly when the timeline to commercial deployment is often long and complex. Risks should largely remain with the Technology Development Company and its shareholders (at this stage likely to be high net-worth individuals, venture capital and a small amount of corporate private equity). HMG has historically taken a role at this stage by providing grants, tax incentives etc.

If financing from HMG at this stage is through grants then HMG should not accept any risk. However the EFWG believes that rather than simply providing small grant funding which will provide little support to companies with significant development costs, HMG should focus its efforts in commercialising the projects at a later stage. Equally if grant funding is to remain a focus for HMG, HMG should only provide grant funding in exchange for IP and other benefits frequently afforded early stage investors. If HMG is to take some benefit then in limited circumstances there may be an argument for HMG taking some limited risk – this would need to be assessed on an individual technology basis.

Whether taking some risk and some reward at this stage or not, HMG should not "choose a technology". Any financing or funding at this stage should be done on a competitive basis with other technologies and various technologies should be supported so as not to distort the market. This may result in HMG owning IP in a number of technologies.

MANUFACTURING CAPABILITY DEVELOPMENT PROJECT RISKS

There is a question as to whether new manufacturing facilities will be developed for FOAK projects. It is unlikely that Technology Developers and/ or private investors would invest in purpose built facilities without a considerable future business case to support such development. However what is important for the FOAK NPP Development is that the vendor (Technology Developer and/or Manufacturing Project Company) will need to prove a high manufacturing capability and not simply a theoretical paper design, for example through the execution of an integrated manufacturing and design capability programme.

Without the specific Manufacturing Capability Development, the vendor will need to prove its manufacturing capability to build the NPP Development through the UK supply chain; otherwise much benefit to the UK would be lost. The opportunity to become a leading manufacturing hub for small nuclear modules is a limited one – before other manufacturing capability is built up elsewhere.

Establishing manufacturing capability within existing facilities is a challenge. This is more challenging should the manufacturing business require the use of fissile material (which could be the case with more advanced technologies) e.g. if a reactor unit is to be built in a factory then the facility would need to be regulated in a similar way to a fuel fabrication facility and therefore a nuclear site license would be required. ONR and insurers would also need to consider how this impacts the construction of plant, particularly quality assurance considerations around how the reactors can be packaged and transported to ensure that the quality of the construction on site is maintained. Providing that quality assurance from factory produced reactors and components would, the EFWG believes, reduce the risk in construction of a NPP Development.

Raising finance through equity and corporate debt for a new facility will require a strong business plan. The EFWG does not support HMG choosing a technology and providing a fleet order to one technology. As such the business plan will fall to be developed by the Manufacturing Company, together with the vendor. This may be easier should small reactors be supported by a RAB support mechanism, if the RAB allows the banking of orders placed with the Manufacturing Capability onto the RAB and thereby allowing earlier repayment of the orders through the RAB. Consideration would need to be given to how this could work in practice without exposing consumers to too much risk and potential energy price rises.

As with most Manufacturing Companies the risks associated with developing the facility should largely sit with the private sector. The reactor vendor could either build reactors/ modules in its own factory or place orders with manufacturing facilities. In either scenario the vendor will need to take risks associated with the technology itself (particularly in the early years before the production is confirmed).

The risks associated with the facility itself will largely fall to the Manufacturing Company and its shareholders to manage – from site selection and ground conditions risk to the building of the facility itself, through the commissioning and into operation. Some of those risks can be off-set through insurance (and the EFWG would expect insurance products to be developed as these types of facilities become more common place).

Few, if any, risks associated with such facilities should sit with HMG. With a free market economy, it is HMG's role to create the market conditions to allow Manufacturing Companies to thrive, and not to support individual facilities. HMG can support the business case for such companies through creating an environment where small reactors can be built (and the most commercial survive) and supporting exports through DIT and FCO.

NPP DEVELOPMENT RISKS

Development and Construction

Risk sharing during the development and construction phase of a commercial NPP Development is much more complex than the Technology Development and Manufacturing Capability Development stages.

As mentioned above, the EFWG concludes that the risk allocation is key to raising any form of private finance during the NPP Development, especially as it will be important to rating agencies to allow the rating of the NPP Development Company to be determined. Anything below BBB+ and the SPV may be unable to raise private finance. A higher rating helps to improve the chances of financing and the terms on which the financing can be raised (including the cost of capital).

During the development stage (pre-FID) the EFWG concluded that most of the risk should remain with the NPP Development Company/ i.e. the owner and its shareholders. It may be possible at this stage to persuade some contractors/ service providers to work at risk (see sources of financing below).

The key risks for HMG in the development stage are likely to be around reputational risk and, if existing nuclear sites are to be used for the development of small reactors, then HMG (or its agency – the NDA) will need to maintain some of the risk associated particularly with the legacy site. This may extend further if the company managing the NDA site is the Site Licensee for the site (particularly if the NDA takes over the ownership of these companies in the future – as with Magnox Limited).

There will be no project finance during the development stage of the project. The financing of the development stage of a NPP Development will come from the shareholders in the owner/development company which could include venture capital, private equity and corporate equity from companies such as utilities. The shareholders ultimately take the risk of the project failing to be developed. Shareholders at this stage would expect a higher rate of return due to the higher level of risk.

Once the project reaches financial close (FID) and moves into the construction phase most of the risks should be split between the NPP Development Company i.e. the owner (and its shareholders), the Site Licensee Company, the Operator Company, and contractors. The insurance market will also be able to assist with mitigating the consequences of some of the risk.

The UK has a relatively unique situation, structured around HMG support mechanisms such as CfDs, the specific regulatory requirements in the UK and, although HMG remains a key stakeholder in securing these nationally important projects, the guiding principle of private sector development. As such, contracting structures and risk sharing are key to the development of any new nuclear project, small or large. While risks should be borne by the party best able to manage it (assuming the party can bear the consequences of the risk), under traditional contracting structures, risks are generally allocated between the parties on a fairly binary basis; allocating risks entirely to one party or the other together with all of the cost and financial consequences of the risk. There is also a focus on the end goal – meeting the particular completion date and performance requirements – with the contractor being left largely to manage risks as best it might in the meantime, and paying compensation at the end if it fails, often leading to problems and claims being "saved up" to the end. Under this binary approach, interference from the NPP Development Company during construction gives rise to claims, and so is kept to a minimum.

Although this works well for traditional construction projects, nuclear projects struggle with this approach. Small nuclear should be able to address some of the traditional struggles within the industry associated with the risk and quantum of potential delays and cost overruns but some of the challenges, particularly for FOAK around market perceptions, will remain. Equally the regulatory requirements surrounding nuclear and the role of the Site Licensee as the controlling mind and intelligent customer (knowledgeable customer in international parlance) requires a greater involvement from the Site Licensee than would be required under a traditional construction contract.

Allocating risks and responsibility remains the focus of contracting and creating the environment for private finance with small nuclear. However much has been learned across the construction industry of sharing the consequences of the risks and encouraging the participants to cooperate in managing and mitigating risks. Working collaboratively, communicating and developing behaviour across the contracting structure to manage the consequences of risks reduces the risks and costs associated with these projects[14].

Having said the above, and the importance of allocating the consequences of risks to the appropriate parties, the financing sector is unlikely to accept any of the risks associated with the construction of the plant, particularly at a reasonable cost of capital.

Small nuclear does however provide a better environment for risk management in that the consequences of risks should, in large part, be much smaller. With the cost of a project below £2.5 billion, the consequences of cost overruns and delays are so much smaller than for large nuclear projects. Those consequences will be able to be borne, particularly by larger contractors and suppliers, in the market. In terms of nuclear third party risks, small reactor designs are being simplified to reduce the probability of safety events occurring, and some technologies being designed such that a nuclear incident with the release of radiation cannot occur. Together with the lower fissile inventory in small reactors, this reduces third party risk by a further order of magnitude. This significantly reduces the risk to the project, the country and in turn HMG in providing cover for the consequences of a nuclear incident. Equally the risks associated with decommissioning and decommissioning funding will be much reduced, partly by the projects

14 Kate Kortenbout's (Norton Rose Fulbright) presented similar themes at the Department of International Trade's Civil Nuclear Showcase 2018 (https://www.events.trade.gov.uk/media.viewer/uploads/pdf/ekp_professional-structuring-and-risk-ma_1520019311.pdf)

simply being smaller and more containable and in part as the scale of the units allows easier management of cleaning etc. thereby providing better trust and confidence in decommissioning plans and funding requirements. With much smaller consequences of risks the private sector is much more able to manage the consequences. As such the role for HMG backstopping some of the consequences of risks that sit with the private sector will be minimal and will be a true backstop and only called upon in extreme circumstances.

The main risks HMG should consider in this phase are around: siting, reputational, political, change in law, change in regulation and the nuclear specific risks such as:

- third party liability over and above the liability of the Site Licensee which is covered by insurance, any nuclear liability that the vendors can accept (particularly for FOAK projects) and the backstop provided by the equity providers; and
- project insolvency once the project is truly a nuclear project (nuclear fuel is on site) as the project could not be abandoned leaving a nuclear site without appropriate controls (although if the Site Licensee is an NDA Site Licensee this may be easier to manage).

Sources of financing and risk

During the pre-FID close stage of an NPP Development, money is in short supply. A GW nuclear project could spend £1 billion during the pre-FID project phase. When this is compared with the £30 million that is the norm for developing an energy project this is striking. From the submissions the EFWG received, it is clear that the development costs for small nuclear should be much smaller than the £1 billion for a GW plant but still likely to be higher than the £30 million needed for a smaller (less regulated) project. Also during the construction, equity can be hard to secure; for a project of circa £2 billion overnight costs the EFWG would expect approximately 30% to be raised from equity leaving the remaining 70% to come from debt.

Equity can come in many forms. Clearly a large proportion needs to come in monetary terms, however more and more companies are prepared to work at risk in the pre-FID stage of an energy project in exchange for an equity share. If the Manufacturing Company for the small nuclear project is an existing entity with a strong balance sheet, it may be willing to work at risk in the early stage for a share in the equity. This could provide a collaborative approach that not only would provide equity but set the tone for risk sharing across the project.

Debt can also come in many forms ranging from debt financing from banks and infrastructure funds through to debt either directly delivered to a project or guaranteed by Export Credit Agencies. The range of debt and whether senior or subordinated will very much depend on the structure of the individual project including where the supply chain comes from.

Creating the right environment for small nuclear together with HMG encouraging the development of small nuclear, is key to encouraging equity or debt investment from the private sector either through money or through working at risk.

Opportunities for cost reduction

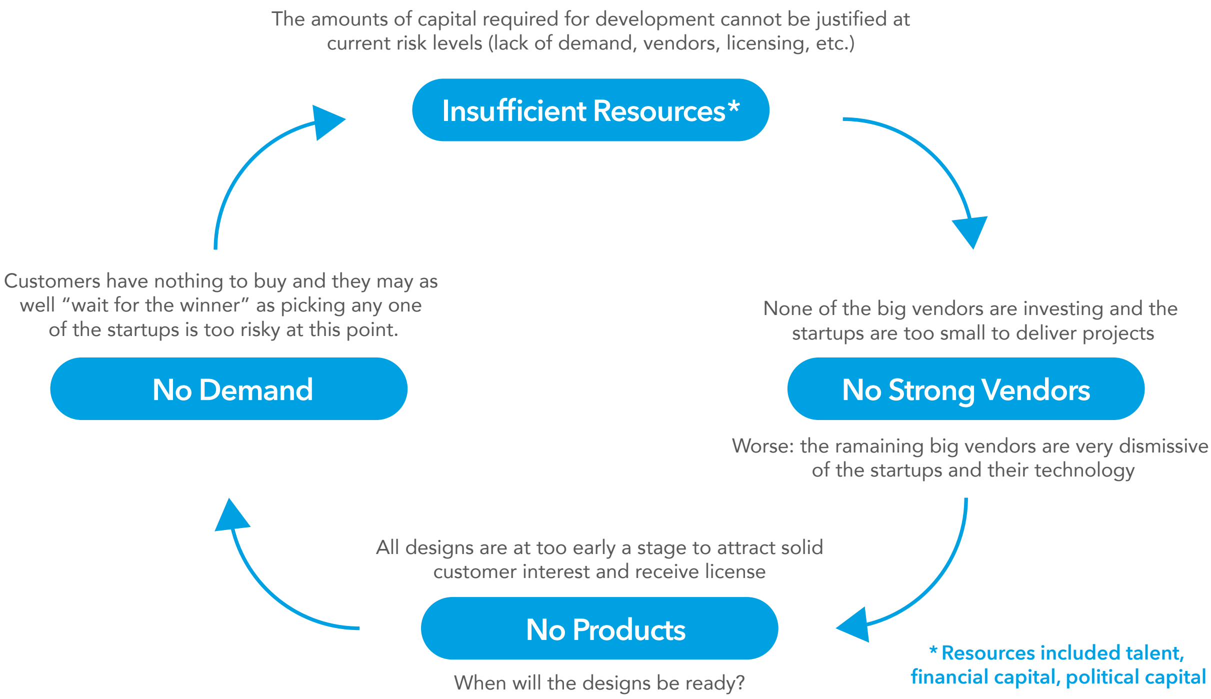
The EFWG welcomes the recent report published by the ETI[15] which identifies major cost drivers that have proven to be a cost escalation or indeed reduction factor in numerous nuclear power plant projects globally. The conclusions in the ETI report on how cost reduction can be achieved in future projects essentially all aim to reduce risk in different aspects of projects. It is encouraging that for small nuclear projects the ETI report "*identified the potential for a step-reduction in the cost of advanced reactor technologies and SMRs*". In particular the benefits of completing plant

15 The ETI Nuclear Cost Drivers Project: Summary Report, 20 April 2018 (http://www.eti.co.uk/library/the-eti-nuclear-cost-drivers-project-summary-report)

design prior to starting construction, following contracting best practices (e.g. through optimal allocation of risk) and maximising the effects of learning through repeat manufacture and build by a common supply chain all align with the findings of the EFWG.

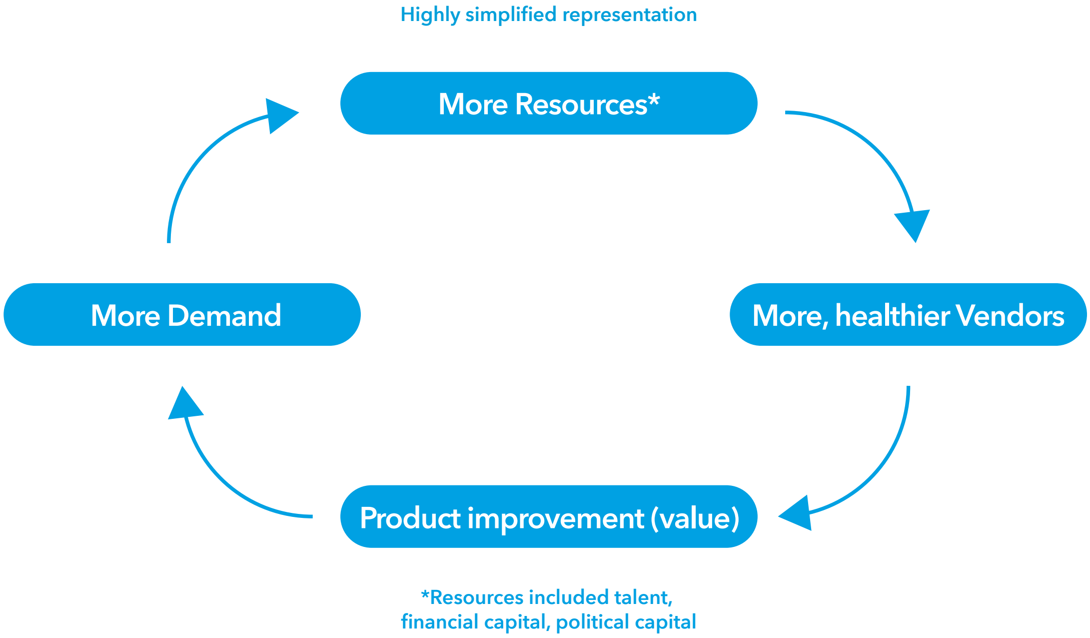
In relation to the benefits of learning, collaboration and the sharing of information can also break the cycle of starting each project as a standalone project, as has historically been the case. Changing the philosophy of how to approach these projects could bring significant cost and time savings and reduce the consequences of risks to a level companies can bear alone. This in turn makes the risk more understandable and manageable in the eyes of the finance sector.

There is the need to move towards a market structure that allows the industry to learn from previous projects to help reduce the costs and risks associated with nuclear projects. Without the learnt behaviour projects remain in a vicious cycle:



Source Lucid Strategy/CleanTech Catalyst

Breaking the vicious cycles in the current model to enable rapid commercialisation of low-cost and low-risk nuclear plants is key to opening up the market to private financing. One proposed approach is 'open architecture', where collaboration occurs not only among companies at different points in the supply chain but also among companies working on the same product subsystem. Modularity, versatile interfaces for subsystem integration, and design toward agreed-upon specifications are important elements of open architecture. Open architecture will lower costs through constructive competition, learning, innovation, standardisation, risk mitigation, and other effects. The collective aim is a virtuous cycle for a strong industry, enabled by standardised designs for high-volume production, leading over successive product generations to increased value for customers, increased demand, and further industry growth:



Source Lucid Strategy/CleanTech Catalyst

Standardisation of as much of the plant as possible (particularly the BOP), which is generally the approach the Technology Developers who presented to the EFWG are adopting, and removal of the additional costs and special certification required for non-nuclear plant – simply because they are being used on a nuclear site – will assist with managing the risks of nuclear projects and bringing down costs. This is turn would bring more certainty to the private finance sector and the ability to create a market that the private finance sector recognises and is comfortable with.

Operation

Once the plant is operational the risk profile of the plant shifts dramatically and the project is far less risky therefore opening up the options for refinancing, if needed. At this stage much of the risks should remain with the NPP Development Company, the Site Licensee Company, the Operator Company and the supply chain. There is however a role for HMG around helping with risks around change of law and change of regulation, changes in international standards (within limits) and backstopping risk around third party liability (as above) and waste management costs (which will be paid to HMG or its entities in any event).

6. POTENTIAL STRUCTURES

The EFWG was asked to consider potential financing structures for small nuclear and to highlight the pros and cons for each structure. The group looked at nine structures in total: Four being subsets of project finance structures and the remainder being structures used on GW projects globally. The structures are:

A. Project Finance

A1. Limited Recourse/ Non-Recourse

A limited recourse (or non-recourse) project financial structure is where project debt and equity used to finance a project is paid back from the cash flow (or revenue) generated by the NPP Development. This allows an organisation to raise funds for a project based on its feasibility and its ability to generate revenue at such a level to cover: construction and operational costs, interest from debt service and a return to investors. Lenders have recourse to the assets themselves and revenue streams but there is no or only limited recourse to the shareholders/ parent companies. No NPP Development has been progressed on non-recourse or limited recourse finance basis.

Non-limited (or recourse) project finance by contrast gives lenders to the project full recourse to the assets / revenue stream of the shareholders for repayment of the loan.

A2. Project Finance: With CfD/PPA (flexible)

This structure is as above with the addition of a CfD or PPA to support the revenue stream. The difference between the two being:

- a PPA would provide a set revenue stream for a project with no reference to market prices; whereas
- a CfD works with the market price and the difference between the market reference price and the agreed price in the CfD is either paid to the NPP Developer or paid by the NPP Developer back into the system. Under the CfD the NPP Developer retains the risk of selling and trading the power and meeting the market reference price.

HMG has shown a preference for CfDs over pure PPAs as they maintain a market link which the EFWG would support. The EFWG considered whether, in its view, a CfD or PPA is a better support mechanism. With a CfD risks remain with the power plant to generate power and to sell it into the market at the market price and it does not provide the same level of support as a straight PPA with a government entity. A CfD also provides a lower level of support therefore is likely to have less impact on HMG balance sheet and have other benefits.

A3. Project Finance: With CfD/PPA and HMG Investment

This structure is as above with HMG taking an equity or debt stake in the project i.e. being one of the shareholders who finance the NPP Development and is reliant on the performance of the project to make a return and ultimately to return the investment to HMG. Combined with HMG Investment a CfD (or PPA) is likely to have a large impact on HMG's balance sheet.

A4. Project Finance: With CfD/ PPA and an HMG Guarantee

This structure is as with structure A2 with HMG (the guarantor) assuming the private debt obligations if the borrower of the loan (the NPP Development Company) defaults. These guarantees can be limited or unlimited and in more broad terms means the debt can be borrowed at a lower interest rate due to the decreased likelihood of defaulting on the loan. Again this is likely to have a large impact on HMG's balance sheet.

B. Mankala

This is the financing structure that is used in the Finnish electricity sector. The Mankala company is a limited liability company making zero-profits.

The shareholders in the Mankala are usually high energy users. They bring financing to the project generally through corporate equity and debt however project debt including ECAs and other financing can be made available to the Mankala. They are responsible for the fixed costs of the NPP Development Company, including debt services and they have the right to purchase the electricity at cost in accordance with their respective share in the company.[16]

The Mankala often sits alongside another major shareholder in the NPP who bring debt and equity to the NPP Development.

C. Exceltium

This was a financing structure established between 2005 and 2010 to address the increasing energy prices in France. A number of industrial investors and banks formed a limited liability company – Exceltium – that entered into contractual arrangements with EDF to finance new build.

The industrial investor payback comes over 24 years through contractual agreements to provide the electricity as a mix of fixed and variable pricing. These investors can then choose to sell the electricity or use it themselves.

The banks are repaid by EDF (rather than simply from the project).

D. Corporate with CfD/ PPA

This structure is where finance is raised within a corporation rather than as a project finance. Therefore a large corporation raises funds on its balance sheet rather than funds being raised on a project finance basis purely for the NPP Development. This structure is only available to the largest companies with the strongest balance sheets.

E. RAB

The RAB model is an approach that has been used to raise finance to build and maintain infrastructure in the UK, including for the transmission network, the water sector, Heathrow Airport and the Thames Tideway Tunnel. It involves the price paid to the power company being set by an economic regulator. The price is typically subject to quinquennial reviews once operational.

This would be a new structure for the nuclear industry to begin to understand. Without longstanding trust and confidence in HMG and the economic (rather than nuclear) regulators to support nuclear projects this could be a challenge for the industry. As discussed throughout this report, raising private finance without such trust and confidence is difficult.

In this model the economic regulator aims to provide efficiency incentives to effectively mimic competition incentives that would be present in a market. The model reflects the value of past investments in infrastructure (and regulators are familiar with the market) and was developed as part of the privatisation process in the UK by being applied to existing assets.

16 www.iaea.org/INPRO/8th_Dialogue.../Plenary_Economics_07_Stahl.pdf

There is considerable flexibility in RAB models. However, broadly RAB models rely on the economic regulators determining what are allowable and disallowable costs, with disallowable costs remaining with the Developers and Contractors. For a RAB to work HMG will need to determine its policy objectives in relation to allowable and disallowable costs and the small nuclear market would need to have trust and confidence in the policy set.

This is also a challenge with quinquennial reviews (or any periodic pricing review) that are the norm in RAB models at which point returns can be reopened and re-established by the regulator – what protection can be given to the NPP Development Company and its investors around costs and rates of return?

However recent RAB models (such as Thames Tideway Tunnel) have seen HMG taking a back-stop position both in relation to insurance and contingent equity. Consideration will need to be given to how this could work in small nuclear NPP Developments as will any State Aid implications and any impact on HMG's balance sheet. Both of these aspects remain unclear.

It will be essential in solving these concerns to determine what protection can be given to the NPP Development Company and its investors around allowable costs and what backstops HMG may be able to provide. For early stage projects the perceived risks to significant stranded costs are currently prohibitive. Providing assurance on sensible rates of return is a further challenge, especially with the current allowable return in the water industry being set at 2.6% and allowable returns in the early stages of recent projects being set at a similar level. The third issue is that the length of the traditional control period is very short given the long-wave nature of nuclear investment. The final issue is one of volume risk and ensuring that the wider system in which small nuclear operates does not create artificial barriers to operation for an industry where the cost of not running is virtually identical to the cost of running.

In answering these concerns, much of this will depend on the RAB model that is established and how it is enshrined in legislation should HMG choose to go down this route for small nuclear.

F.
100% Government Financed

This structure is where a government fully finances a project, through a mix of equity and debt. This structure is not currently available in the UK.

EFWG appraisal of finance structures

The EFWG considered each of the financing structures and the full table of pros and cons can be found at Appendix D.

The panacea for all energy and infrastructure projects is a limited recourse/non-recourse project financing. This has not been achieved for any nuclear project anywhere in the world. This may be achievable for small nuclear projects in the future, once the market is established (as has been shown with wind and solar projects) but it will not be possible for a FOAK small nuclear project. However structures A2, A3, A4 may be possible.

A RAB structure may also be possible; much will depend on the details of the RAB HMG considers establishing and how it addresses market concerns around the RAB. A RAB will require new legislation.

The Mankala and Exceltium systems are not currently possible in the UK. However with the growth in industrial users resulting from the Industrial Strategy it is possible that the UK could reach a position where there are sufficient industrial high energy users who wish to come together in a similar way to fund projects. The system may require new legislation.

The corporate structure is only possible for the largest corporates with strong balance sheets (such as EDF which is ultimately backed by the French Government). It would be a challenge for most corporates to finance even a small nuclear project 100% on its balance sheet.

100% Government financing is not available in the UK as is currently against HMG's policy.

Refinancing

Once the risks of building a small nuclear power plant have been overcome, the plant has been operating and the first fuel load has been achieved then refinancing and attracting private financing should be much easier. At that point the asset is stable, proven and should generate power for many years. This is the same as a GW plant.

However a major difference with many of the small nuclear technologies presented to the EFWG is that they do not have a traditional reload and therefore there may be earlier opportunities to refinance once the power plant is proven. Also where there are multiple reactors within one plant there are opportunities to refinance once the foundations and first reactors are in place and operating. This would allow early refinancing of the plant and before the plant is fully operational.

Where HMG has taken a role in the financing over and above funding support (such as a CfD) which the EFWG believe is required for FOAK projects, then refinancing would allow HMG's investment or guarantee to be released. This would in turn free up HMG's balance sheet. However, if the NPP Development is established competently at the start and risks and the consequences of risks can be managed then the weighted average cost of capital (WACC – equity and debt) ought to be set at a reasonable rate which makes the project viable. Without this, any gain made by the NPP Development Company and its investors upon refinancing will need to be revalued so as to mitigate any significant gain by these parties at a cost to consumers. It is better to establish the framework on risk and cost/benefit sharing of a refinancing at the outset of the project for the long term.

7. RECOMMENDATIONS

As identified above the stages of a small nuclear development from concept through to commercial deployment are different and therefore the risk profile and the potential to attract private financing changes in the different stages. As such, the EFWG has made recommendations based on the life cycle phases in the development of small nuclear reactors.

In short, the EFWG notes that private finance will not come forward to develop FOAK small nuclear projects without some HMG support in helping to remove the barriers to the development. By following the recommendations set out below HMG would be creating a similar environment to the early days of wind and solar commercial development in the UK by creating a market whereby the small nuclear sector can develop and over time bring in more and more private sector financial involvement to create a sustainable industry and to in turn bring down the costs of energy.

It should be remembered that in the early stages of wind projects they were funded 100% by strategic equity, from investment grade rated corporations, particularly during the construction period. Due to the early stage in the technology development some of those projects had total costs of £1 billion to £1.5 billion. In the UK the Renewables Obligation regime was also a deterrent for debt providers given merchant price risk. The wind industry was also supported by various initiatives from HMG to establish the market, help to develop the supply chain and assist with market understanding of wind power. The Gemini Offshore Wind Project in 2016 was a turning point for an NOAK attracting banks during construction combined with ECAs and a CfD to support price risk.

Some of the barriers to small nuclear which HMG can assist with are relatively straightforward – making sites and GDA slots available. Some require the same support that any industry needs to bring innovation forward. Others are more fundamental around a lack of understanding/misunderstandings around nuclear and the need to get the first projects across the line to create the market.

Many of the EFWG's recommendations are around creating the best market conditions for private sector investment and establishing the market.

GENERAL

RECOMMENDATION 1

HMG should enable the small nuclear sector through a clear Policy and a market framework, rather than down-selecting technologies.

a. A clear HMG energy policy supporting (based on these recommendations) the UK becoming a vibrant market place for small nuclear for UK deployment and export is needed for the private sector to come forward to build.

b. HMG should not down-select a preferred technology. HMG should maintain a position of market led deployment through these recommendations.

c. Target skills and capability development to ensure small nuclear technologies can be commercialised – through the BEIS Nuclear Innovation Programme, Innovation Grant Funding, UKRI etc.

COMMENTARY:

A clear HMG policy is key to any energy development. With nuclear this is an absolute requirement particularly due to misconceptions around nuclear generally. HMG's role is to create an environment where a market can thrive. This is not straight-forward as the UK does not have a perfect energy market where different technologies can compete on an equal basis. Under the current system baseload generators are prejudiced by the inability to bid on a day ahead price leaving them to take a lower price in the market on a six monthly basis; this is partly a result of nuclear in the UK being a baseload producer and partly due to the design of the UK's market.

Other technologies such as wind and solar have been supported in the market through HMG assistance for both the development projects themselves as well as the UK supply chain. This has resulted in HMG's success around wind and solar with a supply chain being developed, cost reductions for the projects resulting in lower prices to consumers and the establishment of a market that the finance market can understand and participate in. Nuclear should be no different.

The EFWG does not support HMG choosing a technology and providing a fleet order to one technology. Technologies should be down-selected on the basis of commercial readiness by the GDA and other processes. This will allow the market to lead the development and to bring forward technologies that can meet the regulatory requirements of the GDA process and therefore, at least, have the potential to be commercialised.

RECOMMENDATION 2

HMG should work with stakeholders from the energy, nuclear and finance sectors to develop a common understanding of the risks associated with small nuclear projects; thereby removing perceptions of risks which have previously acted as barriers to investment to enable a level playing field with other low carbon energy projects.

a. HMG should develop mechanisms to bring together the nuclear sector stakeholders (vendors, utilities, developers) with the finance sector to collaborate in small nuclear projects in the context of a sector approach.

b. HMG should work with the financial sector to develop lenders' processes and procedures to reflect accurately and consider the risks and mitigants of small nuclear projects.

c. HMG should work with the finance industry to make Green Bonds available to small nuclear as for other low carbon projects.

d. HMG should consider whether the Funded Decommissioning Plan (FDP) model for the decommissioning and waste management of small nuclear is appropriate and on a level playing field with other industries such as offshore wind.

e. HMG should consider how the Amending Protocols for the Paris and Brussels Conventions should be implemented for small nuclear.

COMMENTARY:

One of the biggest blockers to the finance industry getting involved in nuclear projects is a general nervousness around the technology, largely due to a mix of a lack of understanding and misunderstanding. HMG has gone some way in addressing this issue by making support available to low carbon technologies rather than simply renewables but there is still much progress to be made in developing an understanding of nuclear and its role in climate change and low carbon energy deployment.

The EFWG recommends, as part of its support for the small nuclear industry, HMG facilitate workshops and supply chain events for the finance sector to bring them together with the project developers, vendors and others. The aim should be to encourage transparent and open conversations which allow the nuclear sector to educate and inform the finance sector and to begin to develop a collaborative approach to developing small nuclear projects.

Some financial institutions will never consider investment in nuclear – others may be happy to provide corporate support to nuclear supply chain companies but are still uncomfortable in investing in NPP Developments. Even for those institutions with an interest in nuclear projects, developing processes and procedures to reflect accurately and to consider the risks of small nuclear projects will be a challenge that many financial institutions will not wish to face. HMG can provide assistance in supporting the finance community by working with it to develop the extra questions that credit committees will need to consider when assessing small nuclear projects. In doing so, HMG can provide confidence to the finance market and help to create realistic processes and procedures.

Clean and renewable energy sources are popular with institutional investors in the capital markets who like to exhibit their green credentials. The Green Bond market is discussed below but the conventional markets have far more history, liquidity and duration for financing long term infrastructure and energy projects. The difficulty is that nuclear has had a complex reputation and the larger projects have had a history of construction related and other failures. Accordingly, the main markets remain wary of nuclear as investors do not yet fully understand the risks of nuclear reactors.

Despite these reservations however, numerous investors have expressed a considerable amount of interest in becoming involved in the nuclear sector provided projects can be structured in a prudent manner and achieve an investment-grade rating. In principle, this is a far higher rating than the minimum BBB+ and in order to attract the size of debt finance utilised in small nuclear projects, it is likely that this would have to be single A or higher. The discussions above have highlighted many of the obstacles to achieving such ratings particularly in the construction period and it may be that the capital markets only come into play post construction. This might mean that a CfD/ PPA or RAB structure may be capable of adjustment post construction once the outturn capital cost is known. Funding support structures are likely to be essential to facilitate the use of capital market funding simply because institutional markets and rating agencies are unlikely to accept the potential volatility associated with the forecasting of long-term energy prices and associated merchant risk. It is probably also correct to say that small nuclear reactors need to be prioritised in terms of offtake and dispatch so a clear picture of their revenue profile can be obtained. It is the stability of profile and certainty of cash flow that will reduce volatility of revenue streams that can enable a suitably high investment-grade rating. This is of course not the only factor and it is likely that FOAK will not be able to attract capital market funding because the market will need to see a demonstration of operational capability and sustainability before there can be some comfort that the technology does what it says it will do. Accordingly NOAKs may in future obtain higher levels of capital market interest and funding. Familiarity with the technology and the demonstration of real operational capability and reliability will be essential to demonstrate to both rating agencies and investors that this is an asset class they can reliably invest in.

FOAKs could potentially be funded via the capital markets, perhaps even during construction, however this would require significant levels of guarantee from HMG or other support mechanisms which would likely ensure on balance sheet treatment for HMG and therefore not be desirable. It will require several plant to get through the construction phase and successfully into the operating phase before rating agencies can place high enough investment-grade ratings on these projects to encourage the large volumes of money which are available to finance long-term infrastructure such as small nuclear development. However, and provided that risks are sufficiently mitigated and long term revenue support can be put in place then over time, investors will feel more confident in committing large amounts of money to such assets which will have stable returns required by pension funds and insurance companies. The long economic lives of small nuclear reactors and long-term cash flows derived from mechanisms such as CfDs and sustainable output will facilitate long-term finance from the capital markets. Certainly it is potentially possible to get longer than 30 year financing in place and depending on how prudently structured there could be some element of bullet repayment structure which could reduce the revenue support price required at the outset of the financing. This concept needs further serious consideration by HMG because to fully amortise all of the debt within the existing CfD timeframe (35 years), means that there will be a significant benefit to equity once the debt is fully repaid even though operating in any merchant environment. These are concepts that may be developed over time with advisers.

The Green Bond market has taken off in recent years borne by the desire to promote ongoing environmentally sustainable investment on a global basis. At its simplest Green Bonds are conventional bonds where proceeds are used for green purposes. A Green Bond can be any type of bond instrument for the purpose (i.e. use of proceeds) of financing/refinancing in part or full of new/existing eligible Green Projects and which are aligned with the four core components of the Green Bond Principles (GBP)[17]:

- use of proceeds;
- process of project evaluation and selection (i.e. the issuer should outline the investment decision-making process to determine the eligibility of projects using the issuance proceeds);
- management of proceeds; and
- reporting (pre-issuance and ongoing)

The GBP sets out the guidelines for transparency, disclosure and reporting in order to promote the integrity of the Green Bond market as well as drive the provision of the information required by the market in order to promote greater capital allocation to eligible projects. The GBP were established by a consortium of investment banks, with the ongoing monitoring and development now migrated across to being managed by the International Capital Market Association (ICMA).

The focus on the use of proceeds seeks to guide issuers towards an integrated business model which incorporates greater environmental sustainability project. The principles also recommend Green Bond issuers to undergo a third party verification/certification to establish that the proceeds are funding projects that would produce an environmental benefit, however there is no formal certification for a Bond to be labelled as "Green".

Green Bonds may present a different source of financing particularly during operational phase. HMG is committed to the green economy, natural environment and clean power. As a low carbon power source, small nuclear should qualify for Green Bonds and take advantage of the market.

As the Accelerating Green Finance Report[18] identified: *"Over US$3.3 trillion of private climate finance has been mobilised to date, the global Green Bond market in 2017 reached US$155.4 billion new issuance in the year compared to US$81.6 billion in 2016, global sustainably managed assets under management have increased by 25% from 2014 to 2016 and annual global investment in clean energy has grown seven-fold from US$47 billion in 2004 to US$335.5 billion in 2017."* The report recommends that HMG should issue a sovereign Green Bond to support the development of further green financing to meet HMG's green initiatives including tackling climate change. The EFWG believes that small nuclear should be included in these initiatives.

Much has been talked about in the financing markets around the obligation in the UK for a person intending to operate a nuclear installation to develop a Funded Decommissioning Programme (FDP)[19] during the development/ construction phase and then to pay into the fund (or make other provision for decommissioning) from day one of operation. Concern has been raised by some in the financing market that the payments into the decommissioning fund are higher in the payment cascade than debt repayment. In the EFWG's experience, some financiers have become comfortable with this once they realise that the payment into the decommissioning fund is such a small payment compared to the revenue stream. However with smaller nuclear it may be possible to decommission in a completely different way and therefore different funding mechanisms may be appropriate. Also separating the operator (who has the FDP obligation) from the NPP Development Company (who will be responsible

17 https://www.icmagroup.org/assets/documents/Regulatory/Green-Bonds/June-2018/Green-Bond-Principles---June-2018-140618-WEB.pdf

18 https://www.gov.uk/government/publications/accelerating-green-finance-green-finance-taskforce-report

19 Energy Act 2008 Part 3

for repaying debt) may assist with managing some of the concerns from financiers helping to de-risk projects and to make financiers more comfortable with projects.

Third party liability for a nuclear event has been enshrined in the Nuclear Installations Act for many years. The Site Licensee has an obligation to provide financial security or insurance to cover its strict liability for third party damage arising from a nuclear incident. The level of cover is currently £140 million but is due to rise to £1.2 billion (following the implementation of the Amending Protocols to the Paris and Brussels Conventions). As stated in section 4 above, the insurance market is available to provide cover for third party liability. The cover is dictated by the international conventions, such as the 2004 Paris Convention, and as such the London market will treat small nuclear risks no differently than conventional nuclear risks. The pricing for small nuclear will be based on the specific risks of a particular licensed site and installation. As the risks and consequences of small nuclear will be smaller this may affect the pricing for nuclear insurance on the sites. As mentioned above, there may remain a portion of third party liability for nuclear damage that cannot be covered by insurance and/or the NPP Development Company and/ or the Operator Company and/or the Site Licensee Company and/or contractors and therefore there may remain a role for HMG in backstopping such liability. However, the EFWG understands that the risk of a third party liability for nuclear damage arising in relation to small nuclear projects is much smaller and therefore this, in reality, becomes a much smaller risk and back-stop.

Further, if HMG chooses to use existing nuclear sites for the development of small nuclear (Recommendation 6), consideration will need to be given to how to allocate risks and responsibilities around the existing nuclear developments on those sites. Should HMG choose to maintain the existing Site Licensees then this should reduce the risks around third party liability as the obligations and insurance cover apply to the site rather than the decommissioning, construction and operation activities separately.

TECHNOLOGY DEVELOPMENT

RECOMMENDATION 3

For technologies capable of being commercially deployed by 2030, HMG should focus its resources on bringing FOAK projects to market. HMG should only provide support and grants to enhance the UK's existing capability and/or in exchange for Intellectual Property (IP) and other rights investors would expect.

a. The EFWG recognises that HMG providing small grants to various technologies in the R&D space, while having some value, does not support the commercialisation of small nuclear. High net-worth individual funding, private equity and venture capital is available for the right projects.

b. HMG should only provide central HMG grants for small nuclear during the development stage in exchange for IP and other rights – the level of IP will depend on the level of the grant.

c. HMG should leverage the existing technology centres in the UK, and encourage collaboration to bring forward commercial solutions to advanced technologies including for example Molten Salt Reactors.

COMMENTARY:

HMG grants do not help projects to attract private financing. Equally small R&D grants do not assist Technology Developers to commercialise their technology when they are funding multi-million or even billion pound Technology Development. Although grants can provide a little financial support, corporate private equity, high net worth individuals and venture capital will remain the main forms of financing for the Technology Development.

The EFWG believes that rather than simply providing small grant funding which will provide little support to companies with significant development costs, HMG should focus its efforts in commercialising the projects at a later stage. Equally if grant funding is to remain a focus for HMG, HMG should only provide grant funding in exchange for IP and other benefits given to other investors. This would provide a greater benefit to UK plc. HMG owning IP and having other benefits given to other investors could be translated into HMG equity in the NPP Development. This would provide greater confidence in the NPP Development (subject to GDA and other milestones being met) and could provide a more robust environment for private sector financing.

HMG should provide Technology Developers with access to the existing technology centres in the UK. This would allow the costs of Technology Development to be reduced. Where HMG is providing grants (in exchange for IP) similar technologies should be encouraged to collaborate together and with the technology centres to increase and develop the IP and to develop advanced technologies. This would reduce the costs and risks of new technologies and allow finance to be used positively to bring the best technology to market. While the EFWG recognises that HMG cannot force Technology Developers to collaborate and work together doing so would make the most of development finance and bring the best projects to market as cheaply and expediently as possible.

MANUFACTURING CAPABILITY

RECOMMENDATION 4

HMG should establish an advanced manufacturing supply chain initiative (as it did with offshore wind) to bring forward existing and new manufacturing capability in the UK and to challenge the market on the requirement for nuclear specific items, particularly balance of plant, thereby reducing the costs of nuclear and the perceived risks associated with it.

a. Financial support for manufacturing infrastructure in regions should be available e.g. R&D tax credits, support from funds such as the Industrial Strategy Challenge Fund, local authority and devolution grants, regional development funds, local enterprise zone, rate reduction schemes.

b. HMG should recognise the value of a stable and secure fuel supply route within the UK and consider how to enable this within the context of a small nuclear sector, both in the enrichment and fuel fabrication facilities.

c. HMG should leverage the existing manufacturing development centres and existing capability in the UK to reduce costs and to facilitate bringing forward commercial solutions for small nuclear.

COMMENTARY:

HMG has had great success with the development of offshore wind and supporting the development of the manufacturing supply chain in the UK to support the offshore wind industry. This success has in turn brought down the costs of offshore wind and brought down the CfD strike prices from £150/MWh for the first round of projects to £57/MWh in the latest round. In part this success was due to the Advanced Manufacturing Supply Chain Initiative which the government of the day put in place and was used in combination with other mechanisms to support offshore wind[20]. With the government support initiative the market slowly saw the increase in private financing available to these projects.

A similar initiative should be put in place for small nuclear to help commercialise the projects, develop the Manufacturing Capability, to challenge the market particularly on standardisation and reducing costs in balance of plant which in turn should bring down the costs of the projects and thereby help to attract private financing.

Grants and other financial support are generally available through the regions for supporting the development of the UK's Industrial Strategy whether these be through devolution grants, local authority grants, enterprise zones, enhanced capital allowances or other. These types of support should be available to support the development of Manufacturing Capabilities for small nuclear. This will help to mitigate the project on project risk of Manufacturing Capabilities at the same time as NPP Developments. The private finance sector is always concerned about project on project risk and therefore anything to assist with the acceleration of developing a Manufacturing

20 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/319026/bis-14-880-support-for-the-offshore-wind-industry-overview.pdf

Capability to mitigate any knock on effects on NPP Developments will help to attract financing.

The UK currently has some of the best, globally respected fuel supply companies in the world through Urenco and Springfields Fuels Limited. HMG should recognise the value of a stable and secure fuel supply route within the UK and also recognise the value to NPP Developments of having a secure and stable supply company (with an established balance sheet). Having such established players in the market will help to de-risk fuel supply (where appropriate[21]) for a NPP Development again helping to bring private finance to a development.

There are already a number of existing manufacturing development centres including the Nuclear Advanced Manufacturing Research Centre (NAMRC). These facilities should be utilised to assist small nuclear developers to prove the manufacturing capability and buildability of technologies. This will reduce costs and risks associated with the development of manufacturing capability and in turn power projects and facilitate the bringing forward of commercial solutions for small nuclear. Reducing costs, risks and challenges to deployment all help to bring forward commercial nuclear power projects and attract finance.

NUCLEAR POWER PROJECT

RECOMMENDATION 5

HMG should work with the Office for Nuclear Regulation (ONR) and the Environment Agency (EA) to review regulatory processes to develop an optimised and flexible approach and through the Generic Design Assessment (GDA) process allow the market to down-select technologies.

a. HMG, in consultation with ONR and the EA, should consider how the GDA process can be changed to reduce costs to vendors and assist NPP Developers and lenders in determining risks at an earlier stage through streamlining and gating the process while maintaining a high safety performance in the sector. The process should recognise other gold standard design approvals/ assessments (e.g. the US Nuclear Regulatory Commission (NRC)).

b. HMG, through ONR, should open up two to four GDA slots for small nuclear technologies. This will allow GDA readiness to promote competition and to bring forward technologies. Vendors should remain responsible for the costs of the streamlined GDA with the costs of GDA being spread across a number of NPP Developments rather than it all be included in FOAK costs.

21 Not all small nuclear uses enriched fuel. Some more advanced technologies would not use fuel assemblies. Those advanced technologies could still use the benefits of the established players in the market in dealing with and fabricating components containing fissile materials.

COMMENTARY:

The independence of ONR from HMG is recognised (as established by the Energy Act 2013) and it is for the ONR to regulate nuclear safety, nuclear site health and safety, nuclear security, nuclear safeguards and nuclear transport.

GDAs are carried out by the ONR and the EA. The regulators' costs of GDA are borne by the vendor and are in the region of £50 million. In addition to this the Requesting Party's vendor's costs to pay their own staff and contractors to support GDA, including preparation of documentation, response to regulatory queries, observations and issues, are significantly higher than the regulatory costs. The process is in four stages but is a linear process rather than a truly staged process which can take 4+ years. The EFWG recognises that the costs and risks associated with the current GDA process are high. The risks delay the commercialisation of nuclear plant. The costs are included in the development costs of NPP Developments (through the sale price from the vendor) and as such consumers ultimately pay a higher price. As mentioned throughout this report managing risks and reducing costs are the only way of attracting private financing at a reasonable cost of capital. As such, the EFWG recommends HMG requests the ONR and EA to review the GDA process to reduce costs to vendors and assist NPP Developers and lenders in determining risks at an earlier stage. This could be done through streamlining and outlining a gated process while maintaining a high safety and security performance in the sector.

Only a few countries' regulatory processes are seen as the gold standard for nuclear assessments and the UK is one of them. While the jurisdiction and independence of regulators is propriety for countries, the nuclear industry has long recognised the benefits to nuclear development of reducing costs through accepting regulatory approvals from other countries and thereby doing away with the need to have independent regulatory assessments in each country. The EFWG recommends that HMG should request the ONR to work with other regulators to remove the need for the duplication of nuclear assessments to reduce the costs and risks associated with nuclear design assessments as much as possible.

Currently HMG makes a request for ONR and the EA to undertake a GDA of technologies. The EFWG recommends that HMG should make a request that ONR and the EA undertake GDAs of between two and four of the most commercially advanced small reactors. The ONR and the EA will need to develop a process for determining which of the small reactor technologies are most advanced and ready to be assessed. It is this process to determine GDA readiness that the EFWG believes should be used as a market mechanism to down-select technologies.

The EFWG understands that the ONR and the EA is assessing whether, and if so how, the GDA process for small reactors should change. Developing entry criteria around commercial readiness could allow the process to work as a down-selection process. Further asking Technology Developers/ vendors to provide some financial security for entry into the process would bring forward commercially ready technologies and also provide some certainty to ONR and the EA around funding to provide the GDA.

RECOMMENDATION 6

HMG should makes sites available to FOAK small nuclear projects and should consider maintaining the UK's existing nuclear Site Licensee capability to de-risk the licensee role for small nuclear projects.

a. HMG should enable consideration of previously used licensed sites, such as NDA sites, as potential locations for small nuclear deployment and encourage regional support in consultation with local authorities etc.

b. Where applicable co-locate technologies/ licensed activities on sites to take advantage of supporting infrastructure and shared costs.

COMMENTARY:

Utilising existing nuclear sites for the development of small reactors would significantly de-risk small nuclear projects. The communities and local authorities around the nuclear sites are in favour of nuclear and recognise the benefits of those sites in terms of jobs and the local economy. Having a site which is acceptable to the local community helps to de-risk the planning and public consultation processes associated with NPP Developments. This would reduce the risks of delays and in turn cost overruns of the NPP Development.

Where possible the EFWG should co-locate technologies and licensed activities on existing nuclear sites. This would allow the NPP Developer to utilise the existing Site Licensees on existing sites thereby not only reducing the risks associated with licensing and regulatory compliance but also reducing the construction and operating costs for the facility.

As mentioned in section 4 above, it is often difficult for new build companies with no track record to build the capability and experience to qualify as a nuclear Site Licensee. This company can however be different to the Operator Company[22] and the NPP Development Company. The nuclear sector in the UK currently has a number of established Site Licensees which have developed their qualifications and experience of being a Site Licensee over many years (through the legacy and currently operating nuclear plant).

22 Not the nuclear Operator who in many jurisdictions is the nuclear Site Licensee.

A new build developer could reap the benefit of these many years of expertise through involving one of them as the Site Licensee Company for the new small reactor. This would require the Site Licensee Company learning about the small reactor design and making sure it is qualified to be the Site Licensee for the construction, operation and ultimately the decommissioning of the small reactor. Where existing nuclear sites are to be utilised for the development of small reactors there may well be an incumbent Site Licensee who could add the construction and operation of the small reactor to its portfolio. This would de-risk and significantly reduce the costs of establishing nuclear Site Licensee Companies and in turn small nuclear development significantly. Reducing the costs and utilising a Site Licensee with significant experience of UK sites will help to make projects more attractive to private financing. The EFWG therefore recommends that HMG should seek to maintain the existing Site Licensees and the significant benefits that sit with these established players allowing the UK to keep the baseline knowledge of licensing requirements which has been built on at least since the mid-1980s if not longer.

Recognising the risk mitigation and cost reductions which could be achieved from utilising existing nuclear sites and Site Licensees for small nuclear development and the impact that could have on attracting private financing, the EFWG recommends that HMG should make NDA and old British Energy (now EDF Energy) sites available for small nuclear deployment.

RECOMMENDATION 7

For technologies capable of being commercially deployed by 2030, HMG should focus its resources on bringing FOAK projects to market by reducing the cost of capital and sharing risks through:

- assisting with the financing of small nuclear through a new infrastructure fund (seed funded by HMG) and/or direct equity and/or Government guarantees; and
- assisting with the financing of small nuclear projects through funding support mechanisms such as a Contract for Difference (CfD)/ Power Purchase Agreement (PPA) or potentially a Regulated Asset Base (RAB) model while maintaining the supply chain plans required for larger low carbon projects

For NOAK projects the market should be self sustaining having learnt the lessons of the large nuclear plant and the small nuclear projects that will have gone before.

a. HMG should recognise that a mechanism akin to CfD, a PPA or potentially a RAB is a likely requirement of any NPP Development until the industry has established itself. It is highly unlikely that merchant plants will be financially feasible. However pricing set under a CfD, a PPA or a RAB should be at a level that is a reasonable price compared to other technologies and takes into consideration any social benefit of the projects while maintaining the protection of consumers.

b. HMG should create a framework around risk sharing and risk allocation (see risk register in Appendix C) within which the private sector can develop small nuclear projects.

c. HMG should consider establishing an advanced clean energy infrastructure fund to seed fund/ provide debt/equity to projects in the small reactor space. Such seed funding would bring down the costs of projects and encourage further equity investment from third parties. Without such a fund HMG is more likely to be required to put direct equity into a project.

d. Alternatively HMG should provide a small level of equity for each FOAK project.

e. HMG should consider making the Guarantee Scheme available through to 2030s to assist with the development of smaller nuclear projects

COMMENTARY:

As mentioned in the Technology Development recommendation section above, the EFWG recommends that, for technologies capable of being deployed by 2030, HMG should focus its resources on de-risking projects, managing the potential consequences of risks and focus its resources on the commercialisation of technologies.

As was acknowledged in the Accelerating Green Finance report: *"The sheer scale of capital required dictates that this cannot be driven through either public or private sectors working alone – we need alignment of interests, incentives and policies."*

Regardless of the smaller risks associated with small nuclear and the amount of de-risking HMG and the market working together can do, FOAK projects are inherently risky and by their very nature of being FOAK, the market will not understand those projects. This is the same as wind, solar and even battery storage. As such it is highly unlikely that a FOAK small nuclear project could attract all the private financing it would need to develop a commercial project. FOAK projects are an opportunity for HMG and the financial services to work together.

As with wind and other low carbon technologies, HMG should recognise that a mechanism akin to CfD, a PPA or potentially a RAB is a likely requirement of any project until the industry has established itself. Even with the low LCOE claimed by the small nuclear technologies, it is both highly unlikely that:

- merchant plants will be financially feasible; and
- that significant private finance would be attracted without a revenue support mechanism.

Some of the presentations given to the EFWG suggested that CfD strike prices for small nuclear technologies would be below the current wholesale market price but that the NPP Developer would still require a CfD or PPA to support the revenue for the project. One of the main reasons for this is to attract private financing.

However pricing set under any revenue support mechanism should be at a level that is a reasonable price compared to other technologies and takes into consideration any social benefit of the projects while maintaining the protection of consumers.

As mentioned throughout this report, the key to attracting private finance is through the allocation of risk, risk sharing, sharing the consequences of risks etc. As such for FOAK HMG should establish risk parameters for small nuclear projects. The EFWG believes that the risk register in Appendix C is an acceptable allocation of risk for such projects.

The establishment of an infrastructure fund (Fund), enacting the equivalent role to a public investment institution, could play an important role in implementing the UK's climate change and industry objectives. With a clear rationale, mission and objective to deliver the development and financing of the small nuclear market, via direct funding or investment, a Fund can be an effective way of sharing risk and overcoming financial constraints making the small nuclear market more attractive to commercial financiers, as evidenced within the offshore wind sector where the Green Investment Bank was the enabler, to what is now a burgeoning industry within the UK, now funded by private sector financial institutions.

Although the Fund should be seed funded from HMG it should be empowered and incentivised to source additional funds from the private sector.

Some benefits and objectives of a Fund may include:

- a catalyst to expand the pool of investors and available capital;
- an independent management of funds, with the capability to participate in projects through the supply of its capital in the form of equity, mezzanine debt, senior debt and contingent capital, the latter freeing up capital set aside by other parties to be used for additional small nuclear projects. A Fund could essentially address the under-provision of capital and/or increase the speed of its deployment;
- committed funding with an investment criteria structured with commercial investment acumen that is focussed on ensuring value accretion with the ability to apply explicit investment maturity timelines. This structured investment criteria provides the ability to quantify and monetise the risks and determine timings for divestment. The latter being a key consideration when realising the maximum financial returns on an asset(s)/investment(s), most likely achieved during the operational phase;
- providing flexibility to transition independence to raise additional money or sell should declassification from the public sector balance sheet be required (minimising the risk of triggering State Aid); and
- the ability to co-invest alongside private sector investors – ensuring ability to attract scalable private sector investment. Co-investment may, amongst other benefits, provide the ability to retain IP, should this be a key consideration for HMG.

The EFWG believes that the establishment of the Fund will have a smaller impact on HMG than providing direct equity to the small nuclear projects. However, without the Fund, HMG would need to provide equity into each FOAK project. With the cost of a small nuclear project being below £2.5 billion, the level of equity would be much smaller than that needed by a large nuclear project. However the level of equity needs to be significant enough to show HMG's commitment to the project and thereby attract the additional private finance needed to finance fully the construction. This equity could be released on refinancing which can be much sooner than a large nuclear project due to the way small nuclear differs (see above).

To help support debt into FOAK projects, until a market is established, HMG should consider making the Guarantee Scheme available through to 2030s. While the benefit of the Guarantee Scheme (provided at market rates) has some limitations it may be required by some projects.

APPENDIX A

THE EXPERT FINANCE WORKING GROUP

Announcement

The Department for Business, Energy and Industrial Strategy (BEIS) set up an Expert Finance Working Group (EFWG) in January 2018 as part of the Advanced Nuclear Technologies initiatives announced by Richard Harrington, Minister for Business and Energy, at the Nuclear Industry Association's annual conference on 7th December 2017. The remit of the group was to independently advise HMG on the potential for small nuclear reactor projects to raise private investment in the UK that could enable their future commercial deployment.

The characteristics and mechanisms (i.e. factory build, modular construction, reduced lead times and claimed low capital costs) for building nuclear power stations using smaller scale reactor units suggest that there are opportunities to finance these types of nuclear power stations differently to large scale nuclear, with the potential to realise reductions in the Cost of Capital (CoC). If achievable, reduced and/or more affordable financing costs could allow for competitive, private sector-led small reactor power stations to be brought to market. The goal of the EFWG was to test this hypothesis with a view to informing policy development.

Context

The work of the EFWG forms part of a wider package of BEIS led initiatives that includes up to £44m of funding for feasibility studies and further research into Advanced Modular Reactors (AMRs), and up to £12m of funding to increase the capability of the Office of Nuclear Regulation (ONR) and the UK Environment Agency (EA) to assess and license new designs. As a starting point the EFWG was asked to consider the findings of the SMR Techno Economic Assessment[23].

The work of the EFWG should therefore be considered in this wider context that i.e. BEIS is also actively working on a range of other policy and regulatory "enablers" to create a market enabling framework that encourages the development of small nuclear in the UK. As the EFWG report is independent, it does not reflect existing HMG policy.

23 https://www.gov.uk/government/publications/small-modular-reactors-techno-economic-assessment

EFWG Membership

Fiona Reilly chaired the EFWG. She is currently an Executive Partner at Atlantic SuperConnection (a Disruptive Capital group company) and a Non-executive Director of the Nuclear Industry Association. She was previously Global Head of Nuclear at Norton Rose Fulbright and Global Nuclear Lead for CPI at PwC. She has over 20 years' experience in the nuclear sector and often serves as an expert for the IAEA.

The EFWG comprised of experts from the finance community who bring a wide range of experience from global infrastructure and energy projects, with input from the academic community and the supply chain. A number of the core members of EFWG have experience of working for governments and the private sector on nuclear projects. Perhaps more importantly some of the group has little or no experience of nuclear projects, thereby bringing a fresh perspective to the question at hand.
Its members are:

Amjad Ghori (Ex Credit-Agricole)
Dougald Middleton (EY)
Giorgio Locatelli (University of Leeds)
Greg Pearce (Commonwealth Bank of Australia)
Larry Henry (KBR)
Michael Redican (MAR Consult)
Richard Abadie (PwC)

The EFWG Secretariat was provided by BEIS and the Nuclear Innovation and Research Office (NIRO). The secretariat consisted of:
Richard Deakin and Joshua Scott (BEIS)
Andrew Howarth (NIRO)

A number of HMG observers were present at the EFWG meetings. The observers were:
Craig Lester and Rebecca Pynt (BEIS)
Joshua Buckland (HMT)
Helen Lister / David Clayton (IPA)

EFWG process

The EFWG formulated its recommendations through:

- Consideration of the findings of the Techno-Economic Assessment of SMRs (the TEA) which was published in December 2017.
- Issuing a Request for Information (RFI) on 2nd February 2018 inviting industry views on small reactor financing. This attracted ten responses and the EFWG invited respondents to present directly their financing and business models.
- Investigating and assessing a wide variety of potential financing structures for small nuclear projects.
- Developing a risk register and allocating risk over all stages of reactor technology and nuclear power plant lifecycle. This incorporates external advice from specialist nuclear insurers.

The Group held seven formal meetings between January and May 2018.

Stakeholder Evidence

Small reactor vendors, developers and other interested parties (stakeholders) were invited to provide information relevant to the work of EFWG, through a Request for Information that was published on BEIS' website. The EFWG received submissions from a range of stakeholders each bringing a different perspective to the work of the EFWG. The stakeholders were invited to present to the EFWG, thereby giving the group the opportunity to ask questions on the commercial propositions. The EFWG also received input from academia relating to the potential advantages which may be realised in respect of project delivery including factory build, modular construction, standardisation, reduced lead times and lower capital costs i.e. the common the typical characteristics of smaller reactor deployments. Respondents to the RFI were:

Assystem
A global engineering consultancy with an interest in being part of a consortium to develop and deploy small nuclear reactors. They are not a reactor vendor.

GE Hitachi
Vendor of the BWXR-300, a 300MWe Boiling Water Reactor (BWR) based on conventional technology.

GF Nuclear
Supporting the Korean SMART reactor – a 100MWe PWR based on conventional technology, currently going through approvals in Saudi Arabia.

Lucid Strategy/ CleanTech Catalyst
Clean technology strategy consulting organisations who propose an open-architecture delivery model for nuclear.

Moltex Energy
Technology Developer of the Stable Salt Reactor, a 300 MWe Gen IV Molten Salt Reactor (MSR) concept that uses new technology but conventional fuel assemblies.

NuScale
Vendor of the NuScale Power Module (NPM), a 50 MWe PWR that can be configured in an array of up to 12 NPMs to create a 600 MWe power station.

Rolls Royce
Vendor as part of a UK consortium for the UK-SMR, a 440 MWe PWR based on conventional technology.

Terrestrial Energy
Technology Developer of the Integral Molten Salt Reactor, a 192 MWe Gen IV MSR concept that uses new technology with standard enrichment fuel.

U-Battery Developments Ltd
Vendor of the U-Battery, a 4 MWe (10 MWt) micro reactor based on high-temperature gas-cooled technology designed for co-generation.

Westinghouse
Vendor of the Westinghouse SMR, a 225 MWe Integral PWR based on conventional technology. Also presented their 400 MWe Lead-cooled Fast Reactor (LFR) concept.

APPENDIX B

EXPLAINING THE BEHAVIOUR OF MEGAPROJECTS

By Dr Giorgio Locatelli – University of Leeds

Project management success vs project success

Firstly and most importantly it is fundamental to distinguish between project management success and project success. Project management success refers to delivery of the project within the "Iron triangle" respecting the constraints of time, budget and scope/quality [1]. Project success is more a holistic appraisal of the cost/benefit for the stakeholders across the entire lifecycle of the infrastructure, not just the project phase [2]. For instance, the London Thames Barrier [3] was priced at £110.7 million in October 1973, but ultimately delivered at the cost of £440 million (£1.6 billion in today's money). The initial plan called for four years of work; construction actually took almost twice as long. However, the barrier currently protects 125sq km (48sq miles) of London, including an estimated 1.25 million people, £200 billion worth of property and infrastructure, a large proportion of the London tube network and many historic buildings, power supplies, hospitals and schools. Thames Barrier has paid for itself many times over in the 30+ years it has been operating. So, project management success is different than project success.

Statistics about megaproject overbudget

There is widely reported narrative about megaprojects (i.e projects over circa $1billion) being delivered over budget and late, see for instance [4], [5], particularly for nuclear power plants [6]. Other works focus on the ultimately poor cost-benefit analysis [7]. However, most recently a debate started to assess if the overbudget of transportation infrastructures has been exaggerated [8].

Reasons for overbudget

The literature discusses several reasons to explain overbudget and delay. The following list is not exhaustive and it is a gross simplification of an ontological and epistemological debate. Indeed there is an overlap between the explanatory power of the different reasons across the different authors. This list intends to link the key ideas to the main proponents.

Professor Bent Flyvbjerg (and the team from Oxford University)

Prof Bent Flyvbjerg reasons to explain over budget and delay lies in behavioural psychology (Flyvbjerg 2006):

- Optimism bias: cognitive predisposition found with most people to judge future events in a more positive light than is warranted by actual experience (see also Planning Fallacy)
- Strategic misinterpretation: the deliberate overestimate benefits and underestimate costs in order to increase the likelihood that a project gain approval and funding.

Professor Peter Love (and a team of international researchers)

Prof Peter Love reasons to explain over budget lies in the Evolutionists theory. Strategic and economic decisions taken for a project influences the way in which an organisation processes information, which affects the way they manage risk [9], [10]. So, (inevitable) scope changes, mistakes and rework in construction can explain much of the cost overrun.

Merrow, Independent Project Analysis, Inc. (IPA) and other practitioners

Similar to Peter Love, Merrow (2011) embraces an Evolutionists theory. In his popular book, grounded on decades of experience and first hand data, there are seven top mistakes leading to over budget and delay in megaprojects:

- Greed from stakeholders
- Schedule pressure to reduce construction time and increase the Net Present Value
- Poor bidding phase
- Reduction in the upfront cost leading to poor quality Front End Loading (FEL) and Front End Engineering and Design (FEED)
- Unrealistic cost estimations
- Poor risk allocation
- Excessive pressure on project manager and "blame culture".

Project complexity

[11] investigated the role of complexity in megaprojects, highlighting that underperforming projects are often delivered in a project environment characterised by:

1. rapid changes of technologies; shortened technology cycle time; increased risks of obsolescence [12];
2. increasingly interoperable and interdependent systems [13];
3. emphasis on cost reduction, with tight schedules and without quality or scope reduction [14];
4. integration issue: high number of system parts and organisations involved [15] [16];
5. combining multiple technical disciplines [17];
6. competitive pressures from other technologies within the same market (CCGT vs nuclear) or other designs within the same technology [18].

These six elements are typical for technically complex projects, element 1 being the exception for nuclear.

All these aspects have a major influence on the project governance [19] since "managerial rationalities are limited in understanding their own complex project realities which are themselves bound by limits imposed by overall governance structures and strategies" [20]. Therefore the planning and delivery of nuclear power plants are surely complex, where complexity is intended to encompass both technical/physical and organisational aspects of the project.

Other reasons

The winner's curse is "a tendency for the winning bid in an auction to exceed the intrinsic value of the item purchased. Because of incomplete information, emotions or any other number of factors regarding the item being auctioned, bidders can have a difficult time determining the item's intrinsic value. As a result, the largest overestimation of an item's value ends up winning the auction" [21]. So, in simple terms, the infrastructure that appears to have the most optimistic cost/benefit analysis is usually selected.

Locatelli's research [22]–[24] links a series of project characteristics to successful performance in terms of avoidance of delays and cost overruns. The project environment and its legal and socioeconomic characteristics, in particular, have been identified as having an important relationship with megaprojects success. Other reasons include:

- VAT, contingency and inflation not included in the estimation phase.
- failing to understand that at the estimation phase values should be given as an interval and not a single point
- confusion of cost with the price (and value)

Why this matters for nuclear power and small nuclear

Even if there is not consensus for a monetary threshold for above which "Megaprojects goes bad", the key reasons are more clear. Size, complexity and uniqueness (both physical and organisational) are key determinants. Heavily customised – white elephant megaprojects might incur in several issues (where scope change is a key aspect). Several standardised / simpler projects might reduce the impact of the three key major issues of nuclear reactor: Size, complexity and uniqueness.

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APPENDIX C
RISK REGISTER

Below is a series of risk registers which consider the high level risks for each phase – Technology Development Project, Manufacturing Capability Development Project and NPP Development (as discussed in the main body of the report).

The risk registers are intended to provide a practical guide which can be used by HMG and industry as the starting point for the allocation of risks for each project. The risk registers are not definitive and only seek to deal with high level risks, particularly those few risks unique to nuclear.

The EFWG would like to acknowledge the IAEA whose generic nuclear risk register forms the basis for the risk registers below. The EFWG has augmented the registers to consider the particular aspects that the EFWG is charged with.

Key Players:

Vendor	Reactor technology owner either the Technology Development Company or the Manufacturing Development Company
Debt	Financiers/lenders providing debt to the projects – corporate or project
NPP Development Company	NPP Development Company
Manufacturing company	Manufacturing Development Company
Licensee	The nuclear Site Licensee
Insurers	Insurers
Consumer	Consumer
HMG/taxpayer	HMG//taxpayer

Table 1:
Technology Development Project risks

	Category	Risk	Party/ parties best able to take risks							Comments
			Technology Development Company	Debt	NPP Development Company	Licensee	Insurers	Consumer	HMG/ taxpayer	
A1	Technology risk	Technology development needs are more challenging than anticipated or insurmountable			n/a	n/a				
A2	Cost overruns	Technology development costs more than anticipated			n/a	n/a				If HMG invests through grant/equity in exchange for IP
A3	Delays	Technology development costs more than anticipated			n/a	n/a				If HMG invests through grant/equity in exchange for IP
A4	Market	There is insufficient market pull/interest in deploying the technology. No projects identified			n/a	n/a				This could be due to an inadequate program set by HMG
A5	(Equity) funding	Insufficient funds raised to complete technology development			n/a	n/a				Current HMG funding available – eg. Catapults, grants, AMR project. HMG should perhaps consider equity funding for IP rights
A6	Regulatory – technology	Technology presents challenges in the likelihood of satisfying regulations Failure to complete GDA			n/a	n/a				
A7	Regulatory – capability	Regulator does not have capability/capacity to license new technology			n/a	n/a				
A8	Security/safeguards	Technology/fuel cycle presents security/safeguards issues for deployment in UK or export overseas			n/a	n/a				Assume the vendor is designing within the regulatory framework for the target markets
A9	Decommissioning/ waste management	Associated waste streams not able to be managed currently			n/a	n/a				
A10	Political risk	The technology does not align with or presents challenges for HMG policy Policy uncertainty regarding support for the deployment of new reactor technology			n/a	n/a				

Table 2:
Manufacturing Capability Development Project Risks

	Category	Risk	Party/ parties best able to take risks							Comments
			Vendor	Debt	Manufacturing company	Licensee	Insurers	Consumer	HMG/ taxpayer	Potentially licensable activities on site
B1	Siting	Substantive issues with selection of site			■				■	Only HMG if fissile activities in factory
B2	Planning/ permitting	Substantive issues with planning and/or permitting related issues (including delays, extra costs, etc.)			■					
B3	Factory design	Substantive issues with design of factory leading to construction or operation related issues (including extra costs, lower performance, etc.)			■					
B4	Construction – civils	Substantive issues with construction of factory leading to extra costs and delays			■		■			
B5	Construction – internal equipment	Substantive issues with supply and installation of equipment and tools leading to extra costs and delays	■		■		■			
B6	Cost overrun	Higher than expected costs leading to higher funding requirements, lower returns, tighter debt service cover ratios, insolvency of contractor etc.			■					
B7	Delays	Longer than expected time to completion, leading to higher costs, higher funding requirements, knock on effects to NPP customers/ deployment			■					
B8	Process commissioning	Reduced performance (capacity available, plant efficiency), leading to knock on effects to NPP customers/ deployment	■		■					
B9	Market uncertainty	Revenue stream, ability to sell products etc.	■		■					
B10	Product transport	Substantive issues (delays etc.)/damage to product whilst in transit			■		■			
B11	Skills development	Insufficient capability/ capacity in the workforce to produce manufactured products to time/quality	■		■				■	
B12	Building liability/ accident cover	Accidental damage to factory/equipment whilst operational			■		■			

Table 3:
NPP Development Risks

	Category	Risk	Party/ parties best able to take risks							Comments
			Vendor	Debt	NPP Development Company	Licensee	Insurers	Consumer	HMG/ taxpayer	
C	**Project Development/Licensing Phase (Pre FID)**									
C1	Licensing, permitting	Substantive issues with generic design leading to licensing and/or permitting related issues (including delays, extra costs, etc.)			■	■				
C2	Site characterisation	Substantive issues with selection of site.			■	■			■ *	*HMG risk if HMG designates existing NDA site. HMG/NDA keeps liability for remediation
C3	Social and environmental	Substantive issues (including process related) with social and environmental aspects of the project			■	■				
C4	Reputational	Substantive issues with reputational aspects of the project (including nuclear proliferation, underperforming technology)			■	■			■	Reputationally if something goes wrong it affects everyone associated with the project
C5	Reservation of long lead materials, production slots	Delayed availability of long lead materials (including extra costs) Delayed availability of production slots			■					
C6	Political	List of events to be agreed by the parties, but to include in particular discriminatory changes in law, including changes in taxes or project abandonment			■				■	
C7	Commercial and contractual structure	Substantive issues with regard to the integration and management of various contracts for the construction phase (and also of contractors), leading to onerous project procurement and challenging project management	■		■	■				Most people do not realise that these factors affect the risk structure which has a direct impact on rating and cost of finance

	Category	Risk	Party/ parties best able to take risks							Comments
			Vendor	Debt	NPP Development Company	Licensee	Insurers	Consumer	HMG/ taxpayer	
D	**Construction Phase**									
D1	Design	Substantive issues with detailed design choices leading to construction or operation related issues (including extra costs, lower performance, etc.)	■		■	■				
D2	Technology	Substantive issues with choice and/or combination of technologies selected	■		■	■				
D3	Technical	Higher than expected costs and/or longer time to completion, leading to higher borrowing requirements, lower returns, etc.	■		■					
D4	Cost overruns	Higher than expected costs leading to higher funding requirements, lower returns, tighter debt service cover ratios, greater exposure for the government of the host country, insolvency of contractor etc.	■		■		■			
D5	Delays	Longer than expected time to completion, leading to higher costs, higher funding requirements, lower returns, greater exposure for the government of the host country, insolvency of contractor etc.	■		■		■ *			Note insurance dependent on whether economic to do so or mitigate in other ways
D6	(Equity) funding	Lack of sufficient funds for reaching completion			■					
D7	Foreign exchange (FX)	Variations of local currency and/or other currencies	■		■					Potential for debt/lenders to take risk through hedging pre-risk

	Category	Risk	Party/ parties best able to take risks							Comments
			Vendor	Debt	NPP Development Company	Licensee	Insurers	Consumer	HMG/ taxpayer	
D8	Interest rates	Higher than expected all-in interest rate leading to larger investment costs (e.g. interest during construction), higher than expected borrowing requirements and thinner cover ratios	■		■			■		Mitigants: Hedge interest rates at financial close (FID) and alter CfD strike price or payment profile to final rates fixed at FID. Pre- hedging is possible but costly. However interest rates are low and if financed by bonds for LT financing there will be a lot of certainty in such cost. Several potential ways of reducing risk Addition of Equity and EPC Vendor as primary risk, Assumes primary risk could sit with either party, albeit funding/lenders would normally require hedging strategy, normally involving >75% of total debt being hedged). Balance of unhedged debt would rest with Equity /Owner
D9	Insurance (business and property)	Higher than expected insurance costs and/or non-availability of proper insurance cover (excluding acts of terrorism) Higher than expected insurance costs and/or non-availability of proper insurance cover (acts of terrorism)			■		■			This risk is borne by all project parties if no insurance available nor HMG backstop
D10	Political	List of events to be agreed by the parties, but to include in particular discriminatory changes in law, including changes in taxes or project abandonment			■		■		■	HMG takes risk for change of law assuming there is some form of contractual agreement in place that has supported or enabled the FID, e.g. CfD.

	Category	Risk	Party/ parties best able to take risks							Comments
			Vendor	Debt	NPP Development Company	Licensee	Insurers	Consumer	HMG/ taxpayer	
D11	Force majeure	List of events to be agreed by the parties, but typically including events outside the control of either party such as catastrophic weather related events, e.g. flooding and earthquakes			■		■			
D12	Social and environmental	(Non-nuclear) incident (during construction or testing phase)			■		■			
D13	Reputational	Substantive issues with reputational aspects of the project in connection with construction (including poor monitoring of health, social, environmental requirements)	■		■	■			■	If an issue is realised all parties will be affected but risk will not primarily be borne by debt.
D14	Nuclear incident	Major pollution and/or hazard to population			■	■	■		■	If an issue is realised all parties will be affected but risk will not primarily be borne by debt.
D15	Performance during active commissioning	Reduced performance (capacity available, plant efficiency) of the newly built units, leading to lower than expected cashflows stretching the overall profitability of the completion project	■		■					
D16	Commissioning	Authorisations not all being granted (on time) by the relevant control/safety etc. authorities Failure to pass completion tests	■		■	■				
D17	Supporting infrastructure (roads/ rail/port etc.)	Not completed on time	■		■				■	
D18	Commercial and contracting structure and Interface issues	Risk that owner, contractor, sub contracts and construction manager do not cover project risks collectively	■		■	■				This risk can be minimised by clearly defining roles and obligations in each contract
D19	Project insolvency	Project insolvency leading to risk of late phase abandonment		■	■				■	

	Category	Risk	Party/ parties best able to take risks							Comments
			Vendor	Debt	NPP Development Company	Licensee	Insurers	Consumer	HMG/ taxpayer	
E	**Operation Phase**									
E1	Operation (reduced availability and/or reduced dispatch)	Reduced performance, leading to lower than expected level of electricity generated and/or increased O&M expenses stretching the overall profitability of the completion project	■		■	■				
E2	Fuel supply (quantities and prices)	Increased fuel related expenses stretching the overall profitability of the completion project			■	■				Risks could be mitigated via fixed price contracts and cost pass-through under a CfD, PPA or RAB model under certain circumstances
E3	Electricity sales (quantities and prices)	Lower than expected cashflows stretching the overall profitability of the completion project			■	■				
E4	Foreign exchange	Variations of local currency and/or other currencies against units of account			■	■				Hedging contracts Equity and Licensee primary risk, FX could potentially sit with either party dependent on what arrangements are agreed between equity and licensee. Mitigating cross currency derivatives could be provided by each party. i.e. who is best placed to take the currency risk.
E5	Interest rates	Higher than expected all-in interest rate leading to more important debt service obligations and thinner cover ratios			■					Mitigants: Hedge interest rates at financial close and alter CfD strike price or payment profile to final rates fixed at FID. There is a risk at a refinancing for variations in interest rates. Will HMG allow a rate pass-through? There is no interest rate pass-through for other power generators under a CfD. Pre- hedging is possible but costly. However interest rates are low and if financed by bonds for LT financing there will be a lot of certainty in such cost. Several potential ways of reducing risk

	Category	Risk	Party/ parties best able to take risks							Comments
			Vendor	Debt	NPP Development Company	Licensee	Insurers	Consumer	HMG/ taxpayer	
E6	Insurance (business and property)	Higher than expected insurance costs and/or non-availability of proper insurance cover (excluding acts of terrorism) Higher than expected insurance costs and/or non-availability of proper insurance cover (acts of terrorism)			■	■	■			If an issue is realised all parties will be affected but risk will not be primarily be borne by debt.
E7	Insurance (civil liability for nuclear damage)	Higher than expected insurance costs and/or non-availability of proper insurance cover			■	■	■			If an issue is realised all parties will be affected but risk will not be primarily be borne by debt. May require HMG backstop depending on scale of issue
E8	Political	List of events to be agreed by the parties, but to include in particular discriminatory changes in law, including changes in taxes or project abandonment			■		■		■	HMG takes risk for change of law assuming there is some form of contractual agreement in place that has supported or enabled the FID, e.g. CfD.
E9	Force majeure	List of events to be agreed by the parties			■		■			
E10	Social and environmental	(Non-nuclear) incident (during operation phase)			■	■	■			
E11	Reputational	Substantive issues with reputational aspects of the project in connection with operations (including poor monitoring of health, social, environmental requirements)	■		■	■			■	If an issue is realised all parties will be affected but risk will not be primarily be borne by debt.
E12	Nuclear incident	Major pollution and/or hazard to population			■	■	■		■	If an issue is realised all parties will be affected but risk will not be primarily be borne by debt.

	Category	Risk	Party/ parties best able to take risks							Comments
			Vendor	Debt	NPP Development Company	Licensee	Insurers	Consumer	HMG/ taxpayer	
E13	Spent fuel / waste management	Ultimately, higher than expected financial obligations			■	■	■		■	Reserve fund or other mechanism, e.g. extended CfD or tailored RAB, to be created during the operation phase to cover waste management/spent fuel during O&M phase and if an early closure This is not a risk financiers can manage however they are going to be concerned as the payment into decom fund will be made prior to debt repayment. However, acceptance of funders may become more comfortable with this when they realise how small the payment is
E14	Decommissioning	Ultimately, higher than expected financial obligations			■	■	■		■	Reserve fund or other mechanism, e.g. extended CfD or tailored RAB, to be created during the operation phase to cover waste management/spent fuel during O&M phase and if an early closure
E15	International professional externalities	Changes in (international) standards			■	■			■	
E16	Project insolvency	Project insolvency leading to risk of abandonment		■	■				■	

	Category	Risk	Party/ parties best able to take risks							Comments
			Vendor	Debt	NPP Development Company	Licensee	Insurers	Consumer	HMG/ taxpayer	
F	**Refinancing Phase (after first reload)**									
F1	Operation (reduced availability and/or reduced dispatch)	Reduced performance, leading to lower than expected level of electricity generated and/or increased O&M expenses stretching the overall profitability of the completion project								
F2	Fuel supply (quantities and prices)	Increased fuel related expenses stretching the overall profitability of the completion project								Risks could be mitigated via fixed price contracts and cost pass-through under a CfD, PPA or RAB model under certain circumstances
F3	Electricity sales (quantities and prices)	Lower than expected cashflows stretching the overall profitability of the completion project								
F4	Foreign exchange	Variations of local currency and/or other currencies against units of account								Hedging contracts Equity and Licensee primary risk, FX could potentially sit with either party dependant on what arrangements are agreed between equity and licensee. Mitigating cross currency derivatives could be provided by each party. i.e who is best placed to take the currency risk
F5	Interest rates	Higher than expected all-in interest rate leading to more important debt service obligations and thinner cover ratios								Mitigants: Hedge interest rates at financial close and alter CfD strike price or payment profile to final rates fixed at FID. There is a risk at a refinancing for variations in interest rates. Will HMG allow a rate pass-through? There is no interest rate pass-through for other power generators under a CfD. Pre-hedging is possible but costly. However interest rates are low and if financed by bonds for LT financing there will be a lot of certainty in such cost. Several potential ways of reducing risk

	Category	Risk	Party/ parties best able to take risks							Comments
			Vendor	Debt	NPP Development Company	Licensee	Insurers	Consumer	HMG/ taxpayer	
F6	Insurance (business and property)	Higher than expected insurance costs and/or non-availability of proper insurance cover (excluding acts of terrorism) Higher than expected insurance costs and/or non-availability of proper insurance cover (acts of terrorism)			■	■	■			If an issue is realised all parties will be affected but risk will not be primarily be borne by debt
F7	Insurance (civil liability for nuclear damage)	Higher than expected insurance costs and/or non-availability of proper insurance cover			■	■	■			If an issue is realised all parties will be affected but risk will not be primarily be borne by debt. May require HMG backstop depending on scale of issue
F8	Political	List of events to be agreed by the parties, but to include in particular discriminatory changes in law, including changes in taxes or project abandonment			■				■	HMG takes risk for change of law assuming there is some form of contractual agreement in place that has supported or enabled the FID, e.g. CfD
F9	Force majeure	List of events to be agreed by the parties			■		■			
F10	Social and environmental	(Non-nuclear) incident (during operation phase)			■	■	■			
F11	Reputational	Substantive issues with reputational aspects of the project in connection with operations (including poor monitoring of health, social, environmental requirements)	■		■	■			■	If an issue is realised all parties will be affected but risk will not be primarily be borne by debt
F12	Nuclear incident	Major pollution and/or hazard to population			■	■	■		■	If an issue is realised all parties will be affected but risk will not be primarily be borne by debt

	Category	Risk	Party/ parties best able to take risks							Comments
			Vendor	Debt	NPP Development Company	Licensee	Insurers	Consumer	HMG/ taxpayer	
F13	Spent fuel / waste management	Ultimately, higher than expected financial obligations			■	■	■		■	Reserve fund or other mechanism, e.g. extended CfD or tailored RAB, to be created during the operation phase to cover waste management/spent fuel during O&M phase and if an early closure This is not a risk financiers can manage however they are going to be concerned as the payment into decom fund will be made prior to debt repayment. However, acceptance of funders may become more comfortable with this when they realise how small the payment is
F14	Decommissioning	Ultimately, higher than expected financial obligations			■	■	■		■	Reserve fund or other mechanism, e.g. extended CfD or tailored RAB, to be created during the operation phase to cover waste management/spent fuel during O&M phase and if an early closure
F15	International professional externalities	Changes in (international) standards			■	■			■	
F16	Funding Markets Shutdown	Refinancing risk			■	■			■	This is the risk that the debt capital markets are impacted by a credit event (for example the Credit crisis in 2008). Under such circumstances it may be difficult to access sufficient funding at an acceptable market price during a refinancing period

APPENDIX D

FINANCE STRUCTURES

	Project finance								
	A1	A2	A3	A4	B	C	D	E	F
Attribute	Limited Recourse/ Non-Recourse	With CfD/PPA (flexible)	With CfD/PPA and HMG Equity	With CfD/ PPA and HMG Guarantee	Mankala	Exceltium	Corporate (with CfD)	RAB	100% Government Funded
HMG balance sheet impact	✓ No impact on HMG balance sheet ✓ No HMG support mechanism	✓ Minimise impact on HMG balance sheet depending on risk structure defined in CfD. Subject to how much money comes through the top up payment (LCF impact). If top up less than 40% of the payments over the life of the project then minimal Balance sheet impact	✗ Depending on the level of equity (particularly as in combination with CfD) high chance of impact on HMG balance sheet	✗ Potential impact of entire project on government balance sheet depending on risk level taken by HMG – could result in state aid considerations ✓ Extent of guarantee could minimise HMG balance sheet risk	✗ No impact on HMG balance sheet	✗ No impact on HMG balance sheet	✓ Minimise impact on HMG balance sheet depending on risk structure defined in CfD. Subject to how much money comes through the top up payment (LCF impact). If top up less than 40% of the payments over the life of the project then minimal balance sheet impact	✓ Potentially off HMG balance sheet	✗ Fully on HMG balance sheet
State Aid	✓ No issues	✗ Requires State Aid approval. If CfD then should be straightforward as HPC approved. If PPA State Aid would be a bigger challenge but could be allowable	✗ State Aid challenge potential	✗ State Aid challenge potential	✓ No issues	✓ No issues	✗ Requires State Aid approval. If CfD then should be straightforward as HPC approved	✗ Would require state aid approval but could be allowable	✗ State Aid challenge potential

	Project finance								
	A1	A2	A3	A4	B	C	D	E	F
Attribute	Limited Recourse/ Non-Recourse	With CfD/PPA (flexible)	With CfD/PPA and HMG Equity	With CfD/ PPA and HMG Guarantee	Mankala	Exceltium	Corporate (with CfD)	RAB	100% Government Funded
Policy impact	✓ No policy impact	✓ No policy impact as already covered in the Energy act if CfD. If PPA would need a change in policy and legislation in the UK	✓ No policy impact as already covered in the Energy act if CfD. If PPA would need a change in policy and legislation in the UK	✓ No policy impact as already covered in the Energy act if CfD. If PPA would need a change in policy and legislation in the UK	✓ Directly supports industrial strategy × Would require a change in policy and legislation in the UK	× Require new HMG support mechanism to be created	✓ No policy impact	✓ Enables uncoupling of financing from technology (i.e. strategic investors) and hence encourage competition ✓ Once established and on NOAK could lead to an efficient and economic oversight × Need to create a new regulatory framework (primary and secondary legislation); would take at least 2 to 4 years to implement regulation and could delay the market	× Would require a complete change in HMG policy and subsequent legislation × Runs counter to current policy objectives for privately financed energy sector × Negative signal to rest of energy market
Ability to attract equity	× No market appetite for FOAK × Difficult to attract debt/equity, particularly with unproven technology × Lack of liquidity	✓ Helps rating structure and availability of finance. ✓ If rating achieved is greater than BBB+ then opens up the market for large amounts of long-term financing	✓ If equity is in short supply certainly helps to attract additional investors. ✓ Government involvement in the equity is likely to provide confidence to the market in a project and thereby improve the SPVs credit rating and attract other investors ✓ If rating achieved is greater than BBB+ then opens up the market for large amounts of long-term financing	✓ Helps rating structure and availability of finance. ✓ If equity is in short supply certainly helps to attract additional investors ✓ This would create greater availability of low-cost long-term funding from the capital markets. ✓ If rating achieved is greater than BBB+ then opens up the market for large amounts of long-term financing	✓ Corporate/ project support sits behind the Mankala to fund the project × Requires large number of utilities to agree to collectively fund a new NPP (with potential one large utility shareholder)	✓ Corporate/ project support sits behind the Exceltium to fund the project × Requires large number of utilities and banks to agree to collectively fund a new NPP by funding a corporate utility	× Most technology vendors want to sell equipment/ services are loath to or are not adequately capitalised to take on the whole project risk on their balance sheet. × Not many corporates with the ability to take this on	✓ Arguably easier to attract private equity to new nuclear build which is otherwise very difficult. ✓ Easier to get rating and finance availability ✓ Asset base created early on in project providing early return and reduced WACC	n/a

	Project finance									
	A1	A2	A3	A4	B	C	D	E	F
Attribute	Limited Recourse/ Non-Recourse	With CfD/PPA (flexible)	With CfD/PPA and HMG Equity	With CfD/ PPA and HMG Guarantee	Mankala	Exceltium	Corporate (with CfD)	RAB	100% Government Funded
Ability to raise debt	✗ No market appetite for FOAK ✗ Difficult to attract debt/equity, particularly with unproven technology ✗ Ability to tap into long term debt requires BBB+ rating from 2 agencies. Challenging for FOAK company	✓ Helps rating structure and availability of finance ✓ CfD support provides revenue stream on which to secure debt at lower cost of capital ✓ PPA would reduce risks further and assist with WACC	✓ Helps rating structure and availability of finance ✓ CfD support provides revenue stream on which to secure debt at lower cost of capital ✓ PPA would reduce risk further and WACC	✓ Helps rating structure and availability of finance ✓ Government guaranteeing the debt would allow institutional investors to participate. This would have larger balance sheet impact but the debt from institutional investor could be less expensive and more readily available due to confidence in the project, and therefore bring down the CoC. ✓ Potential to increase debt component and tenor of financing structure (noting parameters to avoiding breach of State Aid and assuming guarantee extends in to portion of operating phase) ✗ HMG can only guarantee 100% of bonds. 80% bank debt tranche	✓ Mankala and support from industrialist help to secure debt to the project ✗ Requires industrialist with strong balance sheets wanting to build a new NPP	✗ Requires an existing utility with existing portfolio who wants build a new NPP ✗ Requires banks and industrials willing to finance an existing utility	✓ Corporate debt could be raised depending on the strength of the corporates balance sheet	✓ Could help the SPV rating structure for the debt market ✓ Debt could be raised with lower cost of capital due to earl establishment of asset base and early return	n/a

	Project finance								
	A1	A2	A3	A4	B	C	D	E	F
Attribute	Limited Recourse/ Non-Recourse	With CfD/PPA (flexible)	With CfD/PPA and HMG Equity	With CfD/ PPA and HMG Guarantee	Mankala	Exceltium	Corporate (with CfD)	RAB	100% Government Funded
Ease of setting up	✓ Financing market well versed	✓ Financing market well versed × PPA would require introduction to market and understanding of parameters	✓ Financing market well versed ✓ Improved project transparency – financial performance of project(s). HMG holding board positions. (consider impact on HMG balance sheet) × If other investors involved there will be issues around governance of the operating SPV and possible conflicts of interest × Involvement of HMG not always positive. Requires carefully drafted shareholder agreement	✓ Financing market well versed ✓ Improved project transparency – financial performance of project(s). HMG holding board positions. (consider impact on HMG balance sheet) × If other investors involved there will be issues around governance of the operating SPV and possible conflicts of interest	× Challenging as need number of industrialists wanting to invest and then an understanding of how Mankala work. Could require legislations	× Challenging as need strong utility wanting to be part of Exceltium plus banks and industrialists Selecting utility would be a challenge as non in UK, HMG owned. Would require legislation	✓ (Assuming vendor is the 'corporate') Reduces the need for complex sub contracts, although corporate may want those to facilitate future refinancing/sales × Ultimately fully reliant on the corporate to deliver – if they fail the project fails	✓ More likely to work with smaller projects ease for market in understanding asset base and revenue return × Unclear how small nuclear with need for recognised funding support over a significant period would fit with quinquennial reviews in a RAB model × Regulator (OFGEM) would require significant further resources and time for sufficient experience to be gained in the market, given new technology × RABs are there to support an existing asset base where additional assets are added – difficult for FOAK/ new markets. The market would need to understand how a new asset base was to be created and when returns accrue and on what basis Incremental cost vs new cost × Beside TTT - a relatively lower risk project with no technology or capacity supply or route to market risk – there has been no single RAB structured asset	✓ HMG control ✓ Overall less complexity

	Project finance									
	A1	A2	A3	A4	B	C	D	E	F
Attribute	Limited Recourse/ Non-Recourse	With CfD/PPA (flexible)	With CfD/PPA and HMG Equity	With CfD/ PPA and HMG Guarantee	Mankala	Exceltium	Corporate (with CfD)	RAB	100% Government Funded
Impact on cost to consumers	✓ None	✓ CfD established mechanism and would probably lower impact on Government support. × If PPA then larger impact on consumers as HMG supporting whole revenue stream	✓ CfD established mechanism and would probably lower impact on Government support	✓ CfD established mechanism and would probably lower impact on Government support	✓ Large number of shareholders share the burden of building an NPP Utilities paid back in power thereby, in theory, reducing their costs of power	✓ Industrials return mix of financial and power	✓ CfD established mechanism and would probably lower impact on Government support	✓ Longer debt amortisation profile lowers the annual price payable by consumers assuming built to time and to budget × Unless HMG changes the RAB profile, any cost overruns/ delays go straight on the RAB and therefore paid for by the consumer. Some form of pain/ gain share and HMG backstops could be contemplated – subject to state aid × The cost of administrating a RAB (regulator/, auditing and assurance of cost base and progress) are significant and will be paid for by the consumer. May also require HMG oversight of regulator particularly on FOAK	✓ Potentially no impact on consumers
Impact on cost to taxpayer	✓ No impact on taxpayers	✓ No impact on taxpayers	✓ Value for money improvement as public sector share in ongoing investment returns ✓ Reduces overall cost of project to the public sector	✓ Value for money improvement as public sector share in ongoing investment returns, reducing overall cost of projects to the public sector	✓ No impact on taxpayers	✓ No impact on taxpayers	✓ No impact on taxpayers	✓ Potentially no impact on taxpayers	✓ Large impact on taxpayers ✓ Potential of HMG to negotiate IP ownership ✓ Potential for HMG to divest on refinancing × High upfront costs for HMG/taxpayers × The cost of administrating (HMG oversight, auditing and assurance of cost base and progress) are significant

	Project finance								
	A1	A2	A3	A4	B	C	D	E	F
Attribute	Limited Recourse/ Non-Recourse	With CfD/PPA (flexible)	With CfD/PPA and HMG Equity	With CfD/ PPA and HMG Guarantee	Mankala	Exceltium	Corporate (with CfD)	RAB	100% Government Funded
Risk allocation	✓ Forces structured analysis and allocation of risk	✓ Forces structured analysis and allocation of risk ✓ Reduces long-term assessment of market risk and threat from new technology. ✓ Does not help to deal with risk assessment of construction risk	✓ Forces structured analysis and allocation of risk ✓ Reduces long-term assessment of market risk and threat from new technology. ✓ More genuine partnership environment allowing for better understanding of perspectives between private and public sectors	✓ Forces structured analysis and allocation of risk ✓ More genuine partnership environment allowing for better understanding of perspectives between private and public sectors ✓ Greater control on transfer of risk onto HMG ✓ Higher risk transfer to taxpayer	✓ Shareholders including industrials share all costs overruns and delays etc	✓ Large number of banks and industrials sharing risk in building new NPP	✓ Majority of risks remain with corporate entity. ✓ Offers integrated risk taken by supplier	✓ Decommissioning risks and waste management would not remain solely with the Utility (require reserves which might not be sufficient) - Consumer may have to continue to pay throughout the decommissioning period to cover costs of decommissioning	✓ No HMG experience in managing let alone taking FOAK risk
Revenue risk	✓ Yes	✓ Mechanism offers lower long-term price risk, and significantly lower short-term price risk for generation. ✓ Complicated mechanism – requiring project developer to determine the level of the CfD strike price versus the wholesale market price on day ahead or seasonal basis	✓ Mechanism offers lower long-term price risk, and significantly lower short-term price risk for generation	✓ Reduces long-term assessment of market risk and threat from new technology. ✓ Mechanism offers lower long-term price risk, and significantly lower short-term price risk for generation	✓ Requires a market where industrials can be supplied directly from the power plant (either physically or at least in theory) ✓ Industrials have to source power from other sources while carrying the burden of building the power plant	✓ Risk to corporate of paying back banks. ✓ Industrialist largely paid in power so no risk there	✓ Unlikely to be economically viable – likely to be too expensive for either a merchant basis or a reasonable strike price	✓ Structured route for costs to be credited to a RAB and returns led on the same ✓ Helps transparency of costs and benchmarking over time	N/A
WACC	✓ More expensive than 100% HMG or corporate balance sheet funded (WACC)	✓ More expensive than 100% HMG or corporate balance sheet funded (WACC)	✓ More expensive than 100% HMG or corporate balance sheet funded (WACC)	✓ Potentially lower financing costs as project is de-risked, HMG seen to be supporting. Guarantee could be subordinated to the senior debt but consideration would need to be given to the risk profile making commercial lending more attractive	✓ Lower WACC as industrials taking risk.	✓ Banks and industrials paid back during contraction period thereby reducing cost of capital	Would depend on the rating of the entity	✓ Lower WACC	✓ Lower financing costs and therefore lower overall construction costs given less risk transfer to consumers

	Project finance								
	A1	A2	A3	A4	B	C	D	E	F
Attribute	Limited Recourse/ Non-Recourse	With CfD/PPA (flexible)	With CfD/PPA and HMG Equity	With CfD/ PPA and HMG Guarantee	Mankala	Exceltium	Corporate (with CfD)	RAB	100% Government Funded
Applicable to small nuclear in UK?	Nuclear projects have not to date been able to be developed under this model. With the development of small nuclear and factory deployment of large components/ reactors it is possible that once proven to be able to be built to time and budget, this model may open up	Potentially but may still be difficult for FOAK. Much will depend on CapEx and potential construction risk. Also financiers may not be willing to take the technology risks. Contingent Equity will be required to satisfy lenders concerned with FOAK The CfD could be tailored to change the risk sharing profile with additional reopeners. This would move the CfD towards the RAB model but would result in a greater impact on HMG balance sheet	Potentially but may still be difficult for FOAK, however HMG equity should help for FOAK. Much will depend on CapEx and potential construction risk. Also financiers may not be willing to take the technology risks. Contingent Equity will be required to satisfy lenders concerned with FOAK	Yes potentially applicable, but not if it results in disproportionate amount on HMG balance sheet	Not available in current market. Would require a change in policy and legislation in the UK Largely used in Finland	Not available in the current market. Only been used in France to date	Would depend on the rating of the entity and its ability to sell power into the market Unclear which corporates could facilitate this	Would need strong trust and confidence in market. Unclear how for this type of project consumers would make the payment to support this kind of structure in the broad electricity market Consider RAB against CfD with different risk allocation	Not applicable – not current HMG policy
Max gearing likely to be achievable (debt: equity)	NOAK - 60:40	FOAK - 50:50 or lower NOAK - 60:40	FOAK - 50:50 or lower NOAK - 60:40 After first reload refinancing and Government equity potentially being released/bought out	NOAK - 70:30 After first reload refinancing and Government guarantee being released	N/A	N/A	0:100	NOAK - 80:20	N/A

APPENDIX E
DEFINITIONS

Advanced Nuclear Technologies
Umbrella term describing the next generation of civil nuclear power technologies that differ from the current generation of conventional nuclear power stations.

AMR
Advanced Modular Reactor – defined by HMG as a broad group of advanced reactor designs that maximise the use of off-site factory fabrication of modules. AMRs use novel reactor systems, fuels and/or coolants. Some AMRs also target new applications for nuclear energy such as the supply of industrial heat.

BOP
Balance of Plant – all components and systems outside of the nuclear island.

capital markets
The markets for medium and long-term instruments, predominantly bonds, notes and other equities and commodities.

CfD
Contract for Difference

CoC
Cost of capital – The rate of return required or demanded on funds deployed by shareholders or lenders to finance an investment.

consortium or consortium members
The group of private sector participants who have come together for the purpose of tendering for a project.

construction period
The period of the design and construction of the facilities that are the subject of the project.

contingent capital
Contingent capital is debt that converts into equity when specific triggers are met.

contingent equity
Contingent equity is equity that only becomes such once a contingency, or defined occurrence, happens. Also called contingent capital, it converts into equity when specific triggers are met. Sometimes these triggers are linked to extreme conditions such as cost overruns above a threshold or a natural disaster.

debt funder
A provider of debt finance to a project. In this context, the term covers a provider of third-party debt finance, including bank debt and bond finance, but excludes subordinated debt provided by a sponsor as a substitute for equity. Also known as a senior funder or senior lender, because the debt provided has priority to other debt (such as equity) and is repaid first by the project company.

debt service
Payments of principal and interest required on a loan over the period for which the loan is outstanding.

decommissioning
Removal of a facility (e.g. reactor) from service, also the subsequent actions of safe storage, dismantling and making the site available for other use.

DIT
Department for International Trade

EA
Environment Agency

ECA
Export Credit Agency – a quasi-governmental institution that acts as an intermediary between national governments and exporters to issue export financing.

EFWG
Expert Finance Working Group

EPC Contract
A contract for covering the engineering, procurement and construction of a facility.

equity funder
An investor who subscribes for equity in the project company or provides quasi-equity, in the form of subordinated debt. Also known as a junior funder or a junior lender, because the debt provided is subordinated to debt provided by the debt funders.

ETI
Energy Technologies Institute

export financing
Transactions involving one or more of the ECAs which can be either supplier credit or buyer credit agreements providing direct loans, guarantees or interest subsidies to parties involved in export transactions.

FCO
Foreign and Commonwealth Office

FDP
Funded Decommissioning Plan

FID
Final Investment Decision

FOAK
First-of-a-kind

FX
Foreign exchange

GBP
Green Bond Principles

GDA
Generic Design Assessment

gearing
Ratio of debt to equity

Green Bond
Any type of bond instrument where the proceeds are used for the financing/refinancing in part or full of new/existing eligible Green Projects and which are aligned with the four core components of the Green Bond Principles (GBP).

guarantee
Instrument being either a bond or guarantee, where performance of the obligations of a party to a credit or loan agreement are guaranteed by a third party, so that the third party will perform any obligations which the borrower fails to perform.

GW
Gigawatt – reference to the large nuclear projects which are typical of those recently built, currently under construction or planned globally.

HMG
Her Majesty's Government

HMT
Her Majesty's Treasury

HSE
Health and Safety Executive

HTGR
High temperature gas cooled reactor

ICMA
International Capital Market Association

investment bank
Term applied to a financial institution engaged in the issue of new securities, including management and underwriting of issues as well as securities trading and distribution.

IP
Intellectual Property

IPA
Infrastructure and Projects Authority

junior debt
Finance provided by the equity funders, who are also known as the junior lenders. Also known as subordinated debt.

LCOE
Levelised cost of electricity – the discounted lifetime cost of ownership and use of a generation asset, converted into an equivalent unit of cost of generation in £/MWh.

licensee
A company, organisation, institution, or other entity to which the domestic regulator grants a general license or specific license to construct, operate and/or decommission a nuclear facility, or to receive, possess, use, transfer, or dispose of source material, by-product material, or special nuclear material in accordance with a county's domestic law.

light water reactor (LWR)
A common nuclear reactor cooled and usually moderated by ordinary (light) water.

Manufacturing Capability Project Company
The company or companies with responsibility for manufacturing components, modules and/or reactors.

mezzanine debt
Debt that a borrower in financial difficulty will repay after senior debt, but before it repays other lenders and shareholders.

MSR
Molten Salt Reactor

NAMRC
Nuclear Advanced Manufacturing Research Centre

NDA
Nuclear Decommissioning Authority

NIA
Nuclear Installations Act

NIRO
Nuclear Innovation and Research Office

NOAK
Nth-of-a-kind

NPV
Net Present Value – the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in capital budgeting to analyse the profitability of a projected investment or project.

NRC
Nuclear Regulatory Commission (US)

NRI
Nuclear Risk Insurers

Nuclear Power Project (NPP) Development Company
The company established to develop the nuclear power project and therefore the owner of the nuclear power project.

ONR
Office for Nuclear Regulation

Operating Company
Any person, organisation or government entity licensed to undertake the operation of a nuclear facility. Note this may not be the same as the Operator as established by the Liability Conventions.

overnight capital cost
The cost of constructing a reactor if no interest was incurred during construction, as if the project was completed "overnight."

owner
The legal owner of the nuclear power plant.

PPA
Power Purchase Agreement

pressured water reactor (PWR)
The most common type of light water reactor (LWR), it uses water at very high pressure in a primary circuit which is heated and used to heat water in a secondary circuit which is used to produce steam.

project finance
The financing of projects based upon a non-recourse or limited recourse financial structure where project debt and equity used to finance the project are paid back from the cashflow generated by the project and the financiers have no recourse or only a limited recourse against the other assets of the project sponsors.

RAB
Regulated Asset Base

rating
A letter grade signifying a security's investment quality. The most commonly used rating agencies are Moody's, Fitches and Standard & Poor's.

reactor pressure vessel (RPV)
A strong-walled container housing the core of most types of power reactors. It usually also contains the moderator, neutron reflector, thermal shield, and control rods.

refinancing
Repaying existing debt and issuing new securities or borrowing a new loan or undertaking some other form of replacement financing arrangement, typically to meet some corporate objective such as the lengthening of maturity or the lowering of margins following construction.

risk allocation
The process of apportioning responsibility for various risks, or operational or financial issues, to the different parties involved in a project.

risk register
A table identifying the risks involved in a project, indicating the provisional risk allocation for each risk and any mitigation of that risk, such as insurance.

senior debt
Finance provided by the debt funders, who are also known as the senior lenders.

Site Licensee
The entity that holds the nuclear site license in the UK. The nuclear Site Licensee has responsibility for nuclear safety, security and safeguarding on the nuclear site.

small nuclear
Any small nuclear reactor technology that has the potential to be commercially deployed for the production of power and possibly heat including micro generation through to larger technologies around 600MWe.

SMR
Small Modular Reactor. A term used to describe a wide range of nuclear reactor technologies under development. The common attributes they share are that they are smaller than conventional nuclear power station reactors and are designed so that much of the plant can be fabricated in a factory environment and transported to site. Note that for the purposes of this report the IAEA definition of SMRs being below 300MWe is not rigidly applied. Also note that BEIS' definition of SMRs is that they are based on conventional water-cooled designs. This technology distinction is not made throughout this report as the EFWG have considered small nuclear more broadly.

sovereign guarantee
A guarantee provided by the host government that a loan or other obligation will be satisfied in whole or part if the borrower defaults.

SPV
Special purpose vehicle.

Technology Development Company
The company with responsibility for developing a small nuclear technology.

tenor
The length of time until a loan becomes due for repayment; often used to describe the length of time until the final instalment of the loan repayment schedule is due for repayment.

TRL
Technology Readiness Level

UKRI
UK Research and Innovation – the national funding agency investing in science and research in the UK. UKRI brings together the 7 Research Councils, Innovate UK and Research England.

Vendor
Reactor technology owner

WACC
Weighted average cost of capital – the average rate of return required or demanded on funds deployed (e.g. equity and debt) to finance an investment.

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