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# Inquiry into nuclear power generation in Australia

Submission to the House Select Committee on Nuclear Energy
Parliament House
Canberra ACT 2600

Stronger Regions for a Stronger Australia

The Page Research Centre welcomes the opportunity to contribute to the **Inquiry into nuclear power generation in Australia**.

This submission is made by the Page Research Centre in consultation with Mr Mike Newman, Executive Chairman & Group CEO of Ginga Vale Investments and former NSW Government Senior Trade & Investment Commissioner, North Asia.

The Page Research Centre is a non-profit organisation which is sustained by individual and corporate donations and by an annual grant from the Australian Government Department of Finance. We seek to inform and influence policy that delivers positive outcomes for rural and regional Australia. Our nation is uniquely reliant on our rural economy and our regional communities, which form the foundation of our national prosperity. We believe that better outcomes for the regions will inevitably lead to better outcomes for all Australians.

Gerard Holland
Chief Executive Officer
Page Research Centre
12 November 2024

**Authors note:** This submission was made after extensive consultation with KEPCO but was not prepared, sponsored or submitted by KEPCO or its subsidiaries.

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# Introduction

The debate over the viability of nuclear energy in Australia has often been clouded by concerns over cost, timelines, and industry capability. However, insights drawn from KEPCO's (Korea Electric Power Corporation) extensive nuclear experience highlight significant opportunities that could reshape Australia's energy landscape. KEPCO's proven success with the APR1400 reactors serves as a testament to nuclear energy's potential feasibility in Australia, presenting an effective model that contrasts sharply with current domestic cost and timeline estimations.

A key advantage of adopting a KEPCO-led nuclear strategy in Australia is the alignment with local industry strengths. The use of domestically sourced materials such as concrete and rebar would invigorate Australian manufacturing, create jobs, and foster industrial growth. The seamless integration of local labour, combined with KEPCO's "One Team, One Goal" approach to project management, further underscores the viability of a nuclear pathway tailored to Australia's unique conditions.

Contrary to widespread assumptions reflected in reports such as CSIRO's GenCost, KEPCO's completion of APR1400 projects demonstrates that nuclear power can be delivered at costs significantly lower than anticipated in Australian projections—**up to 2.6 times cheaper**.

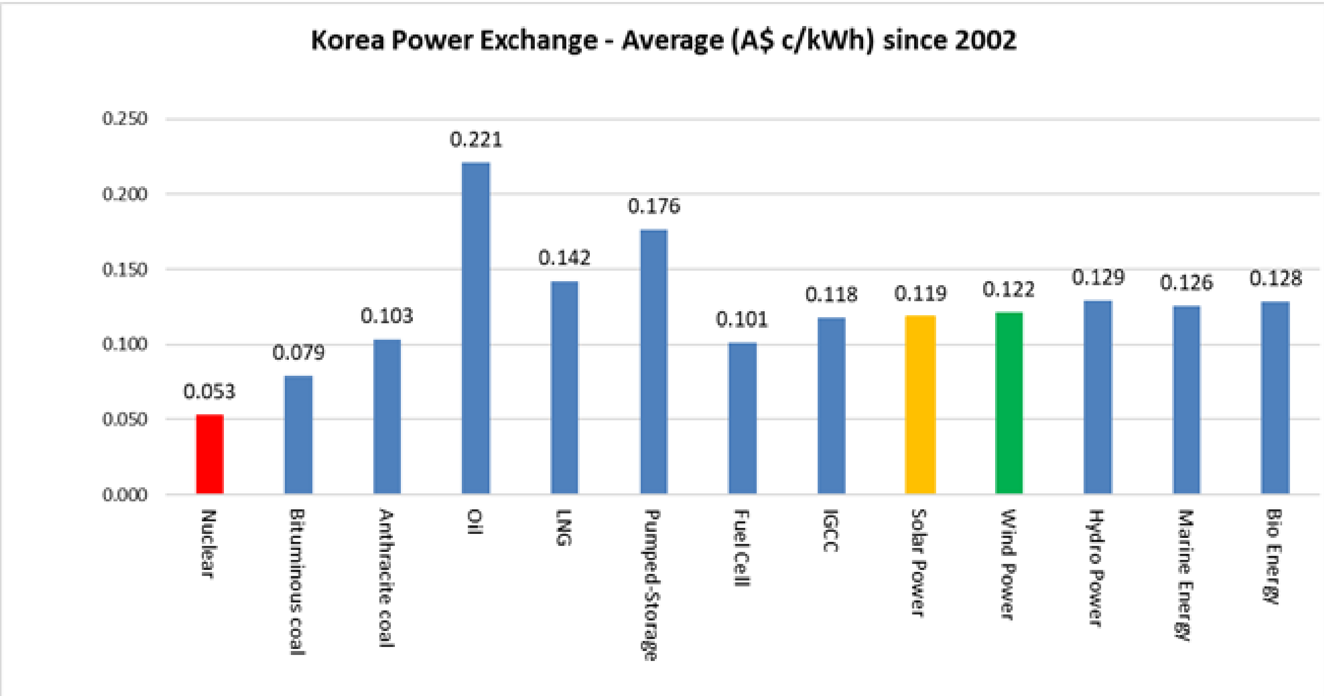
Additionally, KEPCO's project timelines, including the Barakah Nuclear Power Plant (BNPP) in the UAE, which transitioned from first concrete pour to operational status in under five years, challenge the conventional understanding of nuclear build durations. This positions KEPCO as both a model of efficiency and a potential partner for Australia, capable of expediting project delivery without compromising quality or safety.  By partnering with an experienced entity like KEPCO, Australia can pursue a stable, economically viable, and industry-supportive route to expanding its energy portfolio with nuclear power.

# Who is KEPCO?

Korea Electric Power Corporation (KEPCO), a key player in South Korea's energy landscape, is a publicly listed company on the KOSPI, Korea's main stock exchange. The ownership structure of KEPCO reflects a mix of public and institutional investment: 18.2% of shares are held by the Government of the Republic of Korea, 32.9% by the Korea Development Bank (KDB), and 7.2% by the National Pension Service (NPS). Foreign stakeholders account for 13.54% of ownership. This diverse investment base underscores KEPCO's strategic importance and influence in South Korea's economy and energy policy.

KEPCO supplies over 70% of South Korea's total power generation, underscoring its critical role in meeting the nation's energy demands. The company operates through six subsidiary "Gencos," each responsible for electricity generation across five major regions. Among these, Korea Hydro & Nuclear Power (KHNP) leads in the generation of nuclear and hydroelectric power, establishing itself as a backbone of KEPCO's operations and a key driver of South Korea's energy production.

KEPCO understands that nuclear energy serves as a reliable baseload power source that complements intermittent renewable sources like solar and wind. This hybrid approach could mitigate the challenges of energy variability and strengthen grid reliability. In South Korea, nuclear power remains the **cheapest** form of energy generation, as confirmed by the Korea Power Exchange, making it a benchmark for cost-effective, large-scale power solutions.



KEPCO's success can be attributed to its long, uninterrupted history of nuclear plant construction and operation, spanning over 50 years. Unlike other countries whose nuclear programs have experienced disruptions due to incidents such as Three Mile Island, Chernobyl, and Fukushima, KEPCO has maintained continuous progress. This consistency has allowed KEPCO to build extensive technical expertise and avoid the setbacks commonly associated with start-stop project cycles.

A fundamental aspect of KEPCO's success is its vertically integrated supply chain. By acting as the prime contractor and relying almost exclusively on Korean corporations for architecture, engineering, nuclear steam supply systems (NSSS), turbine generators, construction, nuclear fuel, and commissioning, KEPCO ensures cohesive project management and cultural alignment. This approach minimizes miscommunication and cost overruns, resulting in efficient, timely, and high-quality project completion.

KHNP, the pivotal subsidiary in KEPCO's nuclear operations, exemplifies this seamless cooperation. Since initiating the construction of Kori Unit 1 in 1971, KHNP has consistently built nuclear power plants, reinforcing its technical workforce's skillset and knowledge base. This continuity, combined with advanced information technology and a robust supply chain, has positioned South Korea as a leader in nuclear power technology.

Internationally, KHNP has solidified its reputation through rigorous certification processes. The APR1400 reactor, KEPCO's flagship model, received certification from both the European Utility Requirements (EUR) association in 2017 and the U.S. Nuclear Regulatory Commission (NRC) in 2019. It was the first non-U.S. reactor to achieve NRC certification, marking a significant milestone that validated its safety and performance standards on a global scale. This certification paved the way for KEPCO's expanded operations in global markets and affirmed the reactor's reliability.

To cater to varying international needs, KHNP developed the APR1000 reactor, which secured EUR certification in 2023. Since 2020, KHNP has been successful in securing contracts for 10 projects, supplying nuclear equipment to countries such as Romania, Slovenia, and China, with plans to further expand into European and African markets. This track record demonstrates KHNP's strategic flexibility and its ability to adapt its nuclear solutions to meet diverse global energy requirements.

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# Understanding the APR 1400

*"KEPCO designed the APR1400, an evolutionary reactor which incorporates a variety of engineering improvements to enhance safety, improve economics, and increase reliability of nuclear electricity generation in the Republic of South Korea. This reactor is a 1400 MWe PWR that utilizes innovative active as well as passive safety systems to provide high performance and safe reactor operating conditions. The design evolved from the OPR1000 with higher safety and seismic resistance features. The philosophy that safety and economics go hand-in-hand resulted in a worldwide deployable design that can be tailored to a variety of utility requirements. The company has drawn from its extensive experience in areas of construction, operations and decommissioning in the nuclear industry to incorporate lessons learned from their previous endeavours. A parallel research and design process allowed the incorporation of results from a series of experimental research projects with the purpose of protecting workers, the public and the environment."* - IAEA, 2020

As KEPCO's flagship export reactor, the APR1400 has achieved significant international recognition. Its safety and design standards were certified by the European Utility Requirements (EUR) in 2017 and by the U.S. Nuclear Regulatory Commission (NRC) in 2019, making it the first non-U.S. reactor to receive such certifications. **No other overseas reactors have been certified by EUR or NRC before.** These endorsements underscore the reactor's compliance with some of the most stringent safety and operational standards worldwide.

Domestically, the APR1400 was first implemented in the Shin-Kori Units 3 and 4, completed in 2016 and 2019, respectively. Subsequent deployments included the Shin-Hangul Units 1 and 2, completed in 2022 and 2023, with Shin-Kori Units 5 and 6 expected to be finalized in 2023 and 2024.

The design life of the APR1400 is projected to be 60 years, with multiple potential extensions of ten years each, demonstrating its long-term viability and adaptability for extended service in diverse conditions.

# A Case Study for Australia- The UAE Barakah Nuclear Power Plant (BNPP)

Government and media in Australia often refer to CSIRO and AEMO reports as benchmarks for energy market costings. However, direct consultations with KEPCO could have provided more precise insights into the feasibility and cost structures of nuclear projects, especially when comparing BNPP as a model. It is notable that KEPCO Australia, a subsidiary, is based in North Sydney, providing accessible expertise that could inform such evaluations more accurately.

The UAE's Barakah Nuclear Power Plant (BNPP) represents a significant milestone in international nuclear projects, led by KEPCO. While comprehensive cost breakdowns for BNPP are not fully disclosed due to non-disclosure agreements, the total project cost of US$24 billion for a 5,600 MW capacity is accurate. **This results in a cost of approximately US$4,357/kW (A$6,400/kW), which is significantly below the CSIRO GenCost report's assumption of US$5,855/kW (A$8,655).** The difference of approximately **35%** highlights discrepancies in cost estimates used by Australian bodies.

A significant aspect of BNPP not captured by general cost assumptions is the extensive design adaptations needed for its specific environmental conditions. To ensure optimal performance in the UAE's harsh climate, **BNPP incorporated over 20,000 design changes**. These modifications included systems to handle sandstorms, advanced HVAC and water-cooling mechanisms for higher air and seawater temperatures, and filtration systems to mitigate high sea and groundwater salinity. Such environmental-specific changes added to the cost and required additional testing and regulatory compliance.

The comparison between South Korea's Shin-Kori 3 & 4 APR1400 reactors and BNPP underscores the environmental challenges BNPP faced:

| Factor | UAE BNPP vs SK3&4 |
|---|---|
| Seawater Temperature | +26.5% |
| Maximum Summer Temp | +26.4% |
| Salinity (sea) | +37% |
| Salinity (groundwater) | 10.31x |

These modifications, which significantly added to costs, would not be relevant to the sites identified by the Opposition Leader, the Hon Peter Dutton.

It should be noted that the highest safety standards were achieved among the 22,000 workers on the BNPP project, which recorded 100 million long-term injury free hours during construction.

As a result, it is believed that the base design of the APR1400 reactors used in Korea would be more suitable for Australian conditions, reducing the need for additional, climate-specific equipment that increased BNPP's cost. Preliminary analyses indicate that deploying APR1400/APR1000 reactors in Australia could be more economically feasible than projected by GenCost. For instance, the Shin-Kori 3 & 4 reactors in Korea were **completed at around A$3,356/kW,** far below CSIRO's estimates. Even delays such as the four-month postponement on Shin-Kori Units 5 & 6 only marginally increased costs by 1.9%. **The GenCost figures overestimate costs by 2.6 times.**

While domestic construction would naturally be more economical for KEPCO, comparable projects in Australia would still likely be more cost-effective than current CSIRO projections. Concerns about cost overruns, often cited by anti-nuclear advocates referencing projects managed by entities like France's EDF Group, do not reflect KEPCO's track record. Such comparisons fail to recognize the distinctions in project management practices and expertise.

For spent fuel management, BNPP adheres to regulations requiring interim on-site storage, with subsequent relocation to specialized facilities. This approach aligns with international best practices for high-level waste management, ensuring both safety and compliance with legal frameworks.

# Barakah Nuclear Power Plant (BNPP) Structure

The Barakah Nuclear Power Plant (BNPP) project was led by Korea Electric Power Corporation (KEPCO) as the prime contractor. The ownership of the plant is held by the Emirates Nuclear Energy Corporation (ENEC). The project company established for BNPP is Barakah One Company (BOC), in which ENEC holds an 82% stake and KEPCO holds 18%. The operation of the plant is managed by Nawah Energy Company, which is also owned by ENEC (82%) and KEPCO (18%).

Financing for the project was provided by the government of the United Arab Emirates (UAE) through the Abu Dhabi government's Treasury. KEPCO's funding was supported by the Korea Export-Import Bank (KEXIM) and various other development banks.

# BNPP Plant Dynamics

The contract for BNPP was awarded to KEPCO by ENEC on December 27, 2009, under an Engineering, Procurement, and Construction (EPC) turnkey agreement. The total contract value was US$24.4 billion, encompassing the development of four APR1400 reactors with a combined capacity of 5,600 megawatts (MW).

The construction milestones for each reactor were as follows:

- First concrete for Unit 1 was poured in July 2012.
- First concrete for Unit 2 was poured in April 2013.
- First concrete for Unit 3 was poured in September 2014.
- First concrete for Unit 4 was poured in July 2015.

Each unit underwent hot functional tests at different times to ensure operational safety and readiness:

- Unit 1's hot functional test was completed in November 2016.
- Unit 2's hot functional test was completed in August 2018.
- Unit 3's hot functional test was completed in October 2021.
- Unit 4's hot functional test was completed in July 2022.

The commissioning of the units followed a phased approach:

- Unit 1 was commissioned in August 2020.
- Unit 2 was commissioned in September 2021.
- Unit 3 was commissioned in October 2022.
- Unit 4 was commissioned in September 2024.

**The levelized cost of electricity (LCOE) for BNPP is estimated to be conservatively around 8 cents per kilowatt-hour (kWh).**

**KEPCO has reported that the timeline from the first concrete pour to the production of electricity for Unit 1 spanned 56 months.** This period experienced some minor delays, which were attributed to regulatory requirements and ensuring operational readiness on the part of the UAE authorities. Despite these challenges, the project proceeded with high adherence to international safety and efficiency standards.

# Australia and Nuclear Energy

The success of the Barakah Nuclear Power Plant (BNPP) serves as a strong reference model for any potential new nuclear build project in Australia, contingent upon comprehensive feasibility studies. One essential aspect for any international player to provide accurate cost evaluations and recommendations is the establishment of an appropriate regulatory framework. KEPCO has prior experience in consulting on regulatory matters, exemplified by its ongoing work in the United Kingdom, making this model a viable template for similar endeavours in Australia.

**Analysing decades of history, the construction of multiple reactors on the same site maximizes long-term cost efficiency, particularly through continuous engineering practices.** This approach, while potentially limiting the number of reactor sites needed, aligns with long-term population and energy demand forecasts, enabling the reactors to provide a stable baseload that meets growing requirements, even considering improvements in energy efficiency.

Site selection is critical. The placement of reactors near the coast is generally accepted as the best way to guarantee a continuous water supply for essential cooling systems. This strategy ensures that nuclear plants operate reliably with minimized risk of water shortages.

Public ownership of nuclear facilities is proposed as the most pragmatic model, similar to how BNPP is managed. Joint operation and maintenance by public and private entities could foster transparency, trust, and enhanced national energy security. The absence of stable baseload power presents challenges, as seen in other nations that rely heavily on renewables. The Korean government, recognizing the importance of consistent energy supply for an export-driven economy, maintains a diversified energy mix that includes nuclear power to ensure stability and security.

Nuclear energy's integration with renewables addresses their intermittency, smoothing out the fluctuations in energy supply caused by renewables' lower average capacity factors. KEPCO's APR1400 reactor design is engineered to complement renewable energy, reinforcing grid stability. This approach aligns with strategic goals to maintain consistent power and predictable energy prices.

**Analysing KEPCO's nuclear business, it is clear that while the levelized cost of electricity (LCOE) is a common metric, it does not always capture the comprehensive costs of energy supply.** The broader economic benefits, such as job creation and the growth of local manufacturing (notably in concrete and steel production), contribute to a sustainable workforce and long-term training programs.

Additionally, Australia possesses favourable conditions for the management and storage of nuclear waste, supporting a long-term approach to safe and efficient waste handling. The adoption of nuclear energy could thus provide both energy security and economic benefits while being fully compatible with a renewable-centric grid strategy.

## Manufacturing Opportunities – the impact to domestic supply chains

Were Australia to build 12GW of nuclear power, the benefit to domestic manufacturing and jobs creation opportunities would be significant.  3.3 million m3 (equivalent to 12.5% of Boral's 2023 total cement manufacturing) of cement, 500,000 tonnes of rebar, 1.420 kilometres of pipe and 26,000 kilometres of cable could be sourced at home. This not only aligns well with plans to rebuild Australia's manufacturing base but would be strongly encouraged by KEPCO's preference for onshoring these critical materials.

# Conclusion

In light of the extensive analysis provided here, it becomes clear that nuclear energy presents a viable, sustainable, and economically advantageous addition to Australia's energy mix. Drawing on KEPCO's proven track record with the APR1400 reactors and the successful deployment at the Barakah Nuclear Power Plant (BNPP), Australia can approach nuclear energy with a model rooted in efficiency and reliability. The economic advantages of such a move are significant, challenging conventional cost projections such as those outlined by CSIRO's GenCost report and demonstrating the potential for reduced expenses through strategic partnerships and streamlined project management.

Implementing a KEPCO-led nuclear strategy can harness Australia's local resources, foster job creation, and catalyse industrial growth while supporting a low-emissions future. The hybrid approach, integrating nuclear with renewables, addresses energy variability and strengthens grid reliability, ensuring continuous, baseload power to complement intermittent renewable sources. This model has proven successful in South Korea and internationally, reinforcing its relevance as Australia seeks to bolster its energy security and long-term sustainability.

Australia's favourable conditions for nuclear waste management and coastal site potential further support the feasibility of adopting such an approach. With an established regulatory framework and the strategic inclusion of public-private partnerships, nuclear energy could not only meet Australia's current energy demands but also pave the way for future growth. By pursuing nuclear integration thoughtfully, Australia has the opportunity to secure an energy portfolio that is stable, economically beneficial, and environmentally responsible.

# APPENDIX

## APR1000/1400 orders

Korea Hydro & Nuclear Power (KHNP) has been active in international projects involving its APR1000 and APR1400 reactors. The APR1000 was a contender against Électricité de France's (EDF) EPR1200 for the Czech Republic's Dukovany nuclear plant, which is set for test operations in 2036. Following a successful bid, Korean President Yoon was scheduled to visit Prague in September to participate in the signing ceremony. Additionally, KHNP is conducting feasibility studies for the potential installation of two reactors at the Dutch Borssele nuclear plant site, with capacities ranging from 1,000 to 1,650 MWe, targeted for completion by 2035. In Poland, plans are in place for the development of two APR1400 reactors in the Patnow-Konin region, also expected to be operational by 2035.

## Integrated Small Modular Reactors (iSMR)

KHNP has announced the development of its integrated small modular reactor (i-SMR), a pressurized water reactor type with a capacity of 170 MWe. The reactor design is projected to be completed by 2025, with plans to achieve standard design approval by 2028. Indonesia has shown interest in introducing i-SMR technology through a subsidiary of the Indonesian Electric Power Corporation, highlighting the reactor's growing international appeal. The Jordan Atomic Energy Commission (JAEC) is also considering the use of i-SMRs for grid power generation and desalination projects.

In South Korea, KHNP has expanded its collaboration efforts by signing a Memorandum of Understanding (MoU) with Daegu Metro. This agreement focuses on constructing an i-SMR at a high-tech industrial complex near Daegu International Airport, indicating domestic and international momentum for adopting this advanced reactor technology.

## Proposed Nuclear Sites in Australia


Tarong (QLD) - 1400MW

Callide (QLD) - 1720MW

Liddell (NSW) - 2051MW

Mount Piper (NSW) - 1400MW

Port Augusta (SA) - 784MW

Loy Yang (VIC) - 3280MW

Muja (WA) - 1094MW

Total - 11729MW

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