NAVIGATING THE ENERGY LANDSCAPE: CONSIDERATIONS FOR DEPLOYING SMALL MODULAR REACTORS IN SAUDI ARABIA

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Abstract

The article comprehensively focuses on various factors of Small Modular Reactor SMR deployment in Saudi Arabia as one of the strategic decisions that the country needs to make in its quest to have a sustainable and resilient energy future. The study explores the opportunities that stem from building nuclear infrastructure, as many SMRs would be deployed. The article emphasizes how the elements of a favorable framework are considered, which demonstrates the significance of strategic planning and prudent allocation of financial resources in an endeavor to establish a stable foundation for the safe and efficient integration of SMRs. To what extent does Saudi Arabia have to harmonize its elevating energy requirements with a sustainability pledge, the article explores the particularities of the Kingdom's energy environment. This highlights the major SMR advantages and disadvantages in meeting the increased electricity demand and makes it clear how they may be used in concert with renewables at scale and adapt to different conditions quickly. Regulatory technicalities have a crucial role in dictating how fast it is adopted. This article provides ways of creating a rule of law that will be effective, of paying attention to international standards while keeping in mind local details and specific features.

Economic viability is one of the aspects that are considered in the analysis, therefore, new financing mechanisms are to be looked into and potential ways of international collaboration are highlighted. The study analyses the long-term economic viability of SMRs in terms of operational costs, employment creation, and revenue streams, to ascertain their domesticated economic contribution to the Kingdom’s economic goals.

This article attempts to provide a full-scale guide to the policymakers, energy industry representatives, and the entire energy community in Saudi Arabia, as a means of better informed and logical decision-making to achieve a sustainable and diverse energy future.

1. INTRODUCTION

With Saudi Vision 2030 being a proactive plan aimed at increasing economic diversity in order to minimize dependence on oil profits, a plan was revealed by the government of Saudi Arabia in April 2016 which aimed at lessening the country's reliance on oil and broadening its economic base. Saudi Vision 2030 includes the following objectives:

1- Expanding into new fields, such as renewable energy and mining, is part of a plan to reduce the country's dependency on oil revenue through economic diversification. Building a robust and competitive economy that is not easily impacted by shifts in oil pricing.

2- Saudi Arabia's plan for 2030 aims to increase public sector effectiveness by simplifying processes and fostering an environment of accountability and transparency. In addition, by selling off several government-run enterprises and properties, the initiative aims to boost domestic entrepreneurship while enticing overseas capital.

3- This development plan will improve education and other vital social services, such as healthcare. In addition, Saudi residents are provided with greater chances for personal and professional development to elevate their standard of living.

4- Access to quality education and financial and career support for young people is essential for their growth and empowerment by tapping into the imagination and resourcefulness of Saudi youth.

5- The growth of a dynamic cultural and entertainment sector is advocated by Saudi Vision 2030. Efforts are underway to improve tourist destinations globally by promoting arts & culture events and sporting activities.

6- The plan prioritizes environmental sustainability and reduces the country's carbon footprint. Implement initiatives to boost renewable energy, improve efficiency, and preserve our valuable natural resources.

Reforms and initiatives aimed at achieving the goals of Saudi Vision 2030 have been undertaken by Saudi Arabia since its proclamation, including establishing new sectors, introducing tourism visas, and expanding on our existing renewable energy projects. Saudi Vision 2030's ultimate target is to transform Saudi Arabia into a bustling and affluent nation while elevating its citizens' well-being and quality of life [1].

2. SUPREME COMMITTEE FOR RESEARCH, DEVELOPMENT, AND INNOVATION

To achieve its economic diversification goals outlined under Vision 2030, the Saudi Arabian government aims to create an economy based on knowledge and innovation. To achieve that objective, a new organization known as the supreme committee for research development and innovation was established on 9 March, 2021. Developing the research and innovation sector is a major priority for the supreme committee, and the leadership over this committee is associated with the Council of Economic Affairs and Development by formulating policies, strategies, and initiatives that encourage an innovative mindset along with driving progress in scientific research. The Supreme Committee for Research, Development, and Innovation aims to create a pioneering environment within Saudi Arabia and the promotion of an innovative and knowledge-oriented economy is encouraged by collaborating with governments institutions academics businesses from different sectors as well as global partners. [2]. This committee also has a vital role to enable the adoption and integration of Small Modular Reactors (SMRs) into the Vision 2030 energy plan. The committee promotes and enables the advancement of innovative nuclear technology to help the kingdom's efforts in adopting sustainable and resilient energy mix. The strategic emphasis on Small Modular Reactors (SMRs) not only helps to diversify the energy mix, but also aligns with the wider objectives of improving technical independence and minimizing environmental harm. This strategy is also supported by strategic alliances and international collaboration, with the goal of establishing Saudi Arabia as a frontrunner in the worldwide nuclear energy industry.

3. NATIONAL ASPIRATIONS AND PRIORITIES FOR RESEARCH, DEVELOPMENT, AND INNOVATION

With lunching of the supreme committee for research development and innovation, the Saudi Arabian government has adopted four national priorities for the research, development and innovation sector, namely: human health, sustainable environment and supply of essential needs, energy and industrial leadership and economies of the future. Based on Saudi Arabia's natural resources and competitive advantages in the energy and industry sectors, and its leadership in the energy sector in the world, Saudi Arabia aims, through the priority of "leadership in energy and industry," to continue its leadership in the energy markets and to make it a global industrial power by innovating technologies to produce alternative energy such as green hydrogen. In addition, solar energy and wind energy ensure the sustainability of oil demand [2]. The Supreme Committee for Research, Development, and Innovation facilitates this transition by fostering a regulatory environment conducive to nuclear innovation, establishing international partnerships for technology transfer, and investing in local capabilities to design, operate, and maintain these advanced nuclear systems. This proactive approach in adopting SMR reactors technology highlights Saudi Arabia's role as a forward-thinking energy leader under Vision 2030.

4. SAUDI RESEARCH, DEVELOPMENT, AND INNOVATION LANDSCAPE

4.1. Research, Development, and Innovation Authority

The Council of Ministers issued decision number 612 on 1 June 2021, including establishing the Research Development and Innovation Authority RDIA. The authority aims to support and encourage the research, development, and innovation sector, supervise and regulate it, harmonize and coordinate between the roles of research agencies, empower and motivate them, and promote the localization of technology in research, development, and innovation activities and its transfer to be part of the development of local content, thus contributing to the growth of the national economy based on knowledge and innovation increase its production and compete globally [3].

4.2. National Laboratory

Accordingly, King Abdulaziz City for Science and Technology has been restructured to be the national laboratory in Saudi Arabia and a centre for national laboratories in the scientific, technical and research fields, and a reference in the areas of exclusive technology, its transfer, and localization and develop them to be part of the local content. In addition, it works to bridge the gap between scientific research and the industrial application of technology and to provide related services and businesses in accordance with international best practices. The National Laboratory implements basic, applied, and developmental scientific research programs in accordance with the national strategy for research, development, and innovation, publishes its results, and contributes to transforming its outputs into innovative value-added products and services. In addition, it works to develop its research infrastructure according to best international practices and specifications and to enable others to benefit from it. The National Laboratory also houses the Institute of Nuclear Technologies, which supports nuclear research and focuses on the development of small modular reactors (SMRs) under the supervision of a distinguished team of nuclear engineering specialists. [4].

4.3. Universities

The role of universities in driving and promoting scientific research, development, and innovation has become increasingly significant. This is evident in Saudi Arabia's performance in the Nature Index, which evaluates countries, universities, and institutions based on the quality of scientific research. In 2022, Saudi Arabia emerged as the top-ranked Arab country and secured the 30th position globally in the British Nature Index. This ranking results from the data collected and endorsed by the magazine, based on scientific publications in the top 82 international scientific journals. Saudi Arabia contributed a total of 448 publications to these journals. Notably, "Nature" included 26 Saudi universities in its rankings this year, a notable increase from the 16 universities featured in 2018. In Saudi Arabia 29 public and 12 private universities that contribute directly to supporting the national aspirations and priorities for research, development, and innovation. [2,4].

Among these, King Abdulaziz University, King Fahd University of Petroleum and Minerals, and King Saud University are actively involved in the development of nuclear reactors. These institutions play a crucial role in advancing SMR technology, leveraging their research capabilities to drive progress in this innovative field and supporting the country's ambitions for sustainable and advanced nuclear energy solutions.

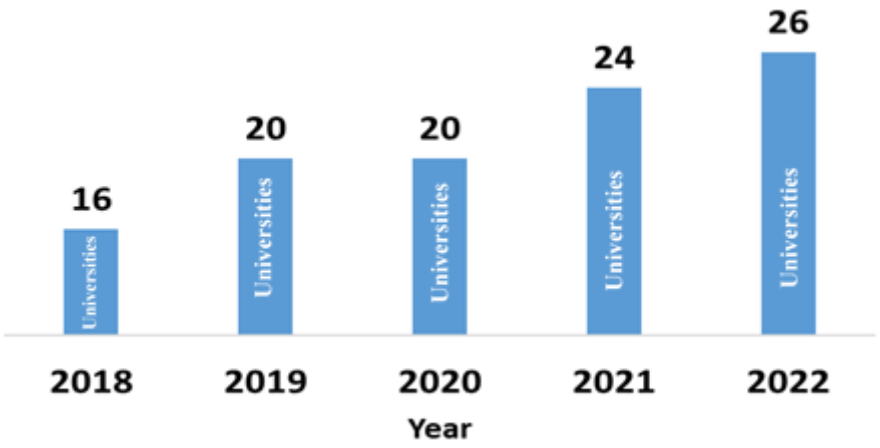

FIG.1. Increasing Saudi Arabia Universities in Nature Index between 2018 and 2022

5. THE ROLE OF RESEARCH, DEVELOPMENT AND INNOVATION OF NST IN THE SMALL MODULE REACTORS

Small Module Reactors (SMRs) have revolutionalized nuclear reactors and power plants. SMRs are advanced types of nuclear reactors with generating capacity not exceeding 300 MW(e) per unit, about one-third of a typical nuclear reactor [5]. Through many years of research, nuclear scientists have made significant progress in modular technology for designing SMRs. Modular technology has made it possible to design and fabricate SMR units in the factory, which can be assembled and installed quickly on-site where nuclear power is to be commissioned. This advancement comes with several advantages. Firstly, modular SMR design has significantly reduced time and cost in comparison to traditional on-site reactor construction. Factory-built component assembly makes commissioning new nuclear power reactors cost-effective [5]. Secondly, SMRs can be situated in unsuitable areas for larger plants like urban zones and industrial parks, reducing transmission costs and promoting smart city concepts. They can also be installed in regions with limited grid coverage, expanding low-carbon power access [5]. Thirdly, SMRs operate simply and safely due to their passive design, lower power, and pressure, making them suitable for urban environments. Lastly, their smaller power output results in lower radioactive fuel needs, leading to less frequent refueling—typically every 3 to 7 years, compared to conventional plants refueled every 1-2 years [5].

Research, development, and innovation (RDI) in the context of small modular reactors (SMRs) encompass multifaceted domains that collectively drive the evolution and optimization of this advanced nuclear technology. There are several areas where RDI in SMRs can be done. These areas span design optimization, where RDI efforts focus on enhancing safety features, fuel efficiency, and operational flexibility. Additionally, RDI plays a critical role in addressing regulatory challenges by providing comprehensive data and analyses to ensure compliance with safety standards. Cost reduction is another critical dimension, with research exploring innovative manufacturing techniques, streamlined construction processes, and novel materials, all aimed at enhancing economic viability. Grid integration and control systems innovation are vital for enabling SMRs to seamlessly integrate into existing energy infrastructure, bolstering energy reliability and adaptability. Furthermore, RDI efforts extend to addressing public perceptions and acceptance by effectively communicating the safety and environmental benefits of SMRs..

6. PROPOSED PLANE TO ADOPT SMR RDI IN SAUDI ARABIA

6.1 Phase 1: Preparatory Stage

Conduct a comprehensive assessment of energy needs, existing infrastructure, regulatory frameworks, and public acceptance to determine the feasibility of SMR adoption. Establish or enhance regulatory frameworks to govern SMR deployment, ensuring safety, security, and environmental protection while fostering investor confidence. Engage stakeholders, including local communities, policymakers, industry experts, and civil society organizations, to gather input, address concerns, and build consensus around SMR deployment.

6.2 Phase 2: Foundation Establishment

Conduct a thorough assessment of existing capabilities, infrastructure, and regulatory frameworks to identify gaps and requirements for SMR deployment.

6.3 Phase 3: Education and Training

Education lays the foundation for SMR adoption. Investment in education programs tailored to nuclear engineering, safety protocols, and reactor operation is imperative. Collaborations with established nuclear powers and educational institutions can facilitate knowledge transfer and skill development. Furthermore, specialized training for operators, technicians, and regulatory personnel ensures competency and compliance with international standards.

6.4 Phase 4: Research, Development, and Establishing Partnership

Investment in R&D fosters innovation and adaptation of SMR technology to local contexts. Research initiatives focusing on reactor design optimization, fuel cycle management, and waste disposal enhance efficiency and sustainability. Public-private partnerships can accelerate R&D efforts, leveraging both governmental resources and industry expertise.

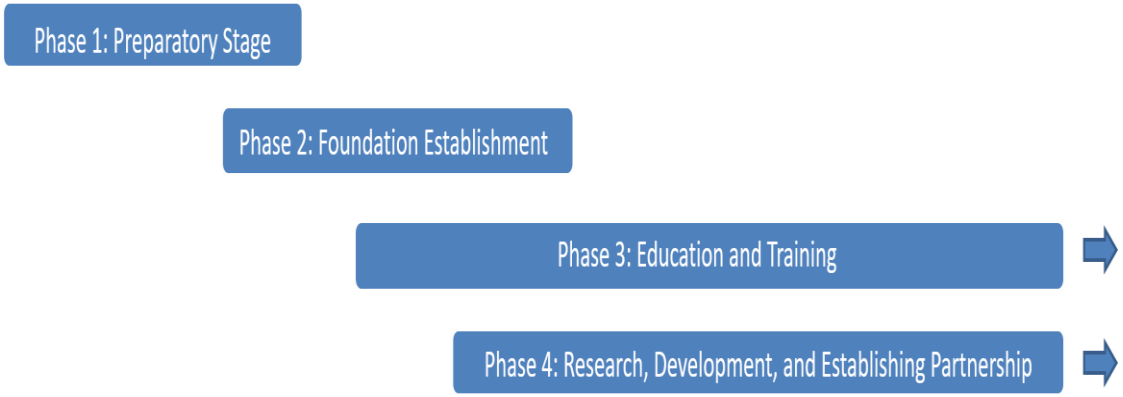

FIG. 2. Proposed Plan Process

7. CONCLUSION

Navigating the energy landscape with Small Modular Reactors (SMRs) presents a transformative opportunity for Saudi Arabia, aligning seamlessly with the nation's Vision 2030 objectives. The deployment of SMRs offers a multifaceted approach to achieving a sustainable, resilient, and economically diverse energy future. The strategic emphasis on SMRs is driven by their numerous advantages, including reduced construction costs and times, enhanced safety features, and flexibility in deployment locations. These attributes make SMRs particularly well-suited for Saudi Arabia's unique energy needs and geographic considerations. By leveraging modular technology, SMRs can be rapidly deployed and integrated into both urban areas and regions with limited grid access, thereby enhancing energy security and reliability across the Kingdom. International collaboration and strategic alliances are key components of Saudi Arabia's SMR strategy. Engaging with global partners for technology transfer, expertise sharing, and joint research initiatives enhances the Kingdom's capabilities and accelerates the adoption of advanced nuclear technologies. These partnerships also contribute to the development of a domestic nuclear supply chain, further supporting economic growth and technological independence. In conclusion, the deployment of Small Modular Reactors in Saudi Arabia represents a strategic and forward-looking approach to addressing the nation's energy challenges and achieving Vision 2030 objectives. By capitalizing on the advantages of SMR technology, fostering innovation through research and development, and establishing

robust regulatory frameworks, Saudi Arabia can position itself as a leader in sustainable nuclear energy. The comprehensive and integrated approach outlined in this article serves as a guide for policymakers, industry representatives, and the energy community, ensuring informed and strategic decision-making in the quest for a diverse and resilient energy future.

8. Further information

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