Programme Area: Nuclear

Project: SMR Deployment Enablers

Title: SMR Deployment Enablers final project and summary reports

Abstract:

The Small Modular Reactor (SMR) Deployment Enablers Project will set out the critical enabling actions that are required in order to retain the option of deploying flexible SMR technology as part of the UK's low carbon transition to 2050. This deliverable (Final Project and Summary Reports) supersedes previous interim Deliverables, or Deliverable Packs, uploaded to the ETI members portal. The project uses established programme development tools and techniques to define an integrated schedule leading to UK SMR deployment and first operations by 2030. The reports explain the logic and necessity for the enabling activities during the first 5 years of such a programme.

Context:

The purpose of the SMR Deplyment Enablers project was to identify the activities needed to take place in the first five years of a development plan for UK SMRs and the necessary capability of the SMR utility/developer organisation during this phase. Selection processes are out of scope so the starting assumption for the project is that both the SMR utility/developer and reactor vendor have already been identified.

Energy Technologies Institute

Small Modular Reactor (SMR) Deployment Enablers Project

15th July 2016

Summary Report

Decision Analysis Services Ltd

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CONTENTS

1 EXECUTIVE SUMMARY

This report contributes to a wider study commissioned by the Energy Technologies Institute (ETI) to understand the opportunities for the deployment of Small Modular Reactors (SMR) as part of the transition towards a UK low carbon energy system. This wider study has considered key factors such as siting criteria and the potential locations for early SMR deployment in the UK; and the development characteristics, timescales, operational performance and cost envelope for SMRs to be an attractive technology.

Building on the findings from this earlier work, the SMR Deployment Enablers (SDE) Project identifies the enabling activities that would be necessary in the first five years of a programme to support potential operations of a first UK SMR by 2030.

Although the case of a single prospective developer/operator and vendor grouping is considered, this project is not constrained to one given scenario. Indeed, the project considers the route map for SMR deployment in generic terms, with detail explored to a level sufficient for examining the required activities, interactions and risks. Therefore, the applicability and durations of certain activities within this route map will vary in practice, according to the particular circumstances of a given combination of developer / operator / vendor electing to embark on such a deployment programme. However, the identified enabling actions are likely to be common.

The project has used a range of tools and techniques that are commonly employed in the management and analysis of major programmes to provide a structured and systematic framework upon which to develop, analyse and articulate a body of evidence relevant to SMR deployment in the UK. This evidence has been compiled by nuclear industry professionals with experience gained from recent large reactor new build programmes in the UK, from the perspectives of investment case development, risk and assumption management, nuclear operator organisational design, regulatory permitting and consents, technology requirements, stakeholder management and analysis of Government policy.

The premise of an SMR deployment differs from a large reactor new build as a result of a range of factors, including:

- The role of design standardisation in enabling economies of multiples.
- The potential for a staged (and therefore more affordable) roll-out of GW tranches of generating capacity.
- The potential of the technology to offer alternative operating modes and therefore diverse revenue streams.
- The potential deployment of SMRs at sites not suitable for large reactors, enabling additional potential nuclear sites and nuclear generation capacity.

These differences from large reactors would certainly be manifested in the structure of an SMR deployment programme. However, it is important to note that SMR deployment projects must address *the same* range of regulatory processes as large reactor programmes in the UK, with the bar associated with licensing a prospective operator and site being set at the same level irrespective of the SMR technology employed. It must also address a *potentially greater* challenge in gaining public acceptance, especially where the locality has no previous experience of nuclear developments and the technology will be unfamiliar to most. Hence the challenges associated with gaining acceptance of the technology from local, national and European stakeholders are likely to be comparable to those associated with large reactors; with particular consideration needing to be paid to the location of early deployment sites.

The scope of required activity within the first five years of a First of a Kind (FOAK) SMR deployment programme has been captured within a Work Breakdown Structure (WBS). This WBS outlines the

discrete tasks to be considered by Government, the Regulators, the developer / operator, and the vendor.

The inter-dependencies between these activities are highlighted within descriptions provided for each WBS item. This has been set against a timeline for deployment, which draws out the logical sequencing of activity and the required interaction between each party involved, in the form of an integrated schedule. This schedule recognises the likely impact of unmitigated delivery risk on the behaviour of private sector investors and the consequential sequencing of activity.

Investor confidence therefore emerges as a fundamental factor when considering the timely delivery of a large scale and highly integrated delivery programme. Indeed, with the aspiration for FOAK SMR operation by 2030, Government is perceived to play a crucial role in creating the "right" investment environment. A timeline is therefore presented, which represents the impact of enabling action being taken to create this investment environment.

It is important to note that the development of such a schedule is not an attempt to predict or recommend a delivery plan, or to comment on the likelihood of achieving FOAK operation by 2030. Rather it is an attempt to identify what actions would be needed, and where delay would be most problematic, if FOAK operation by 2030 was the required outcome.

In considering the scope and timescale for FOAK deployment of SMRs in the UK, the following main conclusions are reached.

Implementation of an FOAK SMR is possible without facilitative action by Government. However, the complexity and non-prescriptive nature of the UK's consenting processes and the scale of the risks that remain through into first operation make it unlikely to be attractive for investors to make the scale of commitment necessary to achieve FOAK SMR operation by 2030.

Pre-Final Investment Decision (FID) investor confidence is of critical importance for achieving the 2030 timeline. Securing and maintaining pre-FID investor confidence will dictate whether the necessary commitment to time-critical decisions / actions is made by those leading delivery. Government and the developer / operator play a key role in creating an environment that fosters this confidence through the progressive reduction of perceived risks.

For an effective programme to achieve FOAK SMR deployment, significant Government commitment and facilitative action is required from the outset. Government action to promote investor confidence is required from the outset since the 2030 FOAK timeline requires the private sector to commission a wide range of work (related to technology, site selection and site development) early within the initial five years**.** Indeed, Government should remain engaged with the progress made and upcoming decision-points of the private sector delivery plan, and ensure that these interactions support the required evolution of the investment case. The specific actions to be considered by Government include:

- Addressing all potential areas of legal challenge so as to deliver a secure, legally robust framework for investment in a FOAK project. This should recognise the adequacy of existing policy and legislation in light of the proposed plans for SMR FOAK operation by 2030 and the experience gained from recent large reactor new build programmes.
- Engaging proactively with potential investors so as to understand and act on their perspective on the UK's fitness for investment in SMR design approval and implementation projects.
- Assessing, reviewing and influencing policy development at UK, European and international level which bears on electricity, nuclear and climate change.
- Providing a prospective vendor and developer / operator from the outset with comprehensive advice and guidance on negotiating the UK's policy, regulatory, land-use planning, and waste and decommissioning liability funding processes.

Without such actions being taken, the timeline associated with an entirely market-led deployment could result in FOAK operation nearly a decade late against a 2030 target.

It is insufficient for the first 5 years of the deployment schedule to focus on just Generic Design Assessment (GDA) and Regulatory Justification. Achievement of FOAK operation by 2030 requires private sector developers undertake a range of activities in parallel, in a manner that increases the complexity of the schedule interactions, and it demands that certain activities be performed at risk. In particular, wider work to develop the site specific aspects and credibility of the operator must commence early if the timeline is to be achieved. To underpin this:

- The developer / operator should formulate a coherent SMR business case and engage in the Government's strategic siting assessment process so as to establish a portfolio of potentially suitable SMR sites to support this business case.
- Preliminary work will be required ahead of FID (i.e. at risk). This includes work to develop the site (such as non-nuclear construction, non-nuclear safety related grid connection and local infrastructure) as well as to de-risk the SMR manufacture and testing timeline (through early procurement of long-lead items).

A strong and early marriage is required between developer / operator and vendor. Although SMR technology may differ in financial scale from that used in recent large reactor new build programmes**,** the bar to licensing a prospective operator / site in the UK is set to the same consistent standard.

The prospective licensee must present credible plans that demonstrate Intelligent Customer and Design Authority capability in respect of the SMR technology. This must include adequate oversight of the vendor's design and development (including relevant manufacturing / assembly activity performed by the vendor's supply chain). Therefore, the prospective operator must develop the required competency at an early stage of the deployment programme in order to assure itself of the adequacy of the vendor's generic design; the optimal boundary between generic and site specific aspects; and the plans for achieving economies of multiples beyond the development and deployment of the FOAK. To this end**,** a strong and early marriage is required between developer / operator and vendor. This must be credible not only in terms of the individual parties involved but also in the terms of their marriage (complementary offerings without anti-trust concerns, a shared delivery vision, access to the full coverage of required resources such as finance, experienced people, etc.).

The notion of a developer / operator / vendor 'boot camp' is proposed as a near-term risk mitigation activity. This recognises the requirement for close-working between all stakeholders involved in a SMR deployment project. The detailed scope of this boot camp should be considered further, however overall it should seek a common understanding by all parties of the required capabilities, information, interactions and timescales. In particular, where parties inexperienced in the UK nuclear market are participating in a SMR deployment project, they may need education in the standards and expectations of the UK regulatory and operating environment.

Deployment of a FOAK SMR in the UK is achievable by 2030 under the bounding scenario considered by this study. This is conditional on facilitative actions being implemented. It should be noted that the actual durations, sequencing and overall timeline of SMR deployment will depend on the specific organisational, commercial and financial characteristics of the parties engaged in such a programme and the SMR technology selected. However, the generic scenario considered by this study incorporates the following bounding conditions:

- That both the developer / operator and the vendor are credible parties to lead an integrated delivery programme:

i. The vendor's technology is sufficiently mature from the outset of the programme to enable GDA and Regulatory Justification to commence early and progress systematically supported by timely submission of evidence.
ii. The developer / operator and vendor have access to sufficient funding (equity or debt) to support the staged investment decisions.
iii. The developer / operator and vendor commit from the outset to a close working arrangement (in whatever commercial / legal structure may be appropriate).

- That substantive work commences in early 2017 (noting that a later start reduces the credibility of achieving FOAK operation by 2030).
- That the approach to site selection for FOAK deployment avoids potentially contentious locations, in order to avoid creating undue challenges from local / regional stakeholder groups.
- That the local infrastructure development excludes work to supply district heating; with FOAK deployment focussing on electricity generation only. Future district heating capability may be accounted for within the design on a 'fitted for but not with' basis.

The scale of the recruitment challenge to establish a Nuclear Baseline should not be underestimated, with staged planning essential. A SMR developer/operator must unequivocally establish itself as a credible nuclear operator, including Design Authority and Intelligent Customer capability, and the power to be a Controlling Mind.

Regulators will need to be able to resource-up without adverse influence on current UK nuclear safety activity. It is recognised that the UK has finite SQEP resource (both direct and indirect) to support the regulatory processes of GDA, Regulatory Justification and site specific assessment. Concurrent regulatory assessment of SMR and large reactor licensing projects may only be achievable where careful consideration is given to the 'prequalification' of vendors (married to credible developer / operators) entering this process.

A co-ordinated public communications plan is required, led by the prospective Licensee, supported by the vendor and facilitated by Government. The developer / operator will lead many of the activities associated with the deployment programme. Achievement of the 2030 timeline will rest, in part, on the competency of this organisation to plan and drive the delivery of a highly integrated schedule, drawing in the inputs, as required from all parties. This requirement extends to the need for the developer / operator to address issues of public perception concerning the deployment of FOAK SMR technology in the UK: an activity that requires a co-ordinated public communications plan, led by the prospective Licensee, supported by the vendor and facilitated by Government. This is an important factor when considering the risk of potential applications for Judicial Review. A priority for the developer / operator is to establish an early, credible presence local to the FOAK site, with the influence to optimise the project's local benefits and mitigate its impacts.

Bounding assumptions were judged to be sound in the context of a deployment schedule leading to a UK FOAK SMR operating by 2030. A number of assumptions were used at the outset to bound the study. Although these assumptions are unlikely to be totally representative of any specific vendor / developer / operator solution, it was accepted that they remained sound at the completion of the study.

The evidence gathered in this study forms the basis of a toolkit which could be used to test or assess the feasibility of specific scenarios for SMR Deployment in the UK. While outside the scope of this study, which assumed a single non-specific solution for the vendor/developer/operator, the evidence (WBS, assumptions, risks and schedules) developed could be used to test or assess a wide range of proposed options for SMR deployment in the UK.

2 INTRODUCTION

2.1 Context

This study contributes to a wider study commissioned by the ETI to understand the opportunities for the deployment of SMR as part of the transition towards a UK low carbon energy system. This wider study has considered key factors such as siting criteria and the potential locations for early SMR deployment in the UK; and the development characteristics, timescales, operational performance and cost envelope for SMRs to be an attractive technology.

Building on the findings from this earlier work, the SDE Project explores the answer to the following critical question:

"What are the enabling activities in the first five years of an SMR programme necessary to support potential operations of a first UK SMR by 2030?"

2.2 Project objectives

The SDE Project is ultimately seeking to determine if UK FOAK SMR operations around 2030 may be possible through timely managed implementation of enabling activities. This purpose has been achieved through three subsidiary objectives:

- Establish the activities comprising the first five years of a development programme for the UK deployment of a SMR.
- Establish a timeline with milestones to accompany this programme definition.
- Establish the necessary capability of the SMR developer/operator organisation during this phase of a UK SMR development programme.

No account is taken in this report of the outcome of the very recent referendum on membership of the European Union and its implications for Regulatory Justification and Euratom Treaty requirements.

2.3 Report structure and deliverables

This report sets out the evidence which has been gathered throughout the project and discusses the analysis of this evidence in response to the main three objectives.

Section 3 – describes the approach to conducting the project, including the means and modes of a) evidence collection/creation and b) assurance of the quality of evidence and analysis.

Section 4 – describes the evidence which has been built by way of discrete deliverables, including a WBS, considerations for organisational design, separate market led and facilitated integrated programme schedules, and the assumptions and risks identified which relate to this work.

Section 5 – discusses the analysis and expert reflection on the evidence which has been gathered, and the consideration of what has been learnt. These sections are presented on key themes: securing FOAK operation by 2030, the role of investor confidence, and the importance of the first five years.

Section 6 – presents the key conclusions arising from this analysis.

Appendix I – sets out key definitions and a list of acronyms.

The detailed output of this work is captured in the SDE Project Final Report which is held by ETI.

3 PROJECT APPROACH

The project approach centres on the development of a conceptual route map for deployment of a FOAK SMR, using a range of techniques commonly employed in the management and analysis of major programmes. These techniques form both the tools used to develop the study evidence and, after iterative development by a team of nuclear industry and programme management experts, form the evidence itself. This dual use of the techniques is shown in Figure 1.

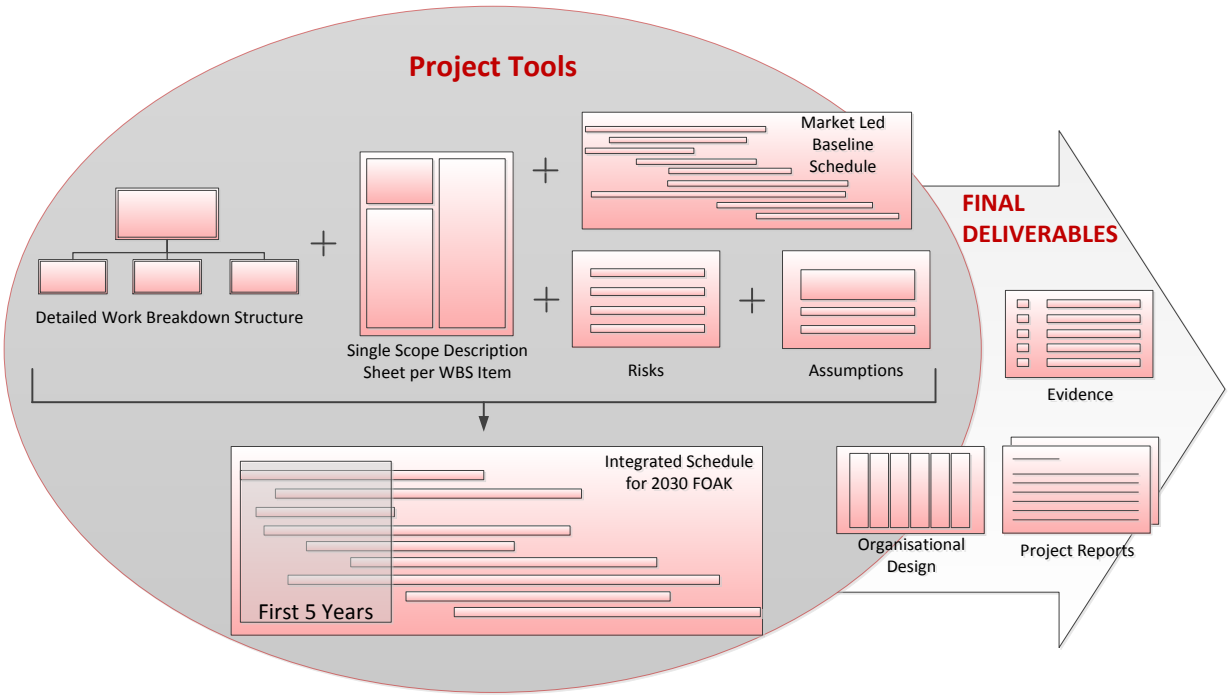


Figure 1: Project Tools and Work Flow

The tools consist of a WBS and associated descriptions of each element, schedules of activity, a Master Assumptions and Data List (MDAL), and a Risk Register

The use of a WBS, scope descriptions, integrated schedules, and risk and assumptions registers provided a structured and systematic framework upon which to develop, analyse and articulate the required scope of the first five years of the SMR deployment programme.

The evidence developed consists of a WBS and associated descriptions, considerations for organisational design of an SMR developer and associated operator, a market-led schedule, a facilitated schedule, assumptions, and risks and opportunities.

Iterative development of each area of evidence was achieved through the application of the tools in team workshops, individual task work and 1-2-1 focussed review sessions. The tools not only informed their associated evidence area but also interactively developed other evidence areas.

At each stage of the iterative evidence development quality assurance methods were appropriately applied, along with the issue of interim deliverables to ensure ETI satisfaction with the evidence during its staged development. Such interim reviews provided progressive quality assurance of the fitness for purpose and accuracy of the evidence creation and analysis. This included:

- A detailed kick-off meeting and information day.
- Collective and task-level pre-job-briefings.
- Independent task level review and sign-off.
- Overlapping internal peer review, through 1-2-1 and workshop challenge.
- Progressive development of project deliverables.

- Periodic validation of findings.
- Verification of references from research.
- Formal sign-off from each team member on all project content, providing further internal peer review and agreement.

Consistent with the methodology, the Project Team was selected to bring significant experience of the UK nuclear new build sector, alongside expertise in major programme delivery support.

4 EVIDENCE

4.1 Work Breakdown Structure

The WBS is intended to enable exploration of the range of activities that must be undertaken over the first 5 years of the SMR development programme. The WBS is intended to be illustrative and appropriate for the purpose of the project, but it is not necessarily exhaustive and complete for a specific solution. In its derivation activities either side of the 5 year period have been considered to ensure completeness of the activities that are required in the first five years to enable FOAK operation by 2030.

The final version of the WBS is presented in Figure 2 on the following page. At the top level it consists of the following areas:

WBS 1: Facilitative action by UK Government - covers actions needed to update the facilitative framework established by UK Government for current new nuclear projects.

WBS 2: Understand and negotiate business case - covers the approach that a prospective SMR developer/operator may be expected to take in constructing a robust business case to justify and underpin the viability of a future development, from conception through to FID.

WBS 3: Establish credible nuclear operator - covers the characteristics, qualities, requirements and culture of an entity which could be licensable under the UK nuclear safety, security and environmental regulations.

WBS 4: Select and acquire site(s), seek consent for preliminary works - covers the work required to achieve a legally robust designation of potentially acceptable sites for SMR deployment, to develop and submit a competent application for development consent, and to establish necessary commercial terms for deployment together with local planning applications for any necessary advance works.

WBS 5: Accelerate technology development - covers development of the maturity of a given vendor technology (rather than any process associated with selecting it) and supply chain, in a manner that supports the premise of the business case.

WBS 6: Establish approved funded decommissioning programme - covers establishment and approval of the Decommissioning and Waste Management Plan and Funding Arrangements Plan, together with agreement on associated Waste Transfer Contracts.

WBS 7: Obtain assessments, permitting and consents - covers securing Design Acceptance Confirmation, Statement of Design Acceptability and compliance with Euratom Treaty provisions, then a Nuclear Site Licence, environmental permits and development consent for the FOAK site.

WBS 8: Identify and engage with FOAK stakeholders – covers identification of stakeholders affected by a proposed project or able to influence or contribute to its success, and establishment of ongoing interfaces through which relevant issues can be addressed.

WBS 9: Initiate supply chain development - covers de-risking actions to ensure a capable and qualified UK supply chain with the capacity to provide long-term support to a UK SMR programme.

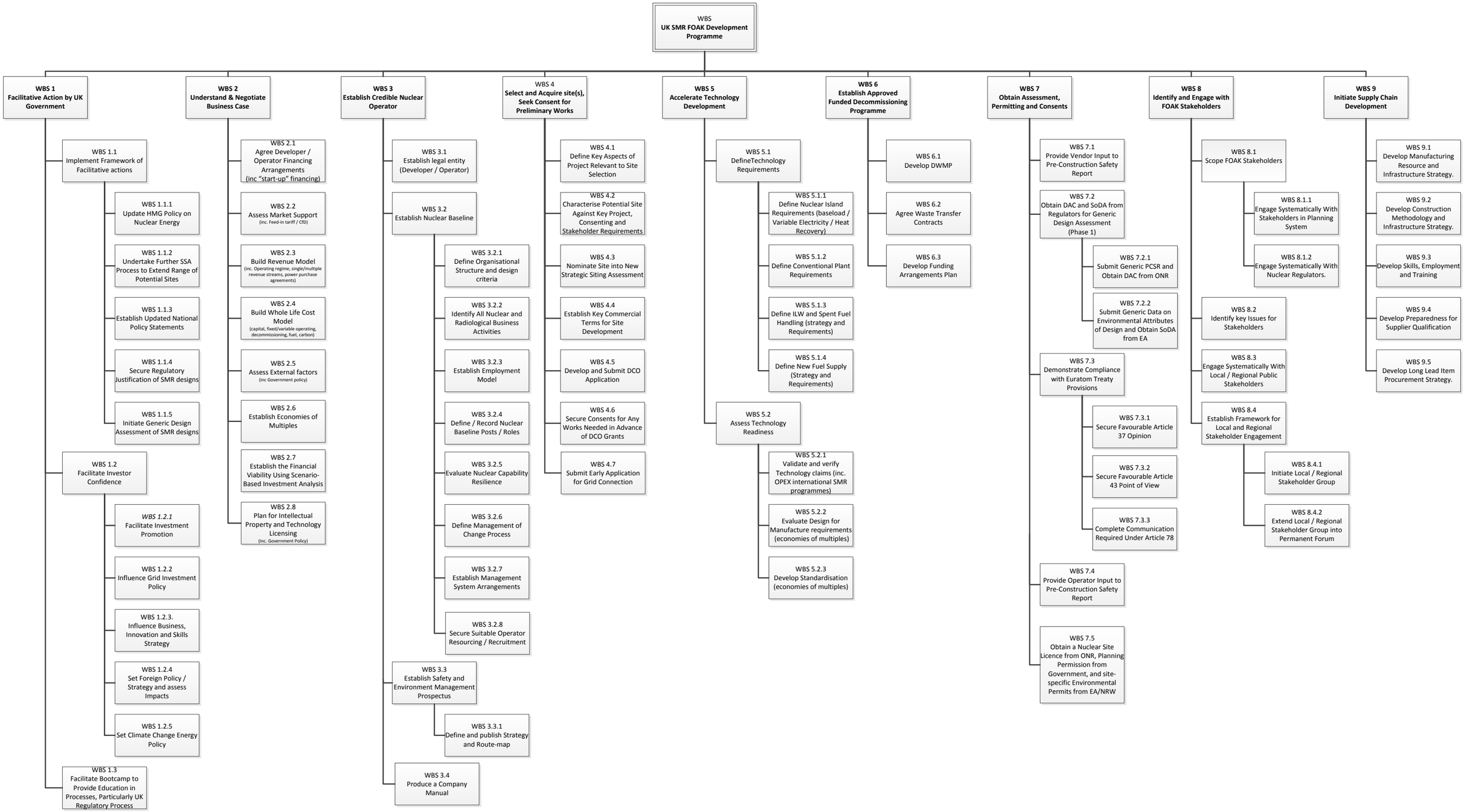


Figure 2: Work Breakdown Structure

4.2 SMR developer and organisational design of the associated operator

This element of the evidence covers two discrete perspectives on organisational design; one upward-looking, focussed on the corporate structural features of the SMR developer / operator, and one inward-looking, focussed on the internal organisational capabilities required within the SMR developer / operator organisation. An illustration of these perspectives is shown in the following Figure 3. Key notes are provided in the following sections.

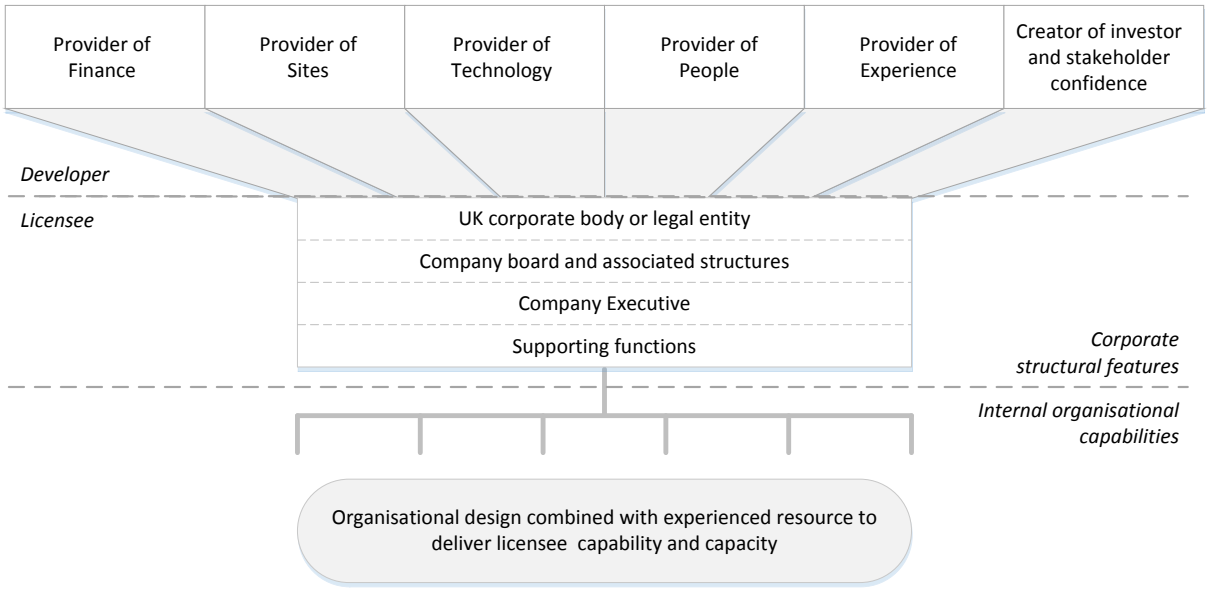


Figure 3: Organisational Design

4.2.1 Corporate structural features

The distinction between the developer organisation and the prospective nuclear site licensee is critical, and needs to be fully appreciated.

In order to secure a Nuclear Site Licence, the prospective licensee needs to establish to the Regulators' confidence that it understands the characteristics and hazards of the plant it proposes to construct and operate, and has or will have the capability to control these effectively by the time they arise. Once its licence is granted, it is subject to a wide range of duties and controls, together with absolute technical and financial liabilities for example in the case of accidents. Furthermore, it cannot end its period of responsibility for its licensed site until it can satisfy the Regulator that there is no longer any danger from radioactivity on the site.

For a developer whose business is wider than the development and operation of one or more UK SMRs, these duties and controls may be unduly restrictive. In such cases, the developer(s) will generally establish the prospective licensee as a separate subsidiary.

However, in this case the relationship between the parent and its subsidiary is different from the norm under company law. In particular, to enable the subsidiary to be licensed, the parent itself will need to ensure that it will have access to the resources it needs to support the licensee to maintain the safety of the licensed site – noting, the licensee cannot devolve its responsibility for safety. The parent will also need to ensure that the subsidiary has the information and power to satisfy itself on the nuclear and radiological acceptability in UK environment of the plant design and the systems, structure and components procured, and to require these to be changed where it has not been satisfied.

In this situation, it is apparent that there is a significant risk of redesign, rework or even project failure if the prospective licensee is not created until after the safety-significant design and procurement decisions have been made.

Nevertheless, there are a range of other aspects of project initiation which the developer can initiate without needing the licensee to participate actively at the outset. Indeed, where the developer wishes to retain unfettered ownership of intellectual property, for example in the reactor design and any generic regulatory approval gained to support this, it may be essential for the parent to take the lead. However, it will still be necessary for the future operator (Licensee) to be provided with the necessary information for it to understand the SMR it is then responsible for.

Accordingly, the work in this area focuses on the capabilities and experience which, based on experience of other UK nuclear projects, the developer must embody in order to progress an SMR project with minimum risk of failure or delay.

The work will then identify the activities and processes which it is essential that the developer addresses, and where it can take an early lead.

The requirements may be met in a number of ways, depending on whether the developer organisation is a single corporate entity with a full range of in-house capabilities, experience and resources, or alternatively a partnership or joint venture in which each participant makes its own contribution. The key point is that, collectively or individually, all the requirements should be addressed including:

Provider of finance: Taking into account the profile over time of increasing financial commitment versus reducing risk to the lifetime value of the project, and including the financial commitment necessary to support the licensee.

Provider of secure access to a suitable site or sites: With geographical, demographic, geological and meteorological characteristics and access to transport networks, cooling water and grid connections that make them capable of being successfully nominated into any new strategic siting assessment and subsequently licensed, permitted and consented under the UK's regulatory and land-use planning systems.

Provider of key nuclear technology: Certainly for the reactor, and also where appropriate for the lifetime storage technology for spent fuel and higher level wastes which is designed for that reactor. This includes the intellectual property necessary to enable licensing, permitting and consenting in the UK regulatory and planning environment.

Provider of suitably qualified and experienced staff: For both the developer and the licensee, particularly with experience in developing and undertaking major projects, major infrastructure-scale procurement and supplier engagement, nuclear legislation, and building constructive relationships with Government, financial and public stakeholders at all levels.

Direct experience of construction and/or electricity generation: Preferably nuclear construction or operation in a regulated environment somewhere in the world, and/or management of major infrastructure projects in the UK or a similarly regulated environment somewhere in the world, and/or participation as generator in the UK electricity industry.

Creator of investor and stakeholder confidence: Experienced in investor relationship management and interfacing with various stakeholders.

4.2.2 Organisational capability and capacity

Key features of Developer / Operator as licensee

The structural features of the developer / operator as a licensee include establishment as a UK corporate body / legal entity, appointment of a company board with associated structures, appointment of a company executive team, and supporting functions to provide capability and capacity.

To become a credible steward of an SMR installation, compliant with the requirements and expectations of the nuclear Regulators, the licensee must embody a number of key features. These cover its organisational structure (such as Design Authority and Intelligent Customer functions), its culture (such as questioning and learning attitudes), its management processes (such as robust governance and management of organisational change), and its financial and commercial arrangements.

In particular, its agreements with fund providers – including its own parent – must ensure it has secure access to the resources needed to ensure safety, and those with safety-significant vendors – including the owner of the SMR design – must ensure it is the controlling mind in specifying and accepting designs for the key systems, structures and components of the SMR. That is, it has the autonomous decision making capability for all issues related to nuclear safety.

Staged development of key features

UK regulatory requirements are applied in a proportionate way. The SMR installation will pass through successive stages of development from design definition through pre-construction, nuclear construction, inactive commissioning, active commissioning and commercial operation. At each stage, the arrangements expected to be in place within the potential licensee will be proportionate to the hazards and risks to the public and the environment at that stage. In the early stages, a potential or candidate licensee is not expected to have all the features in place that will be required to support future operation.

Nevertheless, the licensee must have a clear view and forward plan for the progressive development of its breadth of capability and depth of resource capacity, so as to convey confidence that it has a coherent development pathway, with new capability implemented in good time in advance of need.

Interaction with GDA

Furthermore, certain requirements – in particular, Design Authority and Intelligent Customer functions – are essential at the outset. This arises from the licensee's role with respect to GDA.

Here the Requesting Party engaging with the Regulators would be the SMR technology vendor, rather than the licensee. Accordingly, the vendor will submit information on the design and performance of the structures, systems and components that make up the SMR, together with assumptions on how it will be operated and maintained. It is critical that the prospective licensee has the capability and power to ensure that this information is consistent with its own expectations and requirements.

Contractor resourcing

For a prospective new licensee who cannot benefit from a history of nuclear operation under the UK regulatory regime, and which therefore has limited scope to provide or develop competent and experienced staff from its own resources, it will be essential to draw on support from contract partners.

The nuclear Regulators draw an important distinction between, on the one hand, staff seconded under contract but located within the licensee's own organisational roles and management arrangements; and on the other, staff providing safety-related services from positions within a contractor's organisation and management arrangements. In the former case, the resource is

considered as an integral part of the licensee; in the latter, the specification of the work and acceptance of its outputs must be subject to a formal Intelligent Customer process.

Relating development stage to timeline

The required evolution of the organisational capabilities and capacity of a potential / candidate licensee is determined by the stage of development of the SMR installation from design through to operation, alongside the corresponding progress of licensing and permitting from pre-application consultation through formal application to grant.

This evolution was explored through discrete stages of the programme development and mapped against the indicative timeline of the integrated schedule, and is contained in the full report.

4.3 Schedules

In order to deliver relevant and insightful conclusions, it has been important to consider a route map that is not specific to one particular solution / scenario of vendor technology or vendor / developer / operator arrangements. With this in mind, the approach to this project considers the FOAK deployment route map in generic terms only, with detail explored only to a level sufficient for examining the likely interactions and risks. Accordingly, the applicability and durations of certain activities within this route map may vary in practice, according to the particular circumstances of any given vendor / developer / operator electing to embark on such a deployment programme.

Where formalised processes exist, these judgements draw on the relevant documented procedures – adjusted in light of experience gained from recent large reactor new build programmes in the UK; and accounting for the nuances that are likely to be associated with an SMR deployment programme.

It is important to establish first a baseline timeline, the "market-led schedule", to FOAK operation for a scenario in which the market leads the deployment of a FOAK SMR in the UK, *without external facilitative action* led by the government. This is useful for illustrating the timescales, scope and logical sequence of activity in an environment where the perceptions held by private sector investors of regulatory, legislative and commercial risk remain high throughout the early stages of the programme.

By constraining the completion date of the market-led schedule to 2030, a "facilitated schedule" was created to examine the required sequencing of activity, timing of decisions and required scope of activities to be undertaken within the first 5 years of a UK SMR deployment programme to achieve FOAK operation by 2030. Consistent with the WBS, this schedule considers the required activity and interaction of all parties involved in the delivery programme: technology vendor, prospective operator, Regulators and Government.

It is important to note that the development of such a schedule is not an attempt to predict or recommend a delivery plan, or to comment on the likelihood of achieving FOAK operation by 2030. Rather it is an attempt to identify what actions would be needed, and where delay would be most problematic, if FOAK operation by 2030 was the required outcome.

4.4 Assumptions

It is necessary to define a conceptual scenario upon which to frame and develop a deployment route map, WBS and schedule. In-order to create this scenario bounding assumptions have been applied in the work. Table 1 below contains the key assumptions that bound the study.

Ref	Assumption description
A1	The programme start point assumes that organisations have been identified both for the reactor vendor and the UK operator, and that the five year schedule starts from this point.
A5	Work undertaken will avoid a presumed assumption for a specific reactor vendor, developer, operator or owner. It will also avoid a presumed solution for how these roles may combine.
A117	It is necessary that at the end of the five year schedule, GDA would be substantially complete, and it is assumed that GDA is a 5 year process.
A118	The desired timeline for FOAK SMR operation in the UK is by 2030.

Table 1: Key bounding assumptions

4.5 Risk and opportunities

A high level risk analysis has been used in this project to support and challenge the development of the programme scope and schedule, and introduce and verify thought on enabling actions. It has been used to inform and substantiate the conclusions as part of the underpinning knowledge and evidence on which this project is based. The Risk Register grades risks into four categories: critical, high, medium and low. The 7 risks classified as critical are summarised in Table 2 below.

Ref	Risk Description
R3	Legal intervention by nuclear NGOs building on experience from 2008 programme.
R4	There is a risk that if you don't apply for Parliamentary time early enough, Parliamentary time will not be allocated.
R84	If the Safety and Environmental Management Prospectus document does not meet the required standards and/or there is insufficient evidence of its application then Licence Grant has the potential to be delayed by the Regulators.
R113	Over emphasising passive safety.
R118	PCSR evidence insufficient.
R146	Lack of supply chain appetite to invest in nuclear.
R152	Skills are not available in sufficient quantities in some vocations and professions due to demand elsewhere (nuclear and non-nuclear).

Table 2: Top Risks (classified as critical)

5 DISCUSSION OF EVIDENCE

5.1 Credibility of the market-led schedule

The premise of an SMR deployment differs from a large reactor new build as a result of a range of factors, including:

- The role of design standardisation in enabling economies of multiples.
- The potential for a staged (and therefore more affordable) roll-out of GW tranches of generating capacity.
- The potential of the technology to offer alternative operating modes and therefore diverse revenue streams.
- The potential deployment of SMRs at sites not suitable for large reactors, enabling additional potential nuclear sites and nuclear generation capacity.

These differences from large reactors would certainly be manifested in the structure of an SMR deployment programme. However, it is important to note that SMR deployment projects must address *the same* range of regulatory processes as large reactor programmes in the UK, with the bar associated with licensing a prospective operator and site being set at the same level irrespective of the SMR technology employed. It must also address a *potentially greater* challenge in gaining public acceptance, especially where the locality has no previous experience of nuclear developments and where the technology will be unfamiliar to most. Hence the challenges associated with gaining acceptance of the technology from local, national and European stakeholders are likely to be comparable to those associated with large reactors; with particular consideration needing to be paid to the location of early deployment sites. Finally, despite each reactor unit representing a smaller alternative to those employed by existing large reactor programmes, the generating capacity of any multi-unit site is likely to represent a nationally significant infrastructure project and a tranche of such SMR sites would require large-scale investment.

It is from this perspective that the timeline for an SMR deployment project must draw in the practical experience from recent large reactor projects in the UK, and recognise the likely implications of private sector investor behaviour. This overall timeline comprises a number of interrelated issues, including:

- The *technology*, including GDA, Regulatory Justification and maturity development.
- The *site*, including selection, acquisition, licensing, permitting and development consenting, and preliminary works.
- The *operator*, including the development of the required structures and capabilities, manning and licensing to be a credible nuclear operator.

The sequencing of these activities is driven by a number of factors, including fixed dependencies inherent within the regulatory consenting process and logical decision-points associated with the financial commitments being made.

5.2 Possible outcome of the market-led schedule

The high-level schedule associated with the market-led investment environment indicates that, without any enabling action, FOAK operation is possible but may exceed the 2030 target by a considerable margin (potentially, in the order of a decade later).

Table 3 sets out possible cumulative outcomes of a market-led schedule for FOAK SMR deployment.

Possible outcomes of a Market-led deployment schedule
Delayed commencement of GDA and/or completion in a timeframe > 5 years: • Potential issues securing regulatory resource / commitment (noting that GDA is not a statutory process) and the wider pressures placed on the Regulators by UK nuclear developers, UK nuclear operators and other national and international commitments. • Limited foreign vendor awareness of the UK regulatory context and the standards and expectations of GDA submissions and of Regulatory Justification.
Criteria necessary for compiling case for FID met by end-2028: • Commencement of substantive organisational development and site specific licensing activities only on completion of GDA and Regulatory Justification.
FID achieved as late as end-2030 (estimate): • Protracted period for FID, arising from a cautious investment environment, with achievement >12 months' following completion of necessary criteria.
>5 year timeline post-FID: • No preliminary works or long-lead procurement undertaken pre-FID (cautious risk approach). • Dual critical-path through extended construction phase and SMR manufacture / assembly.
2039 FOAK operation (estimate)

Table 3: Possible outcomes of a market-led delivery strategy

Conclusion 1 (C1): Implementation of an FOAK SMR is possible without facilitative action by Government.

5.3 Securing First of a Kind operation by 2030

5.3.1 The critical path

By working back from a 2030 target for operation, the basic logic of a critical path can be established, as shown in Figure 4, and this, in turn, defines the required activities by all parties involved:

- FOAK operation (subject to clearance of relevant regulatory hold points) would be preceded by a period of site / SMR construction and commissioning. Dominant within this period, *nuclear significant* construction and *active* commissioning would be likely to form the critical path leading to FOAK operation – the timescales for these specific aspects within the wider construction programme being dependant on the given circumstances of the site / design, although notionally considered to be a 5 year period.
- Commencement of *nuclear significant* construction (and *active* commissioning) cannot be undertaken without regulatory consent. Two required milestone precursors to this are the grant of a Nuclear Site Licence (NSL) by the ONR and approval of a Funded Decommissioning Programme (FDP) by the Secretary of State. It is important to note that the grant of a NSL places a wide range of obligations on the prospective operator and would represent a significant step-change in the commitments being made by the developer / operator, over and above the financial commitments incurred through the contracts for nuclear significant construction and the Waste Transfer Contracts supporting the FDP. It may therefore be logical for an investor to

link a FID to, *inter alia*, the grant of a NSL; and for the request for a NSL grant to be delayed to the latest possible point in the programme, in order to enable wider preliminary non-nuclear related site construction work to be undertaken without the need for regulatory consents.

- Pre-FID activity would broadly subdivide into four themes, which influence and would ultimately trigger FID: (i) the *technology*, including generic regulatory assessment, Regulatory Justification and development of a mature design; (ii) the *site*, including selection, acquisition, licensing, consenting and preliminary works; (iii) the *operator*, including the development of the required structures and capabilities, manning and licensing; and (iv) a series of staged investment cases, culminating in FID. The timescales for developing these to a level necessary for FID in 2025 would depend on a range of factors such as the technical suitability of the site and its status in the existing Nuclear National Policy Statement (NNPS), local stakeholder support, and vendor design maturity. Moreover, the required phasing of activity will depend on how late work commences on each of these four themes following the identification of a credible vendor and operator. To illustrate this point, a five-year process of GDA commencing in early 2018 would leave less than three years between GDA completion and the deadline for FID. Within this window, it should be noted that assessment of applications for a Site Licence and environmental permits and the process for securing Development Consent could each take over a year. Such circumstances would require preliminary work to be undertaken ahead of GDA, from early 2017, in order to ensure a timely start and efficient execution of the regulatory consenting process; and development of both operator and site licensing to commence in parallel with the GDA process.

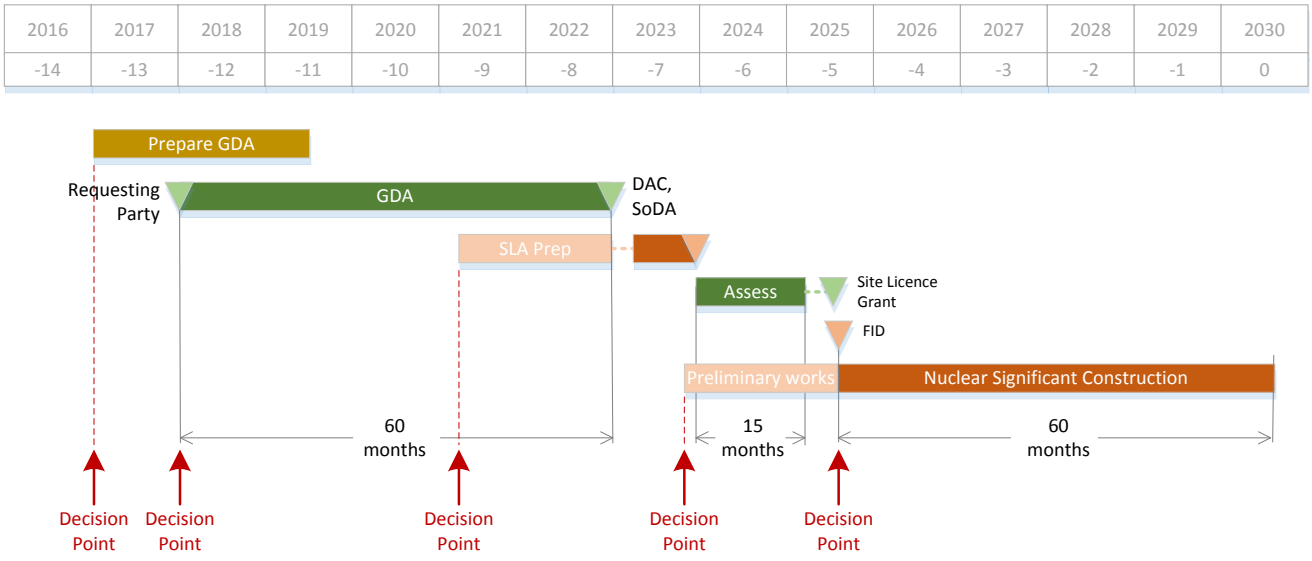


Figure 4: An abridged critical path to 2030 FOAK operation

5.3.2 Required outcomes of a 2030 deployment schedule

Table 4 summarises cumulative outcomes required for FOAK operation by 2030 and contrasts these with the market-led schedule:

Required outcomes of 2030 deployment schedule		Likely outcomes of a Market-led deployment schedule
Required Outcome 1	**Early commencement of GDA and Regulatory Justification, and completion within a 5 year timeframe**	**Delayed commencement of GDA and Regulatory Justification, and/or completion in a timeframe > 5 years** Potential issues securing regulatory resource / commitment. Foreign vendor awareness of the UK regulatory context and the standards and expectations of GDA submissions
Required Outcome 2	**Criteria necessary for compiling case for FID met by end-2024** Commencement of organisational development and site specific licensing activities in parallel with GDA and Regulatory Justification (at risk).	**Criteria necessary for compiling case for FID met by end-2028** Commencement of substantive organisational development and site specific licensing activities only on completion of GDA and Regulatory Justification.
Required Outcome 3	**FID achieved by mid-2025** Efficient process for FID, achieved <12 months' following completion of necessary criteria	**FID achieved as late as end-2030** (estimate) Protracted period for FID, arising from a cautious investment environment, with achievement >12 months' following completion of necessary criteria.
Required Outcome 4	**5 year timeline post-FID** Dominated by nuclear significant construction. Preliminary site works commenced ahead of FID (at risk) SMR long-lead procurement commenced ahead of FID (at risk)	**>5 year timeline post-FID** No preliminary works or long-lead procurement undertaken pre-FID (cautious approach to risk) Dual critical-path through extended construction phase and SMR manufacture / assembly
	2030 FOAK operation	**2039 FOAK operation** (estimate)

Table 4: Comparison of the required versus likely outcomes of a market-led delivery strategy

5.4 Key decision points and the role of investor confidence

The timeline in Figure 4 reveals three critical distinct decision-points associated with the commencement of work necessary to secure 2030 operation:

- The decision by private sector investors to bring together necessary resources under a shared vision to pursue a FOAK SMR deployment by 2030.
- The decision(s) by private sector investors to commence preparations for site-specific licencing, permitting and consenting early, ahead of completing GDA and Regulatory Justification (i.e. at risk), in order to secure FID five years ahead of FOAK operation.

- The decision by private sector investors to commence nuclear significant construction (where consented under a nuclear site licence) and other high value works – FID.

These are further elaborated in Figure 5, as part of a gated review process for project delivery.

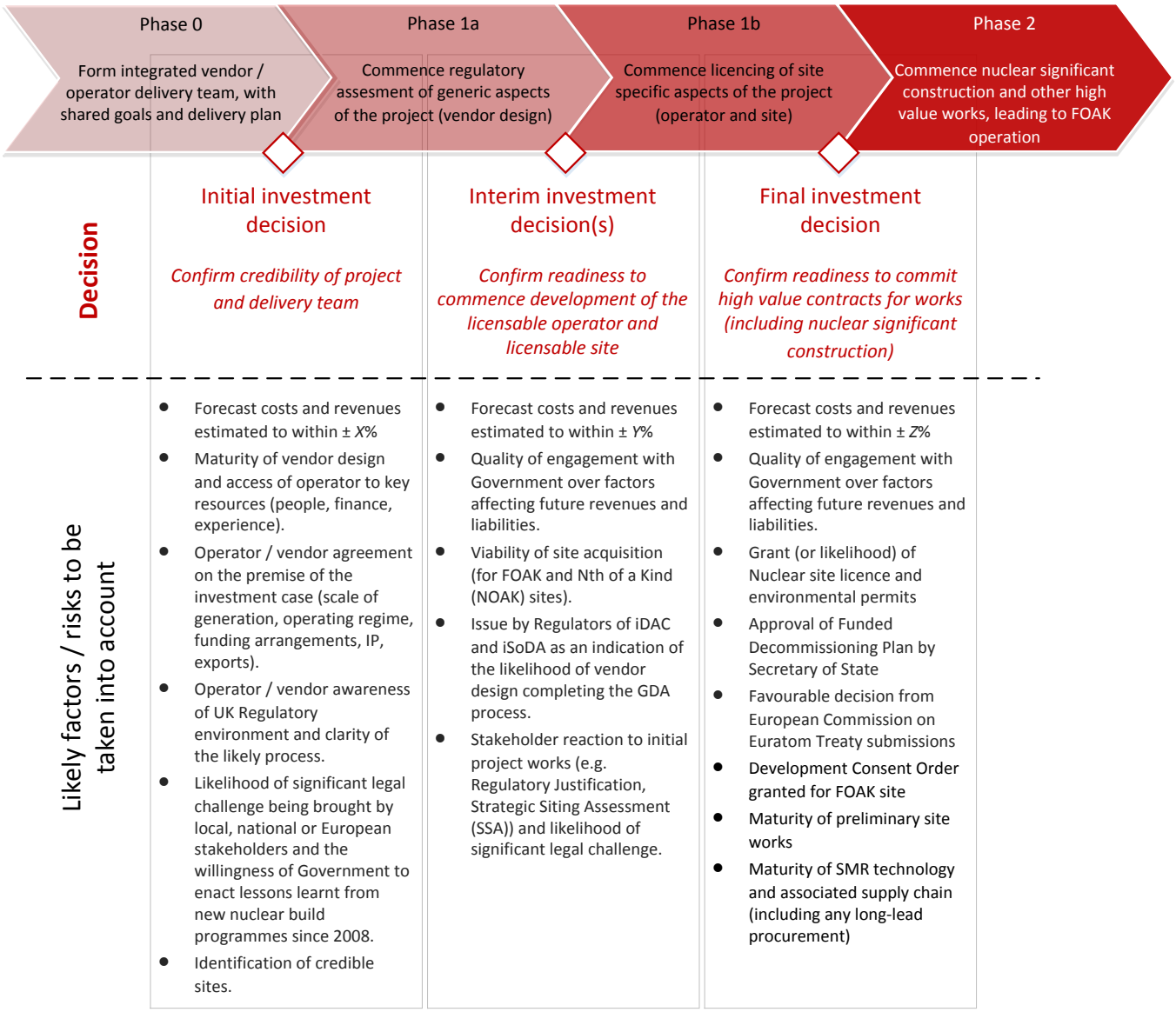


Figure 5: Key investment decisions associated with the deployment project

The timing of these review gates will vary depending on the circumstances, risk appetite and approach taken by any given private sector investor. However, it is only at the point at which risks have been adequately reduced (or bounded) and likely future revenues and costs understood, to the satisfaction of a private sector investor, that such decisions will be taken and therefore the large funds necessary to make substantive progress with the construction of a FOAK site would be committed.

C2: Pre-FID investor confidence is of critical importance for achieving the 2030 timeline.

It is in this context that the Government's role in fostering investor confidence is viewed to be crucial for enabling a 2030 timeline for FOAK operation. It is insufficient for Government to set out an

aggressive timeline for private sector investment without also taking steps to create an environment that promotes this investment through a systematic reduction of risk.

C3: For an effective programme to achieve FOAK SMR deployment, significant Government commitment and facilitative action is required from the outset.

In simple terms, earlier investment in large-scale capital works requires a quicker reduction in an investor's perception of risk. This fundamental concept is illustrated in Figure 6 which contrasts two scenarios:

- A market-led investment environment (that is, one in which delivery risks are actively minimised; but where Government is considered not to be proactive in facilitating projects in the SMR sector and progress is only made by private sector investment taking a cautious perspective on risk).
- A Government facilitated investment environment (that is, one in which Government undertakes certain enabling actions to bound/reduce the commercial risk to private sector).

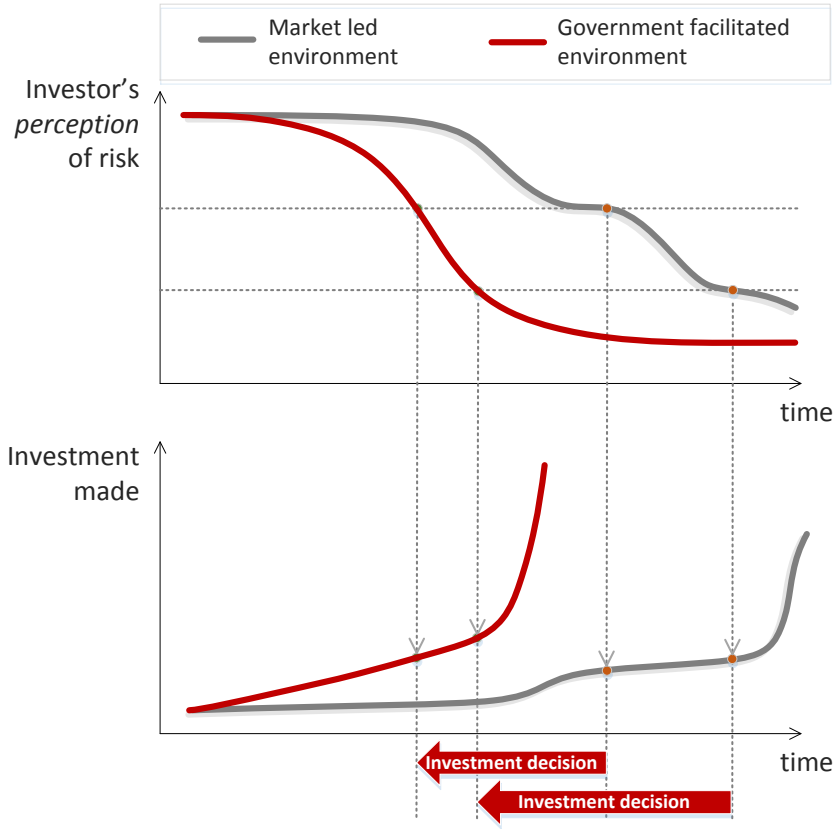


Figure 6: The role of Government facilitation to reduce perceptions of risk and the implications for investment phasing

The risk management analysis also identified opportunities for direct intervention by Government as potential additional mitigations. These interventions include funding or underwriting certain activities at risk, including interim investment decisions ahead of FID, if the private sector is unable or unwilling to accept the risk. Such activities may include commencement of preliminary works ahead of FID, commitment to long lead time items for procurement and grid enabling works. This project has not taken account of such direct interventions in the development of schedules and project conclusions. Neither has it assessed their practicality from the Government perspective or for their risk of legal challenge.

5.5 The importance of the first five years

5.5.1 Pre-FID schedule

As set out, Pre-FID activity would broadly subdivide into four themes:

- The *technology*, including GDA, Regulatory Justification and maturity development.
- The *site*, including selection, acquisition, licensing, permitting and development consenting, and preliminary works.
- The *operator*, including the development of the required structures and capabilities, manning and licensing.
- A series of staged investment cases.

Achievement of a 2030 target for FOAK operation demands that the first five years' activity must progress all four of these themes (not GDA and Regulatory Justification alone). From a timing perspective, it is therefore important to identify the earliest point at which work might credibly commence on the wider site specific and organisational development activities alongside the plans for GDA.

C4: It is insufficient for the first 5 years of the deployment schedule to focus on just GDA and Regulatory Justification.

The Government Facilitated schedule recognises the potential for this decision point (as an Interim Investment Decision) to be triggered by the issue of an interim Design Acceptance Confirmation (iDAC) and interim Statement of Design Acceptability (iSoDA) by the Regulators following completion of a GDA Stage 3 Report and Regulatory Justification, as illustrated in Figure 7.

Such an approach illustrates the need for skilful integrated project management and close interaction between the various private sector parties (vendor, developer / operator, and investor, where these are separate), Regulators, Government and relevant local planning authorities.

C5: A strong and early marriage is required between developer / operator and vendor.

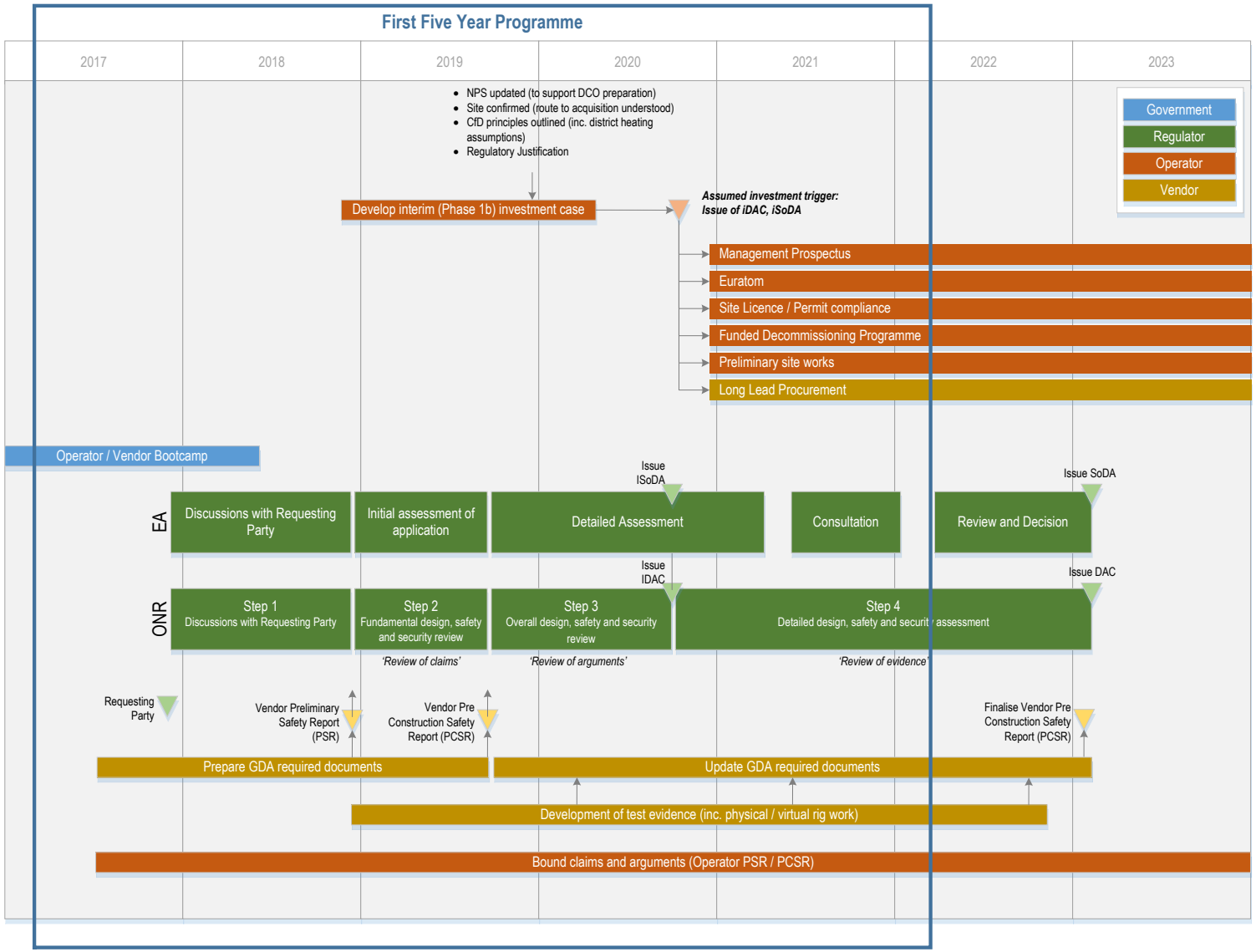


Figure 7: The interaction between investment and the GDA process (iDAC, iSoDA as a trigger for investment)

5.5.2 Enabling actions for 2030 deployment

Government is perceived to play a crucial role in creating the right investment environment to enable such a schedule. Creation of this environment would require action by Government from the outset and throughout the delivery of the timeline to FID. Building on the required areas to address in Table 4, a range of potential approaches is identified in Table 5 alongside a potential role for Government. It should be noted that all four of the required outcomes, as set out, are enabled by actions within the first 5 years of the deployment timeline.

Aim	Method(s)	Enabling role of Government
Commence GDA and Regulatory Justification early and complete within a 5 year timeframe	Enhance the quality of engagement between vendor(s) and Regulators by raising awareness of the GDA process, in particular the UK regulatory standards and expectations, and by promoting progress on GDA and Regulatory Justification processes.	Facilitation / UK awareness: To promote early engagement with vendors, through a UK 'boot camp' (facilitated by an industry body, such as the NIA). Bootcamp includes regulatory aspects but also wider scope. Facilitation / commit resource to: request the Regulators to support GDA (and support headcount implications), invite, resource and progress assessment of Regulatory Justification applications and, encourage a positive relationship between vendor and developer/operator.
Criteria necessary for compiling case for FID met by end-2024	Enhance the confidence of private sector investors that future revenue SMR generation is likely. Identify opportunities for the developer / operator to commence wider site licence and consenting work in parallel with vendor GDA (noting that this will represent a commercial risk to the private sector). Limit uncertainty within the investment case that underpins FID (in order to release interim investment ahead of FID and increase investor confidence concerning FID itself)	Facilitation / statement of intent: To set out a clear statement of intent in relation to SMR development in the UK, the required timescales and facilitative actions that may be taken by Government, including a further round of strategic siting assessment. Risk management / facilitation: To review the adequacy of current legislation in light of the proposed SMR development programme and lessons learnt since the publication of the 2008 White Paper; and pass new legislation where required, in order to minimise the risk of challenge by Judicial Review Risk management / facilitation: To engage early and constructively with developer / operators (and their investors) to confirm agreements that underpin cost and revenue models (including negotiations on CfD, FDP and Waste Transfer Contracts, district heating assumptions, export market facilitation, strategies for waste management and geological disposal). Risk management / facilitation: To engage early with European member states and the European Commission to identify and address potential challenges to Euratom Treaty submissions.
FID achieved by mid-2025	Limit uncertainty within the investment case that underpins FID	Risk management / facilitation: To engage early and constructively with developers / operators (and their investors) to confirm agreements that underpin cost and revenue models (including, CfD negotiations, district heating assumptions, export market facilitation, waste strategies / geological disposal).

Aim	Method(s)	Enabling role of Government
5 year timeline post-FID	Minimise the scope of post-FID construction to nuclear significant works by undertaking as much preliminary site work as is permissible ahead of Site Licence Grant. Ensure the manufacture and assembly of the FOAK reactor is not on the critical path, by commencing the procurement of long-lead items ahead of FID.	Risk management / facilitation: To engage early and constructively with developer / operators (and their investors) to confirm agreements that underpin cost and revenue models (including, CfD negotiations, district heating assumptions, export market facilitation, waste strategies / geological disposal).

Table 5: The potential role of Government in delivery of FOAK operation by 2030

C6: A developer / operator / vendor 'boot camp' is proposed as a near-term risk mitigation activity.

A high-level schedule with a critical path consistent with FOAK operation by 2030 is given in Figure 8.

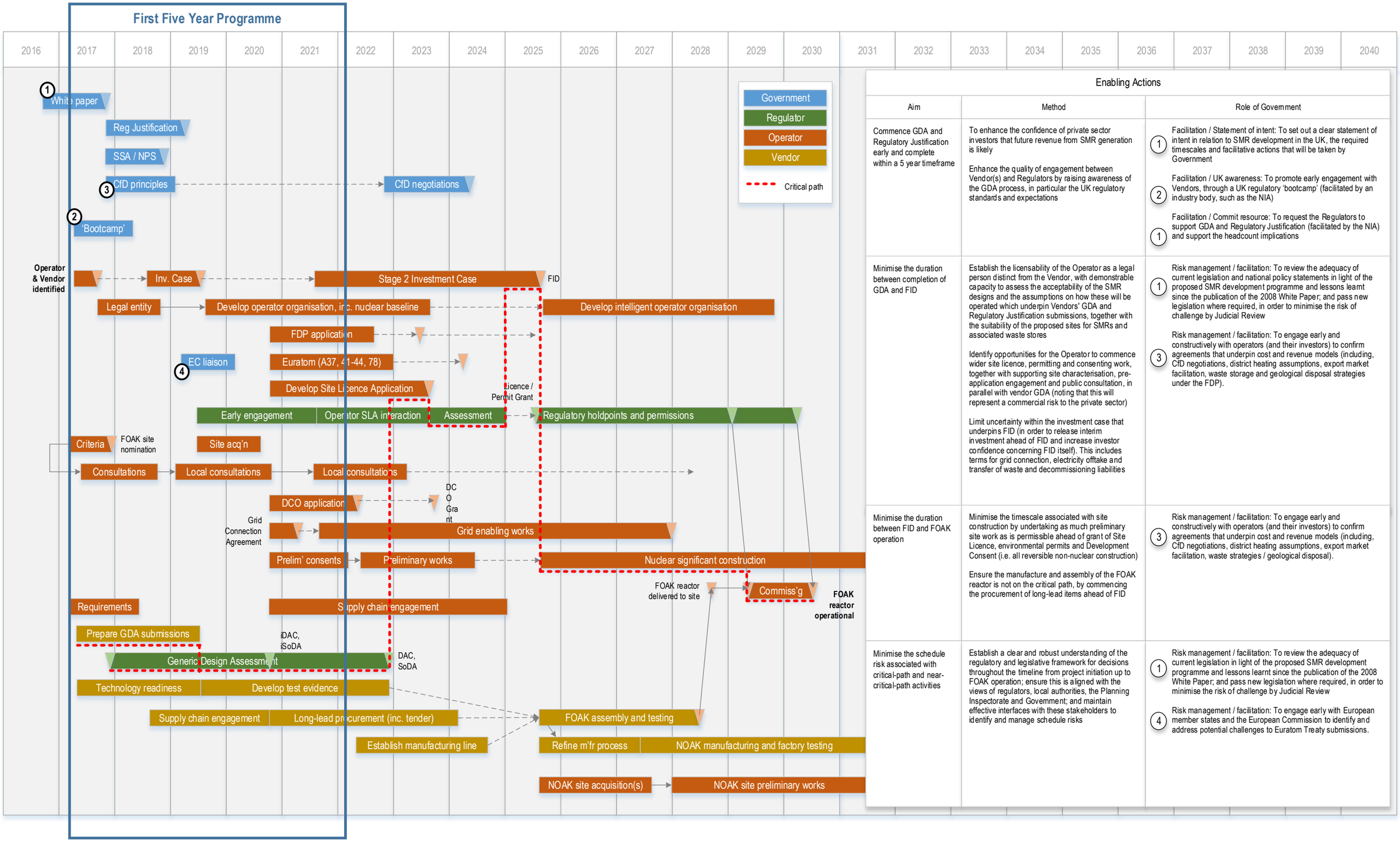
C7: Deployment of a FOAK SMR in the UK is achievable by 2030 under the bounding scenario considered by this study.

The schedule combined with the WBS highlights the enabling activities that would be required within the first five years of such a development programme.

The critical milestones associated to this deployment schedule are shown in Table 6 below.

Milestone	Indicative Timescale
Publication of White Paper, setting out Government intent	September 2017
Initiate Operator / Vendor 'Bootcamp'	September 2017
Commence Generic Design Assessment (GDA) and Regulatory Justification	December 2017
Nominate site into new strategic siting assessment	March 2018
Complete site selection / acquisition	September 2020
Issue of interim Design Acceptance Confirmation (iDAC) and interim Statement of Design Acceptability (iSoDA) to Vendor	August 2020
Commencement / acceleration of site specific licencing/permitting/development consenting and organisational development work	August 2020

Table 6: Key milestones within the first 5 years of the deployment project



Enabling Actions

Aim	Method	Role of Government
Commence GDA and Regulatory Justification early and complete within a 5 year timeframe	To enhance the confidence of private sector investors that future revenue from SMR generation is likely Enhance the quality of engagement between Vendor(s) and Regulators by raising awareness of the GDA process, in particular the UK regulatory standards and expectations	(1) Facilitation / Statement of intent: To set out a clear statement of intent in relation to SMR development in the UK, the required timescales and facilitative actions that will be taken by Government (2) Facilitation / UK awareness: To promote early engagement with Vendors, through a UK regulatory 'bootcamp' (facilitated by an industry body, such as the NIA) (1) Facilitation / Commit resource: To request the Regulators to support GDA and Regulatory Justification (facilitated by the NIA) and support the headcount implications
Minimise the duration between completion of GDA and FID	Establish the licensability of the Operator as a legal person distinct from the Vendor, with demonstrable capacity to assess the acceptability of the SMR designs and the assumptions on how these will be operated which underpin Vendors' GDA and Regulatory Justification submissions, together with the suitability of the proposed sites for SMRs and associated waste stores Identify opportunities for the Operator to commence wider site licence, permitting and consenting work, together with supporting site characterisation, pre-application engagement and public consultation, in parallel with vendor GDA (noting that this will represent a commercial risk to the private sector) Limit uncertainty within the investment case that underpins FID (in order to release interim investment ahead of FID and increase investor confidence concerning FID itself). This includes terms for grid connection, electricity offtake and transfer of waste and decommissioning liabilities	(1) Risk management / facilitation: To review the adequacy of current legislation and national policy statements in light of the proposed SMR development programme and lessons learnt since the publication of the 2008 White Paper; and pass new legislation where required, in order to minimise the risk of challenge by Judicial Review (3) Risk management / facilitation: To engage early and constructively with operators (and their investors) to confirm agreements that underpin cost and revenue models (including, CfD negotiations, district heating assumptions, export market facilitation, waste storage and geological disposal strategies under the FDP).
Minimise the duration between FID and FOAK operation	Minimise the timescale associated with site construction by undertaking as much preliminary site work as is permissible ahead of grant of Site Licence, environmental permits and Development Consent (i.e. all reversible non-nuclear construction) Ensure the manufacture and assembly of the FOAK reactor is not on the critical path, by commencing the procurement of long-lead items ahead of FID	(3) Risk management / facilitation: To engage early and constructively with operators (and their investors) to confirm agreements that underpin cost and revenue models (including, CfD negotiations, district heating assumptions, export market facilitation, waste strategies / geological disposal).
Minimise the schedule risk associated with critical-path and near-critical-path activities	Establish a clear and robust understanding of the regulatory and legislative framework for decisions throughout the timeline from project initiation up to FOAK operation; ensure this is aligned with the views of regulators, local authorities, the Planning Inspectorate and Government; and maintain effective interfaces with these stakeholders to identify and manage schedule risks	(1) Risk management / facilitation: To review the adequacy of current legislation in light of the proposed SMR development programme and lessons learnt since the publication of the 2008 White Paper; and pass new legislation where required, in order to minimise the risk of challenge by Judicial Review (4) Risk management / facilitation: To engage early with European member states and the European Commission to identify and address potential challenges to Euratom Treaty submissions.

Figure 8: High-level schedule for SMR Deployment

5.6 Consequential scope of the first five years

The scope of the first five years centres on several themes, such as:

- Establishing the right environment for investment.
- Forming the developer / operator legal entity and organisation.
- Selecting sites and nominating these into the Government's strategic siting assessment.
- Commencing GDA and developing the necessary evidence for submissions to this process.
- Commencing (when appropriate) development of site-specific licencing and consenting.

The sections below provide a narrative which describes activity in these areas crucial to achieving SMR FOAK operation by 2030.

5.6.1 Establishing the right environment for investment

Positive facilitative action by UK Government should help achieve SMR deployment by 2030. The themes for such action reflect three key purposes.

1. The first is to ensure timely completion of the legal and administrative steps by UK Government, other UK public bodies and the European Commission to facilitate approval of the proposed SMR design and its practical implementation at a FOAK UK site.
2. The second is to anticipate all points on which design approval and practical implementation could be subject to legal challenge after investment has been made, potentially threatening its viability, and to pre-empt this via early and robustly demonstrable completion of all due process.
3. The third is to build on the attractive investment environment thus created to ensure that its benefits are effectively marketed to potential investors, vendors and developer / operators, and that advice and guidance is provided to these from the outset on compliance with the UK consenting processes.

To achieve these purposes, the activity required of Government is to plan and co-ordinate actions by all relevant UK organisations with public functions to:

- Ensure that this plan addresses all potential areas of legal challenge and will deliver a secure, legally robust framework for investment in a FOAK project.
- Engage proactively with potential investors so as to understand and act on their perspective on the UK's fitness for investment in design approval and SMR projects.
- Scan, review and influence policy development at UK, European and international level which bears on electricity, nuclear and climate change.
- Provide prospective vendors and developer / operators from the outset with comprehensive advice and guidance on negotiating the UK's policy, regulatory, land-use planning, and waste and decommissioning liability funding processes.

The organisations through which UK Government exercises these facilitative actions span:

- DECC, other Government departments, including Communities & Local Government, Business Innovation and Skills, and UK Trade & Investment.
- Other public bodies, including the Planning Inspectorate, local authorities, the Nuclear Decommissioning Authority and Radioactive Waste Management Ltd, and the Infrastructure and Projects Authority.

- Regulators including the Office for Nuclear Regulation, the Environment Agency and (in Wales) Natural Resources Wales, and the Office of Gas and Electricity Markets.
- National Grid, both in respect of the UK transmission system and ENTSO-E.
- UK nuclear industry, including particularly the Nuclear Industry Association as its trade body and potential applicant for Regulatory Justification decisions.

Stakeholders engaged in the course of the facilitative actions span statutory and other consultees, including relevant conservation bodies and NGOs, landowners and the general public, especially those in the vicinity (local, district and region) of the proposed FOAK development. The required consultees will include the Fire and Rescue, Police and Ambulance Services, Public Health England, the Civil Aviation Authority, the Ministry of Defence, Highways England, Network Rail, Distribution Network Operators, local planning, emergency preparedness and highways authorities, water, sewage and drainage authorities, RSPB, and Natural England, or for sites in Wales, equivalent bodies under the Welsh Government where these exist. Depending on the location of this site and the extent of its impacts, the required consultees may also include the Marine Management Organisation, Trinity House, the Crown Estate Commissioners, and English Heritage or Cadw (the Welsh Government's historic environment service).

The key risks to delivery of a FOAK SMR by 2030 that arise in this area of UK Government facilitative action are that:

- Appropriate sites are not identified in a National Policy Statement as potentially suitable for nuclear development.
- Applications for its licensing, permitting or consenting will be incomplete or inadequately supported by robust evidence of the acceptability of the design or the suitability of the site.
- Appropriately skilled and experienced workforce or a capable UK supply chain will not be available when needed.
- Grid capacity to accept their output will not be provided on the necessary timescale.
- A predictable price for their output which recognises their benefits for climate change and flexibility, alongside acceptable terms for funding and transferring away their waste and decommissioning liabilities at the end of their operating life, will not be available.
- The project will be subject to legal challenge at any stage by opposing NGOs or European Union member states on the grounds of inadequate administrative procedure.

The effects of these risks materialising are that the consenting of any SMR development would become protracted and uncertain in outcome, with the potential for significant design changes being needed during the process and for conflicting requirements by the planning and regulatory authorities; that construction and commissioning would be subject to delay outside the developer's control; and, resulting from all of these, that the business case for the project would become uncertain, detracting from the case for investing in the UK.

The opportunity is for UK Government to act to address these risks and create an attractive investment climate. The critical components for early action are to develop the plan for delivering a secure, legally robust framework for investment in a FOAK project; to engage proactively with potential investors on the effectiveness of this plan in addressing their concerns and creating a secure and attractive investment environment; and to provide investors, and the developer / operators with which they will be married, with comprehensive advice and guidance at the outset on negotiating the UK's policy, regulatory, planning, and liability funding processes.

Without clarity at the outset on the Government's intent and commitment, potential investors may not make the scale of commitment necessary to achieve the target of 2030 for a FOAK SMR.

5.6.2 Establish Credible Nuclear Operator

Key aspects for a credible nuclear operator fall into three categories, specifically:

- Establishing a legal entity, together with its organisation and staffing.
- Embedding the appropriate culture and attributes necessary both in the "company" itself but also in the supply chain.
- Identifying and developing the necessary submissions forming part of the applications for a Nuclear Site Licence, environmental permits and development consent.

The initial activity within the deployment programme would be to form a body corporate under UK company law since only such entities can be granted a nuclear site licence. When first set up this company need only comprise a few personnel (strictly a director and a company secretary). However, given the timescales to achieve an SMR deployment by 2030, it would rapidly need to employ the essential expertise to develop and operate an SMR. Such expertise and functions would include (but not be limited to), Engineering and Technical, Licensing, Construction Management, Nuclear Safety, Operations, Training, Nuclear Safety Case and HR.

Responsibilities of a company board include the requirement to create and populate the organisational structure along with ensuring its optimised development over the period of the project. To support this, the appropriate employment model would be needed early setting out a plan for which functions might be provided internally or externally. This not only informs the near term resource model and associated recruitment plan for the indicative scale of the licensee organisation according to the stage of development of a UK FOAK SMR deployment programme. The information also forms a main input to the "organisational nuclear baseline" and the "company manual" both of which are documents required at licence application.

C8: The scale of the recruitment challenge to establish a Nuclear Baseline should not be underestimated, with staged planning essential.

Although not part of the formal licence application underlying evidence that the correct safety culture exists in the form of conservative decision making, a questioning attitude and a learning environment would create Regulator confidence and strongly support a positive and timely outcome. There are key lessons to be learnt here which would be valuable in any potential educational boot camp involving the vendor / developer / operator. Further positive evidence would be early identification of and engagement with the supply chain to ensure this nuclear safety ethos permeates the whole project.

The final theme is the creation of all the essential inputs to the submissions applying for a nuclear site licence and environmental permits, along with their supporting evidence in terms of appropriate processes and procedures. All this gives confidence to the Regulators that nuclear safety is given an overriding priority in the company. This is captured at the strategic level in the "Safety and Environment Management Prospectus", a document which forms part of the application. Company functions which must be unequivocally demonstrated are:

- The "Design Authority" - the company employs sufficient suitably qualified and experienced personnel such that it completely understands the safety and environmental implications of the design of the plant it is constructing and operating.
- The "Intelligent Customer" - it employs the capability to specify and oversee any work related to nuclear safety undertaken outside of the company.
- The "Controlling Mind" - at all times, it specifically retains the independent autonomous decision-making power over all matters related to nuclear safety.

All these activities require robust processes and procedures to be established and used as "the normal way of doing business". They also need to be backed up by a robust record keeping capability.

As part of the Licence application a detailed Pre-Construction Safety Report (PCSR) will be required. This is the definitive technical justification for what will be constructed at the particular site. This safety case is the basis of all future safety cases for the plant through commissioning, operation and decommissioning. It must be developed by the company based on the GDA submissions made by the reactor vendor. It follows therefore that very early liaison between the reactor vendor and the company engineering/technical personnel is essential if this is to be robust.

For the proposed SMR programme to be achievable, the early formation of a licensable entity is essential, with all the involved partners agreeing the strategy to develop, construct and operate an SMR within the UK licensing environment. The delivery would be at risk if this formation did not mature quickly. Key to this success is that the involved partners all accept that the decision making on all aspects related to nuclear safety is the responsibility of the company.

5.6.3 Select and Acquire Site(s) and Seek Consent for Preliminary Works

The critical requirements for a prospective UK SMR operator are to select a portfolio of suitable sites, including for the FOAK project, and to progress both these sites and the FOAK project through the UK's land-use planning processes. Alongside this, it must secure terms for all supplies beyond those provided by its associated vendor that are needed to develop an operational FOAK power station, particularly the grid connection necessary to deliver its output.

To achieve this, the operator must first determine the scope of its desired SMR programme. This does not mean an immediate financial commitment to complete the programme: that will progress in phases of which the FOAK power station is the first. However, unless the overall scope is defined – including the number of sites, number of SMR units on each site, the provision for long-term interim storage, etc. – full benefit cannot be taken from the Government's strategic siting assessment and the operator's funded decommissioning programme.

Building on this scope and the vendor's design, the developer / operator must define the requirements for credible sites. These are not only technical, but also those needed for licensing, permitting and consenting, taking into account likely stakeholder concerns. Relevant factors span geology, ground conditions, seismicity, meteorology including climate change, vulnerability to flooding; availability of a heat sink such as cooling water, access to transport networks, a grid connection point and where appropriate a district heating load; and nearby demographics, environmental designations, military, hazardous or sensitive installations. Using these as screening factors, the developer / operator can assemble a portfolio of potentially attractive sites for nomination into a strategic siting assessment, and a specific site for development as the FOAK power station.

Depending on the Government's criteria, nomination into a strategic siting assessment is unlikely to need extensive intrusive investigations. Also, sites do not need to be already owned by the developer / operator, though the landowner's and local authorities' support is highly desirable. However intensive specialist investigations, scoped with the local authorities, will be essential to support the application for development consent for the FOAK site, alongside detailed surveys and modelling of environmental impacts. These impacts include radiological, socio-economic, transport, noise and vibration, air quality, soils and land use, geology and contaminated land, surface and groundwater, ecology, landscape and visual, historic and marine environment, amenity and recreation. Extensive pre-application consultation will also be essential with the affected public and official and non-Governmental organisations, in accord with Planning Inspectorate guidance, and recognising the probable need for S.106 agreement to fund local infrastructure made necessary by the project.

Where this benefits the business case, e.g. by shortening the overall schedule, the developer / operator may apply to the local planning authority for permission for enabling works prior to grant of full development consent. Such works cannot include nuclear construction or pre-empt development consent, and would be undertaken at risk should the full development consent subsequently impose conflicting requirements.

In parallel, the developer / operator must negotiate commercial options for access to the construction and operational site, including unfettered control of the area to be subject to a nuclear site licence, and for long-lead supply beyond that provided by its associated SMR vendor. In particular, early application for a connection agreement (with National Grid Electricity Transmission where the capacity required is over 100MW) will be essential to ensure acceptable technical requirements and timescales for connection.

The key risks to delivery of a FOAK power station by 2030 in this area are, first, inadequate strategic planning of the intended SMR programme and site portfolio, including interim storage of spent fuel and ILW, and hence an inadequate range of sites identified as potentially suitable in strategic siting assessment. The second key risk is inadequate pre-application consultation and substantiation of the application for development consent for the FOAK project, leading to rejection or consent subject to over-restrictive conditions. The third is inability to procure key supplies, including grid connection and long-lead items such as nuclear-grade forgings, on a schedule consistent with project needs. The consequences would be to impair the business case or even the feasibility of proceeding with the FOAK project.

The key opportunity is to establish a portfolio of sites that reflects the developer / operator's long-term business intent, including the most economic and practical disposition of interim storage facilities for spent fuel and ILW. This recognises that a new strategic siting assessment will then bound the range of sites deemed potentially suitable for SMRs for the foreseeable future. The business case for investors, vendors and operators may be substantially less attractive if based on the FOAK site alone: it will benefit from the demonstrable assurance that the SMR design can be replicated across a portfolio of potentially suitable sites, delivering the economy of multiples.

The key enabling actions are first, for the developer / operator to initiate engagement with stakeholders in preparation for formal consultations under the strategic siting and planning processes. This should focus, in particular, on stakeholders local to the sites chosen for nomination into the strategic siting assessment and on establishing a local presence near the proposed FOAK site. Relevant stakeholders are identified under WBS 1 and the actions to establish a local presence under WBS 8. Second, allied to this, the developer / operator must scope and initiate the investigations necessary to support nomination of sites and the application for FOAK development consent, recognising that many environmental surveys will be time-consuming and seasonally dependent. Third, the developer / operator must initiate negotiation on critical supplies, particularly grid connection.

Each of these needs early action if the FOAK power station is to enter operation by 2030.

5.6.4 Establish Approved Funded Decommissioning Programme

Decommissioning arrangements as required by Government and overseen on their behalf by the Nuclear Liabilities Funding Assurance Board (NLFAB) are set out in the Energy Act 2008. These arrangements must be in place and approved by the Secretary of State prior to commencement of new nuclear build to account for the ultimate decommissioning of the plant and its associated waste disposal.

Three themes underpin this process:

- The development of a Decommissioning and Waste Management Plan (DWMP).
- Contracts agreeing the transfer of title of any waste arisings.

- Negotiation of a Funding Arrangements Plan.

The three themes break down directly into three activity steams which are initiated by the development of a DWMP. This task by the developer/operator sets out how the plant will finally be shutdown at end of operating life, defueled and decommissioned, and proposes how any waste arisings will be dealt with. It outlines the needs, if any, for interim storage of materials prior to their ultimate disposal. The plan must also cover the safety case for such activities and show how they align with the Nuclear Site Licence conditions associated with waste handling and decommissioning specifically; LC32, 33, 34, and 35. The ultimate goal of the plan is the remediation and delicensing of the site.

Decommissioning of a nuclear site represents a major change in the focus of activities moving away from energy generation, hence the DWMP needs to recognise this and include how Stakeholder engagement arrangements might have to be amended to cover it.

In the UK the responsibility for the ultimate disposal of radioactive wastes resides with the Nuclear Decommissioning Authority (NDA) and its subsidiary Radioactive Waste Management Ltd (RWM) on behalf of the UK Government. Part of this responsibility is the identification and development of a Geological Disposal Facility (GDF). This work is ongoing and is subject to extensive stakeholder engagement as well as technical development. Hence within the timeframe of a proposed SMR by 2030 it is unlikely that these details will be sufficiently developed to provide certainty in regard to the final disposal arrangements.

As a result, this uncertainty will influence conclusion of the waste transfer contracts which support the DWMP. Such contracts must be agreed between the developer/operator and the UK Government to cover the transfer of title of the high level radioactive wastes (including spent nuclear fuel) which would arise throughout the lifetime of plant operation and decommissioning.

The funding of DWMP and related activities must also be addressed. In the main this will occur after the plant has ceased to provide a revenue stream. To provide assurance to the UK Government that sufficient funds to cover ultimate decommissioning and waste arisings will be available, the Energy Act 2008 requires the developer/operator to establish a FDP. This must be approved by the Secretary for State before construction can begin. Under the FDP, the developer/operator makes regular contributions to a separate fund, commencing immediately on reactor start up. The Act requires the developer/operator to set up an independent entity to hold these funds, including appropriate governance to manage this fund ensuring that the fund receives suitable regular contributions. This includes taking an independent view of DWMP proposals to ensure their practicality, that they account for all the likely waste arisings, that any interim waste storage arrangements have been included, and that appropriate Waste Transfer Contracts are in place. The funding arrangements are overseen by the Nuclear Liabilities Financing Assurance Board (NLFAB), which provides impartial scrutiny and advice to the Secretary of State on the suitability of the FDP, including the financial arrangements and regular review of funding.

A main activity for the developer/operator is the securing of the Secretary of State's timely agreement to the FDP and securing acceptable terms for Waste Transfer Contracts. Failure to achieve timely agreements will cause a programme delay; however successful negotiation of the FDP will be critical for the business case.

In developing the DWMP the operator could encounter resistance from local stakeholders related to the transition from operation to decommissioning when the site effectively becomes a waste storage facility. Mitigation is achieved by the early engagement with stakeholders supported by a clear plan and timeline for the activities leading to the ultimate delicensing of the site, including the consent required under the Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1989.

Technical or other external events might lead to premature shutdown and decommissioning of the plant meaning the decommissioning fund is insufficient to cover all liabilities. This risk is highly unlikely and internally is best mitigated by excellence in plant management.

External risks related to the DWMP stem from the delays in defining the GDF arrangements and the related waste packaging details leading to the potential to double handle waste materials. However, if the GDF and its arrangements are available earlier than expected, the potential opportunity to package and dispose of waste material early could reduce planned decommissioning fund contributions.

5.6.5 Obtain Assessment, permitting and consents

The vendor (with married partner developer / operator input) needs to obtain agreement from the Regulators for the timescales for submission of its GDA submissions, including the generic PSR early in the GDA process, and the generic PCSR during steps 3 and 4 of the GDA process, to resource up to deliver that agreed programme, and to put in place funding arrangements to pay for the Regulators work. The Regulators will need to be able to resource up without impacting existing safety activity. Key outcomes would be step-wise regulatory agreement to the GDA, and issue by Regulators of a DAC and SoDA (4 to 5 years into the GDA process), or, building investor confidence, interim DAC and interim SoDA indicating a positive trajectory to future DAC and SoDA.

C9: Regulators will need to be able to resource-up without adverse influence on current UK nuclear safety activity.

The developer / operator (with support from Government and Regulators) will need to make submissions to the European Commission, under the Euratom Treaty, with the aim of receiving positive responses to submissions under Articles 37 (radioactive waste disposal), 41 (new industrial activities) and 78 (safeguards).

Dialogue between the developer / operator (with married partner vendor input) and Regulators will address:

- The safety, security and safeguards documentation and actions required as the submission for a request for a Nuclear Site Licence.
- What is required in developing the generic PCSR into a site-specific one.
- What ground-clearing and construction activity is able to take place ahead of the Consent (under the future Nuclear Site Licence) to start nuclear safety-related construction.
- The documentation and actions required in order to apply for Consent to start nuclear safety-related construction.
- The documentation and actions required to obtain site-specific environment Permits.
- The likely timescales for all of the above.

Each party has its own specific responsibilities:

- Vendor (with married partner developer / operator input) is responsible for the GDA submissions.
- Developer / operator (with support from Government and Regulators) is responsible for the development of submissions to meet Euratom Treaty obligations.
- Developer / operator (with married partner vendor input) is responsible for applying for ALL of the Licences, Permissions, Agreements and Permits to allow construction and future operation of its SMR.
- Regulators have a responsibility to the public (demonstrably independently of Government and industry) to ensure that everything the developer / operator does is safe, secure and

environmentally acceptable, and to work openly and transparently to published acceptance criteria.

- Government sets the policy (in this case on issues such as siting and balanced electricity generation needs), and enables actions to address those policies.

The developer / operator / vendor marriage needs to be robust and characterised by a high degree of mutual respect such that the vendor's PCSR will easily develop into the operator's site-specific PCSR without significant modification (either to paperwork or plant) and the associated re-assessment by the Regulators (cost and time issues). If the vendor over-emphasises the passive safety features of its design, without adequate evidence to back up the claims and arguments, then the GDA process will either extend, or, at worse, a DAC will not be provided and the developer / operator will be left without an accepted design. An educational boot camp is essential, together with early discussions on the PSR claims between vendor / developer / operator and Regulators. Regulators will look for claims, arguments, and evidence throughout the GDA and future licensing/permitting processes.

Insufficient dedicated and vendor/ developer / operator funded regulatory resource for the GDA and early licensing work will delay the regulatory process, as will insufficiently resourced effort from the vendor/ developer / operator to provide the Regulators with high-quality and timely submissions. Regulators are responsible for their forward plans (they publish them), and should agree the basis of any proposed new work with all stakeholders, including existing operators and Government.

Insufficient corporate developer / operator knowledge of the Euratom Treaty obligations would be likely to lead to poor submissions, and would delay the Commission responses, and the knock-on UK safety and environmental permits and consents. Early submissions, together with knowledge transfer via the boot camp will help. There will inevitably be stakeholder challenge to both developer / operator / vendor and Regulators, and this can be addressed by open and transparent communications, and high-quality submissions and decision documents, all following published due process (policy, acceptance criteria and process guidance). Opportunities exist for vendors to seek regulatory design and assessment harmonisation across international borders via discussions at existing international groups under the IAEA and EC.

Key enabling actions are:

- The boot camp is an essential early action which may be facilitated by an industry organisation such as the Nuclear Industry Association.
- Early Euratom submissions (developer / operator led) are advisable.
- Vendor/ developer / operators should be open to early exploratory discussions with Regulators on timescales, resources and funding arrangements.

5.6.6 Identify and Engage with FOAK Stakeholders

The effectiveness of the developer / operator's engagement with stakeholders is critical to successful consenting of the FOAK project, and will set the tone for the power station's subsequent relationship with its Regulators and the local and regional community through construction into operation.

The key themes are systematically to identify relevant stakeholders; to engage proactively with these, and with the local public more generally, to identify their concerns and the opportunities they present; to demonstrate the developer / operator's values and responsiveness in how these issues are managed; and to establish the foundations for a formal stakeholder engagement framework which will continue through construction into operation.

To achieve this engagement, the developer / operator must first systematically identify those organisations and individuals who may be affected by, or have an interest in, the SMR design and the FOAK project – i.e. its stakeholders. A key enabler is to establish local representation close to the FOAK site as a centre for gathering and disseminating information, and seeking views.

Building on this, the developer / operator must engage with the identified stakeholders, recording and collating the issues and concerns they raise – e.g. on air quality and noise and vibration during construction – and the opportunities they offer – e.g. to contribute to skills training. It must prioritise and optimise the resource spent in addressing concerns, typically seeking to form groups of relevant specialists tasked with seeking to narrow differences or resolve these in advance of the formal applications for consent. In many cases, such as Regulators, their participation will require funding by the developer / operator.

At the same time, the developer / operator must build channels for two-way communication with the wider local public, ranging from face-to-face presentations and drop-in opportunities, through newsletters, to electronic media. As well as gathering and responding to views, this should aim to "beat the grapevine" with authentic progress information on the Government's facilitative actions and the developer / operator's site investigations and consents, and subsequently on construction activities. This is important to build confidence both in the detail of the proposals eventually brought forward, and in the broader values and responsiveness of the developer and future operator.

As mutual experience grows, the developer / operator should develop a forum for representatives of local residents, local authorities, Regulators, and relevant interest groups and NGOs, as a concerted channel for consultation and feedback. Visible involvement of the nuclear Regulators from the outset demonstrates their oversight of the developer / operator's activities and their independent judgement directly to the stakeholders. This is the foundation for an ongoing site stakeholder group, formally constituted under a respected independent chair, and established and resourced as part of the FOAK station's management arrangements. Its terms of reference will define its advisory and consultative rather than executive role.

The key risk in this area to delivery of a FOAK power station by 2030 is lack of commitment to establish an early, effective local presence as prospective developer / operator, present for the long term, with an identity distinct from the vendor. Unless created well in advance of the first formal applications for planning and regulatory consents, this will be a material handicap in building understanding of the Government's actions and the operator's FOAK proposals, and in narrowing differences with local authorities, other agencies and the local community.

C10: A co-ordinated public communications plan is required, led by the prospective Licensee, supported by the vendor and facilitated by Government.

Specifically, it underpins three further risks. First, that the developer / operator fails to identify one or more key stakeholders with strong local influence or interests, misunderstands their concerns or potential to support the project, or fails to open a timely channel of communication with them. Second, it risks the developer / operator's communication with the local public being out of touch with local issues and concerns, failing to "beat the grapevine" in timeliness and salience, and being perceived as "PR-speak" rather than conveyed by an authoritative and credible figure – in short, failing to build trust relative to anti-nuclear NGOs. This risk is especially acute on sites without a history of nuclear development. Third, it misses the opportunity to build a constructive foundation for the future formalised site stakeholder group, risking this becoming antagonistic and ineffective from the outset.

The critical components for early action are to establish a local presence, identify the key local stakeholders, and open channels of two-way communication both with these and with the wider public affected by the FOAK project.

Regarding the range of organisations likely to be involved, key stakeholders throughout the project lifecycle will include the nuclear Regulators ONR, EA and in Wales NRW; members and officials of local authorities; other statutory consultees and official organisations such as the MMO, health authorities, "blue light" services; relevant trades unions; conservation bodies and NGOs such as Natural England / Cadw, the National Trust and RSPB; and local residents and landowners.

However, during initial consenting and construction the range will be broader than during settled-down operation. They will include local companies and Chambers of Commerce wishing to participate in the supply chain directly or by serving construction workers; local educational establishments providing skills training; health and emergency services; highways authorities and drainage boards impacted by the development and its materials and workforce logistics; other local companies, especially nearly nuclear sites, but also industries and residents adjoining the transport route, such as fishermen affected by construction or discharges and factories impacted by traffic congestion; residents subject to noise and vibration; and the planning authorities who will address the conditions necessary to mitigate such nuisances.

5.7 Assumptions in the context of the first five years

Table 1 in Section 4.4 contains the key assumptions that bound the study in the context of the first five years.

Assumptions A1 and A5 – Vendor / developer / operator: As stated, this project seeks to identify enabling actions that are independent of any specific combination of reactor vendor technology, operator or developer. Without reference to any specific private sector parties, it is assumed that progress would be led by a combination of a UK SMR developer / operator and an SMR reactor vendor at the start of the five year period as represented in Figure 9.

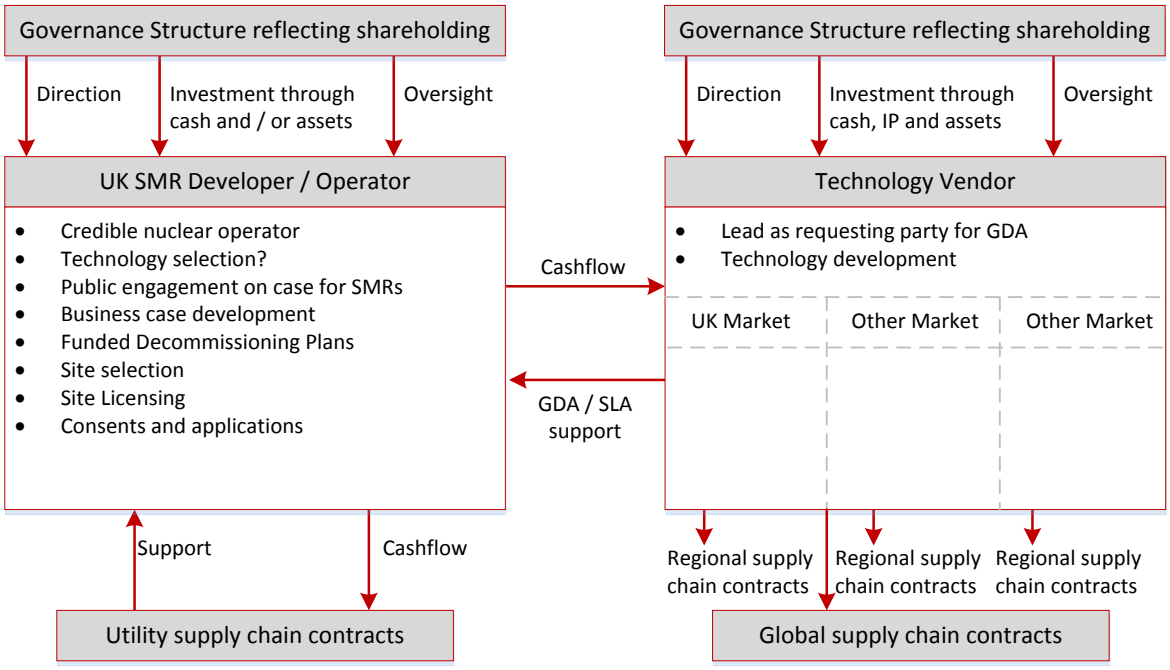


Figure 9: UK FOAK SMR deployment led by a SMR developer / operator and an SMR technology vendor

Assumptions A117 and A118 – Timeline: For the purposes of this study, it was assumed that organisations have been identified both for the reactor vendor and the UK developer / operator, and that the five-year study period schedule commences from this point, in early 2017.

Although the bounding assumptions are unlikely in practice to be totally representative of any specific vendor / developer / operator solution, the project concluded they served as a sound basis upon which to both develop and review the applicability of key findings in the context of FOAK operating SMR by 2030. The assumptions used to define and bound the project have been reviewed at the completion of the project. It is concluded that these remain valid, in particular:

- The schedule necessary to achieve first operations in 2030 shows the need for early parallel work by the developer / operator in advance of licensing. This in turn confirms the need for a vendor and future operator to be selected from the outset of the project.
- Delivery against the assumption that GDA is complete within 5 years will depend upon vendor design choices, the maturity of the design, and the quality of the vendor interaction with Regulators and other stakeholders. This confirms early vendor selection is an important decision.

C11: Bounding assumptions were judged to be sound in the context of a deployment schedule leading to a UK FOAK SMR operating by 2030.

5.8 Risk analysis

In Section 5.6, which describes the consequential scope of the first five years, risks are discussed in context of each specific scope area. This section develops insight from the risk information through analysis of the totality of the risk register.

Each of the risks identified in the study has a defined owner for the risk itself and an owner(s) for the associated mitigation action. Analysis of the risk register has shown for critical risks that the Government is the potential owner of a significant percentage of the risks. Also across the likelihood-impact score range Government is the potential owner of a significant number of the mitigations, even for risks it does not own direct. This supports the conclusion that for an effective programme to achieve FOAK SMR deployment, Government commitment and facilitative action is a key programme enabler.

The ownership of a substantive proportion of the remaining risks and associated mitigations lie with the developer / operator. This supports the need for the early engagement of a developer/operator alongside a vendor.

This analysis of the risk data demonstrates just one way in which the evidence developed in this study can be used to test or assess proposed solutions for SMR deployment in the UK. The WBS, assumptions and schedules can also support such assessment activity.

C12: The evidence gathered forms the basis of a toolkit which could be used to test or assess the feasibility of specific scenarios for SMR Deployment in the UK.

6 CONCLUSIONS

The project approach described in this report completes the required tasks, meets the project objectives, and incorporates a diverse and robust review process so as to ensure that the ETI can rely on the results. The following conclusions are reached:

1. **Implementation of an FOAK SMR is possible without facilitative action by Government (C1).** However, the complexity and non-prescriptive nature of the UK's consenting processes and the scale of the risks that remain through into first operation make it unlikely to be attractive for investors to make the scale of commitment necessary to achieve FOAK SMR operation by 2030.
2. **Pre-FID investor confidence is of critical importance for achieving the 2030 timeline (C2)**. Securing and maintaining pre-FID investor confidence will dictate whether the necessary commitment to time-critical decisions / actions is made by those leading delivery. Government and the developer / operator play a key role in creating an environment that fosters this confidence through the progressive reduction of perceived risks.
3. **For an effective programme to achieve FOAK SMR deployment, significant Government commitment and facilitative action is required from the outset (C3).**
   Government action to promote investor confidence is required from the outset since the 2030 FOAK timeline requires the private sector to commission a wide range of work (related to technology, site selection and site development) early within the initial five years. Indeed, Government should remain engaged with the progress made and upcoming decision-points of the private sector delivery plan, and ensure that these interactions support the required evolution of the investment case. The specific actions to be considered by Government include:
   - Addressing all potential areas of legal challenge so as to deliver a secure, legally robust framework for investment in a FOAK project. This should recognise the adequacy of existing policy and legislation in light of the proposed plans for SMR FOAK operation by 2030 and the experience gained from recent large reactor new build programmes.
   - Engaging proactively with potential investors so as to understand and act on their perspective on the UK's fitness for investment in SMR design approval and implementation projects.
   - Assessing, reviewing and influencing policy development at UK, European and international level which bears on electricity, nuclear and climate change.
   - Providing a prospective vendor and developer/operator from the outset with comprehensive advice and guidance on negotiating the UK's policy, regulatory, land-use planning, and waste and decommissioning liability funding processes.

   Without such actions being taken, the timeline associated with an entirely market-led deployment could result in FOAK operation nearly a decade late against a 2030 target.
4. **It is insufficient for the first 5 years of the deployment schedule to focus on just GDA and Regulatory Justification (C4)**
   Achievement of FOAK operation by 2030 requires private sector developers undertake a range of activities in parallel, in a manner that increases the complexity of the schedule interactions, and it demands that certain activities be performed at risk. In particular, wider work to develop the site specific aspects and credibility of the operator must commence early if the timeline is to be achieved. To underpin this:
   - The developer / operator should formulate a coherent SMR business case and engage in the Government's strategic siting assessment process so as to establish a portfolio of potentially suitable SMR sites to support this business case.

- Preliminary work will be required ahead of FID (i.e. at risk). This includes work to develop the site (such as non-nuclear construction, non-nuclear safety related grid connection and local infrastructure) as well as to de-risk the SMR manufacture and testing timeline (through early procurement of long-lead items).

5. **A strong and early marriage is required between developer / operator and vendor (C5)**
   Although SMR technology may differ in financial scale from that used in recent large reactor new build programmes**,** the bar to licensing a prospective operator / site in the UK is set to the same consistent standard.
   The prospective licensee must present credible plans that demonstrate Intelligent Customer and Design Authority capability in respect of the SMR technology. This must include adequate oversight of the vendor's design and development (including relevant manufacturing / assembly activity performed by the vendor's supply chain). Therefore, the prospective operator must develop the required competency at an early stage of the deployment programme in order to assure itself of the adequacy of the vendor's generic design; the optimal boundary between generic and site specific aspects; and the plans for achieving economies of multiples beyond the development and deployment of the FOAK. To this end, a strong and early marriage is required between developer / operator and vendor (confirming bounding Assumption A1). This must be credible not only in terms of the individual parties involved but also in the terms of their marriage (complementary offerings without anti-trust concerns, a shared delivery vision, access to the full coverage of required resources such as finance, experienced people, etc.).
6. **The notion of a developer / operator / vendor 'boot camp' is proposed as a near-term risk mitigation activity (C6)**
   This recognises the requirement for close-working between all stakeholders involved in a SMR deployment project. The detailed scope of this boot camp has been considered further, however overall it should seek a common understanding by all parties of the required capabilities, information, interactions and timescales. In particular, where parties inexperienced in the UK nuclear market are participating in a SMR deployment project, they may need education in the standards and expectations of the UK regulatory and operating environment.
7. **Deployment of a FOAK SMR in the UK is achievable by 2030 under the bounding scenario considered by this study (C7)**
   This is conditional on facilitative actions being implemented (including those described in items 2 to 6 above). It should be noted that the actual durations, sequencing and overall timeline of SMR deployment will depend on the specific organisational, commercial and financial characteristics of the parties engaged in such a programme and the SMR technology selected. However, the generic scenario considered by this study incorporates the following bounding conditions:
   - That both the developer / operator and the vendor are credible parties to lead an integrated delivery programme:
     i. The vendor's technology is sufficiently mature from the outset of the programme to enable GDA and Regulatory Justification to commence early and progress systematically supported by timely submission of evidence.
     ii. The developer / operator and vendor have access to sufficient funding (equity or debt) to support the staged investment decisions.
     iii. The developer / operator and vendor commit from the outset to a close working arrangement (in whatever commercial / legal structure may be appropriate).
   - That substantive work commences in early 2017 (noting that a later start reduces the credibility of achieving FOAK operation by 2030).

- That the approach to site selection for FOAK deployment avoids potentially contentious locations, in order to avoid creating undue challenges from local / regional stakeholder groups.
- That the local infrastructure development excludes work to supply district heating; with FOAK deployment focussing on electricity generation only. Future district heating capability may be accounted for within the design on a 'fitted for but not with' basis.

8. **The scale of the recruitment challenge to establish a Nuclear Baseline should not be underestimated, with staged planning essential (C8)**
   A SMR developer/operator must unequivocally establish itself as a credible nuclear operator, including Design Authority and Intelligent Customer capability and the power to be a Controlling Mind.
9. **Regulators will need to be able to resource-up without adverse influence on current UK nuclear safety activity (C9)**
   It is recognised that the UK has finite SQEP resource (both direct and indirect) to support the regulatory processes of GDA, Regulatory Justification and site specific assessment. Concurrent regulatory assessment of SMR and large reactor licensing projects may only be achievable where careful consideration is given to the 'prequalification' of vendors (married to credible developer / operators) entering this process.
10. **A co-ordinated public communications plan is required, led by the prospective Licensee, supported by the vendor and facilitated by Government (C10)**
    The developer / operator will lead many of the activities associated with the deployment programme. Achievement of the 2030 timeline will rest, in part, on the competency of this organisation to plan and drive the delivery of a highly integrated schedule, drawing in the inputs, as required from all parties. This requirement extends to the need for the developer / operator to address issues of public perception concerning the deployment of FOAK SMR technology in the UK: an activity that requires a co-ordinated public communications plan, led by the prospective Licensee, supported by the vendor and facilitated by Government. This is an important factor when considering the risk of potential applications for Judicial Review. A priority for the developer / operator is to establish an early, credible presence local to the FOAK site, with the influence to optimise the project's local benefits and mitigate its impacts.
11. **Bounding assumptions were judged to be sound in the context of a deployment schedule leading to a UK FOAK SMR operating by 2030 (C11)**
    A number of assumptions were used at the outset to bound the study. Although these assumptions are unlikely to be totally representative of any specific vendor / developer / operator solution, it was accepted that they remained sound at the completion of the study.
12. **The evidence gathered forms the basis of a toolkit which could be used to test or assess the feasibility of specific scenarios for SMR Deployment in the UK (C12)**
    While outside the scope of this study, which assumed a single non-specific solution for the vendor / developer / operator, the evidence (WBS, assumptions, risks and schedules) developed could be used to test or assess a wide range of proposed options for SMR deployment in the UK. The schedule for UK FOAK deployment operations would depend upon the associated assumptions. Such options may include:
    - A risk-averse deployment plan which focusses on completion of GDA and Regulatory Justification to establish a credible design before commencing work on site specific aspects and developing a credible nuclear operator. This may suggest a schedule with risk of delay to FOAK first operation beyond 2030.
    - A deployment plan for a less technology/design ready SMR. GDA would not commence until later in the schedule with possible plans to complete manufacturing and construction in a

shorter timeframe. This may suggest a schedule with risk of delay to FOAK first operation beyond 2030.

- Assessment of developer / operators with different characteristics and different working arrangements and modes of engagement with the vendor. For example, a developer with a mature and capable licensee organisation which may suggest an opportunity for an accelerated deployment schedule.
- FOAK deployment at a site identified as potentially suitable for nuclear development in the Nuclear NPS. This may again suggest an opportunity for an accelerated deployment schedule.

APPENDIX I KEY DEFINITIONS AND LIST OF ACRONYMS

Key definitions

Developer	A possible combination of an Operator and a Vendor, or a grouping consisting of an Operator and a Vendor amongst other parties, which has the intent to progress the deployment of a UK FOAK SMR.
Engineering	Variously covers all disciplines mechanical, electrical, C&I, civil, structural, metallurgy, chemistry, reactor physics, Radiological Protection Advisors (RPA) and Radioactive Waste advisors (RWA), and management of the SMR construction project. It encompasses the Design Authority and the Intelligent Customer capabilities. These latter two functions are identified as separate in the early development of the organisation but ultimately reside in the Engineering function. Additionally, as the plant moves to operations the Safety and Environment case capability and management would also reside in this function.
First of a Kind	The first unit in a tranche of SMRs equating to a capacity of 5 to 10 GWe.
Government	UK Government, encompassing or referring to the relevant department as appropriate.
Nuclear Safety	Variously refers to nuclear safety, conventional safety, environmental safety, radiological safety and health issues for workers and public. Here the term "Nuclear Safety" is used to encompass all of these.
Operations	Used generally as defined in LC1 of the Nuclear Site Licence Handbook: *"Operations" includes maintenance, examination, testing and operation of the plant and the treatment, processing, keeping, storing, accumulating or carriage of any radioactive material or radioactive waste and "operating" and "operational" shall be construed accordingly.*
Operator	The organisation responsible for the operation of an FOAK SMR, which transitions from a prospective operator to an actual SMR operator through the phases of the deployment programme. Includes variations of operator / licensee.
Regulators	Used to cover the Office for Nuclear Regulation (ONR), which regulates nuclear safety, security, safeguards and transport, and the Environmental Regulators, including the Environment Agency and Natural Resources Wales, and the term consents can apply to any or all of these.
Responsible Organisation(s)	Recognising the complexity of deployment, there may be more than one group named as a responsible organisation for the WBS one page scope. Responsible organisations are listed with the main one first, followed by those that may be supporting.
Vendor	The provider of the SMR technology solution, which transitions from a prospective vendor to the actual UK FOAK SMR vendor.

List of acronyms

ALARP	As Low As Reasonable Practicable
ANT	Alternative Nuclear Technologies
AoS	Appraisal of Sustainability
AP1000	Advanced Passive 1100MW nuclear reactor (Westinghouse)
BAT	Best Available Techniques
BIS	Department for Business Innovation & Skills
C&I	Control and Instrumentation
CfD	Contract for Difference
CHP	Combined Heat and Power
CIC	Construction Industry Council
CSN	Construction Skills Network
DAC	Design Acceptance Confirmation
DAP	Duly Authorised Person
DAS	Decision Analysis Services Ltd
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
DH	District Heating
DWMP	Decommissioning Waste Management Plan
EA	Environment Agency
EC	European Commission
ECITB	Engineering Construction Industry Training Board
EDF	Electricité de France
EFSI	European Fund for Strategic Investments
EIB	European Investment Bank
EMR	Electricity Market Reform
ENTSOE	European Network of Transmission System Operators
EPR	Evolutionary Pressurised Reactor (Areva)
ETI	Energy Technologies Institute
ETS	Emissions Trading System
EU	European Union
FDP	Funded Decommissioning Programme
FID	Final Investment Decision
FiT	Feed in Tariff
FOAK	First of a Kind
GB	Great Britain
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
GIB	Green Investment Bank
GQAS	General Quality Assurance Specification
GW	Gigawatt
GWe	Gigawatt electrical
HLW	High Level Waste
HMG	Her Majesty's Government
HPC	Hinkley Point C
HR	Human Resources
HRA	Habitats Regulations Assessment
HS&E	Health, Safety and Environment
IAEA	International Atomic Energy Agency
ICE	Institution of Civil Engineers
iDAC	Interim Design Acceptance Confirmation
ILW	Intermediate Level Waste
INPO	Institute of Nuclear Power Operators
IP	Intellectual Property
iSoDA	Interim Statement of Design Acceptability
IT	Information Technology
LC	Licence Condition
LCoE	Levelised Cost of Electricity
LR	Large Nuclear Reactor
MRF	Materials Research Facility
MS	Microsoft
MW	Megawatt
NAMRC	Nuclear Advanced Manufacturing Research Centre
NESA	Nuclear Energy Skills Alliance
NIA	Nuclear Industry Association
NIRAB	Nuclear Innovation and Research Advisory Board
NIRO	Nuclear Innovation and Research Office
NLFAB	Nuclear Liabilities Funding Assurance Board
NNB	Nuclear New Build
NOAK	Nth of a Kind
NPS	National Policy Statement
NRW	Natural Resources Wales
NSAN	National Skills Academy for Nuclear
NSANM	National Skills Academy for Nuclear Manufacturing
NSIP	Nationally Significant Infrastructure Project
NSL	Nuclear Site Licence
O&M	Operations and Maintenance
ONR	Office for Nuclear Regulation
OPEX	Operating Experience

PCSR	Pre-Construction Safety Report
PESTLE	Political, Economic, Sociological, Technological, Legal, Environmental
PPA	Power Purchase Agreement
RAE	Royal Academy of Engineering
REPs	Regulatory Environmental Principles
RfP	Request for Proposal
RoM	Rough Order of Magnitude
RPV	Reactor Pressure Vessel
RWE	Rheinisch-Westfälisches Elektrizitätswerk AG
SAPs	Safety Assessment Principles
SLA	Site Licence Application
SMR	Small Modular Reactor
SoDA	Statement of Design Acceptability
SQEP	Suitably Qualified and Experienced Person
SSA	Strategic Siting Assessment
TAGs	Technical Assessment Principles
TSO	Transmission System Operator
TTIP	Transatlantic Trade and Investment Partnership
TYNDP	Ten Year Network Development Plan
UK	United Kingdom
UKTI	United Kingdom Trade and Investment
US	United States (of America)
WANO	World Association of Nuclear Operators
WBS	Work Breakdown Structure
WtE	Waste to Energy