

Preliminary Study on Financing Strategies for Small Modular Reactors: Insights from the Barakah Nuclear Power Plant Example

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1. Introduction

In the current stage of Small Modular Reactors (SMRs) development, while promising flexibility, lower initial capital costs, and enhanced safety features, the challenge of financing stands as a significant barrier. The Barakah Nuclear Power Plant (NPP) in the United Arab Emirates (UAE) is one model to be examined in addressing these challenges. This model's success provides insights into leveraging governmental support and international partnerships for the financing of nuclear projects. As the global energy sector shifts towards more sustainable and diverse sources including nuclear power, searching for an effective financing model becomes crucial. The Barakah NPP model, with its distinctive features and outcomes, offers a framework for understanding and replicating success in future nuclear projects.

In this study, the Barakah NPP model is briefly touched in terms of financing strategies and international partnerships and its application to SMR projects is investigated. Challenges in SMR projects and governmental roles are identified. Finally, suggestions for international collaboration for SMRs will be provided according to each country's nuclear infrastructure status.

2. The Barakah Nuclear Power Plant Model

2.1 Overview of the Barakah NPP Project

The Barakah NPP consists of four APR 1400 reactors (total capacity of 5.6 GWe), first unit of which went on-grid in 2020. When the four reactors become fully operational, the plant is expected to produce up to 25 percent of the country's electricity.

According to ENEC, the project (approximately US\$ 24.4 billion) is financed from multiple sources; largely direct loan agreements (US\$ 19.6 billion) and equity commitments (a total of US\$ 4.7 billion). The direct loans includes US\$ 2.5 billion from Korea's Export-Import Bank (KEXIM), US\$ 16.2 billion from the Emirati Government and a total of US\$ 250 million from commercial banks. The equity commitments were provided by ENEC and Korea's Korea Electric Power Corporation (KEPCO) [1].

With a stable and predictable financing supported by strategic partnerships, the Barakah NPP set a successful model for nuclear businesses.

2.2 Financing Mechanism and Implementation

Central to the Barakah model is a financing strategy that combines governmental support with strategic partnerships and contracts. This approach mitigates financial risks through state guarantees and leverages funding from a consortium of international investors. The model also highlights the importance of long-term power purchase agreements (PPA), ensuring a stable revenue stream and financial viability to the project.

2.3 International Partnerships and Expertise

A point widely noted in Barakah NPP project's development was its open collaboration with foreign corporations. By partnering with KEPCO, the UAE accessed nuclear technology and expertise, facilitating the transfer of knowledge and the development of local capabilities. These international partnerships were instrumental in securing financing, as they provided reassurance to investors regarding the project's technical viability and management competence.

3. Applicability of the Barakah Model to SMR Projects

3.1 Addressing Financing Challenges in SMRs

Despite of the differences between large commercial nuclear power plants and SMRs in terms of scale and applications, the Barakah NPP model's principles suggest some considerations for the financing of SMR projects-particularly for first-of-a-kind (FOAK) plants. SMRs, while benefiting from lower individual project costs compared to traditional large reactors, face challenges related to FOAK expenses, regulatory uncertainties, and market acceptance. Adapting the Barakah model's approach-especially its emphasis on government support, risk-sharing mechanisms, and international collaboration-can provide a solid foundation for overcoming these challenges [2,3].

It is worth noting that while co-siting and learning accumulation have proven to be effective tactics for lowering project costs in traditional nuclear power plants, such techniques might not be deployable for SMRs [4]. Many areas targeted for SMR deployment may not require the scale of power generation that co-siting provides, rendering it an unviable option for regions

seeking small-scale electricity sources. Additionally, the high risks associated with SMR projects could deter investors and utilities from substantial investments. These variabilities in project funding composition could hinder the continuity of learning—spanning financing strategies, operation techniques, and construction capabilities—across projects.

3.2 Government Role and Policy Support

A critical lesson from the Barakah model is the indispensable role of government in facilitating nuclear projects, an aspect even more pronounced in the context of SMRs. Despite the growing involvement of private sectors in SMR development, in this early phase of SMR deployment, governmental support is not just beneficial but essential.

Governments can mitigate the initial risks through direct investment, guarantees, and by providing a regulatory framework tailored to the unique needs of SMRs, thereby accelerating their path to market—while the degree of governmental involvement is still an area to be explored [5]. Moreover, the role of government in the SMR sector may extend beyond the FOAK projects due to the broader responsibilities inherent in nuclear sectors. The question of liability and insurance associated with nuclear accidents remain within governmental jurisdiction. The comprehensive management of nuclear liability requires a legal and regulatory framework that can only be provided by state authorities, and this responsibility underscores the importance of government role and policy support in SMR projects and thus their financing.

3.3 Diverse Approaches to International Collaboration for SMRs

International collaboration in SMR development and deployment offers distinct benefits to countries at different stages of nuclear sector development.

For countries with little to no nuclear infrastructure, providing a turn-key approach to acquire nuclear capability from experienced nations can help access advanced technology and safety standards—offering better financing options. The collaboration model, as exemplified by UAE's partnership with KEPCO for the Barakah NPP, demonstrates how strategic alliances can facilitate both equity (governmental and private) and debt financing, from combining foreign expertise while advancing energy diversity and security.

In contrast, nations in more advanced stages of nuclear energy production may seek international collaboration to diversify their energy portfolio, especially in the integration of SMRs into their existing energy infrastructure. International partnerships that rely on turn-key solutions may not be as appealing to these countries with established nuclear infrastructure, as these approaches could potentially diminish the value and standing of domestic corporations within their own

nuclear sector. In such cases, international partnerships can focus on joint research and development, regulatory harmonization, and shared safety practices. Such collaborations should promote the domestic nuclear industry's maturity and also contribute to the global pool of nuclear knowledge.

The essence of international collaboration, therefore, shifts based on a nation's nuclear background—from a more pronounced reliance on foreign expertise for nuclear newcomers to a more reciprocal exchange among experienced nuclear nations.

4. Conclusions

The Barakah NPP model highlights the critical role of government support and international partnerships in SMR financing, offering insights for countries at various stages of nuclear development. Most notable is that governmental support helps leverage private investment. Given the uncertainties arising from innovative features of SMRs, in terms of technology as well as business, a solid financial strategy supported by governmental or public funds seems compelling in early stage of SMR deployment. Future researches in this field should focus on incorporating the insights from the Barakah model with other financial frameworks like the Build-Own-Operate (BOO) and Mankala models, to develop financing strategies that cater to the unique aspects of SMR deployment [1,6]. Such studies will be vital in leveraging SMRs for a sustainable energy future, emphasizing the need for strategic financing.

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