IAEA TECDOC SERIES

IAEA-TECDOC-1750/Rev. 1

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Contracting and Ownership Approaches for New Nuclear Power Plants

IAEA

International Atomic Energy Agency

CONTRACTING AND OWNERSHIP APPROACHES FOR NEW NUCLEAR POWER PLANTS

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INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2024

Marketing and Sales Unit, Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
fax: +43 1 26007 22529
tel.: +43 1 2600 22417
email: sales.publications@iaea.org
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For further information on this publication, please contact:

Nuclear Infrastructure Development Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
Email: Official.Mail@iaea.org

Printed by the IAEA in Austria
May 2024

IAEA Library Cataloguing in Publication Data

Names: International Atomic Energy Agency.
Title: Contracting and ownership approaches for new nuclear power plants / International Atomic Energy Agency.
Description: Vienna : International Atomic Energy Agency, 2024. | Series: IAEA TECDOC series, ISSN 1011-4289 ; no. 1750/rev.1 | Includes bibliographical references.
Identifiers: IAEAL 24-01680 | ISBN 978-92-0-118324-8 (paperback : alk. paper) | ISBN 978-92-0-118424-5 (pdf)
Subjects: LCSH: Nuclear power plants. | Nuclear power plants — Planning. | Nuclear power plants — Management. | Nuclear power plants — Licenses.

FOREWORD

This publication explores the variety of contracting and ownership approaches for a nuclear power plant, illustrated with recent case studies, to assist Member States in understanding the range of options available and the associated benefits and challenges of each approach. Regardless of the approach adopted, the requirements for the safe, secure and peaceful operation of a nuclear power plant remain the same. The challenge is to make sure that these requirements are adequately considered and addressed in Member State nuclear power programmes.

This publication is a revision of IAEA-TECDOC-1750, Alternative Contracting and Ownership Approaches for New Nuclear Power Plants, published in 2014, which examined build–own–operate and build–own–operate–transfer models as well as regional approaches in relation to contracting and ownership. The publication used the word ‘alternative’ to reflect that both the regional approach and build–own–operate / build–own–operate–transfer models were different from those used historically in the nuclear power industry, thus representing an alternative pathway for embarking and expanding countries at that time.

Since then, various projects have used a variation of ownership and contracting approaches in addition to regional and build–own–operate / build–own–operate–transfer approaches. Member States have also expressed an interest in examining various contractual, ownership and financing approaches for recent new build projects to include an analysis of the roles and responsibilities of the various stakeholders. In addition, Member States have expressed a growing interest in small modular reactor technologies, their applications and possible deployment for a nuclear power plant project. This publication intends to address these areas without the continued use of the word ‘alternative’, recognizing that there is not one definitive project approach that will suit all cases.

This publication expands on discussion in the 2014 publication about build–own–operate / build–own–operate–transfer and regional approaches, which continues to be useful information for Member States when considering the structure of nuclear power plant projects.

The IAEA is grateful to those who assisted in the drafting and review of this publication. The IAEA officers responsible for this publication were E. Mathet and T. Shimizu of the Division of Nuclear Power.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

In developing their nuclear power programmes, countries have explored a wide range of options related to ownership, financing, and contracting approaches for the NPP project. Several of these options have been used for non-nuclear projects, but a number of the characteristics of NPP projects, not least their timescale, scale of investment, regulatory, and liability implications, provide additional challenges to their use.

The Milestones Approach, which was first published by the IAEA in 2007, defines three phases of development and provides a sequential process to embark on a new or expanding a nuclear power programme [1].

In Phase 1, the country will establish a coordination mechanism, the nuclear energy programme implementing organization (NEPIO), in order to analyse all the issues that would be involved in introducing nuclear power. Issues related to ownership, financing and contracting options are a key part of the analysis by the NEPIO, as is an overall risk assessment of both the programme and the intended NPP projects.

In Phase 2, the country will establish two key organizations – an owner and operating organization[1] for an NPP (owner/operator) and the regulatory body. During this phase, the country will also need to determine its ownership and contracting strategy. The required resources and organizational structure of the owner/operator will vary depending on contracting strategy selected. Once identified, the owner/operator will need to build project management capabilities and establish a procurement team to implement the strategy and prepare technical specifications through a competitive bidding process or a strategic partnership. The financial ownership of the owner/operator organization will impact the availability of funds, capability of taking risks and credit worthiness, etc.

Phase 3 is where contracts are negotiated and signed. Although the owner/operator will be the customer for all these contracts, the government also needs to recognize that it has a key role in this phase. It is important that adequate time and effort is given to ensure the contracts covering all of the scopes necessary for implantation of the NPP project and to agree these contracts with the involved parties in a timely manner.

This publication will discuss three key elements, namely, ownership, contracting and financing, and how they fit together. It will provide an explanation of the concepts of contracting and ownership approaches, with examples, to assist Member States and future owner/operator in understanding the range of options available as well as the associated benefits and challenges.

It is important to note that there is no 'one-size-fits-all' approach, which is the same conclusion as the IAEA-TECDOC-1750 [2]. The selection of the appropriate approach will depend on the specific circumstances of each Member State. Moreover, the economics of the project, the risk

[1] In most cases, a single organization is the owner and the operating organization. This publication mainly assumes that the same organization will own and operate the NPP, therefore the term 'owner/operator' is used in following sessions. However, there are examples where two separate organizations are involved, motivated by factors including, but not limited to, nuclear liability, equity financing, and shared ownership structures. In this case, there also needs to be a contractual arrangement between the owner organization and the operating organization. This will be more explored in Section 3.

allocation of the parties, and the financing sources that are available will, in turn, influence the contracting and ownership structures that are possible. Similarly, the contracting and ownership structures that are envisioned may also impact economic structures, financing options, and overall project risk allocation.

In addition to this publication, IAEA provides the Nuclear Contracting Tool Kit [3] to help Member States plan and implement procurement and contracting processes for their NPP projects. Furthermore, IAEA supports Member States with relevant expert missions, workshops and peer review and advisory services on the subject of ownership and contracting for new NPP projects. These efforts also support Member States for their successful NPP projects.

1.2. OBJECTIVE

The objective of this publication is to facilitate an understanding of the available ownership and contracting options, including the benefits, challenges, and influence of the project risks over the project structuring, contracting, and financing options. This publication also discusses several key issues for contracting and ownership option that are needed for a successful project structuring. This publication is not intended to recommend a preferred approach to contracting and ownership for an NPP project. Instead, it can be viewed as a description of multiple options that each have different merits and challenges.

1.3. SCOPE

This publication provides an explanation of the various ownership and contracting approaches with the associated benefits and challenges related to structuring of nuclear power generation projects. Various industrial applications of nuclear energy, such as utilization of heat and production of hydrogen, is not the main focus of this publication.

This publication does not focus on overall NPP project management as well as integral risk management in as much detail since they are sufficiently covered by other IAEA publications. For example, IAEA Nuclear Energy Series No. NG-T-1.6 [4] provides a framework of NPP project management, and IAEA Nuclear Energy Series No. NR-T-2.15 [5] covers integrated risk management for the lifecycle of NPPs.

Financing is closely linked to ownership and contracting, however, financing is not included in the main scope of this publication. A separate IAEA publication provides the overview on financing for NPP projects [6].

1.4. STRUCTURE

The structure of this publication comprises seven sections, including this introduction. Section 2 discusses the elements for successful project structuring. Section 3 describes ownership approaches based on the organization structure, financing regime as well as the electricity market condition. Section 4 explores contracting approaches adopted by recent NPP projects. Section 5 briefly discusses financing arrangements and financial risks. Section 6 examines specific issues of SMR developments in relation to ownership, contracting, and financing issues. Section 7 presents the conclusions of the analysis. This publication also includes the Annexes that provides case studies from recent NPP projects as well as SMR projects that are in the initial planning stages.

2. ELEMENTS OF SUCCESSFUL PROJECT STRUCTURING

Various factors at the nuclear power programme can create obstacles for a successful NPP project, and such factors have to be properly addressed throughout implementation of the nuclear power programme to support the successful project development.

For instance, public support and political commitment are critical for successful nuclear power programmes as an NPP project needs to endure long time horizon from project conception through achievement of the commercial operation of NPPs. In this context, the recommendation for inclusion of nuclear power in the EU Taxonomy as a sustainable energy option, with relatively low impact on ecosystems and biodiversity, will serve to gain public perception and to mobilize investment toward a sustainable net zero world. Moreover, with the rising prominence of Environmental, Social, and Governance (ESG) investing, and the assessment of portfolios for ESG content, ESG treatment for NPP projects could bring new sources of capital to the civilian nuclear power industry [7]. Due consideration also needs to be given to design the electricity market that enables the owner/operator to recover invested costs. Electricity markets tend to be deregulated in many of developed economies and some of developing economies. NPPs, as baseload generating units, struggle to compete in the current design of deregulated markets, when renewable powers receive favourable treatment (subsidies, tax credits, dispatch preferences, special financing terms). Furthermore, if externalities are not priced into the cost of generation, nuclear energy, as a clean generation source, has difficulties competing with other thermal sources, particularly in markets where the associated fuel sources are cheap and environmental standards are not aligned with industry best practices. Also, if total system costs are not properly ascribed to each generation source, then certain forms of generation unjustly benefit (e.g., when intermittency and additional grid management are not accounted), with others then comparatively hurt (e.g., nuclear) [8].

The IAEA Milestones Approach provides guidance to Member States to develop the required nuclear infrastructures, which are briefly introduced above, for implementation of the nuclear power programme [1]. Based on the enabling environment fostered by the nuclear power programme, various activities will be undertaken to implement the first NPP project.

The history of NPP projects demonstrates that there are significant challenges to be addressed, and thus, it is necessary to introduce “a structured and methodical framework” for management of NPP projects ranging from the project planning to decommissioning stages [4]. In addition, there are many cross-sectoral issues across the nuclear power programme and each NPP project that needs close interaction of all stakeholders throughout implementation of the nuclear power programme and the NPP project.

This section focuses on elements to structure the successful NPP project in relation with contracting and ownership approaches.

2.1. FRAMEWORK OF PROJECT STRUCTURING

The IAEA Milestones Approach identifies three key organizations in the development of a nuclear power programme: (a) the host government or the NEPIO; (b) a regulatory body that is responsible for oversight and ensure compliance with requirements for safety, security, and safeguards; (c) an owner/operator to develop, own and operate the project [1]. It is this latter organization that will own the NPP and will be responsible for most of the contracts related to the project. However, the host government will also play a crucial role in areas such as nuclear cooperation agreements and/or inter-governmental agreements with the vendor country as well as financing arrangements (e.g., sovereign loan guarantees). In addition, the State will need to conclude the international legal instruments that are necessary for a nuclear power programme.

Furthermore, given the nature of the asset, the host government may view the NPP as a strategic asset within the country, which might result in special rules relating to the ownership of the NPP in addition to ensuring the security of the asset. There are a number of different ways that the owner/operator organization can be financially 'owned' and structured, and these are discussed in detail in Section 3.

All key stakeholders, such as the host government, regulatory body, owner/operator, reactor vendor, EPC contractor, fuel supplier, and financiers for both debt and equity are involved to implement a successful NPP project. These stakeholders help ensure that the project is developed in a reasonable time period in a manner that is economically viable, financeable, operable and reliable, and under a structure which is durable (to include considerations on safety, security, and safeguards) over the life of the NPP asset (to include decommissioning and storage and disposition of spent fuel).

A successful NPP project also involves a number of contracts and agreements between a wide range of stakeholders. These contracts and agreements will define the functions to be carried out by these stakeholders and set out their rights and responsibilities (usually to carry out a service, and/or to deliver equipment, spare parts, nuclear fuel, etc.). The number and nature of the contracts and agreements will depend on how the project is structured.

The possible relationships between stakeholders in an NPP project are shown in Figure 1. Those in yellow will exist in some form in all projects, as they are the contracts required to support the project. Those in blue may depend on how the project is structured, as they reflect potential parties involved in the project. The form and nature of these contracts and agreements are discussed in the following sections.

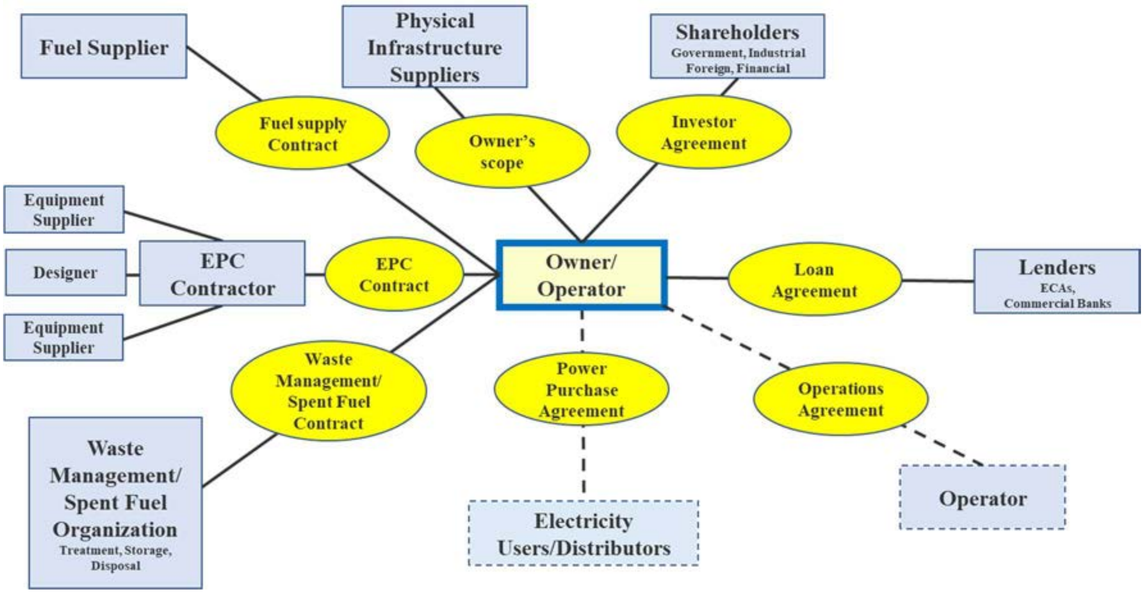

FIG. 1. An example of a contracting structure (reproduced from [2])

In addition to the contracts and agreements shown in Figure 1, there may also be an agreement to frame the overall cooperation in the field of nuclear power between the vendor country supplying the NPP and the recipient country. This framework may begin with Nuclear Cooperation Agreements to be concluded as a prerequisite to the exchange of information related to nuclear technology. Intergovernmental Agreements (IGA) or, in some cases, a high-level political statement can also formulate a framework for bilateral nuclear cooperation. IGAs may also be used for a project-specific cooperation framework, however, some projects have also chosen a competitive bidding process. Project IGAs are discussed further in Section 4.

For embarking countries, and some of expanding countries, the main construction contract may be a 'turnkey' contract with a single EPC contractor, shown on the left of Figure 1. The EPC contractor will conclude a number of contracts with other organizations, such as designers and equipment suppliers, and will act as an integrated supplier, managing the interfaces with many stakeholders to deliver the project. The reactor technology provider could be a subcontractor to the EPC contractor, or a consortium could be formed between the EPC contractor and the reactor technology provider. A fuel supply contract will also have to be negotiated, usually as a separate agreement. The owner/operator will also have contracts with local suppliers covering physical infrastructure related to the site and the grid, which is often referred to as the 'owner's scope of work'.

The financing of the project will be a combination of equity and debt. The right-hand side of Figure 1 shows agreements with lenders and shareholders. It is important to note that while the owner/operator holds the NPP on its balance sheet, this organization may have shareholders, which could be other organizations, the government, or a combination of the two.

The owner/operator will need to sell the electricity generated by the NPP to cover the costs of construction, operation and decommissioning. In a regulated market, the utility will pass along these costs to the rate payer. In a deregulated market or in a regulated market where the NPP is independently developed or developed outside of the vertically integrated regulated utility structure (i.e., a special purpose vehicle sells the power to the regulated utility), this is generally covered by a power purchase agreement (PPA), and it can take many forms, discussed in Section 4. It is important to recognize that the structure and associated risks of any PPA (price, duration, terms, creditworthiness of the off-taker, market structure, etc.) will have a direct influence on the equity rate of return and the ability to attract/discourage equity investors. In addition, the structure of the electricity market will also influence the need for a structured offtake solution, such as a PPA, when the market is deregulated.

The owner/operator will also need to develop arrangements to manage spent fuel and radioactive waste in accordance with the national strategy/policy and the legislation. For spent fuel, this could involve an agreement with the supplier of the fuel or with a waste management company, or the spent fuel could remain the responsibility of the owner/operator until a national disposal mechanism becomes available. For radioactive waste, this could again remain with the owner/operator until decommissioning, or there may be one or more agreements with a waste management company. The government needs to implement a funding mechanism for spent fuel and radioactive wase management and the owner/operator needs to provide appropriate funding as required by the national law/regulation. The detailed mechanisms of such funds are beyond the scope of this publication, but the funding arrangements will influence the overall financial model of the NPP project.

In the case where the owner and operator are separate organizations, there will need to be an agreement between them relating to the costs of operation and the expected output.

The NPP project will also involve various risks including technical, political, commercial and reputational risk etc., and occurrence of such risks either in a part or full during the NPP project life cycle will have the impact on the project economics [8]. Such risks need to be identified and properly addressed through various means including contracts and/or agreements. Each of these agreements or contracts will include clauses that effectively allocate the commercial risks involved between the supplier and the recipient.

The owner/operator is a contracting party for all these contracts and will, therefore, generally seek to transfer some of the risk to the other parties. However, the contracting party will usually charge a risk premium for taking on and managing risks, depending on the probability and magnitude of the risk and the corporate risk tolerance of the contracting party. This may still be the best arrangement for the owner/operator if the supplier is best placed to manage the risks. While this is the traditional approach to risk management, it may need to be reconsidered in the nuclear context by considering the total price against the overall viability of the project. Even in cases where a party manages the risk from a project management/execution perspective, the commercial aspects of the risk might be shared or completely transferred, depending on the risk and its cost/schedule impact.

In determining how risk is allocated, important factors include understanding how well any party can manage the risk and how important certainty of costs and performance are to the owner/operator. However, it is also important to recognize the benefits and drawbacks of allocating risk in certain ways as well as considering whether an organization can take the risk. The way that contracts are structured, and risks are allocated, is the subject of Section 4.

2.2. FUNDAMENTALS OF A SUCCESSFUL PROJECT IN RELATION WITH CONTRACTING AND OWNERSHIP APPROACHES

In order to successfully structure and implement an NPP project, sound project fundamentals needs to be equipped. Followings are fundamental elements for a successful project structuring and implementation in relation with contracting and ownership approaches.

2.2.1. Strong ownership team

Successful project structuring and implementation depends on having strong project management capabilities. While strong project management techniques are an important element of the EPC consortium's success, strong project management needs to reside on both sides – both contractor and owner/operator. Having a strong ownership team goes beyond being a knowledgeable customer. The owner/operator cannot rely solely on the EPC contract to protect its interests, nor it can rely solely on the capabilities of the EPC consortium. Successful project structuring necessitates that the owner/operator is actively involved in the project.

Active involvement of the owner/operator begins with the owner/operator clearly identifying its goals for the project, including an articulation of both key buying factors (e.g., price, output, prior experience, key personnel, etc.) and key performance indicators (e.g., safety, reporting, number of defects, etc.). The owner/operator needs to be clear in what it wants and what objectives it hopes to achieve. To that end, the owner/operator cannot simply accept that the proposal submitted by a bidder but rather needs to have the ability to evaluate the proposal in all aspects – particularly, the project execution plan. Through this review, it can independently conclude that the project is achievable, relative to the terms of the contract and objectives of the project. The ownership team also needs to be capable to formulate contracting strategy and to manage contracting negotiations with project stakeholders as well as its oversight and implementation. Moreover, it needs to have the ability to monitor progress, oversee construction and be actively involved in any troubleshooting when the project experiences challenges in execution.

In order to take true 'ownership', the owner/operator needs to ensure that it has the requisite skill sets and capabilities within its project management team, whether directly or through the engagement of an owner's engineer and specialist advisors (e.g., legal, financial, commercial, technical) and/or technical support organizations (e.g., an owner's engineer and/or a project manager). To the extent that the owner/operator has a capable team, it will be able to balance risk allocation with economic impact in an effort to optimize project execution relative to project economics.

Finally, a strong ownership team will be able to actively participate in pre-construction planning and project development activities. Lessons learned from recent projects demonstrate that the more time spent on planning, the greater the risk reduction in project execution. Investing time, money, and resources in planning activities is a key predictor of success for the project, but these planning activities can only be done effectively if a strong team is in place. Additionally, a strong team will have the conviction to resist the urge to rush the project execution cycle, especially in the face of undue political pressures.

For building up the strong ownership team, the owner/operator needs to develop its own Human Resources Management (HRM) strategy after establishment or designation in Phase 2. The owner/operator HRM strategy needs to consider not only workforce planning for the operation stage in future, but also to consider building up the strong ownership team to manage the project development stage. The strong owner/operator may consist of experienced national staffs in the relevant field as well as the foreign personnels who have led the nuclear power programme or the NPP project [10].

2.2.2. Experienced and capable delivery team

Even when the preferred technology provider that has proven/reference plant in the originated country has been selected, establishing a project execution team that has a demonstrated history of success in delivering NPP projects is a significant means of reducing project execution risk. Such experience can not only include overall NPP project experience but can also include knowledge of/experience in the host country. The development of this national expertise can be reflected in the project execution plan prepared by the EPC contractor, taking into account country-specific issues (e.g., labour conditions and availability, import procedures, logistics, environmental factors, and legal/regulatory regimes and approaches).

Furthermore, the owner/operator needs to require the EPC contractor to allocate appropriate professionals for project execution within the project contracts, recognizing that those professionals in critical positions will have a significant impact on the success of the project. Key personnel can be defined in a number of ways, but they are customarily the project director/project manager, lead engineer, site manager, and other direct reports of the project director/project manager. Regardless of the track record of successful cases of the EPC contractor, the personnel that will be specifically assigned to the project can be of major interest to the owner/operator. Moreover, the owner/operator will need to be comfortable that the EPC consortium has the bandwidth to support the project within the desired schedule. If the participating companies are engaged in multiple projects, it reduces the likelihood that the most capable team will be assigned to the project and increases the likelihood of supply chain and delivery bottlenecks.

2.3. RISK ASSESSMENT

NPP projects face various risks throughout lifecycle of an NPP. Integrated risk management that consists of: 1) identifying risks; 2) identifying risk management techniques and establishing the risk management strategy; 3) implementing risk management strategy; and 4) monitoring the effectiveness of solutions taken, needs to be introduced and implemented in order to minimize negative risks arisen during the project implementation, and comprehensive explanation on integrated risk management is available from [5].

A project specific feasibility study needs to be conducted during the preparation period of the NPP project in Phase 2. The feasibility study serves to "detect any underlying issue(s) that may pose a threat to the construction project, and therefore significant effort can be made to address any and all potential risks" [11]. The issues identified by the feasibility study need to be considered from the very beginning of the project development cycle and through the development of a comprehensive project risk register[2].

While contracts formally allocate project risks that were identified by the feasibility study, the overall responsibility for the project resides with the owner/operator. How well the project is structured and how the risks are allocated will impact ownership and financing options, recognizing the critical aspect of the equity element of the financing that ties together the concepts of ‘financing’ and ‘ownership’. A more detailed discussion and explanation on risk allocation and financing can be found in [9].

An NPP project involves the identification, allocation, mitigation, and management of a series of risks. How such risks are addressed will have consequences, as risk and price tend to move together. Given how risks can impact the overall project, it is very important for the host country and the owner/operator as the lead developer to identify the various risks that could impact the project. Ultimately, this risk analysis would be reflected in the relevant contract as well as a project risk register, which would categorize the probability of the risk, the impact of the risk should it occur, a potential allocation of the risk to one or more parties consistent with the contract, and mitigation and management techniques that could be used to address the risk.

The outcomes of the risk analysis will impact the terms of all key project contracts for the development, construction, and operation of the NPP project. The outcomes will also impact the ‘investability’ of the project, as further supported by the risk allocation reflected in the key project contracts. Given the importance and scope of the project risk register, it remains a living document throughout the project development and delivery process. As such, it will need to be regularly updated, particularly throughout the financial closing. To the extent there are subsequent financing efforts (e.g., refinancing after commercial operation), the project risk register will need to reflect performance delivered under the EPC contract.

The following is a list of some of the risks that may be reflected in a project risk register:

(a) Development and construction risks:
- Design and technology selection;
- Permits and licenses for nuclear regulatory matters;
- Site characterization;
- Cost overruns;
- Delays in construction;
- Plant completion;
- Availability of associated infrastructure;
- Project procurement and project delivery;
- Supply chain capacity and availability;
- Labour availability and productivity.

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[2] A comprehensive project risk register will identify risks, assess the risks (magnitude, likelihood), consider possible risk allocation, and develop both risk management and risk mitigation techniques. It will be the result of inputs from a variety of subject matter experts (technical, commercial, legal, financial, etc.) that have experiential knowledge in NPP development, construction, financing (and project economics), and operation, together with representatives of the host country that are able to address country-specific issues and aspects to the risks and the assessment of such risks.

(b) Operational risks:
- Plant performance;
- Sales of electricity (volumes and prices);
- Fuel supply.

(c) Project life risks:
- Insurance and insurability;
- Nuclear liability;
- Commercial counterparties;
- Public acceptance/stakeholder support;
- Political situation;
- Reputation;
- Force Majeure;
- Regulatory;
- Legal.

(d) Financing risks:
- Capital structure;
- Equity availability;
- Debt provisions;
- Foreign exchange and interest rates;
- Credit ratings.

Overall, the level of risk tolerance that is acceptable to the owner/operator of the NPP in the end, as well as to the project stakeholders involved in the project delivery and financial considerations, may vary due to a number of factors. These may include project economics, prerequisites by project participants and other stakeholders, and/or market standards in the nuclear industry. In order to create a viable project, the key parties need to reach a common understanding regarding the risk allocation for the project.

Given the complexities in NPP project development, the risk allocation desired or agreed might not support a financeable or investable project. In the nuclear context, the 'best' allocation of risk from a risk-sharing view may not necessarily be the most desirable from a total project cost and investment pricing point of view. In that context, the owner/operator needs to acknowledge the fact that the 'optimum' mitigation may be one that combines and balances the procurement with the successful acceptance of the investment proposal.

A final factor in the risk allocation analysis is the capacity of the parties involved. As noted above, while the risk should be borne by the party in the best position to manage it, it needs to recognize that the risk-takers have limitations in their capabilities. While the pricing is the first consideration, the second consideration is given to the capacities of the risk-taker. The capacities of a risk-taker can be assessed by financial and/or technical capability. One criterion for assessing the financial capability is the strength of the balance sheet of the risk-taker. Without having sufficient financial basis, it is not possible for the risk-taker to address the risk when it occurs. In case of technical capability, even if a party is in a position where traditionally is assumed to take the risk, allocation of the risk may be inappropriate without having adequate technical capabilities or experiences.

Thus, when assessing and managing risk, two ideas need to be incorporated into the analysis.

First, risks change over time during project phases. Any project development and financing strategy should account for this factor. An NPP project has a long development and construction period, roughly 7–10 years, which is the period of the greatest risk for the project while this is a relatively short period of time in the NPP's lifecycle, considering that the operating life of new units will be at least 60 years. Financing sources are both limited and expensive for this risky period. Once the project enters commercial operation, the risk profile changes dramatically. Similarly, especially in the case of proven technology, the project risk profile declines as the construction progresses.

Second, contracting parties will have different exposures to that risk, particularly in respect of the economics around their participation (i.e., the EPC contractor's profitability is determined solely during the construction period, whereas the owner's profitability is determined over the operating life of the asset).

Thus, from a financing and risk allocation perspective, there might be a party that has the ability to take the longer view of the NPP project, possibly taking some or all of certain risks at a unique moment in time for the good of the project, to include providing financing at more favourable terms. As further discussed in Section 2.4 below, the host government is in such a position.

2.4. THE ESSENTIAL ROLE OF THE HOST GOVERNMENT

Reflecting on the nature of NPP project development, the limitations of financial modelling, and the scale of NPP projects (both cost and schedule), the role of the host government becomes fundamental to project success. In addition to being involved in the programme and in the NPP project itself, the host government also needs to be involved in risk allocation and contract structuring.

Beyond the leadership and policy development roles of the host government, the government also needs to provide the necessary support to understand its full responsibility when it comes to providing an appropriate degree of 'certainty' with regard to a number of backstops, which are required from the financiers' (both debt and equity) perspective.

In order to manage the risks in a commercially reasonable manner and to create a rational risk/reward balance within the contracting and/or ownership structures, the host government may consider providing material support to the project, particularly during the time that the project is exposed to the greatest set of risks – project development and construction. Nevertheless, this period is only a small element of the project's overall lifecycle. Government support, if structured properly, can be limited, but highly effective, during this early period. By building broader support for the nuclear power programme within the government and to the public, it becomes easier to justify the support that is needed, whether it be through risk sharing/transfer techniques or through fiscal and financing tools to enhance project economics and support financing strategies. It is difficult for other stakeholders – particularly those that are private corporate entities – to take a long view of the project and to capture all the benefits of that long view. Governments, however, are better positioned to endure throughout all phases of the project.

By appreciating the challenges and articulating the benefits of an NPP, the host government can play a key role in defining an overall project framework, the risk strategy, and the overall financing and economics of the project. This, in turn, will establish a sound foundation for the project and will lead to the optimal contractual terms and conditions.

3. OWNERSHIP

As mentioned earlier, the Milestones Approach recommends the early establishment of an owner/operator organization in Phase 2 [1]. The roles and responsibilities of that organization are well explained in [12]. This section explores various models for the owner/operator, based on the structure, financing regime and electricity market structures that are utilized for the project.

3.1. STRUCTURE OF OWNERSHIP

The structure of the owner/operator varies depending on the decision of the host government. Many operating countries have a single organization that owns and operates the facility, however, there are instances in embarking countries where the owner and the operating organization are two different entities with distinct roles and responsibilities.

One of the biggest challenges faced by an embarking country is the development of an operating organization that meets the licensing requirements established by the regulatory body, in accordance with international best practices. While an embarking country could try to develop its own operating organization in isolation, the more realistic approach is to utilize foreign experience including the support provided by the vendor. Such foreign assistance could take the form of subcontracting by the owner organization for operational support in addition to seconding experienced personnel into the owner's organization. It would also be possible to contract out the entire operating function, in which case the owner and operating organizations would be separate, or for the organization to hire already experience personnel. An operating entity could also result from the creation of a joint venture between the owner organization and an experienced NPP operator possibly from the vendor country.

Another reason that embarking countries might seek to separate these entities is to optimize the cost of electricity by deploying external financial resources and an independent governance mechanism between the owner organization and operating organization.

In all cases, it may be emphasized that the owner of the NPP needs to allocate appropriate funds to the operator, which is the licensee and bears 'the prime responsibility for safety and security', in order to ensure the safe operation of the NPP [12]. Such roles and responsibilities between the two organizations need to be clearly defined in contracts.

3.2. FINANCIAL OWNERSHIP

Historically, a common feature of the contractual and ownership models employed for NPP projects was that much of the risk surrounding such projects was ultimately transferred either to taxpayers, the power consumers, or to both. This was because either the plant was owned and operated by a state-owned company to which taxpayer subsidies could be transferred in the event of construction cost overruns, or else the plant was built and operated within a regulated market, which allowed for all 'reasonable' costs associated with the plant to be passed on to power consumers. Specifically, then, nuclear power development occurred either as part of a national nuclear power programme that was led by the host government or by national or regional public utility companies that were able to recover project costs through a regulated rate base.

However, governments are now looking for constructors and/or private investors to finance and bear more of the risk associated with new project investments. The reasons for this are complex, but a major factor in some regions of the world, such as Europe and North America, is that there is now less opportunity to cover development costs through the regulated customer base due to the liberalization of the electricity market. Instead, potential NPP projects in those regions need to be assessed on the strength of the underlying economics of the project within the competitive market structure.

For embarking countries, the main motivations to seek outside financing include: (a) providing a source for the equity needed for the project; (b) creating a situation where an investment by the vendor's country would help ensure a vested interested in the success of the project; and/or (c) establishing a long-term relationship around the project that spans the construction and operation phases.

The following describes the two basics historically used NPP project financing structures, the 'sovereign based' and 'corporate based' models, and adds a third that has not been used in the nuclear context to this point, the 'project based' model.

Sovereign based model

Under a sovereign based model, investment in the NPP project is financed through contributions from the national (sovereign) budget and/or borrowing. Often, borrowing will take place as part of overall government borrowing, rather than being identified specifically for the NPP project. In such a case, lenders will implicitly have the same assurance that they will be repaid as they would if they were to lend to the national government for other purposes. Traditionally, governments have been regarded as being highly likely to repay lenders, since they have a reliable source of stable revenues under their control – the tax base. Under the sovereign based model, the financial risk that the investment will not produce revenues sufficient to cover its costs and provide a profit is ultimately borne by taxpayers. As a final note, the viability of the sovereign based model is a function of the credit rating of the host country.

Corporate based model

Under a corporate based or balance sheet finance model, the investment in the NPP project is financed through a combination of debt and equity obtained by a company on commercially driven terms. A bank or bond holder that lends to the corporation has a claim against the company's entire cash flow unless the loan is secured against a particular asset. The financial risk that the investment will not produce revenues sufficient to cover its costs and provide a profit is borne by all providers of capital to the corporation, since lenders' claims on corporate revenues and assets typically have priority.

Project based model

There has been some interest amongst countries as to the potential viability of a project-based structure. Under this structure, which has been widely used in the oil and gas sectors, investment in a project is financed through a combination of debt and equity as in the corporate based model but, differently, lenders have recourse only to the revenues and/or assets of the project itself and not to any other revenues and/or assets of the project's owner(s). Legally, the project in question is financially 'ring-fenced', meaning that it is structured so that lenders have no right, in any circumstances, to revenues or assets other than those of the project itself. Typically, this is achieved by establishment of a special purpose vehicle (SPV). Thus, project owner(s) do not expose their entire balance sheets to the risks arising from a single project. Lenders agree to finance the project purely based on their expectations as to its future viability and profitability, and their assessment of the value of the asset to which they will have access in the event of financial distress. Comprehensive contractual and financing arrangements are required to support a project-based structure.

It is important to note that a project financed NPP face the following issues that makes financing arrangement extremely challenging:

- Termination of the EPC consortium is not a viable remedy, given the unique link between the delivery team and the technology. While there may be a large number of civil engineering companies capable of completing a half-built natural gas plant, it is unlikely that completion of a half-built NPP could proceed smoothly given the specificity of the nuclear reactor design. If the original EPC consortium is terminated during construction for poor performance, no readily available alternative exists, forcing a complete restart of the project with a different technology and associated delivery team. It is worth noting that some suspended projects have continued at future dates; however, such projects are exceedingly complex and do not lend themselves to simple financing structures, given the uncertainty around the completion effort and the inability to obtain facility-wide and full performance warranties;
- Lenders are ill-suited to assume control over an NPP, particularly in the case where the NPP is viewed as a strategic asset in most countries. Moreover, given the complexities of an NPP project, and the associated liabilities, lenders would have little desire to foreclose on the asset, noting that foreclosure is a classic project finance remedy, based on the security package usually held by the lenders;
- Similarly, if lenders were to assume control over the asset during operation, it would most likely involve a termination of the owner/operator, in which case a new operator would need to be identified and then licensed by the regulatory body. Such a process would involve a significant period of time, where the asset is not operating and thus not generating revenue. It would be very difficult for lenders to take the long-term liabilities associated with the operations of NPP in trouble;
- Uncertainty in the nuclear regulatory process is not conducive to project financed structures. Given the magnitude of the project, a project delay can be fatal in a project finance structure, given the accrual of interest during construction;
- In deregulated markets, electricity market risks do not support the operating mode of NPPs, which are baseload generation assets, especially in situations where other forms of generation are favoured through subsidies, dispatch preferences, tax incentives, etc.

Variations in the above three models are possible, thus providing flexibility for the governments to design a project structure that is tailored to suit specific requirements. Consideration needs to be given to the economic and legal/regulatory environment that may constrain these models. More specifically, an NPP project will face an environment where: (a) the electricity market is liberalized or regulated; (b) the government seeks to transfer more or less risks to the developer; and (c) the commercial and contractual structure allocates risks between the different financing parties (namely the shareholders and also the lenders).

The relationship between the different models relative to aforementioned factors that affect the allocation of risk is shown in Figure 2:

- Degree of market unbundling and market liberalization: The project based model can typically be developed when the degree of market liberalization is high. The corporate based model is more likely to be grown when the market liberalization is low, which implies that the level of government involvement in the market possibly remains influential. This leads to the corporate based model is similarly more likely to be grown when the market liberalization is low;
- Amount of risk transferability (from public to private sector): The corporate model (assuming the corporation is not state owned) supports an extended transfer of risk from the public to the private sector. The project based model can be geared toward one end or

another, depending on the shareholders in the project company, the various stakeholders involved in the project contractual environment, the nature of recourse, etc. Therefore, it is positioned in the middle depending on the specifics of each project;
- Degree of recourse on shareholders: The corporate based model supposes recourse to shareholders (i.e. in case of failure of the project). Therefore, this model is placed to the level of recourse is the highest together with the sovereign based model, while the project based model is positioned to the least level of recourse. This is due to the fact that the project owners are fully or partially protected from financial recourse in the project based model.

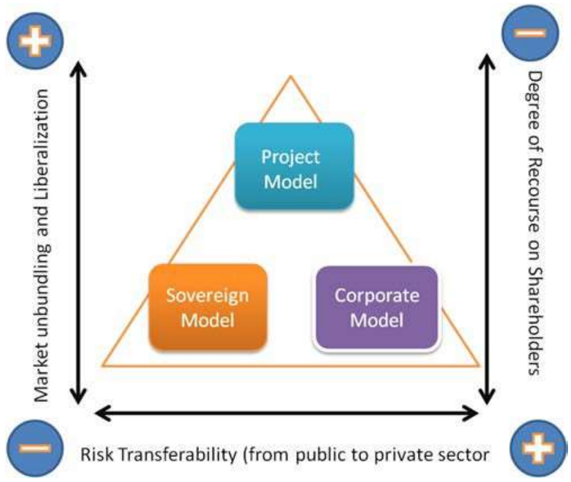

FIG. 2. Relationship between ownership models and economic and regulation factors [2]

3.3. POSSIBLE PATHWAY TO DECIDE OWNERSHIP APPROACH

In light of the foregoing discussion, a pattern for embarking countries can be described as follows:

- As project development activities emerge, the owner/operator, defined by the Milestone Approach and separated from the NEPIO, will need to assume the classic 'developer' role [12], to develop and oversee the project-level activities;
- The owner/operator could take the form of an existing national utility or a specially designated entity that will take responsibility for the project. Depending on the chosen project structure, including the technology selection, a foreign partner could be integrated into the owner/operator. This may lead to the owner/operator to be jointly owned by the national utility/designated entity and the foreign partner. The necessary competencies of the owner/operator will also need to be met either by recruiting experienced staffs and/or utilize external resources that have experience in NPP project development, and this will enable the owner/operator organization to be transformed into the 'operator';
- As consideration is given to certain project risks, contracting approaches, and financing/ownership structures, the NEPIO needs to coordinate to ensure these risks are identified and that there is a plan to mitigate these risks should they emerge;
- The planning process needs to examine the period going beyond the Final Investment Decision (FID), which leads to financial close with financiers, signs the contracts, and starts construction of an NPP. By reaching commercial operation of the NPP, with reduced project risks, the host government can reallocate resources, such as equity provided to the owner/operator and contingent funding to complete construction, etc., to the new NPP project.
- Throughout the planning and implementation phases, the owner/operator as well as the host government will need to consider 'market' perspectives, if it wishes to attract third party

investors to the project. In order to reduce the host government's risk, the economics of the project need to support the investment case with secured electricity offtake over a satisfactory period of time;
- Third party investors will likely be more passive investors, who do not participate in day-to-date decision making. Therefore, the level of NPP project expertise needs to remain within the owner/operator, even if the operator is a separate entity, as some level of capable oversight of the project will need to remain. The owner/operator will need to have the requisite skills sets in order to attract third party investors. If the owner/operator is an entity of the host government, it is important to recognize that the risk tolerance and investment metrics of the third-party investor may very well be different. Such a situation could create a misalignment of interests, which, in turn, could create obstacles to more diverse ownership structures.

With these considerations in mind, in addition to three models described above, variations on ownership models also have arisen that may be of interest to embarking countries as described below:

- In Finland, the *Mankala* model was used, where a collection of intensive users of electricity combines under a joint ownership model to obtain electricity from the project at cost. In the United States of America (USA), NPP projects have employed a multi-utility owner model, where the NPP project ownership group is comprised of several smaller utilities, municipalities, and/or cooperatives, either with a lead utility or a separate operator that is used to then manage the asset;
- The BOO(T) model, now being pursued for the first time in Türkiye (as a BOO) and used in non-nuclear sectors, can take a concession-based approach (in whole or in part)[3] to NPP project development, whereby the foreign developer assumes responsibility for technology, construction, financing, ownership, and operation in exchange for a contract for the purchase of the electricity generated from the NPP, thereby minimizing the up-front financial resources needed by the host country. In such cases, the operator is incorporated in the host country even if the shareholders are foreign entities;
- Attempts at regional models are driven by the need to spread the overall project risk and financing responsibility, as well as to achieve economies of scale in construction of a large NPP, which would be too large for any individual participant;
- In an effort to reduce the total project cost, governments have also considered taking direct equity stakes in NPP projects in order to lower financing costs, which can represent a significant share of the total project cost. Such a strategy recognizes that 'government equity' behaves differently than 'private equity', as the former does not require a customary /higher rate of return on investment. In such a case, the government equity is really 'facilitating equity', as the host government's main goal is to get the NPP built to achieve larger, socio-economic objectives (including energy security, energy diversity, clean energy, etc.).

[3] For instance, it can be the exclusive right to supply a particular customer base, often on terms set out in a PPA. With 50% of the generation under contract for the Akkuyu NPP project in Türkiye, such a structure is a partial concession.

4. CONTRACTING

As noted earlier, a suite of complex contracts supports the development, construction, financing, and operation of an NPP project. Contracts provide clarity to the roles and responsibilities of each of the project participants, with the terms and conditions establishing risk allocations among the contracting parties. Contracting structures impact pricing and the ability to finance the project, and will reflect the relative capabilities of the parties within the subject matter of the contract. Contracts will address various elements of the project, to include various phases of the project development cycle.

It should be noted that categories of the contracts explored below may vary depending on the selected contracting and ownership approaches. For instance, it may be possible for some vendor companies to provide human resource development supports through the EPC contract while others might provide this support through a project development or operation and maintenance contract.

In any case, requisite contracts need to be identified and negotiated for realization of the NPP project that are in line with the overall framework defined by the nuclear power programme.

This section will consider a number of key contracts and optional approaches that are relevant to the NPP project development and implementation.

4.1. PROJECT SPECIFIC INTERGOVERNMENTAL AGREEMENT

As previously discussed, project-IGAs may be agreed as a form of bilateral cooperation that are used to implement an NPP project between an exporting country of an NPP and a host country. While a project-IGA is not an essential element of an NPP project, it has been used in recent NPP projects.

A project-IGAs can come in several different forms, depending on the bilateral relationship between the countries. Some examples include:

- The project-IGA may relate to all the contracted areas shown in Figure 1 or only a selection of them;
- It may also define elements of a long-term strategic partnership to support the owner/operator and the host country's regulatory body in developing competencies;
- The project-IGA may define some specifics, such as the amount and the terms of a loan, or the price of electricity that will be paid, but the project-IGA might also identify more specific contracts that will be agreed under the umbrella of the project-IGA;
- The project-IGA might identify activities early in the project development cycle that will be developed further by the two countries (e.g., project structuring and financing strategies);
- The project-IGA might identify other areas of technical cooperation and transfer, training, human resource development, and educational exchanges;
- Recognizing that the project-IGA is created at an early stage of the project development cycle, definitive commercial commitments and financing arrangements might be somewhat premature, in which case the project-IGA will need to have adjustment mechanisms, as the project evolves over time;
- Approval of a project-IGA may be considered relative to existing national legislation. If approval of a project-IGA gives the agreement the status of law, it might be difficult to make adjustments in the future;
- The parties to the project-IGAs are governments, however, there will be several entities involved in carrying out the activities related to the NPP project. Therefore, such entities

will need to be considered as the project-IGA is developed, especially in cases where commercial and financing arrangements are made. Project-IGAs may not be seen as replacing the contracts needed for the NPP project delivery.

4.2. CONTRACTING FOR EPC PROJECT DELIVERY

An EPC contract, where a prime contractor serves as the sole counterparty [4] to the owner/operator and takes responsibility for project delivery, is another contracting structure that can be employed to deliver the NPP project[5]. The prime contractor of the EPC contract could be either an engineering and construction firm, or it could take the form of a joint venture or consortium that is comprised of several engineering and construction firms, which may even incorporate the NPP vendor.

The discussion of contract forms and variations that follows reflects different allocations of risk between the contracting parties. As more risk shifts away from the EPC contractor, the contract price may decrease, with the owner/operator assuming a more active role in the project delivery process. As these contracts form move away from a model where the EPC contractor guarantees price, schedule, and performance, the owner/operator likely has less certainty of outcome. Ultimately, the decision on the contracting structure becomes more a function of the following items:

- Length of the contract delivery period (longer period → greater uncertainty → greater contingency);
- Complexity of the project (more complex → more variability in outcome/higher likelihood of things going wrong → greater contingency);
- Maturity of the technology (less mature → more uncertainty in project execution and performance; more regulatory risk → greater contingency);
- Experience of the project delivery team (less experience → less certainty of outcome);
- Experience of the host country/owner (absence of a track record → greater uncertainty, particularly in regulatory and related matters and in labour productivity → need for risk transfer away from EPC contractor);
- Financial capability of the project delivery team (less capable → less ability to take on significant liabilities);
- Technical capability of the owner/operator (less capability → less ability to manage project (unless third party assistance is acquired) → need for greater risk transfer to EPC contractor → more expensive EPC contract).

The ability of the owner/operator to oversee the construction process will be considered as a part of the due diligence by potential financiers. Similarly, to the extent that a lump sum turnkey

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[4] The owner may seek to divide the procurement based on the three main elements of the plant: the nuclear island, the turbine/generator, and the balance of plant. This is termed a split-package approach, where the owner might work with different entities, based on perceived strengths and/or relationships, also possibly mixing foreign delivery (nuclear island) with domestic delivery (balance of plant and, perhaps, turbine/generator). With the three elements occurring simultaneously, the owner will need to take more of a managerial role (as opposed to the more monitoring role under the EPC structure), in order to ensure that the three elements come together successfully.

[5] In case an owner/operator has the experience and internal capability to serve as architect-engineer, whereby it enters into a myriad of contracts for various services (engineering, design, and construction) and equipment. This is termed as Multi package contract. The owner then became the operators of the plants following completion of construction. It is not likely that that this approach could be used by an owner looking to develop its first NPP, since it would typically lack the necessary expertise.

solution is not offered, completion support through a mean to ensure the availability of adequate funds for completion, will be required by third party financiers for the project.

In addition, bid invitation specifications (BIS) that include the target for local content to transfer economic benefits to the local/regional/national populace under the government strategy need to be considered against the need for the EPC contract to comply with cost, schedule, and performance requirements. To the extent that the host country wishes to capitalize on its national supply chain and human resources, the host government will need to take an active role in preparing the local industry to meet the project's needs [13].

Several EPC contracting options with its variations are presented below with the respective pros and cons as well as necessary competencies to adopt such options. The government needs to decide the most suitable one for the owner/operator in line with the government strategy and their capability.

4.2.1. Contract type 1: Lump sum contract

Lump sum contracts are contracts under which the contractor agrees to deliver the scope of work for a fixed price under an agreed schedule. These contracts can also be referred to as 'fixed price contracts' or 'firm fixed price contracts'. Sometimes, the term 'lump sum turnkey contract' is used, with 'turnkey' reflecting the idea that the contractor provides a completed project, which can be handed over to the owner/operator for operation.

Because the contractor is taking execution risk under fixed pricing and schedule, a lump sum contract is the most expensive contract, in comparison to the other contract forms discussed below. In theory, a lump sum structure provides the greatest certainty to the owner/operator, as the contractor is delivering the contract under a set price and guaranteed schedule, but the trade-off is that the owner/operator is paying a premium for such certainty. Such premium is reflected in the pricing in two ways: first, it is assumed that the contractor is building in a higher profit margin for the assumption of such risk; second, the contractor is carrying contingency in the cost and schedule to account for such risk.

For the contractor, its profit is embedded within the fixed price, with ultimate recovery of profit based on the final project cost and schedule achieved. From a transparency perspective, an 'open book' process is not customarily used. Open book refers to a contract development process where the contractor reveals all its pricing and schedule/execution logic to the owner/operator during the contract negotiations. While unit rates might not be delineated, the owner is able to see the full price build up of the contract, and the owner has the opportunity to discuss such costs and associated contingencies with the contractor to create an agreed final price and schedule.

Further, the owner generally takes a more 'hands off' approach during project execution, given that the contractor is carrying cost and schedule risk. Hands off does not imply that there is no owner scope, owner involvement, or owner oversight. However, the owner/operator has a more passive role, observing, reviewing, and approving contractor's work, but not having significant decision-making authority over the project execution or supply chain. In comparison to other contracting forms discussed below, the owner has the least involvement, as the owner is relying on the contractor to deliver the project.

Generally speaking, lump sum contracts are most suited to situations where the costs and risks are known and where 'first-of-a-kind' (FOAK) issues are not present. The exception would be where a technology developer wishes to get a project to market and is willing to assume all risks in the first, or demonstration, project (but this becomes more untenable, the bigger the project gets). As projects get more complicated, more expensive, and are of longer duration, lump sum contracts become less suitable. This reduced suitability is due to the inability to predict events far into the future. With such inability a reflection of uncertainty, such inability is translated into larger cost and schedule contingencies. These larger contingencies in turn, create inefficiencies in the total project cost and the project schedule.

Lump sum pricing does not necessarily mean absolute pricing. Often, in a lump sum contract, certain prices are indexed or escalated through the use of formulas which are discussed and agreed during negotiation process. The outcome is that the quoted price on the date of contract signature becomes the unadjusted or un-escalated price, with the final price only determined at the end of performance when all indexing/escalation has been applied. In addition, the price and schedule can be adjusted through the change order (variation) process within the EPC contract.

4.2.2. Contract type 2: Target price/Fee-at-risk contract

Moving away from the lump sum approach, the parties can agree to a target price for the work, in which case the price is ultimately a floating number, with incentives built into the contracting structure to create greater certainty around the target price. By moving away from lump sum pricing, the contractor is taking less risk; thus, the target price should be less expensive when compared to a lump sum contract. Similarly, by creating less risk around the price, the contractor may carry far less contingency, which also may serve to lower the target price. Essentially, under a target price structure, some risk is being shifted from the contractor to the owner.

The target price/fee-at-risk structure contains several components:

- First, the parties agree to a target price for the contract. This target price does not give the owner final pricing certainty;
- Second, the parties establish the target price and schedule under an open book process. The open book process creates a collaborative and transparent environment;
- Third, the contractor's fee is placed at risk, relative to how the contractor performs against the target price. Usually, there is a 'dead band'[6] above and below the target price. If the contractor underruns the target price (and dead band), then it has the opportunity to earn an additional fee. If the contractor overruns the target price (and dead band), it will be paid a lower fee. If it achieves the target price (performing within the dead band), then it earns its expected fee.

Several considerations factor into the fee-at-risk concept:

- The parties have to agree to the size of the dead band. This might start with the elaboration of the shared risk register between the owner/operator and the contractor during contract negotiation phase;
- The parties have to agree to the amount of the fee-at-risk. This amount is project-specific, with no rule as to the size of the fee. That said, the idea is to create a significant pool of money that adequately incentivizes the contractor to perform to the target. Moreover, the

[6] A 'dead band' can be thought of as a range. The reason for the phrasing dead band is that there is a zone around the target price within which the fee earn/loss is not triggered; in effect, if the actual price upon completion lands within the 'dead band' around the target price, the contract treats such result as the actual price as having achieved the target price.

contract needs to be structured in such a manner so that the contractor believes that the fee pool is achievable;

- The parties have to agree on the rate by which the fee is lowered, or additional fee is earned;
- The parties have to agree as to how much fee can be lowered. When all pricing components are built up, there are several elements: contractor's direct project costs; contractor's overhead costs;[7] and fee. Fee can be further broken down into a 'base fee' that is not at risk, and then a separate component which is placed at risk. The parties will need to negotiate how much of the pricing can be recovered. Overhead cost might be agreed to be lowered so that the portion of losses between contracting parties is adequately shared;
- The parties can agree that other performance factors can be monetized into the cost calculation for fee earning/fee lowering purposes. The easiest example of monetization is treatment of schedule delays, where the schedule liquidated damage for delay is not paid by the contractor, but added to the actual contract price, against which fee earn/loss is then assessed;
- All performance factors do not have to be monetized into the cost calculation but can be reflected in a project scorecard. The owner/operator can select 'key performance indicators' (KPIs) against which fee can be earned or lost (and with no need for upside and downside equivalency), such as safety, small business involvement, environmental and/or social targets, training, etc. KPIs can be very specific to the project[8];
- The parties need to agree on what costs are 'allowed costs' (also referred to as 'reimbursable costs') and 'disallowed costs' (also referred to as 'non-reimbursable costs'). The contractor is entitled to recover all allowed costs which are then charged to the 'actual price' as measured against the target price, with all disallowed costs for the contractor's account. The parties can establish these cost categories in either of two fashions: (a) all costs are allowed, unless they fall into a list of disallowed costs (approach favoured by contractor); or (b) costs are only allowed if they fall on the list of allowed costs (approach favoured by owner/operator).

Under a target price framework, more burden is placed on the owner/operator during the open book process. While the target price creates less certainty regarding the ultimate pricing outcome for the project, the owner/operator will need to evaluate the contractor's price build-up and execution plan. The owner/operator will need to assess all key risk factors and the possible deviation from any provisional sums[9], in order to achieve comfort with the target price and the incentives built into the fee-at-risk structure. The goal of this assessment is to enable the owner/operator to make an informed decision to proceed with the project (or for an investor/owner to make an FID). Additionally, under this approach, the owner/operator will have to closely manage the contract, especially with regard to the monitoring of allowed/disallowed costs and it requires the owner/operator to develop capability to oversee the

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[7] Overhead costs are costs related to running the business. They are not costs directly incurred by the project, but they relate to central corporate functions (including office rent, etc.) which are part of the company's ability to break even as a business. If these overheads are not covered, then the business is in a loss scenario as a going concern. For contractors, these overheads are often charged to the project.

[8] Depending on the importance of the KPIs selected, the KPIs could serve to increase the size of the incentive structure. For example, if the fee-at-risk were to be set at 5-10%, the KPI scorecard could create an additional 2-3%, depending on the value that the owner places on the KPIs. As an aside, percentages can be a helpful benchmarking tool, but, as contract sizes get particularly large, percentages need to be re-evaluated, as the actual dollar amounts might become untenable (i.e., when the percentage is converted into an actual sum, the reward can become disproportionately large).

[9] A provisional sum is a pricing element within the overall target price, whereby an amount is assigned to a particular risk, without full knowledge of the ultimate outcome. Arguably, a target price is a type of provisional sum in a sense; however, provisional sums are usually assigned to certain aspects of the scope of work that reflect either 'Known Unknowns' (KUs) or 'Unknown Unknowns' (UUs).

contractor. Such elaborative works also enable parties to start a transparent approach prior to the entry into the contract, and furthermore, it allows them to define mutually acceptable level of detail of the open book approach.

Target price/fee-at-risk contracts are well-suited to situations where many of the costs are known, but that certain risks (e.g., certain key commodities, labour availability, regulatory issues) are unpredictable thereby optimizing execution and reducing inefficiencies in cost and schedule metrics

4.2.3. Contract type 3: Cost reimbursable contract

Under a pure cost reimbursable model, the project owner reimburses the EPC contractor for all costs incurred during the project. An owner/operator may wish to use cost reimbursable models as a means of driving down contract costs while assuming the risk of cost overruns. A cost reimbursable approach is designed to pass along the true costs of the project to the owner/operator, however, the owner/operator may find it difficult to embark upon a massive capital outlay without having a full understanding of the final cost of the project. Without having the ability to pass all costs through a regulated rate base, owners are necessarily reluctant to pursue pure cost reimbursable structures.

A pure cost reimbursable approach does not require a target price element; however, the target price aspect is utilized to impose a performance metric (with consequences) on the EPC contractor.

4.2.4. Variation 1: Hybrid contract

In cases of complex, expensive, lengthy projects, the contract that is ultimately chosen might not fall exclusively into one of the traditional categories. Instead, the parties might recognize that the approach best suited to the project and its collateral conditions involves aspects from several models.

A hybrid contract is a contract that incorporates various elements of the classic models, including cost reimbursable approaches. As such, a hybrid contract can contain both fixed and variable pricing elements. For those aspects of the work that are known and that the contractor has confidence that it can control, the contractor might take on a fixed, or lump sum, obligation. For those aspects of the work that are more uncertain, the owner/operator might wish either to share those risks with the contractor or to assume the risks in full, thus eliminating the need for excessive levels of contingency in the cost and schedule.

Even where the owner/operator assumes such risks from a cost and schedule perspective, it might mean that the contractor still has responsibility to manage the risk. In such instances, the contractor can be incentivized to manage the risk against a provisional sum, and it can suffer consequences for failing to exercise proper project management.

An owner/operator may wish to assume or share the risks, and these risks can include (but not be limited to) labour, commodities, and regulatory delays. Project-specific KUs and UUs are also opportunities for shared risks and/or risk transfer.

4.2.5. Variation 2: Phased contract

Phased contracts are contracts that segment the contract and associated work scope into pre-determined phases. Often, a phased approach is necessary in cases where the situation ‘on the ground’ is unclear, requiring assessment by the contractor, in coordination with the owner/operator, before finalizing the detailed scope of work, execution plan, cost, schedule, and other performance metrics.

Phasing could involve:

- Initial studies (particularly regarding site conditions);
- Initial engineering to arrive at a final design or execution plan (and, thus, a more precise cost and schedule after having the benefit of such initial engineering);
- Segmenting a long-term project into discrete and more manageable scopes of work;
- Early works activities to maintain a final completion date while certain aspects of the project are not yet resolved, such as the final negotiation of terms, conditions, and technical appendices for the complete project.

Phasing involves a staged approach to a complex, longterm project, often with the recognition that arriving at the final, precise cost and schedule metrics over an extended execution period can become an unrealistic and uncertain exercise, due to incomplete information and lack of familiarity by the contractor and/or the owner/operator.

One aspect of this approach is to utilize an early works agreement (EWA) prior to the EPC contract itself. The main benefit of such an EWA phase would be to align common objectives through:

- The assessment of the required design adjustments for site conditions and for local regulatory requirements;
- The preparation of the preliminary Safety Analysis Report;
- The elaboration of a shared overall schedule and budget, involving all major contributors;
- The firming-up and consolidation of a robust business case;
- The site preparation and the development of the on-site organization in charge of delivery activities;
- The review and approval by the owner/operator, according to applicable regulatory requirements, of long-lead items, with consideration given to the scheduling and ordering long-lead items for project schedule optimization.

Phased contracting also attempts to price ‘knowns’ early on, while leaving definitive pricing on ‘unknowns’ until after initial work has been done (e.g., detailed engineering and design, placement of major equipment orders, etc.). While this stepwise approach seems sensible, the risk to the owner/operator is that it commits to a contractor and an approach before the final price is known.

Preventing an unexpected escalation of the price requires that the owner/operator is actively involved throughout the initial phase(s) in order to gain confidence in the overall process and ultimate price. Some pre-award planning by the owner/operator can also create greater certain for the project success, but that will require that the owner/operator will have stronger engineering, estimating, and overall project development capabilities. In addition, the contract structure could place limits on the level of price adjustments after certain phases are completed.

Finally, while a phased approach can be thought of as a gradual ‘firming up’ of the ultimate contract price, a phased approach can also use different pricing structures for different phases of the project delivery process. While a hybrid contract combines different pricing elements within one contract, a phased contracting approach could segment the overall work scope into different contracts with different pricing structures.

4.2.6. Collaborative contracting models[10]

Collaboration is fundamental to the success of NPP projects. This idea of collaboration, particularly in complex projects, has led to new contracting models that fall under the title 'collaborative contracting'. This collaborative model has not been utilized in NPP projects in embarking countries, but it is being deployed in part or in full in NPP projects or NPP refurbishment project[11]. Given the scale (both cost and schedule) and complexity of a NPP project, it might not be possible for one entity to take full delivery responsibility as the prime contractor under an EPC contract. Moreover, the traditional, adversarial approach in an EPC contract is not well-suited to the identification and resolution of challenges that arise during project development and construction. It has been pointed out that lack of collaboration among contractors/project key stake holders has caused significant project delays and cost overruns in a current project.[12] Taking note of these issues, as well as the success that collaboration has had in other sectors,[13] the potential to utilize such approaches for NPP projects warrants consideration by both contractors and owner/operators. Thus, embarking and expanding countries need to understand this concept, given its potential applicability for future projects, as it will require Member States to appreciate these concepts relative to classic risk allocation models.

The title, definition and scope of the model will vary depending on the country. Collaborative contracting is also referred to as 'Alliance Contracting'. In the USA, it is sometimes referred to as 'Integrated Project Delivery'. The following is a discussion of the fundamental elements of this model.

(a) Key assumptions:

- The underlying assumption is that, in the complex huge projects, collaboration among project stakeholders is the sole enabler for proper risk management. By aligning interests of each stakeholder with collective and project-level goals, an environment is created that creates transparency and proactive project management for the good of the project;
- Collaborative contracting models depart from the 'single point of responsibility' approach that exists under traditional, more adversarial contracts;
- Collaborative contracting models are a legal mechanism which is created to harness all aspects of a large scale projects involving management of engineering and construction. Decision on project risk management is made through a 'board' consisting of all key players

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[10] The following discussion draws from materials developed by one of the authors of this section. The work was done in collaboration with several colleagues of the author at that time, which the author wishes to note. Special recognition goes to Ms. Maxime Symington. Additionally, reference is made to the report by Mr. Owen Hayford, "Collaborative Contracting", accessible from www.pwc.com.au., which is of particular quality. Appendix A of the report above provides an excellent table, which compares a variety of collaborative contracting models across a number of contract elements.

[11] Darlington Refurbishment project in Canada is being implemented by this model, and Hinkley Point C project in the U.K. is an example of a partial implementation.

[12] One of example is presented in a case of Flamanville Unit 3 construction project. The report titled "RAPPORT au Président Directeur Général d'EDF, La construction de l'EPR de Flamanville" is available at: www.economie.gouv.fr.

[13] Alliance contracting is now customarily used in the following industries: oil & gas, airport construction, water, gas and electricity transmission and distribution, defense, and retail. Alliance contracting is now trending the following industries: rail, highways, offshore wind, nuclear decommissioning, and wastewater tunneling. Alliance contracting has been used heavily in the U.K., both by companies and for projects: BP, Heathrow, Anglian Water, National Grid, Highways England, SSE, Virgin Trains, Alstom, Sellafield Ltd, London Olympics (2012), Crossrail 2, Thames Tideway Tunnel, HS2, and the U.K. Ministry of Defense.

in project delivery. Risks are shared among the key players and financial incentives are provided with them;
- Collaborative models recognize that, in a situation with a high level of uncertainty, as well as interdependency among the key actors, risks and responsibilities tend to overlap and are not easily allocable. Such an environment necessitates collaboration, information exchange, and transparency;
- Key principles include early notification of problems, elimination of delay damages, a 'no blame'/'no claims' culture, an integrated management team, and cash neutral payment mechanisms;
- The 'no blame' culture is particularly important. Under this approach, the parties agree that they will not bring legal claims against the other participants, except in very limited/extreme circumstances (e.g., fraud, gross negligence, wilful misconduct). By avoiding the claims management process, the parties are not concerned that candid discussion of issues and problems will have negative legal ramifications for their respective companies.

(b) Factors for success:

- Early involvement: Key parties need to be engaged early in the project development and contract formation stages. The process needs to ensure that none of the major participants for project delivery is excluded from the discussion and development of a decision that this participant might be responsible for implementing;
- Selection by value: Project award is based more on quality and on the strength of potential relationships, as opposed to prioritization based on lowest price. The idea is that quality and experience will result in value creation, as opposed to focusing on delivery of the work for the lowest cost.

Thus, the selection of the contracting alliance is based on a 'value for money' assessment. Such an assessment may include various elements as quality, expected asset life or project duration costs, and certainty of outcome, as described below:

- Aligned commercial arrangements: Key parties are aligned through the collaborative contracting form, as well as through collaborative risk sharing and risk management, open book processes, target pricing with pain/gain share metrics, and project insurances;
- Common processes and tools: Key parties will agree to use common project management and file sharing platforms, along with other agreed management tools. Work teams can also be co-located to create collaborative work environments (i.e., a project team environment, as opposed to a corporate team environment);
- Performance measurement: KPIs are project oriented, and they are regularly monitored and scored throughout the life of project execution. Such KPIs can also serve as benchmarks for continuous improvement activities;
- Long-term relationships: Prior working relationships are valued. Extended relationships on the project are encouraged, as a means of avoiding repeated tendering of work packages, which can involve new parties that lack the project history and relationships that have been established over a period of time.

(c) Pain/gain share metrics

A key component of the model is pain/gain share provision. It is easy to think of this relative to the target price/fee-at-risk approach discussed earlier. Under this approach, a shared incentive pool is established. Essentially, fee is awarded or lost, depending on how the project does against a certain outcome. 'Sharing' occurs at two levels. First, the contracting alliance shares the fee earn or loss among the members of the alliance. Second, the fee earn or loss is also shared between the owner/procuring authority and the contracting alliance.

This two-pronged tiering incentivizes all parties within the contracting consortium to collaborate, as well as incentivizes sharing ‘across the table’ between owner/operator and contracting alliance. Ultimately, under the incentive sharing mechanism, stakeholders can work toward common objectives including outcomes on price, schedule and performance, and jointly solve problems.

The commercial aspect of sharing is similar to the target price/fee-at-risk model, where the ‘at risk’ amount is a lowering of fee, the level of which is negotiated. In addition, scorecards can be used to consider factors beyond final project cost outcome, to include performance against schedule, safety, localization, overall quality, sustainability, operational efficiency, lifecycle costs, community satisfaction, training, etc.

It is important to note that with a pain/gain share metric the compensation is based on a performance-based regime.

As noted earlier in the target price/fee-at-risk model, the parties have to agree to the amount of the fee-at-risk. This amount is project-specific, with no rule as to the size of the fee. That said, the idea is to create a significant pool of money that adequately incentivizes the parties to perform to the target. Moreover, the contract needs to be structured in such a manner so that the contractors believe that the fee pool is achievable. The distinction in the collaborative contracting model is that multiple parties are sharing in the incentive pool, which creates an additional level of complication, as multiple parties will need to have confidence that the incentives are achievable, both individually and collectively.

4.3. FUEL SUPPLY

Ensuring a stable fuel supply is critical for all NPP projects. The fuel supply contract will be a due diligence matter for the lenders. This contract may also be incorporated into the overall package by the project delivery consortium, given the linkages that oftentimes exist between the NPP vendor and the fuel supplier. In comparison to the EPC contract, the fuel supply contract is less complicated from a risk and financing perspective, given the specialization involved in the process and the level of control that the fuel supplier has over the fabrication. Even though the fuel supply contract might be a multi-decade arrangement, risk and performance issues are segmented by delivery and involve a repeated process that does not vary over time, which limits execution exposure under the contract.

There are a number of key objectives to be considered when contracting for nuclear fuel including:

- Security of supply;
- Competitive fuel pricing;
- Fuel licensability, quality, and performance;
- Nuclear safety, nuclear security, and safeguards;
- Clear and appropriate transfer of nuclear liability risk with respect to the nuclear fuel.

It is noteworthy that nuclear fuel can be stored on site. Therefore, NPPs are not necessarily subject to the same supply chain challenges of other forms of electricity production. Such storage capability may be factored into ordering under the fuel supply contract.

There are four distinct nuclear fuel processes and contracts that are required for the production of nuclear fuel assemblies:

- Purchase of uranium ore: These contracts are for the purchase of natural uranium ore concentrates, U_3O_8r 'yellowcake';
- Conversion: Pursuant to a conversion contract, a vendor converts uranium ore concentrates into uranium hexafluoride. UF_6 gas is pressurised, cooled to a liquid, solidified, and shipped to an enrichment vendor for enrichment;
- Enrichment: Pursuant to an enrichment contract, a vendor enriches the UF_6 gas to increase the content of U_{235} to the necessary specifications (3 to 5%);
- Fuel fabrication: Pursuant to a fuel fabrication contract, a vendor organizes the enriched uranium into bundles (fuel assemblies) to be inserted into the reactor core. Assemblies are highly engineered and designed to satisfy each customer's specifications.

Accordingly, it is important for an owner/operator to develop a long-term fuel supply strategy which can either be: (a) multi-source, meaning the separate procurement of uranium, conversion services, enrichment services, fuel fabrication, and delivery; or (b) single source, meaning a single contract for the delivery of complete fuel assemblies. Owner/operators need to keep in mind that the choice of technology may impact this strategy. Typically, in new build NPP projects, the initial core and 1–2 reloads of nuclear fuel are provided as part of the EPC contract. Separate fuel supply agreement(s) will then handle future fuel supply.

Before the fuel assemblies may be used in the customer's nuclear reactor, they will be licensed by the country's regulator body. Licensing covers the design of the fuel and the manufacturing, and it is vital that the adequacy of the design and manufacturing is demonstrated by the fuel supplier to the owner/operator and the regulatory body before the fuel manufacturing starts.

Some of the provisions that need to be addressed in nuclear fuel contracts include:

- Non-proliferation and IAEA safeguards;
- The submittal of design information for the licensing of the nuclear fuel;
- Export controls;
- Third party liability for nuclear damage;
- Quality assurance;
- Price and pricing adjustment mechanisms;
- Transfer of title and risk of loss, as such issues apply to transport and liability in respect thereof;
- Warranties, including defects and fuel performance.

4.4. OPERATIONS, MAINTENANCE AND SUPPORT

As explored in Section 3, this publication does not suggest a specific ownership approach to be taken in an NPP. Nevertheless, following explanation is based on separation of the owner and the operator for illustrative purpose. In a case single owner/operator organization is adopted, a contract would be dedicated to operational support by the vendor company. Consequently, many points raised below can be point of reference for a single owner and operator case.

Contracting for operations (or operations support in the case that a single owner/operator structure is taken) and maintenance (O&M) is a complex and bespoke arrangement that is intended to help an owner for arranging an operator of the NPP.

O&M contracts fulfil a similar role in the operations phase of the NPP as EPC contracts serve in the construction phase. However, while the negotiation of the EPC contract is a complex process where various risks and responsibilities are negotiated and allocated, operations and maintenance issues are less debatable in terms of overall responsibility. Ultimately:

(a) The project will not proceed if a capable operator does not exist, as the operating license for the NPP is held by such an operating entity;
(b) Ultimate responsibility for safety resides with the licensed operator;
(c) Third party nuclear liability is channelled to the licensed operator[14].

The capability of the operator is a critical matter, both for regulatory approvals and for the project due diligence process conducted by financiers. This capability can be developed either domestically or internationally. When considering O&M contracts, owners have two possible options:

- The owner can operate and maintain the NPP with external operational support; or
- The owner can contract with a professional operator to fully manage and maintain the NPP.

The final decision will need to consider both regulatory and financing matters. Both the regulator and financiers will want to see that experience resides within the operating organization. While the NPP vendor and exporting country might provide training to support the development of an operating organization and technical support to the regulatory body, operational experience will be a matter of particular focus.

Some examples of what may be included within the scope of O&M contracts include:

- Trained and qualified operational staff to provide operational expertise, guidance, and operational skills during maintenance and operations;
- Development of a management system for the organization;
- Operational support in all aspects of NPP operations;
- A training programme designed to support licensing of owner's staff, including simulator training;
- Staffing and capacity building;
- Outage planning;
- Maintenance;
- Fuel-cycle management;
- Environmental monitoring;
- Decommissioning and waste management planning;
- Arrangements for adequate funding to cover the operational budget, including reserves for unplanned outages and major maintenance.

[14] With the USA being the exception, which has economic channelling under Price-Anderson, as opposed to the legal channelling regime that is used internationally.

Typical provisions in O&M contracts cover:

- Operating manuals, procedures and programmes: The designation of operating manuals, procedures and programmes pursuant to which the plant will be operated, whether developed by the owner, the operator or jointly;
- Safety culture: Obligations to maintain safety culture within owner and operating organizations with fitness for duty or behavioural assessment programmes to support a safety conscious work environment;
- Performance warranties, payments, and incentives: How to pay and properly incentivize the operating organization;
- Limits on operator's authority and owner's consent: Identification of the decision-making structure and respective authority of operator versus the owner;
- Owner's responsibilities: Identification of the responsibilities of the owner, such as staff, plant access, power supply, environmental liabilities, spent fuel and decommissioning, noting that the ultimate responsibility for safety resides with the licensed operator. The owner will also be responsible for ensuring that the operator has adequate funds for the operation of the NPP, to include reserve accounts for regular and major maintenance, as well as unforced outages;
- Human resources: Designation of key senior staff/representatives of both owner and operator;
- Regulatory compliance: Ensuring the ongoing validity of the operating licence;
- Nuclear liability and insurance: Designation of the licensee with responsibility for nuclear liability. Obligation to obtain and maintain insurance;
- Confidentiality, and safeguards information: Articulation of obligations with respect to confidentiality of sensitive and controlled information.

Lenders and investors will scrutinize O&M contracts to ensure that the operator has a demonstrable ability to operate the NPP safely, efficiently, and reliably, with adequate funding.

As a final note, the operating arrangements can include the involvement of the operator during construction of the project, as well as having some input prior to execution of the EPC contract to ensure that operational considerations are factored into the EPC contractor's scope of work and overall plant design.

4.5. ENSURING PROJECT REVENUE STREAM[15]

From a financing perspective, the ability to generate adequate revenue to ensure the overall viability of the NPP is essential. Consequently, creating a secure, creditworthy, and long-term revenue stream supports financing options – particularly refinancing options – and serves to de-risk the project. In regulated markets, a vertically integrated utility can address this through the rate structure, ultimately passing along costs to the ratepayers, with an established rate of return that can be modelled for the purposes of financeability assessments. However, in deregulated markets, financiers of a NPP will want to see revenue certainty, which can only be obtained through a structured offtake solution. Traditionally, this is done through a PPA; however, other approaches can be used or an independent power producer. This section focuses on the PPA approach but also notes more recent structures that are being used or about to be implemented for NPPs.

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[15] The following discussion draws from materials developed by one of the authors of this section in collaboration with Mr. Edward Kee, the Nuclear Economics Consulting Group.

4.5.1. **Background of the PPA**

A PPA is a contract that dictates the terms and conditions for the sale of the electricity from the NPP. Early PPAs were typically regulated arrangements that received review and approval from electricity regulators. The utilities were usually monopolies, and only the regulated utility could sell power to end-use customers. As the electricity industry was restructured and power markets were liberalized, a new type of PPA developed where a non-utility generator or an independent power producer sold power to the regulated or government-owned electric utility.

The electric utility, which is often a national company in embarking countries, usually agrees to take the power generated from the NPP, based on the availability of the unit and the usage of the power. Such 'off take' arrangements, traditionally through a PPA, are structured in a manner under which the developer, as the owner/operator, is paid under pre-established terms for both availability and for actual usage.

The length of time of the PPA as well as the credit strength of the entity purchasing the electricity will be a key factor in the developer's economic analysis of the project. Outside lenders and investors will require that the nuclear projects in which they are involved have secure and demonstrable payment of debt service and returns to equity investments.

For a regulated utility, the discussion of how costs are transferred into the rate base, including disallowed costs, will be the key element of the discussion. The greater risks for a regulated utility are: (a) whether or not the project is completed; and (b) the impact that the project has on the utility's credit rating. In contrast, similar to an EPC contract, a PPA will be a commercial environment within which risk allocation issues will be negotiated. Some examples of this risk and possible consideration on it may include:

- Delay in project implementation. Adjustments, such as extension of the offtake period or postponing the commencement of the offtake period, would be considered. If appropriate, penalties for the owner/operator would also be considered;
- Occurrence of an unforced outage;
- Outbreak of cost overrun. An adjustment of the pricing would be considered;
- Increase of electricity generation cost: Adjustment of the offtake price;
- Changes of the regulation that imposes new costs on an operating NPP.

How these issues are resolved will impact financing (particularly equity) considerations, and they will be viewed within the larger context of the overall risk profile for the asset. As noted earlier, changes in electricity market structures have had a major impact on the economic viability of operating NPPs and a major influence on where NPPs are developed and under what conditions.

4.5.2. The difference between nuclear power purchase agreements and conventional power purchase agreements

A PPA is effectively a guarantee of a secure revenue stream to the owner /operator of an NPP. As such, it provides a degree of financial security which will be attractive to investors – both lenders and shareholders to the extent that creditworthiness of the off taker is acceptable. In the case where a PPA covers a significant period of operations and is supported by a sovereign guarantee, the developer would have greater confidence in the overall project profile when compared to an opportunity without such a guarantee. The key point for embarking countries is that the financeability of a project is a direct function of the project's economics. In order to obtain external financing, the economic structure needs to be clear, secure, and creditworthy in order to support financeability. As a result, the host country will need to consider how it will establish viable economics relative to financeability and overall project risk.

There are a number of differences between PPAs for conventional energy projects and PPAs for NPP projects as summarized below:

- NPP projects need to account for greater development, construction and commissioning risks. The time required for the development and construction of conventional power plants is both shorter and more certain than the time required to develop and build an NPP. Accordingly, a nuclear project will require a longer PPA term. A conventional power plant PPA is usually 15 to 25 years, which is tailored to the operating life of the asset. An NPP, with at least a 60-year operating life, may have a longer PPA to maintain the economic profile of the asset for an investor. When considering the 18-year repayment period on ECA debt, a 20-year PPA is viewed as sufficient, but that does not answer the needs of long-term investors who will look beyond the initial 20 year period and not want to take market risk;
- Nuclear projects have different fixed and variable costs. PPAs for fossil fuel power plants have variable costs, such as fuel costs, that are a large part of total electricity costs. Since NPP costs are largely fixed, regardless of operation level, these plants are usually operated as much as possible in order to generate as much electricity as possible in order to maximize financial results;
- Nuclear projects face uncertainty due to unpredictable, high-impact events. An NPP has the potential for large outages (i.e., a year or more) that are related to regulatory issues triggered by natural disaster or political decision, during which total costs may actually rise for the NPP. These outages may be unrelated to the NPP itself and could be connected to a major nuclear incident in another jurisdiction. Therefore, a nuclear PPA could include provisions that reflect the potential for major nuclear outages and accidents with significant economic consequences including long shutdowns or early closure;
- Insurance coverage: An NPP will be required to maintain third party nuclear liability insurance coverage up to the limit on third party liability, as establish by international treaty and/or national law. Such insurance is expensive, and for embarking countries, it might not be available at the level (and price) needed to support the NPP;
- Funding of spent fuel disposal and decommissioning: For an NPP, the costs of spent nuclear fuel disposition and decommissioning are typically required to be funded in a manner that the funds are segregated and auditable, ensuring that there are sufficient funds available for spent fuel disposition and decommissioning in accordance with the mechanism implanted by the government. Often, the funding of these externalities is done by passing the costs through to end-use customers. Also, a typical approach is to make contributions to funds that will be used to pay for spent nuclear fuel disposition and decommissioning. National laws will typically establish the approach to and requirements for funding these costs, often tied to the proceeds from electricity sales. Accordingly, a nuclear PPA could reflect the responsibility for, approach to, and requirements for funding spent nuclear fuel disposition and nuclear plant decommissioning;
- Financial incentives and penalties: In a typical PPA, the obligations of the seller and the buyer may often be ‘enforced’ with financial incentives and penalties. For an NPP, it is important that any financial incentives are within the context of safety being the priority. It is possible that incentives may raise issues for lenders and investors. Therefore, nuclear PPAs may be structured to drive proper behaviours and ensure a healthy safety culture in the operating organization;
- Environmental benefits: The PPA could specify who owns the value of environmental benefits created by NPPs;
- NPP uprates and performance improvements: The PPA could specify how a power uprate be reflected in PPA, such as maintaining an option to increase the PPA maximum quantity.

Two variations on the PPA structure are the contracts for difference (CfD) model and the regulated asset base (RAB) model. Each structure fulfils the same purpose of a PPA, but they adjust the mechanics relative to market structure and function.

The next segment provides a brief overview of both structures. What is most relevant for embarking countries is: (a) these structures are being considered for new reactor programmes; (b) they underscore the need for structured solutions in deregulated electricity markets; (c) the economics established by the two structures recognize the importance of a creditworthy counterparty.

4.5.3. Contracts for difference model

CfDs are used in liberalized power markets where there is a public spot price, and it is understood as a variation of PPA. Typically, such electricity spot prices are highly volatile, and buyers and sellers use CfDs to 'lock in' energy prices to manage the risk of the price of power in the spot market. The power buyer agrees with the power seller to purchase a specified physical quantity of energy at a set price (which is called the 'strike price').[16] If the actual price paid by the purchaser is higher than the strike price, the seller pays the purchaser the difference in cost. Conversely, if the price paid by the buyer is lower than the strike price, the purchaser pays the counterparty the difference.

The CfD model is currently being used for the Hinkley Point C (HPC) project where a 35-year offtake period is given in the United Kingdom (U.K.). However, NPP project developers for future projects in the U.K. are requesting additional support from the government, with a particular emphasis on reducing the financing costs. While the CfD model creates revenue certainty when the NPP generates electricity, the developer takes project delivery risk. Moreover, it is important to remember that the CfD provides no revenue until electricity is produced. As a result, it provides no support as development and construction costs are incurred, and, thus, it has no impact on interest during construction or completion risk.

4.5.4. Regulated asset base model

One option to address the perceived shortcomings of the CfD approach, is the use of the RAB model for the construction of an NPP. Under a RAB model, a regulated market structure is created (within the overall deregulated electricity market), whereby the NPP owner/operator would benefit from regulated rates of electricity generated to cover the costs associated with developing, constructing, and operating the asset. The RAB structure would allow for a profit element, and it would also allow for cost recovery during construction. This will have a favourable impact on the overall economics of the project by bringing forward revenue streams since it is ultimately reflected in the financial model for the NPP project. While the RAB model has been used for non-nuclear projects in the U.K. and is now being targeted for the next large reactor project in the U.K., the idea of cost recovery during construction has been utilized in the USA for some time in regulated electricity markets as well.

[16] Alternatively, the generator could sell electricity on the market, with a government-structured counterparty paying the generator the delta between the market price and the strike price.

4.6. TECHNOLOGY TRANSFER

National industrial participation and involvement to the NPP project is one of the interests of the embarking countries as numerous facilities, equipment, parts as wells as relevant services are required to construct the first NPP and sustain its safety operation. Technology transfer can contribute to build up the enabling environment to foster the national nuclear ecosystem.

Generally, the objective of technology transfer is to move technology from the holder to the recipient, and it can be regarded as successful if the recipient effectively uses the transferred technology [13]. This is why technology transfer is described as "a learning process" and this process will go through "negotiation, education, facility development and training" [13]. Such a commitment from both side needs to be documented and contracted properly.

Technology transfer in relation with the NPP project may include a variety of elements such as design, manufacturing, construction, engineering and management, and the subject of transfer may take various forms ranging from equipment, technical documents, intellectual property, know-how, skills and among others. This may include wide range of stakeholders, such as universities, industries, research institutions, governmental bodies in addition to the owner/operator. It is worth noting that there are significant limitations for the transfer of technologies related to enrichment and reprocessing technologies.

In order to achieve successful technology transfer, various types of contracts may be agreed by different stakeholders. The target of the technology transfer varies according to the scale of nuclear power programme, intended reactor technology, existing nuclear and industrial capabilities as well as selected ownership and contracting approaches, and thus, selection of the suitable type of the contract is determined based on these elements.

Figure 3 illustrates different areas of technology transfer and stakeholders in different stages.

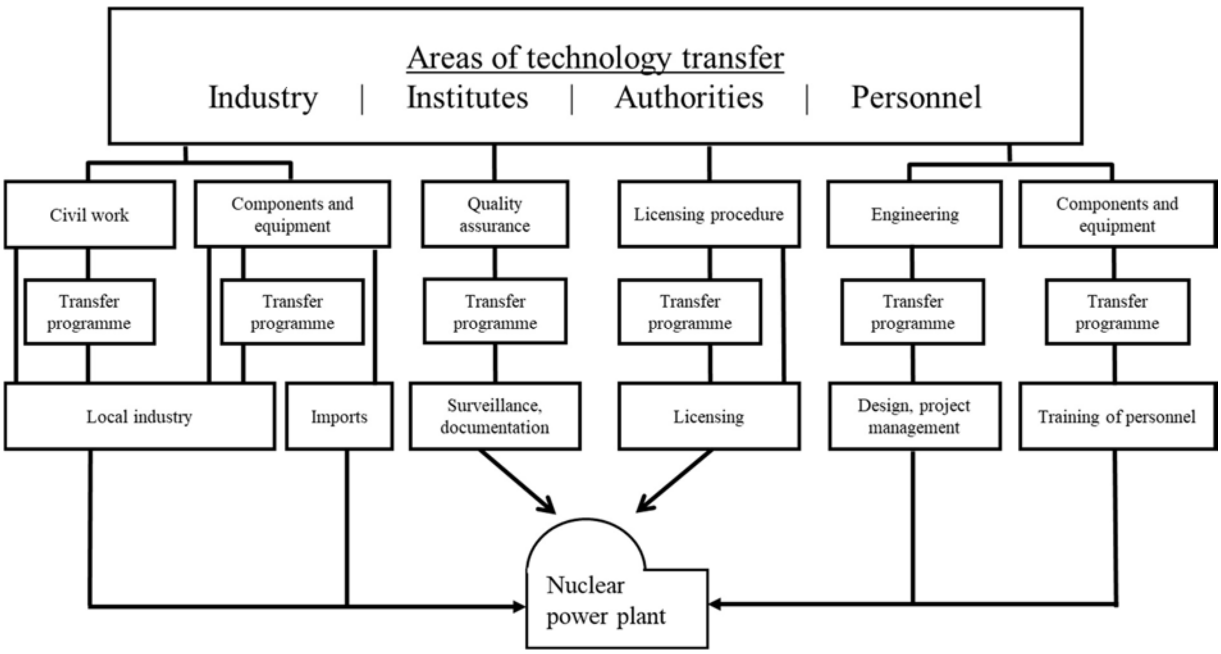

FIG. 3. Areas of technology transfer for NPPs reproduced from [13]

In many cases, the basis for the technology transfer begins with the IGA that provides the overall framework of nuclear cooperation for peaceful use between the technology providing country and the recipient country. A project specific IGA may be concluded to provide further foundation in relation with the specific NPP project.

Specific contracts can be followed to materialise each area of subject. Such a contract needs to clearly define the technology to be transferred, and the way the technology transferred, through ownership or license.

In case of technology transfer aiming at intangible assets, the licensing contract can allow the licensee to use the selected intellectual property, such as patents, trademarks, copyright, and know-how. The licensor on the other hand may guarantee that:

- “The technology is suitable for the products covered by the agreement.
- The know-how transferred belongs to the licensor.
- The technology is capable of achieving the level of production that is specified.
- The content of the technology transferred is full and complete.
- The delivery of drawings, specifications and material is completed within the specified time period.” [13]

In order to avoid future disputes, the licensing contract needs to clearly address the ownership of the existing technology that each party brings (commonly referred to as ‘background technology’) as well as what rights the parties may have to changes or improvements of the technology by the recipient as well as jointly developed technology, all of these commonly referred to as ‘foreground technology’). The licensor may want to restrict the use of foreground technology by the recipient to avoid possible competition in the market. Mutually agreeable licensing fee and treatments needs to be discussed and clearly stipulated in the contract.

Another type of a contract to support technology transfer is a technical cooperation contract. The technical cooperation contract involves not only simple transfer of a set of technical documents or physical assets, but also includes hands on training or consultancy-type support to enhance the technical capability of the recipient, and this support will be typically provided by the vendor. Technology cooperation contracts include a number of articles that may be similar to the licensing contract, but it also needs to specify the methods of implementation through training or consultancy service.

Other forms of contracts can also be used for NPP projects. For instance, joint venture contracts may be used for efficient technology transfer under which the technology holder bring the technology to the company established under the law of the host government and the local shareholders can acquire the provided technology through training or daily operation.

5. FINANCING IN RELATION WITH OWNERSHIP AND CONTRACTING

5.1. FINANCING AND FINANCIAL RISK

Nuclear new-build projects have very unique characteristics that make an NPP project unlikely to based purely on an economic basis by investors, at least during the development and construction phases. Specific features, which include the long life-cycle, a challenging development and construction phase, a lengthy and costly regulatory process, and long-term underlying commitments regarding waste management and decommissioning, make the investment case for embarking countries uncertain from a financing perspective for an equity investor. Additional factors, such as the need for sustained government commitment over decades of project development, construction, and operation, also create uncertainties for the investor community. All these factors are enhanced in the case of an embarking country, where no track record exists for NPP development.

For several years, many governments have been under financial constraints to provide large budgets for long-term investments in NPP projects, and the situation is unlikely to change dramatically in the near future. The capacity of private sector stakeholders to assume that responsibility is also increasingly difficult, due to a broad range of reasons, including weaker balance sheets, challenging electricity market conditions, more stringent social and environmental requirements, and competing investment proposals.

As a consequence, NPP projects, like most large infrastructure projects, need to seek a variety of sources for their financing, comprised of a combination of equity and debt.

As noted in Section 3, three financing models can be defined for an investment in NPP projects: (a) the sovereign-based type; (b) the corporate-based one; (c) the project-based one (theoretically). None of these ownership and commercial structures is either definitive or exclusive. It is possible to take combinations and/or variations of these three models, and this would give flexibilities for project developers to structure the NPP project to be suited for prerequisites under the nuclear power programme.

Five forces act together, which define and shape the financing model and hence the structuring (from a corporate, commercial, contractual and financial point of view) of an NPP: (a) the key stakeholders promoting the project; (b) the availability and the depth of the various sources of financing that are available; (c) the financial instruments used to finance the investment; (d) the risk profile of the proposed project structured by the contracts; (e) the revenue profile for the project (i.e., the electricity market/offtake structure). These elements find a balance based on the various parties' appetite for risk, notably financial risk. This is particularly the case for new-build projects in embarking countries.

5.2. EQUITY FINANCING

Issues concerning ownership were introduced in Section 3. In the broader context of financing, though, additional equity considerations should be noted, which impact the overall financeability of an NPP project.

First, during the development and construction phases of an NPP, there are limited sources of equity. While certain forms of debt are available (as discussed in Section 5.3 below), and such debts can provide the majority of the financing for the project, the equity component remains a challenge. Given the unique factors that have been previously discussed which NPPs face during project development, developer capital is most likely limited to host country sources –

chiefly the host government, the national or regional utility and industrial users to obtain electricity at cost.

Second, as a technology partner is identified, vendor equity could be sourced, but commercial vendor companies would face difficulty to finance equity, except in certain cases where state owned entities are involved. If such vendor equity is a priority for the host country, then such a requirement does have the potential to limit technology options, depending on (a) the amount of vendor equity sought; and (b) the timing of when such equity is needed.

Third, if one were to assume a 5–7 year period from first safety concrete to commercial operation, as well as history of schedule overruns for NPP projects, such a profile does not suit passive equity investors, who do not wish to have capital that is at risk and not earning returns until many years into the future.

Fourth, with electricity market deregulation, equity investors are unwilling to deploy significant levels of capital and then take significant market risk, especially in scenarios where other forms of generation, such as wind and solar, are favoured through the use of subsidies or feed-in tariffs, tax credits, and dispatch preferences, among other things.

Fifth, given the asset life of NPPs, certain forms of revenue support are not matched in a manner that favours long-term equity hold strategies (e.g., a 20-year PPA does not fit an NPP that will operate for 60 years or more).

Given these equity considerations, several conclusions follow:

- If external equity, not tied to the major project participants, is desired, the project will need to be structured to attract such equity. Such structuring work will need to occur early in the project's development cycle, as such efforts to attract equity go beyond the construction of the project. Such structuring may need to consider electricity market structure, national and supranational laws, and market support mechanisms (e.g., CfD, RAB, PPA). Attracting such equity may impact the overall risk allocation for the project, especially if host government resources are limited. Consequently, it will be beneficial for the government and the owner/operator to establish long term equity finance plan, including refinance strategies explored below, at the early stage of the project development;
- With the reluctance of investors to support NPP projects during the development and construction phases, coupled with the reduced risk profile of the asset after commercial operation, refinancing strategies can be developed for the NPP project. Under a refinancing approach, the overall cost of capital for the project can be lowered, as less expensive equity (and debt) can be sourced, particularly from an investor group that wish to make long-term investments in stable assets and more leveraged financial structure might be considered. However, in order to create a viable refinancing strategy, the project needs to be structured in a way to attract investors. Such structuring around offtake/electricity market concepts was discussed in Section 5.4;
- If the host government carries some risks (e.g., regulatory uncertainty, cost overruns) and takes on certain equity financing responsibilities to support the riskiest period of the NPP project, such short-term burden will, in turn, minimize the government's exposure to the project. In an environment where policy/public support is needed at the development stage, one possible approach would be to pre-package the refinancing, such that the refinancing is legally committed prior to major construction but not funded until commercial operation or, more likely, a year or two of successful operation. There is room for examination of feasibility of this sort of arrangement as it has not been utilized in past projects;

– Noting the challenges associated with NPP project financing, and the trend for NPP project development to occur within a bilateral framework, Government-to-Government (G2G) financing has become more prevalent. Such financing occurs between the exporting government and the host government, often as a sovereign-to-sovereign loan between each Ministry of Finance. The loaned amount is then invested as host government equity into the project or be on-lent via a state-owned financing institution to the owner/operator for financing debt. Under this G2G structure, the repayment obligation is not tied to the commercial operation of the underlying asset being financed. While such a method has the potential to provide additional financing sources for the project, the debt repayment obligation has the potential to have a credit rating impact on the host country's sovereign debt rating, depending on the size of the debt and the perceived risk and scale of the underlying project. Alternatively, the G2G approach could involve state-supported equity investment into the project itself, whereby the exporting country, either through its NPP vendor or state-administered fund takes an equity stake in the NPP project. At the extreme end of the G2G approach, combining both debt and equity from the exporting county, is the BOO (or BOOT) model that was examined in [2]. As noted earlier, such a model can be done on a concession-based approach (i.e., a government-developer agreement on the project, which incentivizes the developer to take certain development risks in respect of the project).

5.3. DEBT FINANCING

In addition to raising the more challenging equity component for the financing of the NPP project, the owner/operator of a new NPP can benefit from deploying capital by using debt instruments, recognizing that the cost of capital on debt is significantly lower than the cost of capital on equity.

5.3.1. Available debt financing sources

In addition to government financing, there are two main sources for raising debt on the commercial market in order to finance large, capital-intensive infrastructure projects, namely the debt capital markets (DCMs) and the commercial bank debt market. Under current circumstances, DCMs have not been utilized for raising finance of NPP projects. More specifically, DCMs are not a suitable option to finance debt for a new owner/operator to build up the very first nuclear fleet. It might be considered for an operating organization to raise debt thorough DCMs for expansion of their NPP projects as the redemption of securities could be covered by revenues of operating NPPs.

Although there have been a limited number of exceptions, multilateral banks and development agencies (e.g., World Bank, African Development Bank, Asian Development Bank, etc.) do not take exposure to NPP projects as a matter of their policies and therefore will not be considered in this section. The commercial bank debt market, therefore, has been the market of reference for raising long-term debt for infrastructure projects at present. However, changes in regulatory and prudential requirements introduced after the financial crisis in 2008-11 have increased costs and constraints for commercial banks, subsequently leading them to limit/reduce their appetite to lend debt on a long-term basis.[17]

[17] Changes to the existing so called Basel III requirements by the Basel Committee on Banking Supervision are currently under discussion, which may impose additional requirements on banks to incentivize them lend to low-carbon project. Those new rules remain to be understood in detail to assess the treatment likely to be applied to nuclear new build projects.

As a consequence, key features of recent market trends include:

- The ‘typical’ maturity of loans to corporates is closer to 5 or 7 years than to 10 years;
- Banks are less keen to lend to infrastructure projects due to the longer timeframe (>12 years) usually expected for such projects and the lower liquidity of those assets on the debt secondary market;
- Banks considering long-term lending require additional risk mitigation through guarantees from project sponsors, or insurance coverage from ECAs or the private insurance market and other government institutions (e.g., political risk insurance, which can also come from entities like United States International Development Finance Corporation, Nippon Export and Investment Insurance, and Multilateral Investment Guarantee Agency);
- When lending, banks look for participations with a limited size to manage their exposures which require large syndicates to raise larger amounts;
- A limited number of ECAs have been involved in the provision of direct loans to nuclear new-build projects in the past, notably the Export-Import Bank of the Republic of Korea and the Export-Import Bank of the USA. These loans are intrinsically associated with the support provided by those ECAs to companies signing export contracts of goods and/or services from the Republic of Korea and the USA. respectively with clients based abroad;
- Commercial lenders also often lack the subject matter expertise needed to evaluate potential NPP projects. Hence, certain institutions are reluctant to support nuclear project - not because they have an anti-nuclear stance, but due to a lack of comfort with the asset class, given its complexity.

Thus, when considering traditional sources of debt financing, applying them to the nuclear context, and setting aside public money, the financing of a new-build NPP will result in the following:

[total amount of financing required] less [any amount of ECA-backed debt that can be raised through export credit or supplier credit, together with any amounts of ECA-provided direct loans] = [total amount of financing that has to be provided by the shareholders of the project and/or the host country]

5.3.2. Export credit agencies

ECAs have been established by governments to support the exports of services and capital good equipment by their exporters, and to promote jobs in their industries. ECAs are involved to support national exporters at an early stage of the development of the projects (e.g., planning and bidding stage, or before signing of a commercial contract).

The OECD Arrangement on Officially Supported Export Credits (OECD Arrangement) provides a range of guidelines[18] to provide “a level playing field” between officially supported export credits among OECD member countries while ECAs of non-OECD member countries, such as China and Russia, do not abide by the terms and conditions of the OECD Arrangement [14].

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[18] In case of direct lending, an applied interest rate is calculated according to the commercial interest rate of reference (CIRR), a minimum interest rate for fixed-rate loans tied to government bond yield and fixed margin, plus risk premium. The loan amount is equivalent to no less than 85% of export value contained within the total project cost. ECAs can also provide financing to support local costs. Such financing is capped at 50% of eligible national content. Long loan tenors for a new-build project stretched to 22 years (from the Commercial Operation Date) to reflect the requirements of the project’s economics.

Notwithstanding the ability of some ECAs to lend directly, their role is typically to provide, on behalf of government of the supplier's country, insurance or guarantee covering: (a) "the risk of loss arising from manufacturing"; (b) "the credit risks borne by suppliers under commercial contracts(and) banks under credit agreements" [9].

Within the NPP project context, and among the range of long-term debt financing instruments theoretically available, export credits backed by an ECA remain a tool of reference for all the parties concerned:

- For exporters of nuclear power technologies, the ability to offer financing solutions has become a critical competitive advantage, especially for exports to embarking countries. Often, this is because the borrowers in those countries may not have credit worthiness for international banks to procure necessary finance;
- For lenders to NPP projects, insurance against political risks and commercial risks are critical features to be able to commit financing on a long-term basis. The cover provided by ECA can protect the lenders against such risks caused by the borrowers and facilitate to structure financing for the NPP project. In addition, ECA coverage allows banks to manage their prudential obligations, support the liquidity of their portfolio of assets - all leading to offering more competitive pricing.

6. IMPACT OF SMALL MODULAR REACTORS DEVELOPMENT ON OWNERSHIP, CONTRACTING AND FINANCING

While the preceding sections of this publication have focused on matters of general NPP project applicability - risk allocation, ownership, contracting, and financing - the discussion that follows is adjusted to account for technological differences, which might offer new ways of thinking about these classic issues.

SMRs are viewed as a new wave of technological development within the nuclear power generation sector. Traditionally defined as having outputs at or below 300 MWe, whose components and systems can be prefabricated and then transported as modules to the sites for installation as demand arises. SMRs represent a paradigm shift for NPP project development. A wide variety of SMR technologies are under global development and detailed information is available in [15].

Among the positive attributes suggested by the SMR vendor community, SMRs are intended to have a lower aggregate cost, a shorter construction period, and a greater construction certainty due to factory assembly. In addition, through technological innovation, designs have been simplified, along with advanced, passive, and inherent safety features. However, SMRs are still in development[19], which creates uncertainty from a project delivery (both cost and schedule) and financing perspective.

6.1. KEY ISSUES

Key issues, both positive and negative, related to SMR technology are discussed below.

(a) Lower upfront cost

At a lower upfront cost (relative to a large reactor), SMRs could provide a pathway for countries that cannot afford a large reactor. A lower upfront cost means that less debt and less equity need to be sourced. The lower upfront cost also creates greater possibilities for balance sheet financing, as well as having less of a balance sheet (and credit rating) impact for sponsors/owners.

(b) Shorter construction period

A shorter construction period means there is less accumulation of interest during construction. In addition, a shorter construction period also reduces the equity hold period for investors (i.e., less time between commitment of funds to revenue generation/return on investment).

Combined with a lower cost, the shorter construction period (currently indicated as three to five years) also reduces the aggregate contingency needed in the financing plan (and, thus, less completion support).

(c) Small & scalable

At a size that can vary from microreactors in the 1–5 MWe range to multi module packages approaching 1000 MWe, SMRs offer a variety of options for owner/operators. This is particularly relevant in two instances. First, an embarking country, given grid constraints and overall demand considerations, might not need a large reactor. However, a small reactor might

[19] The two notable exceptions are the Russian floating reactor being deployed in the Arctic and the Chinese HTR-PM in Shandong province.

fit within its energy resource planning programme. Second, these smaller ranges might be suited to the needs of dedicated industrial/process end-users (e.g., mining operations, desalination, hydrogen production, district or industrial heat, 'inside the fence' industrial projects, etc.), which might make a stronger business case and/or investment more attractive or for remote communities as well as for non-electric applications).

A smaller size also lends itself to scalability. For a country with a growing demand, building a series of smaller reactors, as opposed to one large reactor, might be a more sensible approach to matching demand growth and/or available financial resources. In addition, from a financing perspective, instead of waiting for one large unit to reach commercial operation and begin generating revenue, a multi-unit SMR approach has the added benefit of earlier revenue generation, which can support the financing for additional units in the series.

(d) FOAK risk

As mentioned above, SMR technologies are on the way to deployment and embarking countries may face risks associated with FOAK. Regardless of the design basis of a reactor technology, "the risks associated with FOAK can be significantly greater than for follow-on units" [9]. FOAK risk can be present in several different attributes such as regulatory process, deliverability by the vendor team and available operational track record in the vendor country. Therefore, it might be prudent for technology recipient member states to wait for such SMR technologies to become 'proven', typically, "a technology that has an operational track record at least one reference plant domestically or internationally" [9].

6.2. ATTRACTIVENESS FOR INVESTORS

In order to broaden available options of ownership approaches, it is beneficial to attract new investors for SMR projects. The SMR technologies have attractive virtues for potential investors:

- First, investors could be interested in an SMR design from a technology development perspective, particularly those that might have an interest in investment in clean energy technologies;
- Second, given potential applications for desalination, hydrogen production, mining, etc., industrial partners that are application-focused could look to SMR designs as investment opportunities;
- Third, as has been already demonstrated in several cases, engineering, construction, and manufacturing companies might wish to partner with an SMR developer, either through direct financing or through 'in kind' contributions, as a way of strategically positioning these companies as exclusive participants in future reactor deployments;
- Fourth, governments (usually technology developing countries) may provide grant financing for technological development, licensing, and prototype or demonstration projects, as part of a technology development and export strategy for the country. Governments can also take direct equity in the vendors, with the most robust case being that the vendor is a state-owned entity.

Based on above, the investment case for an SMR project is a combination of several factors. While these are relevant for large reactors as well, the segment that immediately follows this list highlights some issues for particular consideration linked with positive and negative issues aforementioned:

- The timing of the equity investment, relative to the commercial operation (and revenue generation) of the unit(s)[20];
- Feasibility of achieving targeted tariff;
- Structure of cost recovery mechanism (the strength of the revenue stream (market risk versus regulated return (and the long-term future of such electricity market structures), offtake structures in deregulated markets (e.g., power purchase agreements, contract for difference mechanisms, etc.), including the tenor, rate, and creditworthiness of such structures;
- The likelihood of on time, on budget delivery;
- Country-specific risks; The availability (and cost) of debt finance including from institutional investors;
- The liquidity of the investment (i.e., exit strategy, market interest in refinancing, etc.).

Of course, the previous factors reflect the interests of a classic equity investor. Two considerations, however, may change that dynamic.

First, the more that nuclear power is considered part of a clean growth strategy with the corresponding recognition in favourable fiscal and financing tools, the more likely that investors will see SMR projects with its positive characteristics as a viable investment as part of a 'green' portfolio, particularly those investors focused on ESG investing [7]. In this context, inclusion of Nuclear Power in the EU Taxonomy as a sustainable energy option, with relatively low impact on ecosystems and biodiversity, will serve to mobilize investment toward a sustainable net zero world as descried.

Second, to the extent that parties are interested in SMRs as the electricity and/or heat source for industrial processes (hydrogen, desalination, etc.), industrial investors could view the SMR investment case as more of strategic investment within an overall business strategy, as opposed to a stand-alone investment. In this case, the convergence of public policy and clean growth strategies is critical to the investment case. Furthermore, the contracting structure will need to bring together all elements of the industrial process, such that the SMR project element is placed within the larger framework.

In addition, insurance markets and nuclear liability regimes have not fully addressed SMRs. How these two critical components of an NPP project structure evolve (as regulatory structures evolve) will also impact the investment case for an SMR project.

As a final point from an investor's perspective, the bottom line is that the technology has to work and be deliverable. While there is promise about variations on SMRs and advance reactor technologies, particularly with new, innovative techniques, most investors will be more results-oriented than process-oriented. To the extent the project is de-risked, government and public support is strong, and the economic case is robust, investors that might consider nuclear assets will favour certainty (and time to market) over further incremental advancements that resonate more with the engineering community.

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[20] Note that, under a multi-module or multi-unit SMR project development approach, the entry into operation (and corresponding revenue generation) of the earlier module(s) or unit(s), can enhance the investment case, as revenue is brought forward in the project lifecycle.

6.3. CONSIDERATION ON CONTRACTING APPROACHES AND RISK MANAGEMENT

Until an Nth-of-a-kind (NOAK) state is achieved by each SMR technology, the question of risk allocation is critical. From that perspective, it is not just about how the risk is allocated and whether a party has the technical ability to manage the risk; it is also about the credit behind the deal. Specifically, a mitigation plan needs to be considered in case the project does not go forward as planned. For instance, finding available financial supports that can solve the problem and drive the project forward to commercial operation is critical to achieve the successful NPP project.

Thus, from a contracting perspective, the parties will have to establish a robust risk allocation framework to deal with a technology and project delivery framework that, in all likelihood, has not reached NOAK status. In such a situation, all parties will need to establish a rationalized and commercially reasonable balance within the contracting structure. A viable project contracting structure will account for the uncertainties that exist – both ‘known unknowns’ and ‘unknown unknowns’.

From a risk mitigation structure, several elements will be significant:

- An experienced project delivery team (particularly from EPC contractor);
- Some level of prior experience by the project delivery team in the host country;
- A believable project execution plan, utilizing critical path analytics;
- Country-of-origin design recognition by the host country (certification or generic design assessment as facilitator for the specific design and site related host country authorization);
- Degree of harmonization of regulatory frameworks (to internationally recognized standards, as well as minimal deviations from the regulatory approach in the country-of-origin);
- Relief for regulatory delays not arising from the owner/operator;
- Reduction (to the extent possible) of country-specific risk factors by the host country prior to contract award;
- A flexible contracting structure;
- Strong public support and sustained government support within the host country;
- The existence of a prototype/demonstration project, or, ideally, a reference plant;
- Credibility and capability within both the host country regulator and owner/operators.

Given the variety of SMR technologies and project models that are under consideration, no ‘one size fits all’ approach to contracting and investing exists. Deployment of SMR technologies will give more clarity on the impacts of SMR technologies on ownership and contracting approaches.

7. CONCLUSIONS

With the increasing interest of Member States in developing large NPPs or small modular reactors and the challenges associated with bringing an NPP online, a wider set of options have to be considered for NPP development, as all Member States are not similarly situated.

Each NPP project is unique and has very specific to national conditions when considering factors such as: technology preferences, the localisation strategy, regulatory environment, economic conditions, public acceptance, political systems, level of development, electricity pricing markets, financial resources, and technical capabilities.

The main purpose of this publication was to provide insights into how Member States think about NPP project development and how to prepare for the main issues that need to be addressed in the areas of structuring, ownership, contracting, and financing.

The ownership approach defines the capability of the owner/operator in terms of financial and/or technical. It leads the owner/operator to identify the most suitable contracting approach that enables the owner/operator to allocate risks to project stakeholders. The project structure formulated by ownership and contracting approaches is the decisive factor of financeability of the NPP project.

Member States need to appreciate the interconnectivity of the issues, particularly the importance of risk allocation and risk management, which can directly influence all structuring considerations. These elements merge around the concept of project viability. While viability involves a number of concepts, financing may be one of the most important. If a project is not financeable, there is no project.

A well-designed project is one that balances risks relative to financeability. Ultimately, a successful project is one that delivers an operating NPP within a desirable timeframe under a structure that is sustainable, both operationally and economically, for the asset's useful operating life, while maintaining the highest standards for safety, security, and safeguards.

No one approach will work for all. Taking into consideration the challenges foreseen by a country embarking on nuclear power, classical models that have been used for prior and current NPP development might not be suitable for their particular situations. In light of these concerns, this report has attempted to identify other possible options for NPP development. In doing so, the following principles should be considered, as a Member State attempts to assess whether a particular approach is feasible. These include:

(a) The host government has a critical role to play in NPP project development, particularly with regard to financing structures and risk management techniques. Furthermore, a sustained commitment by the host government is critical to project success;
(b) The owner/operator will need to have strong project management capabilities, either directly or through the use of external sources, to oversee all aspects of project development. Ultimately, an experienced, interdisciplinary team will be required to develop the project, negotiate the requisite contracts, and manage the project on a going-forward basis. This experience factor will be particularly important in developing operational capabilities, whether it be within an existing ownership structure or separated under separate ownership and operating entities;
(c) Several different EPC contracting options are available, but the pricing structure is driven by the risk allocation under each option, and the viability of each option is a function of a number of factors, to include the capability of the owner organization;

(d) Several contracting and ownership structures are available for developers and planning authorities. Project- and country-specific considerations will impact what contracting and ownership structures are best suited to a particular NPP project. With that in mind, it is essential for developers and planning authorities to understand the strengths and weaknesses of each of these structures before selecting the one that will maximize overall project viability;
(e) Financing options are limited during development and construction, but, as the risk profile of the project changes, new sources of financing can be utilized to reduce the overall cost of capital;
(f) Lessons learned from prior and current NPP projects need to be integrated into project planning and structuring;
(g) Pre-award planning (and the associated financial and schedule investment therein) can reduce project risks and create greater project efficiencies;
(h) Financing is a function of the project structure and of available sources of capital relative to the phases of the project. Most importantly, external financing will be a function of the project's economics and the strength of the offtake structure for the project. Economic viability needs to be considered relative to both the electricity market structure and the creditworthiness of the off-taker;
(i) The nuclear sector continues to evolve. As attitudes change towards nuclear energy and the global community's priorities reshuffle, new opportunities (e.g., ESG investing; clean finance/clean energy taxonomy) are arising, which, in turn, will impact how projects are structured and financed. Nevertheless, even if new financing sources become available, availability does not mean investability, and the latter will be a function of whether the proposed project meets financiers' assessments of a 'good' project;
(j) As SMRs come to market, new options exist for embarking countries and existing nuclear countries as they consider SMRs for their energy portfolios. With the hope that SMRs de-risk certain aspects of NPP project development, nuclear energy can become a more readily available option for Member States;
(k) Ultimately, project success is about sound project fundamentals that are established by the suitable ownership and contracting approaches, while recognizing certain unique characteristics (e.g., the nuclear regulatory process) of nuclear energy;
(l) A successful NPP project needs to align activities at both the national and project levels in order to achieve project success.

The annexes provide further information on actual Member States' experiences.

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ANNEX 1: ARAB REPUBLIC OF EGYPT: EL-DABAA NPP PROJECT

I. 1. EXPERIENCE WITH NUCLEAR POWER

The importance of the applications of nuclear power for peaceful purposes has been recognized in Egypt since the early 1950s, with the formation of the Atomic Energy Commission in 1955, which was closely followed by the formation of the Atomic Energy Establishment in 1957 (now known as the Egyptian Atomic Energy Authority (EAEA)). Upon its formation, the EAEA was charged with the promotion of nuclear science and the peaceful applications of nuclear power within Egypt, including with respect to the generation of electricity.

Egypt constructed its first research reactor, the Experimental Training Research Reactor 1 (ETRR-1) in 1958. ETRR-1, which achieved first criticality in 1961, was later followed by the construction of the Egypt's second research reactor, the Experimental Training Research Reactor 2, in 1992, which achieved first criticality in 1997.

In parallel, with its research reactor programme, Egypt first took steps towards the establishment of a civil nuclear power programme in the early 1960s which, over time, culminated in both the founding of the Nuclear Power Plants Authority (NPPA) as the future owner and operator of NPPs and the signing of a contract to identify potential sites to host a n NPP in Egypt. After evaluating a number of potential sites, the El-Dabaa site along the northern west coast of Egypt on the Mediterranean Sea (approximately 170km west of Alexandria) was designated for further evaluation and was eventually selected as the location for a future NPP. BIS were subsequently drafted, and an international tender conducted to select a vendor for Egypt's first NPP. However, in 1986, before the procurement process was completed, the Chernobyl accident occurred, and Egypt suspended the development of its programme.

Following its decision made in 2007 to resume a civil nuclear power programme, the Egyptian Government adopted Law No. 7 of 2010 "On the Enactment of the Law on Regulation of Nuclear and Radiation Activities", established the Egyptian Nuclear and Radiological Regulatory Authority (ENRRA) as Egypt's independent nuclear regulatory body. According to Article 12 of Law No. 7, ENRRA is responsible for "all regulatory and control functions and duties" that are related to the nuclear and radioactive aspects of nuclear energy. ENRRA plays a key role in Egypt's development of nuclear power, representing the national point of contact for nuclear safety, security, and safeguards.

I.2. FRAMEWORK OF THE PROJECT

I.2.1. National decision and strategic partner

On the 27th of October 2007, the President of the Arab Republic of Egypt announced that a strategic decision had been made to resume the civil nuclear power programme and to construct a number of NPPs in Egypt. The strategic decision to include nuclear energy in its energy generation mix, which is also contemplated under Egypt's 'Integrated and Sustainable Energy Strategy to 2035', is driven primarily by a desire to diversify Egypt's energy mix in order to phase out the use of fossil fuels and address constraints on domestic energy resources in light of a growing population and the associated increase in demand for electricity, with a current electricity consumption growth rate of around 5%. Notably, most of Egypt's available hydropower, a key renewable source within the country, is already being exploited.

A feasibility study, first carried out in 2001 on the possible construction of an NPP for electricity generation and seawater desalination at the El-Dabaa Site, was updated by NPPA in 2007 with the assistance of the IAEA through its Technical Cooperation programmes.

NPPA prepared a BIS in 2011 in preparation for the launch of an international tender for a contractor to deliver the El-Dabaa NPP project, which was reviewed by an IAEA mission in 2011. In early 2015, Egypt instead decided to select a strategic partner for the implementation of the El-Dabaa NPP project and proceed through direct negotiations with the Government of the Russian Federation. In November of 2015, the Egyptian Government concluded an IGA with the Government of the Russian Federation on "Cooperation in Construction and Operation of the Nuclear Power Plant on the Territory of the Arab Republic of Egypt", which, amongst other things, contemplates the delivery of four Russian designed VVER-1200 (AES-2006) units with a capacity of 1200 MWe each.

I.2.2. Egyptian electricity market structure

Egypt has been taking steps towards liberalizing its electricity market since 2000, with the passing of the new Electricity Law No. 87 in 2015 marking a significant move towards commercially-oriented competitive generation markets in the country. Currently, the Egyptian Electricity Holding Company (EEHC) owns 90% of the installed electricity generation capacity, and its subsidiaries are in charge of transmission and distribution.

The El-Dabaa NPP Project will contribute 7 % of the total capacity of the electricity grid after it is brought online.

I.2.3. Key national stakeholders

NPPA has developed a stakeholder involvement strategy which includes specific plans of action that are accompanied by approved activities, responsibilities, timelines and budgets.

The main Egyptian Government stakeholders of the El-Dabaa NPP project include: The Ministry of Electricity and Renewable Energy (MOERE); NPPA; ENRRA; EAEA; the Nuclear Materials Authority (NMA); EEHC; the Ministry of Finance; the Ministry of International Cooperation; the Ministry of Foreign Affairs; and relevant Egyptian security agencies and authorities. Interfaces with such stakeholders were established to support the development of nuclear infrastructure and to implement the nuclear power programme.

MOERE supervises and oversees the three nuclear authorities in Egypt namely: NPPA, EAEA, and NMA. It serves as the secretariat and primary liaison and communication channel between the Coordinating Committee of the Supreme Council for Peaceful Uses of Atomic Energy and the development of the nuclear power programme. EAEA is responsible for radioactive waste management in Egypt and NMA is responsible for exploring possible uranium ore deposits in Egypt.

The Ministry of Finance and the Ministry of Investment and International Cooperation represent the Egyptian Government in matters related to the financial terms under the IGA and the Credit Inter-Governmental Agreement (CIGA). The Ministry of Foreign Affairs liaises with its respective counterparty in the Russian Federation in relation to various bilateral matters arising between both countries with respect to the implementation of the El-Dabaa NPP project.

ENRRA, the regulatory body, is responsible for the regulation of safety, security, and nuclear safeguards, as well as the licensing process for NPPs in Egypt. ENRRA receives support from the Russian Federal Environmental, Industrial and Nuclear Supervision Service (Rostechnadzor), as well as Russian and international technical support organizations.

I.3. OWNERSHIP AND FINANCIAL STRUCTURE

I.3.1. The owner

Law No. 13 of 1976 "*On the Establishment of the Nuclear Power Plants Authority for Generating Electricity*" and its amendment by Law No. 210 of 2017 (Law No. 13) and Law No. 7 designate NPPA as the authority solely responsible for the construction and operation of NPPs in Egypt and will be the future owner and operator of the El-Dabaa NPP project. On the basis that NPPA is owned by the Government of Egypt, the El-Dabaa NPP project is fully owned by the Government of Egypt. There are no other shareholders in the project.

I.3.2. Financing arrangement

The El-Dabaa NPP project is financed by credit extended by the Russian Federation, which was first contemplated under the IGA and then arranged in detail between the Government of Egypt and the Government of the Russian Federation in a separate CIGA. Under the CIGA, 85% of the El-Dabaa NPP project is funded through a credit line extended by the Government of the Russian Federation.

The project related contracts contain several provisions which allow NPPA to properly manage the financial risks associated with contractual implementation of the El-Dabaa NPP project.

Funding in relation to the Egyptian nuclear power programme as a whole, including the budgets of ENRRA, NPPA and other involved Government authorities, is provided by the general state budget of the Egyptian Government.

I.4. CONTRACTUAL STRUCTURE

I.4.1. Intergovernmental agreement

As discussed in Section 2.1. above, the IGA was signed in November 2015. The scope of cooperation between the Government of Egypt and the Government of the Russian Federation contemplated under the IGA includes:

- Design and construction of four Russian VVER-type reactors;
- Supporting works and services in relation to commissioning, operation and maintenance of the El-Dabaa NPP;
- Long-term supply of nuclear fuel for operation of the El-Dabaa NPP;
- Spent nuclear fuel and radioactive waste management services;
- Site survey works;
- Human resource development;
- Infrastructure development for a nuclear power programme.

I.4.2. Contracts for implementation of the project

On the basis of the IGA, contract negotiations took place with various companies within the Rosatom State Atomic Energy Corporation group between 2015 to 2017 and were conducted by dedicated NPPA negotiating teams supported by technical, financial, legal and insurance advisors, across a suite of project contracts[21] which include:

- the EPC contract with Atomstroyexport Joint Stock Company (JSC);
- the nuclear fuel supply (NFS) contract JSC TVEL;
- the operation support and maintenance (OS&M) contract with Rusatom Service JSC;
- the spent nuclear fuel treatment (SNFT) contract JSC Federal Centre for Nuclear and Radiation Safety (now known as NFC Logistics JSC).

The suite of project related contracts, which includes fuel supply and fuel management services, reflects a 'turnkey approach' to the deployment of the El-Dabaa NPP project in which the NPP and associated facilities are delivered through a comprehensive set of contracts.

The negotiation of the project related contracts was informed by a study conducted by Egypt following its decision to embark on a strategic partnership with the Russian Federation. The study evaluated the economic and financial feasibility parameters of the El-Dabaa NPP project against other international NPP projects and included detailed financial analysis on the internal rate of return, the capital recovery period, and projected long-term profits. This information ultimately served as 'guiding principles' during negotiation.

The project related contracts define the roles of the contractors in relation to the construction and future operational phase of the El-Dabaa NPP.

I.4.2.1. Engineering, procurement, and construction contract

The EPC contract provides for the delivery of the El-Dabaa NPP on a turnkey basis, which includes all necessary design, engineering, construction and commissioning works. Extensive training of NPPA's personnel is also contemplated under the EPC contract, including theoretical and Russian language training, and also on-the-job and practical training at the reference plant in the Russian Federation in relation to the design, construction, commissioning, operation and maintenance of the El-Dabaa NPP.

A project Information Management System (IMS) is also developed in accordance with the EPC contract. The main objective of the project IMS is to provide an effective means to acquire, store, retrieve and edit the information and data necessary for the design, procurement, supply, construction, commissioning, future operation and maintenance of the El-Dabaa NPP. The Project IMS also ensures proper communication and exchange of information between all El-Dabaa NPP Project participants.

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[21] Further information with respect to the project related contracts is summarized in the IAEA's report following the completion of its Phase 2 INIR Mission to Egypt ("Mission Report on the Integrated Nuclear Infrastructure Review (INIR) - Phase 2", accessible on the IAEA's website).

I.4.2.2. Operation support and maintenance contract

The OS&M contract ensures the provision of the necessary operation and maintenance support to NPPA for the initial operating phase of the El-Dabaa NPP, and it contains mechanisms for extension if necessary. In addition to operational consulting services and maintenance and repair services and works, the OS&M contract also provides for:

- The provision of training services to ensure that NPPA personnel are appropriately qualified to perform their future job responsibilities relative to maintenance and repair;

- The provision of necessary consumables, materials, equipment and spare parts for both operation and ongoing repair and maintenance of the El-Dabaa NPP.

Importantly, the OS&M contract makes clear that NPPA will be the operator of the El-Dabaa NPP.

I.4.2.3. Nuclear fuel supply contract

The NFS contract provides for the supply of nuclear fuel throughout the operational life of the El-Dabaa NPP. The NFS contract also defines additional services to be provided by the NFS contractor to NPPA, including fuel management services, ongoing technical assistance and support, and an associated training programme.

I.4.2.4 Spent nuclear fuel treatment contract

The SNFT contract provides for engineering, procurement, construction, and commissioning works required to deliver a spent nuclear fuel storage facility and casks for the dry storage of spent nuclear fuel on a turnkey basis. The SNFT contract contains the optionality to expand the scope of work to include additional facilities and storage casks, and also provides for an associated training and maintenance programme and licensing support services

I.4.2.5. Contract for securing revenue stream

Due to the financing arrangements for the El-Dabaa NPP, there was no need to secure an early offtake agreement to support the financing. There is no PPA for selling the electricity generated from the El-Dabaa NPP, rather, the price for the electricity produced will be set by the Egyptian Government, similar to the electricity produced by any other conventional power plants connected to the Egyptian national grid.

I.5. CURRENT STATUS

The El-Dabaa NPP project is being implemented in three stages: (a) preparation/pre-construction activities; (b) the construction process until the commencement of operational testing; (c) commissioning and testing activities.

I.6. LESSONS LEARNED

Lesson learned during project development are listed in the Table 1 below.

TABLE 1. LESSONS LEARNED DURING PROJECT DEVELOPMENT

Major Challenges	**Impact**	**Solution**
Large capital investment (million US$) relative to alternative energy sources	Significant pressure is placed on decision makers and concerns is raised by the public due to the large scale project cost.	85% of upfront costs of the El-Dabaa NPP project are being financed through credit extended by the Russian Federation. Terms agreed within the CIGA, such as a favourable interest rate and the commencement of the repayment of principal after the operation of the El-Dabaa NPP, contribute significantly to promoting the commercial viability of the project.
Financing risk	Availability of adequate financing is a determining factor in order to proceed with El-Dabaa NPP project.	Extension of credit from the Russian Federation proved an acceptable financing mechanism in order to proceed with El-Dabaa NPP project.
Construction risk	It makes project finance almost impossible, especially for a FOAK NPP.	Extension of credit from Russian Federation. Integrated packages of contracts with highly experienced contractors. EPC turnkey contract for construction. Effective project management.
Technology risk	Technology risk is substantial, particularly for FOAK designs.	Use of proven design and employment of “reference plant” concept. Regulatory basis well-defined and experienced regulatory body with TSO support.
Security of fuel supply	Once construction of NPP is completed, it must have s secure and economically feasible supply of nuclear fuel.	Long-term contractual arrangements made with a highly experienced contractor for supply of fuel, with supply risk mechanisms addressed in the contract.

Safe Operation and Maintenance of NPP	Safety incidents have a significant impact on the nuclear industry, both globally and domestically.	Strong legal and regulatory framework and competent nuclear regulatory body with TSO support. Training and licensing of El-Dabaa NPP operators. Training commences early in project deployment and includes training on reference plant and other similar NPPs. Contractual arrangements made with a highly experienced contractor to ensure ongoing operational support and maintenance services.

TABLE 1. LESSONS LEARNED DURING PROJECT DEVELOPMENT (CONT.)

Major Challenges	**Impact**	**Solution**
Spent fuel and nuclear waste management	Spent fuel and waste management requires long-term planning, proper public and international acceptance and funding arrangements in place.	Government policies are in place. Contractual arrangements were made with a highly experienced contractor in relation to spent fuel and waste management services.
Political risk	Political decisions could be affected by public objections to nuclear power.	Public hearing sessions have been held in local community. Establishment of a technical school in local area. Promotion of the advantages of nuclear power as a clean and reliable energy source.
Regulatory risk	On account of regulatory inexperience and lack of understanding of the regulatory framework, regulatory-caused delay can occur and impact the delivery schedule of NPPs under project contracts.	Close coordination and continuous communication were fostered and maintained between the licensee and regulatory body (in a manner that does not impact its regulatory independence). Both the licensee and regulatory body received support from experienced professional consultants. Developing human resources and competencies is a focus of the nuclear regulatory body.

Others	Deployment of highly-technical project between the host government and the international supplier requires very different language and cultural adaptation.	English was chosen as the 'working language' for the El-Dabaa NPP project and project related contracts. International consultants are fluent in English, some of whom have familiarity with the Russian language, have been employed. Training programmes were agreed under the project related contracts that include Russian language training in the Russian Federation. International standard contracts were negotiated with the support of international experts in areas of technical, legal, finance and insurance matters.

ANNEX 2: ROMANIA: CERNAVODA UNITS 3 AND 4 PROJECT

II.1. EXPERIENCE WITH NUCLEAR POWER

Romania’s energy supply is well diverse consisting of coal, hydropower, natural gas, nuclear energy and wind.

Romania has deployed nuclear power since 1980’s. Currently, 2 units of Canada Deuterium Uranium 6 reactors with 1400 MW capacity in the Cernavoda site are operational. Nuclear power in Romania provides around 20% of national energy production. Cernavoda Unit 1 was completed in 1996 and produces 705.6 MW of electricity and Cernavoda Unit 2 achieved the initial criticality in 2007 and produces 706 MW of electricity. Based on the service capacity factor of both units (91.6%), Romania has a high-capacity factor of nuclear power plants worldwide according to Nuclear Engineering International. The last years of operation records demonstrated that the Cernavoda NPPs continuously advanced on the path to nuclear excellence. The National Company NUCLEARELECTRICA S.A. (SNN), a state-owned entity, is the owner/operator of Cernavoda NPPs, having experience of NPP project construction, commissioning and operation.

On the same Cernavoda NPP site, there are also two other nuclear units under construction, Units 3 and 4 (C-U3/4) and the completion of this project is the subject of this case study.

II.2. FRAMEWORK FOR THE PROJECT

The project completion of the C-U3/4 is mentioned by all the scenarios of “Romania's Energy Strategy until 2030, with the perspective of 2050”, as well as by the “National Integrated Plan in the Field of Energy and Climate Change 2021–2030”.

The main challenges to complete the C-U3/4 project are related to the necessary financing, which may include contractual and ownership. Romania has a well-developed nuclear power infrastructure, which include legal and regulatory framework and existence of a competent regulatory bodies, with experience in finalization of the Cernavoda Units 1 and 2. The safeguards requirements are well known and fully respected by the NPP owner/operator and the Romanian Regulatory Body for nuclear safety, National Commission for Control of Nuclear Activities.

The environmental requirements are also well known and fully respected by the Cernavoda NPP, Units 1 and 2 having valid environmental authorizations in accordance with the European Union applicable requirements. The process of granting these environmental authorizations included the cross borders environmental impact assessment and neighbouring countries consultations.

There are in Romania specific limitations related to the government support for the power project financing, imposed by the European Union directives requirements, which do not permit national government participation in the projects financing and also specific state aid (state guarantee for borrowed financial loans).

The acquisition/procurement legal framework in Romanian, which is based also on the European Union directives, impose a competitive process for the power project, including NPPs, and do not allow ‘sole source’ procedures for acquisition/procurement of an NPP or of the goods and services dedicate to power projects.

The owner of C-U3/4 project is SNN, the actual owner/operator of Cernavoda Units 1 and 2 which presently are in operation. Starting with 2004, SNN took the different actions trying to identify the alternative methods for financing the project completion. The descriptions of the alternatives for project completion and their past results are described in the next section.

II.3. HISTORY OF THE PROJECT

Pre-Feasibility Study for C-U3/4 completion performed in 2004 showed based on the financial analysis that although the project is financially/economically sound, it does not generate sufficient cash flow to reach the target debt-service coverage ratio during the first decade of the plant operation and is not able to sustain the required profitability, especially in the beginning of the operations.

Commitment to nuclear new units will involve long-term investment decisions by energy companies, banks and institutional investors. Under the above-mentioned circumstances, the owner of the project (SNN) started to identify the different solutions like long term electricity sales and project structuring arrangements in order to assure sufficient cash flow during the first decade of unit's operation.

II.3.1. Mankala model

In order to make the C-U3/4 project not only economically feasible, but also bankable, SNN selected the so-called Makala model. In this model, the new electricity generation units are jointly owned by several parties that have to assume the investment/cost in proportion to their ownership in the company and in return, they have rights to purchase energy from the company, on a cost price basis.

Using these principles, the following steps for the C-U3/4 implementation were performed by SNN:

(a) June 2007: Approval of the strategy for investor selection and foundation of the SPV like a Project Company by the Romanian Government.

(b) August 2007: Request of SNN for Binding Offer from the interested companies, with Letter of Interest. The request included a draft of Investment Agreement for comments of potential investors.

(c) November 2007: Binding Offers received from potential investors and 6 were selected for the negotiations of the Investment Agreement. These were well known company in Europe and in the world, involved in the electricity production, distribution and consumption.

(d) 2008: Common negotiations of SNN with all 6 potential investors in the following 6 area:

(i) investment agreement; (ii) operation and maintenance contract (Terms and conditions); (iii) finance (terms and conditions); (iv) nuclear safety and licensing; (v) final radioactive waste and decommissioning; (vi) technical issues (such as pre-project activities and contractual approach).

(e) 2009 January: Signature of the investor agreement by SNN and the selected investors.

(f) 2009 March: C-U3/4 project company was registered in Romanian as ENERGONUCLEAR, having 7 shareholders (6 electricity producers, including SNN and 1 big electricity consumer).

ENERGONUCLEAR stated to work on the pre-project activities (mainly the licensing and authorizations) definitions having a limited budget established by the shareholders.

In 2010 November, ČEZ one of the investors/shareholders, decided to stop his participation to the project and SNN took his shares. Also, in January 2011 another three investors/shareholders (GDF Suez, Iberdrola and RWE Power) decided to stop their participation to the project and SNN took their shares. In that moment EnergoNuclear remained with only three shareholders (SNN, ENEL and Arcelor Mittal Steel).

In 2013 December, the others two shareholders (ENEL and Arcelor Mittal Steel) stop their participation in the Project Company and the implementation of the Mankala model was interrupted by SNN. The project company remain as a subsidiary of SNN, being responsible only for C-U3/4 preservation and completion.

II.3.2. Contract for difference model

Next attempt to target financial resources to complete C-U3/4 project was initiated in 2014 by SNN, based on the U.K.'s experience, where EDF Energy together with China General Nuclear Power Corporation (CGN) started to finance in a specific mechanism, the construction of an NPP at Hinkley Point, Somerset.

CfD was considered for the C-U3/4 project in order to secure revenue stream to the owner of the NPPs. CfD enables the power producer to secure its revenues for the duration of the contract at a set price, 'the strike price', with adjustment mechanism where actual market price is higher/lower than the strike price.

This model was implemented for C-U3/4 based on the intention CGN to participate in project finalization. This intention was included into an inter-ministerial agreement[22] signed in 2013 November.

Based on the above mentioned MoU a "Letter of Intent between SNN and CGN for participation to Cernavoda Unit 3 and 4 project" was agreed and signed in the same year. Agreed steps were as follows:

- June 2014: New governmental strategy to select an investor;
- October 2014: CGN was selected as an Investor;
- November 2015: MoU was signed by SNN and CGN;
- July 2018: Romanian Government issued a Support Letter for the Project;
- May 2019: SNN and CGN signed the Preliminary Investors Agreement.

[22] The title of agreement was "Memorandum of Understanding (MoU) between Romanian Department of Energy and China Nuclear Agency for cooperation in the field of peaceful utilization of nuclear power".

Based on this agreement, SNN and CGN started to work for pre-project activities definition, using EnergoNuclear as Project Company.

In June 2020, the Romanian Government decided to stop the negotiation and discussions with CGN and to identify new partners/solutions for the project finalization.

II.4. CURRENT STATUS AND PERSPECTIVES

II.4.1. Governmental actions for project completion support

By decision of the Prime Minister of Romania, issued in July 2020, the Strategic Coordination Committee for the implementation of the Project of C-U3/4 NPP was created. This committee, which also includes the ministers of energy and finance, has as main objectives the analysis, crystallization and substantiation of strategic decisions and measures necessary for the implementation of the C-U3/4 NPP project.

In October 2020, the USA Secretary of Energy and the Romania's Minister of Economy, Energy and Business Development announced "Initial Agreement on Cooperation for the Cernavoda Nuclear Power Projects and Civil Nuclear Power Sector in Romania" and it is expected that. This Inter-governmental agreement will "lay the foundation for Romania to utilize USA' expertise and technology with a multinational team building Units 3 and 4 of the Cernavoda Nuclear Power Plant" [23]. In addition, the U.S. Export-Import Bank showed intention to finance US$ 8bn to the country for the energy and infrastructure projects including nuclear power.[24]

It is expected that this agreement shows strong commitment by the two governments to secure energy supply in the region, and underscores the importance of nuclear energy to the national energy mix of Romania.

The European Commission has approved in November 2020 the agreement between the Governments of the USA and Romania to add two reactors to the Cernavoda NPP, which represented an important step for signature of this document by the Parties. The Agreement was signed on December 10, 2020 in Bucharest, in the presence of the U.S. Export-Import Bank President.

At the same time (2020 Q4), Romania and France signed an intention declaration for a partnership regarding the construction of C-U3/4 NPP project. Also, Nuclearelectrica signed a partnership with a French group specialized in nuclear power.

In March 2021, the Romanian government approved the "Agreement between the Government of the United States of America and the Government of Romania on Cooperation towards the Cernavoda Nuclear Power Projects and the Civil Nuclear Power Sector", and it was followed by ratification of the Parliament in June 2021. The agreement would remain in force for a 30-year period and would be automatically extended for successive periods of 5 years.

These actions demonstrated the political support in Romania for the completion of C-U3/4 NPP.

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[23] See the press release by the United States DOE "U.S. and Romania Announce Initial Agreement on Cooperation for the Cernavoda Nuclear Power Projects and Civil Nuclear Power Sector in Romania", available at: www.energy.gov.

[24] See the press release by the United States Exim Bank "EXIM Signs $7 Billion Memorandum of Understanding with Romania's Ministry for Economy, Energy and Business Climate", available at: www.exim.gov.

II.4.2. Project owner activities

In December 2020, EnergoNuclear completed the revision and update of the "Feasibility Study for the completion of the C-U3/4", the conclusion being that in the new conditions of electricity market in Romania the project is financially sustainable, the requirements for cash being fulfilled. During the mentioned study, the costs of completing the investment (in 2020 prices), of the existing assets (land, existing buildings, equipment) as well as of the heavy water stock were updated.

In April 2021, based on the results of the Feasibility Study, for restarting and completion of the project, taking into account the good international practices in the field (allocation of the significant funds in the preparatory/pre-project phase) SNN decided a staged approach for the C-U3/4 development, as follows:

(a) Stage 1 - Preparatory stage, with the following objectives:

- Operationalization of the EnergoNuclear project company;
- Updating the Technical Procurement Specification (BIS) for project completion;
- Launching the bid and selecting and awarding the EPC contract(or), in two phases (Phase 1 - Preliminary works and Phase 2 - Project Implementation).

The required budget for this preparatory stage, estimated at 15 million Euro, will be provided to EnergoNuclear (Project Company) by SNN. The duration of this stage it is estimated at 24 months.

(b) Stage 2 - Preliminary Works (Phase 1 of the EPC contract) with the following main objectives:

- Development of the critical engineering of the project and nuclear safety licensing documentation required for construction authorization;
- Local market analysis for equipment and services costs, in order to determine the fixed/firm type cost for a considerable percentage of the required works and services for project completion;
- Preparation of the project notification documentation to the European Commission, based on Article 41 of the EURATOM Treaty.

At the end of this stage, which will have an estimated duration of 18–24 months, the project feasibility will be re-analyzed. This would lead the project to 'FID', if economic and technical parameters found in the feasibility study are met.

In this stage 2 a number of conditions need to be met in order to take the FID, including obtaining the necessary authorizations from the European Commission for support measures and structuring and closing the financing package for the Project.

(d) Stage 3 - Construction (Phase 2 of the EPC contract), with an estimated duration of 69 - 78 months, consisting in the effective start of construction, procurement, erection and installation and commissioning with the project completion (Unit 3 planned in 2030 and Unit 4 in 2031).

Also, SNN approved the strategy for the C-U3/4 project completion, which includes the following basic principles:

(a) The Project will be developed and implemented by EnergoNuclear, established as a joint stock company, ‘project company’ type, registered in Romania.

(b) The Romanian Government and SNN will explore the available financing options which leads the project to ‘financial close’.

(c) SNN will contribute to the share capital of EnergoNuclear with the existing assets related to the project, that include land, existing civil structures, equipment and materials, the quantity of 75 tons of heavy water, the technical support studies already issued for obtaining the authorizations and approvals of the European Commission, in connection with the project.

(d) The Romanian State will contribute in kind to the share capital of EnergoNuclear subject to approval of the European Commission. In-kind contribution, such as land, capital good, etc., can be considered.

(e) An agreement between the Romanian State and SNN will be concluded to set the responsibilities of the parties in relation with finance, providing supports to the project and securing the readiness of necessary infrastructure for the completion and operation of the project. This agreement is a precedence for the preliminary investment decision related to the C-U3/4.

The appropriate solution for C-U3/4 financing will be established in stage 1 of the implementation process, based on the previously experiences, learned lessons, using the available loans offered by United States Export-Import Bank and Romanian State support to be established in the specific agreement with SNN.

II.5. LESSONS LEARNED

When considering the development of a national infrastructure for nuclear power and a new NPP project, a Member State might face difficulties against their existing nuclear infrastructures defined in the Milestone Approach [1]. The Member State tries to seek the best suitable option from the traditional contractual and ownership approaches or combination of them. There might be the case where the alternative options, such as the Mankala or BOO model, would fit into the project structure.

In the case of the C-U3/4 project, different alternatives have been tried in the last 15 years, Mankala model, CfD model, which, for various reasons, did not lead to the desired final result. This process offered an important experience and lessons learned that will be presented further.

The experiences and lessons learned by application of the Mankala model for the C-U3/4 are presented in Table 2.

TABLE 2. LESSONS LEARNED BY MANKALA MODEL APPLICATION

BENEFITS	CHALLENGES
It is a long-term model (can be applied for the whole period of NPP operations).	Some problematic features concerning European Union competition law and state aid rules as it involves state-owned or controlled entities.
It may provide sufficient cash flow to serve the debts at the NPP project Company level.	Liability for costs (owners suffer from losses if the energy produced in the plant is more expensive than in the market).
The shareholders, independently from each other, can decide what to do with the electricity produced.	It is not widely used for NPP projects. Even in Finland, it was not successful.
The model has proven track of implementation (already applied to Olkiluoto NPP project).	NPP completion risk remains, affecting the NPP project's bankability.

The experiences and lessons learned by application of the other options including CfD are presented in Table 3.

TABLE 3. LESSONS LEARNED BY CONTRACTS FOR DIFFERENCE MODEL APPLICATION

BENEFITS	CHALLENGES
Would reduce the market price risk for the NPP project during the most challenging years of operation (first decade of loan repayments).	The scheme holds a state aid component, therefore it has to be approved by the European Commission.
The mechanism should not have negative effects on the electricity market.	Sufficient market liquidity needed in order to support an effective CfD.
Being approved for the U.K., it might be easier for Romania to get it approval by the European Commission.	Such scheme is not being applied in EU, even in the U.K. is used for HPC NPP project.

Such a scheme can be long-term, however it does not have to be applied for the whole operation.	The market price risk is not eliminated, but transferred to other parties (most likely the final consumer).

As explained in the Tables above, available options need to be considered in relation with objectives and goals of the nuclear power project, and the most suitable option should be selected according to economic situations and circumstances of the Member States. In case of Romania, the State Aid rule of the European Commission was one of the important factors to narrow down available options.

Taking new ownership approaches poses challenges, and implementing such alternative options take time because there are no available clear references and similar experience cases, especially for NPP project implementation. Also, the specific conditions of each Member State, such as evolution of the electricity demand, electricity market processes and regulatory body requirements, will impact on the selection of the particular solution.

The new ownership approaches request proper planning of the national energy sector, reflecting the specific needs of the country and taking into account other requirements such security of supply, competitiveness and climate change. This is the reason that the government will play a very important role in establishing the new ownership approach. Also, considering the important role of the government in some important aspects of the national nuclear energy programme such as long-term radioactive waste management, decommissioning and nuclear civil liability, the ownership option can be selected only with the involvement and approval of the government.

ANNEX 3: REPUBLIC OF TURKIYE: AKKUYU NUCLEAR POWER PLANT PROJECT

III.1. EXPERIENCE WITH NUCLEAR POWER

Türkiye has sought to deploy nuclear power since 1965 with the aims of: (a) increasing use of domestic energy resources; (b) reducing dependence on imported energy resources. Recently, necessity to address climate change was added to the aims.

The "Law on Construction and Operation of Nuclear Power Plants and the Sale of Energy Generated" (Law No. 5710) and the "Regulation Regarding the Principles, Procedures, and Incentives for the Contracts and the Contest" were introduced in 2007 and 2008 respectively, and this set the framework for selecting nuclear technology provider along with the criteria provided by the Turkish Atomic Energy Authority (TAEK). The purpose of the regulation is to regulate the procedures and principles regarding the construction and operation of NPPs for electrical energy production, and to regulate energy sales. In accordance with this, TAEK issued a set of criteria that establish general principles to ideally be met by investors.

The Electricity Trading and Contracting Company (TETAŞ) started the Fourth competition in 2008 and sole consortium made a bid, however, submitted conditions were not met and the process was closed by TETAŞ in 2009.

In May 2010, an IGA was signed with the Russian Federation for the construction and operation of the first NPP at the Akkuyu site as a BOO project. A project company, Akkuyu Nuclear Power Plant Electricity Generation Joint-Stock Company, Akkuyu Project Company (APC), was established. In February 2011, TAEK recognized APC as the owner.

A second NPP will be built at the Sinop site. An IGA with Japan was signed in May 2013. After the finalization of the Host Government Agreement (HGA), the IGA together with the HGA ratified by the Turkish Parliament in 2015. According to the IGA, the national utility Electricity Generation Company (EUAS) would be shareholder of the Sinop NPP project company together with the Japanese consortium which consisted of Mitsubishi Heavy Industries, Itochu and GDF Suez Companies. However, both sides have decided to discontinue on the Sinop NPP project.

III.2. FRAMEWORK FOR THE PROJECT

III.2.1. Project overview

The Government of Türkiye and the Government of the Russian Federation started negotiation in 2009 and signed an IGA titled "Agreement between the Government of the Republic of Türkiye and the Government of the Russian Federation on cooperation in relation to the construction and operation of a nuclear power plant at the Akkuyu Site in the Republic of Türkiye" in May 2010 [16]. It was agreed to implement the project by the BOO model.

The Akkuyu NPP project comprises of construction and operation of four units of VVER-1200 type reactors[25]. The first concrete of the first unit began to be poured on 3 April 2018. It was

[25] Reference power plant is Novovoronezh NPP-2 (Russia, Voronezh region). It was developed on the basis of the VVER-1000 reactor versions built for foreign customers in the 1990s and 2000s; Bushehr NPP (Iran), Kudankulam NPP (India), Tianwan NPP (China). Each parameter of the reactor was further improved and upgraded and a number of additional safety features were introduced reducing the likelihood of accidents.

aimed that the first unit will be operational by the end of 2023. The remaining three units were planned to start commercial operation every other year until the end of 2026. The Akkuyu NPP project is being implemented in compliance with all regulations, standards and guides of Türkiye, the IAEA, Russian Federation and other third parties, and puts the safety as the top priority for safe and reliable operation of the NPPs.

III.2.2. Electricity market in Türkiye

Türkiye has reformed electricity market for long time. Notable change occurred in 2001 by adopting the Electricity Market Law (Law No. 4628). Also, in parallel, the Türkiye Electricity Generation and Transmission Company was transformed into three separate companies: (a) Electricity Transmission Company; (b) Electricity Generation Company (EÜAŞ); (c) TETAŞ. This reform was to introduce competition and maintain sustainable growth of the market.

Amendment of the Electricity Market Law (Law No. 6446), which was introduced in 2013, facilitated liberalization of the electricity market. In this regard, the Energy Markets Operating Corporation was created as an operator of the electricity market that handles the day-ahead market as well as intraday market.

TETAŞ was incorporated into EÜAŞ by the Decree Law No. 703 in 2018, and by this reformation, EÜAŞ is in charge of signing and implementing PPAs with electricity producers.

III.3. OWNERSHIP AND FINANCING STRUCTURE

III.3.1. Ownership structure

According to the IGA Article 5/2, "(t)he Project Company shall be owner of the NPP, including the electricity generated by it." Therefore, Akkuyu Nükleer Anonim Şirketi, renamed and reformed into the Akkuyu Nuclear Power Plant Electricity Generation JSC in 2010 and again renamed as Akkuyu Nuclear JSC in 2014 as the APC, owns the asset of the NPPs. Shareholding structure is presented by Rosatom Group companies (JSC Rusatom Energy International, JSC Koncern Rosenergoatom Atomstroyexport, Atomtechenergo JSC, Atomenergoremont JSC). On 7 February 2011, TAEK recognized APC as the owner of the NPPs, according to the Decree on Licensing of Nuclear Installations.

In 2020, buy-back transaction has been completed and one of the founding shareholders, Inter RAO UES, transferred its shares to the Akkuyu Nuclear JSC. In the near future, no share transfers and changes in shareholder structure are expected.

III.3.2. Financing arrangement

The Russian party is arranging financing of the project. The financing structure of the Akkuyu NPP project includes funds from the Federal budget of the Russian Federation, equity from the shareholders and debt financing.

Starting from 2019, the company started to raise debt financing in the form of loans (tenor is for 7 years). Financing for 2021-2022 is expected through debt financing. By the end of 2022, it is planned to finalize the structuring of the project financing. Repayment shall be from the revenues under the existing PPA.

The company aims to attract ECA-covered loans and regularly convenes negotiations with international export credit agencies. Also talks were held with VEB.RF, one of the largest development and export support institutions in the Russian Federation. The key activity of VEB.RF is export development and innovation support.

III.3.3. Guarantees provided by the sovereign

Following arrangements are made in accordance with dedicated IGA articles through PPA:

- The IGA Article 7/1 stipulates that "(t)he Turkish Party (the host country) shall allocate the Site with its current license and existing infrastructure, free of charge, to the Project Company (Akkuyu Nükleer Anonim Şirketi) until the end of the decommissioning process of the NPP. Additional land on which the NPP will be built, and which is owned by the Turkish State shall also be allocated to the Project Company free of charge." According to the IGA Article 10/3, "(i)n case of excess power production per unit than the volume obliged for the entire period of the Power Purchase Agreement, such excess power production shall be purchased in compliance with the provision of the Power Purchase Agreement";

- The IGA Article 10/5 provides "(T)urkish Electricity Trading and Contracting Company shall guarantee to purchase from the Project Company the fixed amount – 70 (seventy) per cent for Unit 1 and Unit 2 and 30 (thirty) per cent for Unit 3 and Unit 4 – as stipulated in the Power Purchase Agreement of the electricity planned to be generated by the NPP during 15 (fifteen) years from the date of commercial operation of each power unit at weighted average price of 12.35 (twelve point thirty five) US cents per kWh (not including Value Added Tax)."According to the IGA Article 10/10, "(a)nnual variation of electricity price within the tariff scale agreed between Turkish Electricity Trading and Contracting Company and the Project Company, being an integral part of the Power Purchase Agreement, shall be calculated by the Project Company in order to ensure the payback of the Project, taking into account the price limit at the maximum level of 15.33 (fifteen point thirty three) US cents per kWh."

III.4. CONTRACTUAL STRUCTURE

III.4.1. Intergovernmental agreement

The IGA set the framework of the NPP project in the Akkuyu site of Türkiye consisting of construction and operation of four units of VVER with generation capacity of 1200MW and providing the key parameters[26] of the BOO model. The IGA also stipulates provision of training for human resources for NPP operation as well as a full scope simulator.

III.4.2. Subsidiary contracts

III.4.2.1. Construction contract

In accordance with the IGA Article 6/3, JSC Atomstroyexport (ASE) is envisaged as the general contractor in relation to construction of the NPP. However, significant scope of work of ASE is assigned to TİTAN2 IC İÇTAŞ Inşaat A.Ş., a joint venture established between CONCERN TİTAN-2 JSC (Russian Company) and IC ICTAS Insaat Sanayi ve Ticaret A.Ş. (Turkish Company), through a trilateral agreement among Akkuyu Nükleer Anonim Şirketi., TİTAN2 IC İÇTAŞ Inşaat A.Ş. and ASE. In the light of the foregoing, the CPC contract for Units 1, 2, 3 and 4 of the Akkuyu NPP is signed between Akkuyu Nükleer Anonim Şirketi and TİTAN2 IC İÇTAŞ Inşaat A.Ş.

There are three construction related contracts were agreed:

(a) EPC contract[27] between the Akkuyu Nükleer Anonim Şirketi and a Joint Venture between the Concern TITAN-2 JSC (Russian company) and the IC Içtas Construction JSC (Turkish company). "The EPC contract covers the full cycle of works related to the construction of the main part of the NPP facilities, which allows applying holistic approach in terms of design, engineering, supply of equipment, quality control and safety of construction works", as well as control of the project schedule [17].

(b) Turnkey contract for project design and construction of hydro technical structures of Akkuyu NPP between the Akkuyu Nükleer Anonim Şirketi and the Cengiz Inşaat Sanayi ve Ticaret A.Ş. covering the design, construction and implementation works, supply of equipment and other materials, works on maritime hydro technical structures, construction and implementation of utility water supply systems for Units 1, 2, 3 and 4 of the Akkuyu NPP.

(c) Agreement between the Akkuyu Nükleer Anonim Şirketi and the ASE on designer supervision and preparation period works.

There are also contracts between the Akkuyu Nükleer Anonim Şirketi and nuclear construction inspection companies, the Assystem Engineering and Operation Services, Türk Loydu

[26] These parameters include: "general technical characteristics of the units and terms of their commissioning; scope of cooperation under the project; terms and conditions of the incorporation of the project company, as well as its status as the employer, owner and operator of the NPP; major parameters of PPA; free of charge training of the Turkish operating personnel for the NPP; free of charge land allocation to the project company (including the site); project funding issues; ranging from NPP construction and operation in Akkuyu–Mersin, to decommissioning; taxation; fuel supply; intellectual property rights; international nuclear framework and nuclear liability".

[27] Equipment suppliers and other construction related contractors are: Atomenergomash (the nuclear and the turbine islands); AAEM comprised of Atomenergomash, GE and Alstom Power Systems (turbine); Atomenergoproekt (general project designer); OKB Hydropress (designer of the nuclear island).

Uygunluk Değerlendirme Hizmetleri A.Ş. and the Ersis Enerji Mühendislik Müşavirlik İnşaat Ltd. Şti. For quality assurance of construction and equipment manufacturing works, a contract was signed with the JSC VO Safety.

To address construction risk for the Akkuyu NPP project, the project owner uses quantitative risk analysis to calculate possible variations for construction cost/schedule. Quantitative risk analysis procedure was developed in accordance with the AACE International recommendations and guidelines. Project's budget includes combination of fixed and non-fixed costs. Method for cost calculation of project element was determined based on each element's influence on the project's goals and results. Also, for overall risk management, integrated risk register was developed at early stages of the project. This register includes high-level risk and decomposed sub-risks for different elements of the project.

For commissioning, according to the IGA Article 6/2, "(t)he Project Company (Akkuyu Nükleer Anonim Şirketi) with the full support of the Russian Party shall put into commercial operation Unit 1 within seven years from the date of issuance of all documents, permits, licenses, consents and approvals necessary to start the construction. The Project Company (Akkuyu Nükleer Anonim Şirketi) with the full support of the Russian Party shall put into commercial operation Unit 2, Unit 3 and Unit 4 with one year intervals consecutively after the start of the commercial operation of Unit 1. In case of earlier or later entry into commercial operation of the NPP units, the responsibilities of the Parties shall be determined in the Power Purchase Agreement accordingly."

III.4.2.2. Operation, maintenance support and training contract

As the Akkuyu NPP project is based on the BOO model, the project company is responsible not only for design and construction, but also for maintenance, operation and decommissioning of the NPPs. The BOO model provides an additional guarantee of construction and operation quality during the operation period of the NPPs. Currently, no contract has been signed for the operation and maintenance.

In accordance with the purpose and scope of the IGA Article 3, the cooperation related to training includes: "the training and retraining of operating personnel for the NPP"; "the development and use of technical training facilities, including simulators, for training of operating personnel for the NPP". In addition to that, pursuant to the Article 6/5, "the Parties agree that Turkish citizens shall be trained free of charge and widely employed for the purpose of operating needs of the NPP. Such training shall include, but not limited to, the establishment, without financial burden on the Turkish Party, of an on-site full scope simulator."

In accordance with the Article 20 of the Regulation on operating organization, qualifications and training of operating personnel and licenses of operating personnel in NPPs, "the authorized entity (Akkuyu Nükleer Anonim Şirketi) is responsible for training of operating personnel and ensuring that these people meet the requirements of the position in which they are assigned to". The Akkuyu Nükleer Anonim Şirketi has a training programme for all operating personnel. All operating personnel, which should be certified in accordance with the Personnel Licensing Regulation of NDK, will take necessary exams and be certified.

Furthermore, according to the IGA, a special personnel training programme for the Akkuyu NPPs is being implemented to train specialists from Türkiye in Russian universities, and such specialists are expected to be employed by the Akkuyu NPPs. The education programme was initiated by the Akkuyu Nükleer Anonim Şirketi in 2011. The training costs of are borne by the Russian side.

III.4.2.3. Nuclear fuel supply contract

Nuclear fuel will be sourced from the suppliers based on long-term agreements between the Akkuyu Nükleer Anonim Şirketi and the suppliers. At the current stage, the Akkuyu Nükleer Anonim Şirketi plans that the first core and further reloads for the Akkuyu NPPs will be supplied from JSC TVEL, a subsidiary of ROSATOM, based on a long-term contract. The scope of the contract with JSC TVEL starting from 22 December 2017 covers the supply of nuclear fuel for commissioning of units VVER-1200 and its operations during the design lifetime. The obligation for shipment of SNF to Russia included in the contract with JSC TENEX as an option. At present, the parties are negotiating the spent nuclear fuel return agreement.

III.5. CURRENT STATUS

The Akkuyu Nükleer Anonim Şirketi obtained the construction licenses for all four units. The Akkuyu NPP site is currently one of the world's largest NPP construction site. In addition, the construction of temporary structures, hydro technical structures (water intake, water discharge and breakwater) and other utility structures also continues. Furthermore, construction of electricity transmission lines is also proceeded.

III.6. LESSONS LEARNED

On the signing date of the IGA, the nuclear energy legislation of Türkiye was not fully developed. Therefore, there were some deficiencies in terms of laws and regulations as previously mentioned. Since then, during last 12 years period, Türkiye has developed and established the national nuclear legislation. NDK, which was formed within this aim in 2018, worked on and issued many new sectoral regulations and cooperated with organizations of the nuclear sector to make sure their interests and contributions are incorporated into the national legislation.

Additionally, the IGA does not cover the taxation issues of the project. For this reason, many questions have arisen in terms of tax-related matters of the project. Many of these issues were resolved by issuing the Strategic Investment Certificate for the project company with specific tax incentives and benefits and special determination of these matters within in the PPA.

Due to increase of taxation changes in tax legislation conditions have deteriorated because of increasing in withholding tax from 3% to 5%. For companies involved in the project, as a result of the stated change, shortage of funds for contractors occurs, which in turn affects entirely the provision of the project with financial resource.

ANNEX 3: UNITED ARAB EMIRATES: BARAKAH NUCLEAR POWER PLANT PROJECT

IV. 1. EXPERIENCE WITH NUCLEAR POWER: AT THE START OF THE BARAKAH PROJECT, THE UNITED ARAB EMIRATES WAS A NEW ENTRANT TO THE CIVIL NUCLEAR POWER INDUSTRY.

The United Arab Emirates (UAE) started to consider the nuclear power option for its future energy mix in 2006 driven by growing energy demand and consideration of the environment. After the detailed study on available proven technologies against the various parameters, such as environment, safety and energy security, the federal Government of the UAE published the UAE Federal Government published the UAE Policy on the Evaluation and Potential Development of Peaceful Nuclear Energy in April 2008 [18]. This document established the national position of the UAE to embark on the nuclear power and demonstrated policies and disciplines pursued throughout the nuclear power programme in the UAE. The UAE nuclear power programme has four prime disciplines where the Barakah NPP project is implemented through its life cycle [18]:

- Commitment to the highest standards of safety and security;
- Open collaboration with responsible nations and international agencies to incorporate international best practices and lessons learned;
- A commitment to transparency and active public engagement;
- A commitment to the highest international standards for nuclear safeguards and nuclear non-proliferation.

Detailed information of these disciplines is described in the case study document[28], and the most suitable ownership and contracting approaches were created to enable the Government of the UAE to achieve the goal of the nuclear power programme.

IV.2. THE PROGRAMME FRAMEWORK WAS DRIVEN BY INTERNATIONAL PARTNERSHIPS, CENTRALIZATION OF RESPONSIBILITY, LOCAL CAPACITY BUILDING, AND EMPHASIS ON QUALITY, SAFETY, SECURITY AND OPERATIONAL TRANSPARENCY

With the UAE Policy on the Evaluation and Potential Development of Peaceful Nuclear Energy in place, technology and partner selection became a key milestone in establishing the overall project framework, as the UAE Peaceful Nuclear Energy Programme and the Barakah NPP were from their very inception build around the idea that good international partnerships would provide the best framework for success.

The selection process was designed to choose the best suitable international partner to develop four NPPs and to secure learning opportunity from the reference plant. After the rigorous evaluation process involving 75 experts, the APR1400, certified by the United States Nuclear Regulatory Commission with the reference plant in the Shin Kori site in the South Korea, was found to be the most suited design to achieve the targets under the UAE nuclear power

[28] In detail, see, "Case Studies and Insights from Past Successful FOAK Projects, 4.10 Barakah Nuclear Power Station Units 1 to 4", available at https://hba-inc.com/

programme. It was followed by the selection of the consortium in 2009 led by the Korea Electric Power Cooperation to construct and delivery of NPPs on the ground of its reactor design reliability, strong commitment to nuclear safety and affirmation to transfer know-how to the employed UAE nationals.

The Emirates Nuclear Energy Cooperation (ENEC) was created by the Royal Decree issued in 2009 which mandated ENEC "to deliver the UAE Peaceful Nuclear Energy Program" and to "develop the cornerstone of the UAE Program" [29]. ENEC is the centralized organization which is responsible for implementing the Barakah NPP project and achieving a series of milestones toward the successful and continual safety operation. ENEC was mandated to submit the operation license for the first three units on behalf the operator, the Nawah Energy Company (Nawah), which was established on the later phase of the project. ENEC is fully committed to adhere the highest international standards to implement the Barakah NPP project and it makes the UAE as one of the role models to the embarking countries.

As discussed in more detail in Section IV. 3 below, a tailor-made governance structure was created under which three companies, ENEC, Nawah and Barakah One Company, share responsibilities on its domain and make the concerted efforts to deliver the Barakah NPP project while implementation of the project fully conforms to the highest international standards.

IV.3. THE OWNERSHIP AND FINANCING STRUCTURE OF THE PROJECT WAS PURPOSE-BUILT TO ENSURE KEY STAKEHOLDER REQUIREMENTS ARE SATISFIED

The question of plant ownership and capital structure initially presented unique challenges for the UAE programme. However, using its standard systematic approach, ENEC devised an ownership and financing structure that was tailored to its stakeholders' requirements, including (a) building on international partnership and collaboration, (b) ensuring sufficient control at all times over the plant as critical national infrastructure, and (c) deploying external capital in support of the project in a way that best optimizes the tariff and ultimate cost to end users of electricity generated by the plant.

In October 2016, a joint venture agreement between ENEC and Korea Electric Power Corporation (KEPCO) was signed for a long-term cooperation and success of the nuclear power programme.

Under the joint venture agreement, the Barakah One Company was established and KEPCO owned the minority share of the company. The same arrangement was made with Nawah. The transaction therefore resulted in an enterprise consisting of three companies, ENEC (the top holding company in the group), Nawah and Barakah One. This three-company structure, in turn, established a governance framework where each company focuses on responsible work, and at the same time, these companies work closely in compliance the highest international standards to achieve successful operation of the NPPs for long term.

Of paramount importance to the Abu Dhabi government stakeholder group sponsoring the Barakah NPP, ENEC at all times owns all of the physical asset comprising the plant. As such, ENEC is the title holder to the 'bricks and mortar' that make up physical plant structures, and ENEC in turn provides a concession-like grant to Barakah One Company to own and operate the plant.

[29] Detailed information of ENEC is available at: https://www.enec.gov.ae.

Under that concession-like grant, Barakah One Company, as the financial and commercial subsidiary of ENEC and KEPCO, is responsible for managing the Barakah NPP's commercial interests, securing tens of billions of USD in financing from export credit, host country government and commercial lenders around the world, and taking revenues from electricity generation of NPPs. The PPA was signed between the Abu Dhabi Water and Electricity Company, later transformed to the Emirates Water and Electricity Company, and the Barakah One Company to secure revenue stream and facilitate consideration on the finance to the project. Barakah One Company has also entered into a plant services agreement under which it has retained Nawah on an exclusive basis to operate and maintain the plant.

Nawah's mission, as the operating and maintenance subsidiary of ENEC and KEPCO, is to safely and reliably generate electricity from nuclear energy. It is responsible for operating and maintaining the four units at Barakah, making it one of the newest operators in the global nuclear energy industry.

All three companies, ENEC, Nawah and Barakah One, come together to form "a multinational, multicultural and Emirati-led" enterprise. The combined team consisting of international experts and the UAE nationals, who play the key role of the UAE's nuclear industry, is closely working together toward the success of the Barakah project.

IV.4. THE CONTRACTUAL STRUCTURE OF THE PROJECT IS BESPOKE AND WAS PURPOSE-BUILT TO ACHIEVE ENEC'S OVERRIDING PROGRAMME OBJECTIVES

As a newcomer country to the civil nuclear power industry, the UAE studied a variety of internationally recognized contractual structures and adopted best practices from around the world to create a wholly bespoke contractual framework designed to meet a variety of important objectives.

First, the Barakah project contract structure was designed with excellence in governance in mind, to ensure that the people, processes and resources necessary to ensure safe and reliable plant development and operation are properly placed within a contractual framework that ensures clarity of roles and responsibilities and best aligns internal and external stakeholder incentives for the success of the programme.

Second, the requirements of lenders, the power off taker and other financial and commercial parties with limited expertise in nuclear power were taken into close consideration, so that the Barakah contract structure would in and of itself mitigate certain concerns of parties with a purely commercial and/or financial interest in the project.

Third, the role of the Abu Dhabi Government in sponsoring the project was considered at length, with a view to ensuring that the host country government maintained responsibility and accountability for geographically bounded risks, but also the mechanisms and controls to ensure that it and its delegated instrumentalities have the ability to properly manage those risks.

More specifically, as follows:

Excellence in governance: ENEC and its stakeholders embraced a philosophy of promoting contract structures that best enable clarity of roles and responsibilities across the ENEC enterprise and among the stakeholders involved in advancing the project. Specifically, by separating commercial and financing matters (vested in Barakah One Company) from the significant task of preparing to operate an NPP for the first time in a newcomer country (an activity vested in Nawah), ENEC was able to ensure that resources within each group entity were focused on different, but interdependent, tasks required to achieve commercial operation of the Barakah NPPs. By placing both human and other resources in the relevant corporate vehicle most appropriately suited to the expertise, roles and responsibilities, ENEC was able to harness great efficiencies in aligning the behaviours and efforts of multiple interdisciplinary and multi-cultural teams working together for the first time to achieve the key milestones on the UAE's journey to commercial operation of its first nuclear power generating unit. This has been a cornerstone in ENEC's governance model.

Notably, under this governance arrangement and contract structure, ENEC technically remains the asset owner at all times, granting a right to commercial use of the plant to Barakah One Company, which in turn enters into a long-term operation and maintenance contract with Nawah, the licensed operator, to operate and maintain the plant on Barakah One Company's behalf. This structure nicely segregates roles and responsibilities, and also allows financiers and investors to participate at the Barakah One Company level, where they are structurally removed from any direct dealings with the licensed operator.

Contracting in a way conducive to the requirements of financiers and other stakeholders: Creating a financially viable structure in the nuclear industry can be challenging. ENEC studied stakeholder requirements for years before ultimately concluding a structure that optimized the requirements of all stakeholders. In fact, the three-company structure described above was, in part, born out of efforts to contractually and structurally separate the commercial and financing vehicle for the project (Barakah One Company) from nuclear plant operations in Nawah. Those structural separations, together with the UAE's accession to multiple international conventions on nuclear liability and its adoption of its own internal laws channelling liability for damages associated with any radiological release, were pivotal to creating a viable structure for the Barakah NPP without having to rely on unlimited and uncapped sovereign indemnities.

Furthermore, ENEC employed a single-point accountability turnkey engineering, procurement and constructing contract with KEPCO for the construction of the plant. ENEC believes that the structure it has adopted under which the contractor for the project is also a joint venture partner with equity invested in the plant creates the best framework possible for aligning incentives between the owner and contractor. From the very outset, ENEC has intentionally driven contractual structures like these that harness the alignment of partnership to ensure success in programme execution.

Geographically bounded risks: For nuclear projects in general, national leaders have to consider that certain risks associated with a new programme for a newcomer country, such as the UAE, are uniquely weighted toward the programme host country. For instance, matters such as treaty adherence, peer review by international agencies, establishing the boundary conditions for the treatment of claims in the event of a nuclear incident, and other similar matters of significant reputational and diplomatic consequence pose unique country-wide considerations for any newcomer country; and at the same time, they are risks that inevitably are discussed among commercial participants such as lenders and other investors. Therefore, from the outset, ENEC has taken a view in its contracting structure that ENEC and its Abu Dhabi stakeholders need to retain accountability and responsibility. However, with accountability and responsibility need to come the ability to control and manage such risks. As a result, various contractual mechanisms are introduced into the project and governance framework to ensure that ENEC is consulted and has certain unique rights and powers to ensure that these risks are managed to the highest standards of safety, security and reliability.

IV.5. CURRENT STATUS

The project continues to be supported by a diverse group of international lenders and a multi-cultural Emirati and international staff mix bringing diverse views, experience and expertise to the programme.

The two operating subsidiaries for the project carry on with their respective visions, missions and values as joint venture subsidiaries solidifying the partnership between ENEC and KEPCO for the advancement of the project: (a) Barakah One Company, with a paramount focus on the commercial and financial aspects of the project; (b) Nawah, with a paramount focus on safe, secure and reliable plant operations and maintenance.

IV.6. LESSONS LEARNED HAVE BEEN CONTINUALLY ASSIMILATED INTO THE OVERALL PROJECT STRUCTURE AND PROGRAMME TO DATE

Since the inception of the programme, ENEC has worked hard to ensure that lessons learned, both in the UAE and internationally in the industry, have been systematically reviewed and applied in the course of programme advancement. A few of those lessons learned, covering technical, transactional and stakeholder considerations, are described briefly below:

Safety Enhancement measures in the Barakah NPPs after Fukushima Daiichi Accident: The Fukushima Daiichi plant accident occurred in March 2011. At that time, preparatory works were being conducted in the Barakah NPP site to commence construction of the first unit. The site location of the Barakah NPP project was decided supported by the IAEA's Siting and External Events Design review, and the Construction License Application for Units 1 and 2 was submitted to Federal Authority for Nuclear Regulation (FANR) in December 2010 by ENEC and being reviewed.

In response to the requests by the FANR, ENEC, in cooperation with nuclear operators from operating countries, thoroughly reviewed safety of the Barakah NPPs' design against risks, especially arisen from severe natural disasters. The result of this review showed conformity with the plant design with various risks especially in relation with natural disasters and loss of external electricity supply. It was submitted to the FANR in December 2011 as a part of the on-going construction license application.

Additionally, ENEC proposed voluntary safety enhancement measures for the Barakah NPPs' design, which provided additional safety margins of the reactors with the operator, to the FANR. Such voluntary measures well show strong commitment of ENEC to put safety as the priority of the nuclear power programme and willingness to cooperate with the nuclear industry in the world to incorporate best practices and lessons learned to the Barakah NPP project.

Aligning transactional incentives: Historically, projects within the civil nuclear power industry have faced significant cost overruns and delays, in particular in countries that are new entrants to the global nuclear power industry. A number of these case studies taught ENEC an important lesson in approaching its contracting and transactional framework for the programme on the criticality of alignment between all parties. As a result, ENEC was insistent on a transactional structure that optimizes and best aligns incentives among key stakeholders. Most notably, in structuring its contractual and ownership framework for the project, ENEC's contractor was also committed to long-term success through a JV partnership, with a mutual commitment to resolving challenges together. This is perhaps the single most important feature of the transactional framework for the Barakah project and was derived from lessons learned across multiple transactional case studies.

Stakeholder management: Early and frequent engagement with stakeholders has been a topic that registers frequently in the lessons learned data that ENEC continues to accumulate. Developing NPPs is a uniquely governmental undertaking, even when pursued through private, commercial entities, and it also touches on many issues that can be sensitive for local and international community groups. As such, ENEC has consistently found that challenges in stakeholder management are best avoided by early and frequent engagement, supported by dissemination of information in clear, concise terms. The complexity of issues that arise in developing the physical, human capacity and transactional frameworks for a new NPP project can at times feel daunting and can lead to propensity to withdraw from stakeholders due to lack of clarity around outcomes and issues, or to over overcomplication of stakeholder interfaces by disseminating important information in too much complexity or technical or legal jargon. For a newcomer country, a multitude of stakeholders, many of whom are unfamiliar with even basic concepts and challenges associated with nuclear power generation, will need to be brought up to speed and kept engaged and abreast of developments in technically or legally dense areas. The importance of managing these stakeholder relationships well cannot be overstated, and it is the very reason that ENEC invests heavily in communication and engagement with local and international stakeholders.

This commitment to effective stakeholder management is a part of ENEC's wider dedication to ceaseless efforts for improvement and transparency. As such, ENEC and Nawah are committed to contribute to the world nuclear industry to share its operational experience and lessons learned throughout the operating life of the Barakah NPP which will last for 60 years or beyond.

ANNEX 4: UNITED KINGDOM: HINKLEY POINT C NUCLEAR POWER PLANT PROJECT

V.1. BACKGROUND OF THE HINKLEY POINT C PROJECT

At the end of the 1990s, the U.K. Government established a new energy policy with the following objectives, that are to secure the availability, competitiveness and decarbonization of energy. With the need to 'renew' the means of electricity generation (coal power plants to be closed and the age limit of the existing NPPs, successive U.K. Governments have confirmed their support for nuclear energy since 2005 as a part of a diversified energy mix and have introduced the carbon price floor in 2012 which was a fundamental change of the electricity market encouraging the investments into the production of the decarbonized electricity.

The U.K. is one of the first states to legally commit a target of net zero greenhouse gas emissions by 2050 in the context where electricity demand in the U.K. may nearly double at that time from today's levels according to estimates. This target requires ambitious actions to reduce emissions while keeping energy costs low and electricity supplies secure.

To meet this increasing demand by 2050, the U.K. will need to have a substantial increase in low carbon generation by renewable technologies and new NPPs as existing nuclear power plants will reach the end of their operational lives around 2030.

Even if the cost of offshore wind and solar continues to decrease, NPPs are likely to provide most of low carbon generating capacity in 2050 in the U.K. Indeed, NPPs will play a critical role for low-carbon and base load power to meet net zero while maintaining security of supply, as of today the nuclear power provides around 20% of total country's power needs in the U.K. energy mix

EDF Energy operates 8 nuclear reactors in the U.K., EDF Energy accounts for 5,3 million customers (professional and individual client). EDF Energy is the only operator of civil nuclear power in the United Kingdom.

The EDF group operates 72 nuclear power units in the U.K. and France and has an excellent safety record, with over 2000 years of safe operation, and spends around £2m per day on R&D essentially focused on nuclear field.

To develop and implement nuclear new built (NNB) projects in the U.K., EDF Energy is acting through its affiliates (project companies).

The 2 nuclear reactors at HPC, in Somerset, south-west England, together with 2 nuclear reactors planned to be built at Sizewell[30] located in Suffolk, England, represent a major renewal programme of the existing installed base.

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[30] Sizewell C, located in Suffolk, England, is the 2nd EPR project currently developed by the EDF group in the UK. Sizewell C will comprise of two EPR units with a total site capacity of 3,340 MW, located adjacent to Sizewell A and B plants, with a grid connection already in place.

V.2. FRAMEWORK OF THE HINKLEY POINT C PROJECT

HPC will be the first nuclear power station of a new generation in the U.K. providing 3,260MW of electricity for 60 years.

In 2016, the U.K. Government approved to develop and construct NPPs at HPC, and this was the first decision to build an NPP in the western countries after the Fukushima nuclear accident. These two reactors are the 5th and the 6th reactors of the European Pressurised Reactor (EPR) technology to be built in the world which allows the project to benefit from lessons learned from the previous EPR units built. Indeed, HPC is benefiting from the French and Chinese EPR experience and solutions.

The HPC project represents the relaunch of the nuclear energy in Europe. The two reactors at HPC are the first new nuclear reactors built in the U.K. in last 20 years which will provide enough low carbon electricity to power five million homes.

V.3. OWNERSHIP STRUCTURE

The NNB holding company (HPC) is owned by 65.5% by EDF Energy (EDF group) and 33.5% by CGN. The project is owned by the NNB Generation Company (GenCo) HPC, the affiliate of the NNB Holding company (HPC) Limited. The HPC project has been structured with HPC GenCo as the licensee and the owner-operator of the NPP.

On 28 July 2016, the EDF's Board of Directors made the 'FID' to construct and operate of 2 units of EPRs at Hinkley Point C.

Following the FID and series of negotiations, EDF entered into agreements with the U.K. Government, CGN and the main contractors and suppliers. Other investors may join the HPC project at a later stage, during construction or commissioning or even during operation.

V.4. CONTRACTUAL ARRANGEMENT OF THE HINKLEY POINT C PROJECT

V.4.1. Key contracts

V.4.1.1. Contract for Difference

The main purpose of the CfD is to ensure a defined level of stable revenues for 35 years from the commercial operation date of the NPP.

The CfD is executed by HPC GenCo and the Low Carbon Contracts Company Ltd. (LCCC), private company owned by the British State. This contract is designed to ensure the revenues from the sales of the electricity produced by HPC NPP through a financial exchange mechanism of the difference between the reference price (Strike Price) and the market price.

During the CFD, NNB GenCo will sell the electricity produced at market price and will be paid the difference by the LCCC between the Strike Price and the market price (or, as the case may be, HPC GenCo will reimburse the money to the LCCC if such difference is negative). The Strike Price is fixed at 92,50£/MWh.

The EDF group companies and other investors are not parties to the CfD, however a specific agreement with the U.K. Government is providing some protection, such as with respect to political risks, and in return, the profit distribution mechanism with the government has been set out in case the financial return becomes higher than the levels approved by the European Commission.

Except through the CfD mechanism, HPC has not benefited from any other souverain guarantees or any export credit arrangements, etc.

V.4.1.2. Nuclear decommissioning and nuclear waste management funds

The financing of the decommissioning is a one of the legal obligations of the nuclear operator according to the applicable laws and regulations which corresponds to (a) securing of the decommissioning costs and expenses as well as the nuclear waste storage and (b) the nuclear waste property transfer to the U.K. Government. The functioning of this fund is similar to pension fund, the financing is generated from the revenues of the electricity sale during the duration of the CfD.

V.4.2. Supply chain's contracts and contractual strategy

The HPC industrial scheme has been developed such that all the contracts have been entered by HPC GenCo with its contractors and suppliers, encompassing equipment, systems supply and services contracts.

The feasibility studies have been performed and integrated directly to the project development process led by the EDF group. Notably, an essential portion of such feasibility studies were processed through Generic Design Assessment (GDA).

To mitigate industrial and delay risks, some EWAs have been implemented prior to the FID of HPC. The EWAs have been implemented for Nuclear Steam Supply System (NSSS) scope, for turbine and alternator' scope and for the overall design and engineering activities.

Most of supply contracts have been placed on a design, engineering and procurement or engineering, EPC basis. In addition to this, with specific contracts for main civil works and marine works, design and engineering contracts, specific erection contracts, etc., HPC GenCo has managed the overall integration of the project.

The construction risks have been allocated between HPC GenCo and its contractors consistent with their scope, their ability to control the risk and defined commercial conditions. Some contracts are based on a fixed price model and others on a target price model, in some cases, contracts are encompassing both fixed price and target model.

The commissioning has been placed under the responsibility of the owner/operator, HPC GenCo. Some portion of the commissioning is covered under specific contracts, such as NSSS and the turbine contracts.

The main contracts of HPC have been placed as follows[31]:

- Design and engineering (so called "Responsible Designer" contract[32]);
- Turbine island;
- HVAC (heating, ventilation and air-conditioning) system;
- Nuclear island piping;
- Marine works;
- Earth works;
- NSSS;
- Civil works;
- Electrical installation;
- Fuel supply contract for the first core and some reloads.

The contractual strategy for HPC has been elaborated with use of New Engineering Contract 3, known as NEC3, and the International Federation of Consulting Engineers' contract models adjusted with the objective to promote the collaboration and interests alignment, to enhance the productivity, performance focused on the key performance indicators (including key project milestones), transparency and, finally, to contribute to the building of the collaboration approach between the contracting parties.

In addition, a new project commercial and contractual manual has been developed, including measurement tools specifically adjusted to the project KPI's.

Specific agreements related to site working conditions have been negotiated with the contractors, social partners, and professional unions. Particular focus had been made on health and safety on site.

V.4.3. Major challenges

One of the major challenges of the project was to incorporate U.K. regulatory requirements in the design of the NPP. In this respect, the GDA process was launched to certify the EPR technology within the United Kingdom regulatory context and to clarify the U.K. requirements applicable to the NPP.

An additional major challenge was to integrate the available lessons learned from other nuclear projects, such as, design modifications and development of the robust project time schedule as one of the mitigation tools regarding the risks of delay.

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[31] To develop capabilities of GenCo, such as human resources, operation service etc., project execution contracts and personnel secondment agreements were agreed with the vendor company.

[32] The performance of the design and engineering 'Responsible Designer' contract for detailed design and engineering and overall integration of works by architect-engineer between HPC GenCO and EDF.

A third major challenge is to manage the numerous and various interfaces between contractors, various fields of expertise and scope; including the coordination of joint activities at site.

Some key elements of risk mitigation implemented for HPC project were:

- Establishment of a robust project management organization;
- Alignment of contractors' interests with relevant KPIs of the project;
- Establishment of a robust contract management organization to monitor the performance of the contracts' value chain.

V.4.4. Readiness for execution phase/construction

The following activities have been performed prior to the project execution phase:

- Contractors have been selected (about 65 contractors) for 90 % of contracts (in value);
- All authorizations, licences and permits necessary at this stage were obtained;
- The detailed time schedule of the project, with a particular focus on the construction phase (so-called construction execution plan) has been elaborated with involvement of contractors and suppliers;
- The earthworks contract, the contract for supply of the turbine island, the NSSS contract as well as the civil works contract have been signed or finalized.

V.4.5. Stabilization of design, readiness for the construction launch

To enhance project preparedness prior to the project execution phase the following activities have been performed:

- Analysis and integration of the lessons learned from other EPR projects under construction at the moment in the world (Flamanville in France, Taishan in China, Olkiluoto in Finland);
- Approval of EPR design by nuclear safety authority of the U.K., Office for Nuclear Regulation, though the GDA;
- Definition of the design reference configuration which includes the modifications resulting from the GDA, modifications resulting from Flamanville project and the design optimization;
- Fully integrated time schedule for the entire project enabling the definition of the interfaces between design, engineering, equipment deliveries and the erection and construction activities at site;
- Use of 3D model allowing the construction preparation by integrating the time line (4D model);

- Open and transparent relationship with the nuclear safety authority including the upstream collaboration and sharing of the information starting from the documentation preparation phase;

- Early involvement and cooperation with major contractors and suppliers in order to start preparation of the detailed design and embed the supply chain's lessons learned from other EPR projects.

V.4.6. Project control organization

The project control organization has been set up and operational procedures have been defined. The project control's monitoring is mainly relying on the integrated project time schedule from design up to commissioning and start up phases.

Prior to the project launch, the detailed construction schedule has been elaborated, it fully integrates all contractors and suppliers' activities up to J0 (corresponding to first nuclear concrete).

The earlier involvement of the suppliers and the subcontractors has allowed optimization of the construction and sequences of the project time schedule and to mitigate related construction risks.

3 D and 4 D models were also used for the optimization of the construction efficiency and for the elaboration of a more robust and resilient project time schedule.

Monthly reviews have been established with rigorous monitoring of the ongoing activities.

V.4.7. Costs evaluation

The project team developed the costs evaluation model at very early stage of the project.

The initial project costing was based upon bills of quantities of the previous French EPR project which has been compared to the benchmark of the unit costs in the U.K.

At the date of the final investment decision, more than 90% of costs have been validated by comparison with competitive procurement and tests of the market prices.

The main contracts were finalized and their entry into force conditional on the approval by EDF's Board of Directors.

Furthermore, the due diligences performed respectively by the Department of Energy and Climate Change, the European Commission, the Infrastructure U.K. and investors have reviewed the project costs.

V.4.8. Site preparation and readiness for construction phase

To prepare the site construction phase, the project team initiated and performed activities, such as:

- The nuclear safety awareness training as well as the health and safety and security training prepared;

- Main equipment necessary for site activities available at site;

- Site organization defined;
- Qualified site personnel employed;
- All support and facilities services operational;
- All procedures tested in a trial mode;
- Majority of roads upgraded;
- Site mobilization planning prepared;
- Construction plan finalized up to the 1st nuclear concrete milestone.

The early contractor involvement, mentioned above, has enhanced the project constructability and the robustness of the project time schedule. Some information contained in selected bids allowed the project to anticipate the preparation of the site activities and civil works prior to the FID.

Framework agreements regarding the site productivity, hiring process, health and safety procedures, common set of social protection for all workers at site has been implemented based on discussions with contractors, social partners and the labour unions. This approach based on the best available industry benchmark increased the confidence in the project sustainability.

V.4.9. Main project risks and mitigation actions prior to the project launch

The identification, assessment and monitoring of the project risks are key enablers for a successful project. Thus, the projects risk registers have been developed and maintained at NNB GenCo level for HPC.

V.4.9.1. Design robustness

An action plan was developed following the review of the major HPC risks.

The risk mitigation actions embrace different subjects relating to the design, project time schedule, control of the industrial partnerships, empowerment and individual responsibility of the leaders, project organization and project governance.

The GDA made by the Office of Nuclear Regulation and the Environment Agency was obtained in 2012.

The initial project reference configuration was established, it incorporated lessons learned from other nuclear projects. The design modifications resulting from the Flamanville project were integrated into the HPC design reference configuration.

The constructability was significantly reinforced due to the use of the 3D and 4D model. The early involvement of the main contractors and suppliers was beneficial for clarifications of technical specifications and requirements of subcontracts.

V.4.9.2. Robustness of the project time schedule

The Integrated Working Schedule (IWS) includes the lessons learned of the other EPR projects. The IWS has been reviewed by independent experts, i.e., experts and advisors of the U.K.

Government, investors and potential investors. The main contractors have been involved in the review with specific attention to task logistics relevant to their activities.

The risks related to on-time project execution are ultimately borne by the project company which is in the overall control of the project time schedule.

In order to reinforce the project time schedule robustness, many mitigation actions have focused attention on the project time schedule optimization and the probabilistic analysis, the use 4D model (3D model with the integrated timeline) and commercial and contractual strategy based on stakeholders' alignment of interests on identified key milestones.

The time schedule is also designed as a project management tool serving to (a) detailed forward planning and (b) the reference tool for project control and reporting.

V. 4.9.3. The structured and optimized engineering organization

The implementation of the Engineering Command Centre and the Delivery Command Centre combining representatives from NNB GenCo, EDF (Responsible designer engineering teams) and main contractors has increased the efficiency of interfaces' management.

These two Command Centres have been shown to be of crucial importance for integration of different engineering and supply activities of contractors and their sub-contractors.

V.4.9.4. Level of project's costs certainty

One of the big challenges of the nuclear project is to define reliable costs estimation at the very beginning of the project, and then to monitor and secure the costs expenditure throughout the project execution phase.

At the time of the FID, 90 % of the supply chain costs had been secured though binding offers. In addition, the costs estimates had been reviewed and confirmed by numerous internal and externals audits and reviews notably by the experts of the U.K. Government and the European Commission. The project control organization has been reviewed and reinforced based on benchmark from other nuclear projects.

V.5. LESSONS LEARNED

HPC is being financed by EDF and CGN, with a CfD providing long-term price stability for the generator once the plant begins generating (but leaving construction and operating risk with the investors). The CfD model was appropriate in this instance as HPC was the first new nuclear EPR project to begin construction in the United Kingdom since many years. At the point the decision was taken to enter the CfD, the EPR technology was not operational anywhere in the world, and similar projects in France and Finland had suffered from important delays and cost overruns. It was therefore decided that all construction and operational risk should remain with the project investors.

The context is different for future new nuclear projects. Despite the progress at HPC, the challenges facing the global nuclear industry have meant that replicating a CfD model for further new nuclear projects has proved very challenging. Very few project developers have a balance sheet that can accommodate the £15–20bn cost of delivering a new nuclear project, and financial investors have been unwilling to invest during the construction phase given the long construction period and risk of cost increases and delays. One of the biggest challenges for nuclear new built is to develop an alternative funding model that can attract private finance at a cost that represents value for money to consumers and are considering its wider applicability to other firm low carbon technologies.

For the Sizewell C project with lower NOAK risk profile, a RAB model[33] will be applied and it makes the project an attractive proposition for the implementation of a funding model able to bring private capital, including pension funds. A NOAK project with a moderate to low risk profile provides an opportunity to reduce the cost of finance and lower consumer bills.

The cost of finance in the Sizewell C project is around two-thirds of the HPC Strike Price and more than half of such cost is due to the construction risk premium. A NOAK nuclear project represents a substantial reduction in construction delivery risk which can be translated into a reduced cost of finance.

The findings from the National Audit Office's assessment of HPC found that a RAB model could drive significant improvements in value for money for new nuclear build by reducing the construction risk premium and securing private investment in new nuclear build. Under the HPC's CfD, the developer bears the full risks of development and construction. For projects with reduced construction risks, models which could transfer construction risk to consumers and taxpayers are more likely to deliver value for money.

[33] Detailed explanation of RAB model is available at: https://assets.publishing.service.gov.uk.

ANNEX 5: JORDAN: CONSIDERATION ON A SMALL MODULAR REACTOR

VI.1. EXPERIENCE WITH NUCLEAR POWER

Jordan imports more than 90% of its energy needs. This high dependency on imported fossil fuels in the past, and due to regional political instabilities, has led to interruptions of supply which cost the government heavily. Taking this into consideration, Jordan embarked on the Energy Diversification Policy in 2007. In 2011–2014 and due to repeated interruptions of the gas from Egypt (Arab Gas Pipeline), the National Electric Power Company (NEPCO)/Ministry of Energy were forced to resort to more expensive alternative sources (heavy fuel oil, Diesel Oil) for electricity generation incurring the Government billions of Jordanian Dinars in Debt.

The Jordan Atomic Energy Commission (JAEC) was established in 2007 by the Jordan Nuclear Energy Law No. 42. Following an amendment of the law, JAEC was mandated to lead the development and implementation of the nuclear energy strategy and to manage and coordinate efforts throughout the nuclear energy programme in the country. JAEC is an independent governmental body, reporting directly to the prime minister, and mandated to articulate a vision, strategy and roadmap to develop the use of nuclear energy for research, applications and generating electricity.

JAEC was identified and have been acting as the effective “NEPIO” based on the IAEA Milestone Approach [1] for Jordan and is supervised by the Council of Commissioners, comprising of the Commissioner for Nuclear Power Reactors and International Cooperation; Commissioner for Nuclear Fuel Cycle; Commissioner for Nuclear Research; and the Commissioner for Nuclear Sciences & Applications.

JAEC is responsible for representing Jordan in all areas related to the implementation of the Jordan nuclear programme. JAEC has signed Nuclear Cooperation Agreements with the following countries: France, China, Republic of Korea, Canada, Russian Federation, the United Kingdom, Argentine, Spain, Japan, Romania, Italy, Turkey, Saudi Arabia, Armenia, and the Czech Republic. Furthermore, JAEC is in charge of planning a national nuclear human resource strategy, and conducting the economic impact assessment throughout the cycle of the nuclear power programme. In addition, JAEC provides guidance and oversight of the uranium exploration, covering mining activities and exploration under the Jordan nuclear power programme.

JAEC is working on developing, exploring and marketing Jordan’s natural uranium resources, as well as vanadium, zirconium and thorium since 2007. Jordan’s reserves have been confirmed by the Joint Ore Reserves Committee, and JAEC continues to move forward with solid strides in this project.

In addition, the prime target of JAEC is to the develop a commercially viable NPP project and commencing its operation in Jordan. This target is based on the Jordan’s national strategic energy plan aiming at energy diversification. As per this, JAEC has embarked on an ambitious project to deploy a large NPP with around 1000 MWe and signed a project development agreement (PDA) with Rosatom Overseas for that purpose in 2014 after an extensive period of technology selection and evaluation. Due to several factors including market conditions (low growth in electricity due to the regional economic situation), the PDA was terminated.

JAEC commenced evaluation of SMRs as a viable alternative for medium term deployment with all the advantages they possess (suitability for small grid, smaller upfront investment, flexibility in deployment, etc.). Currently, JAEC is concentrating on the technical and economic evaluation of viable SMR technologies that could meet Jordan's requirements. The focus has more recently shifted towards water desalination.

VI.2. FRAMEWORK FOR THE PROJECT

As for the NPP project, the plant is expected to be in operation between 2030–2032 with the aim of: (a) replacing the imported fossil fuels; (b) decreasing the carbon footprint of energy in Jordan; (c) stabilizing the electricity prices; and (d) mitigating the energy supply risk.

Jordan's electricity market is a regulated market with one electricity off-taker, NEPCO. NEPCO is a 100% state-owned company responsible for the transmission system, system operation, and market operation. As the off-taker, NEPCO purchases electricity from the generators through long-term PPAs. In addition, and for the existing plants, NEPCO is responsible for the Fuel procurement for the generators. NEPCO buys fuel from the open market and sells electricity to distribution companies based on a regulated tariff. As a result of this structure, all fuel risk is borne by NEPCO, and due to the cost fluctuations of fuel in 2011–2015, NEPCO ended up with a severely skewed balance sheet (as mentioned earlier).

Although Jordan is blessed by a stable government and good relationships with most countries, Instability in the region has negatively affected on Jordan's economic situation due to the influx of refugees, closing of borders (heavily effecting trade, both exports and imports) and thus economic growth. The repercussions of this transcend trade to reach all sectors. Investment into megaprojects including energy will see the regional political risk as a factor for the appetite to invest. Another challenge for the implementation of the project in the meantime is the financial inability of the Government of Jordan to take on debt thereby proceeding forth with the project that is 100% owned by the Government with all the loans guaranteed by it.

Geographical conditions also pose challenges as Jordan is a nearly landlocked country with a small coastal area on Aqaba (27km that is occupied mainly by the vital Aqaba port, major vital industrial areas, and seaside resorts). In this regard, availability of cooling water needs to be considered in the site selection process. In addition, Aqaba is on the great rift and high in seismicity, therefore, a suitable NPP design in this area is high seismic one and it is more expensive than a standard design. This led the Government to consider another site, the Amra site, 60 km from AlSamra wastewater treatment plant (about 400 km inland). This site has been studied the most as it does not have seismicity issues and is far from population centres.

VI.3. OWNERSHIP AND FINANCING STRUCTURE

The proposed project will be owned by an independent company (SPV) set up solely for this purpose. As for the ownership structure, several options are currently being considered (JV and BOO/T). Each of these has its advantages and drawbacks.

As for the financing, in both cases the participation of the vendor country in the financing will be mandatory (ECAs, etc.). Depending on the technical characteristics of the plant selected, technologies might be sourced from several countries giving the potential for tapping into several sources of financing.

VI.4. CONTRACTUAL STRUCTURE

JAEC has conducted several feasibility studies in the development of the project. These were primarily aimed at assessing the technical & economic feasibility to proceed forth to the next phase. The first feasibility study was conducted in 2010, as a preliminary feasibility study for the viability of nuclear energy as an option, and this was primarily conducted by the off-taker. The following feasibility studies were mainly conducted with the vendors for the deployment of the technologies. To be clear, the feasibility studies conducted were all preliminary in a sense that none were prepared or updated with all the information available for project delivery or for financial closure. Vital information was still under discussion or estimation (as it was not available at the time).

As part of the ongoing process of project development, JAEC developed and maintained a risk register at every stage of the project (identification, evaluation, and mitigation, revaluation). As the risk management process can be dynamic, the risk register is regularly updated.

As this project will be the first NPP project in Jordan, as for the construction of the first unit, it will be a turnkey contractual structure that is the most risk-averse, regardless of the ownership approach. Splitting contracts and managing the risk of the different components might be open for discussion for the construction of following units after gaining the experiences from the first unit. In the operation phase, for the first step, the strong support from the technology provider and the associated companies is necessary for transferring the know-how. However, it is envisioned that the number of Jordanian crews gradually increase, and they take more roles and functions in the operation and maintenance of the NPP as their capabilities are enhanced.

VI.5. CURRENT STATUS

Based on the updated studies for Jordan’s electricity and water demand, JAEC has conducted studies on the feasibility of implementing an NPP based on SMRs’ technologies with installed capacities of 50–300 MWe. Compared to conventional large NPPs, SMRs require lower initial capital investment for the project, thus lower financial risk exposure in general. The investment costs for grid upgrades for SMRs are lower than for large reactors. Scalability (flexibility in deployment) and suitability for the grid is also an advantage, as this will be a determining factor for deployment suitability in the coming decade.

JAEC has been conducting SMR technology assessments since 2017 to select the most optimal and viable technology for deployment in Jordan for co-generation purposes including electricity generation and water desalination. The SMRs undergoing assessment represent the most proven light water reactor and high-temperature gas cooled reactor designs with inherent and enhanced active/passive safety features, integrated and factory-built modules, grid load-following capabilities, and an internationally profound supply chain with established nuclear vendors. The majority of these SMR designs are licensed and/or under construction in the respective country of origin. Furthermore, JAEC has finalized the site suitability studies for the Amra site. As per the results of these studies, the suitability was confirmed; therefore, JAEC can continue with further site characterization work based on the selected technology.

Currently, SMR vendors are being assessed, and the BIS is being finalized. Once completed, it is expected that the Request for Proposal/BIS will be released to the shortlisted SMR vendors to proceed with the bidding process.

In addition, JAEC is in the process of evaluating the potential for water desalination using process heat or reverse osmosis to produce an initial 100 MCM/year of potable water.

VI.6. LESSONS LEARNED

NPP projects in embarking countries will face many challenges. The most important mitigation factor is to include as many stakeholders during the project inception/development stage and prior to vendor selection/negotiation as this will guarantee all complaints and objections to be addressed and ironed out in the early stage of the programme. It also enables the Jordan Government to incorporate necessary requirements to the nuclear power programme.

Market assessment should be conducted realistically as this will have a material effect on the decision making or choosing the option in the project. Being conservative can be advantageous at times as this will guarantee that the choices moving forth will be implemented. It should be taken into consideration from day one, the most optimal generation capacity and the best means to achieve this.

It is very important to take the time to make all the decisions prior to signing any project implementation agreements and any commitments to the project. This is especially true for financial agreements and committing to contracts that will expose the project company to financial burden. It is important to spend time to check the information carefully, to explore the best means and technologies available, and to consider when and how to address any open issues prior to exposing the balance sheet of the project owner to debt (or equity invested in a project). These efforts will make the project less costly. The deeper the project company goes into the NPP project, the more costly delay in project delivery causes.

LIST OF ABBREVIATIONS

APC	Akkuyu Project Company
BIS	Bid Invitation Specifications
BOO	Build-Own-Operate
BOOT	Build-Own-Operate-Transfer
CfD	Contract for Difference
CGN	China General Nuclear Power Corporation
CIGA	Credit Inter-Governmental Agreement
C-U3/4	Credit Inter-Governmental Agreement
DCMs	Debt Capital Markets
ECA	Export Credit Agency
ENEC	Emirates Nuclear Energy Corporation
ENRRA	Egyptian Nuclear and Radiological Regulatory Authority
EPR	European Pressurised Reactor
ETRR-1	Experimental Training Research Reactor 1
EÜAŞ	Electricity Generation Company
EWA	Early Works Agreement
FANR	Federal Authority for Nuclear Regulation
FID	Final Investment Decision
FOAK	First-of-a-Kind
GDA	Generic Design Assessment
GenCO	NNB Generation Company
G2G	Government to Government
HGA	Host Government Agreement
HPC	Hinkley Point C
HRM	Human Resource Management
IAEA	International Atomic Energy Agency
IGA	Intergovernmental Agreement
IMS	Information Management System
IWS	Integrated Working Schedule
JAEC	Jordan Atomic Energy Commission
JSC	Joint Stock Company
KEPCO	Korea Electric Power Corporation

KPIs	Key Performance Indicators
KUs	Known Unknowns
LCCC	Low Carbon Contracts Company Ltd.
NMA	Nuclear Materials Authority
NEPCO	National Electric Power Company
NEPIO	Nuclear Energy Programme Implementing Organization
NNB	Nuclear New Built
NOAK	Nth-of-a-Kind
NPPA	Nuclear Power Plants Authority
NSSS	Nuclear Steam Supply System
O&M	Operations and Maintenance
PDA	Project Development Agreement
PPA	Power Purchase Agreement
RAB	Regulated Asset Base
SMRs	Small Modular Reactors
SNFT	Spent Nuclear Fuel Treatment
SNN	NUCLEARELECTRICA S.A.
SPV	Special Purpose Vehicle
TAEK	Turkish Atomic Energy Authority
TETAŞ	Turkish Electricity Trading and Contracting Company
UAE	United Arab Emirates
U.K.	United Kingdom
USA	United States of America
UUs	Unknown Unknowns

CONTRIBUTORS TO DRAFTING AND REVIEW

Al-Mutawa, O	Emirates Nuclear Energy Corporation, United Arab Emirates
Ayoub,R.	ED Advisory, Jordan
Bastos, J.	International Atomic Energy Agency
Borovas, G.	Hunton Andrews Kurth LLP, United States of America
Çamaş, E.	Ministry of Energy and Natural Resources, Türkiye
Çelik, A.	Akkuyu Nuclear ASC, Türkiye
Cometto, M.	International Atomic Energy Agency
Dulinets, L.	International Atomic Energy Agency
Dutta Ray, A.	International Atomic Energy Agency
Guerra, E.	RIZZO International, Inc., United States of America
Hegazy, H.	Nuclear Power Plants Authority, Egypt
Javaux, E.	Électricité de France, France
Lazarev, A.	JSC Afrikantov OKB, Russian Federation
Lugo, F.	McConnell Valdés, LLC, United States of America
Malev, V.	JSC Afrikantov OKB, Russian Federation
Maurin, M.	Électricité de France, France
Mortin, S.	Consultant, United Kingdom
Murphy, P.	Murphy Energy & Infrastructure Consulting, LLC, United States of America
Rakan, A.	ED Advisory, Jordan
Rollat, X.	Consultant, France
Rotaru, I.	Consultant, Romania
Salnikova, N.	JSC Afrikantov OKB, Russian Federation
Scott, M.	International Atomic Energy Agency
Shmelev, I.	JSC Afrikantov OKB, Russian Federation
Van Sickle, M.	International Atomic Energy Agency

Technical Meeting

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No. 26

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24-01636E

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