RCA
Issue Brief

VOLUME 5 | MAY 2026

Indonesian Nuclear Energy : From Last Option to Main Solution

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Summary

Indonesia's strategic decision to reposition nuclear energy from a **"last resort"** option to a fundamental component in its energy system marks the most significant structural shift in national energy policy in the past decade. This change is not a sudden step but rather a cumulative result of institutional maturation, economic transformation, and the pressure of global climate commitments, culminating in mid-2025. Based on the evolution of national policy instruments (KEN, RUKN, RUPTL), as well as a comprehensive evaluation through the 2021 Nuclear Infrastructure Self-Assessment, aligned with the International Atomic Energy Agency's (IAEA) Milestones Approach standard, Indonesia has substantively completed Phase 1 and is intensively transitioning to Phase 2.

0.5 GW
Nuclear capacity in RUPTL 2025–2034

16 / 19
IAEA infrastructure conditions met (2021)

35 GW
Nuclear target by 2060 NZE(Net Zero vision)

2032
Target: first SMR operational

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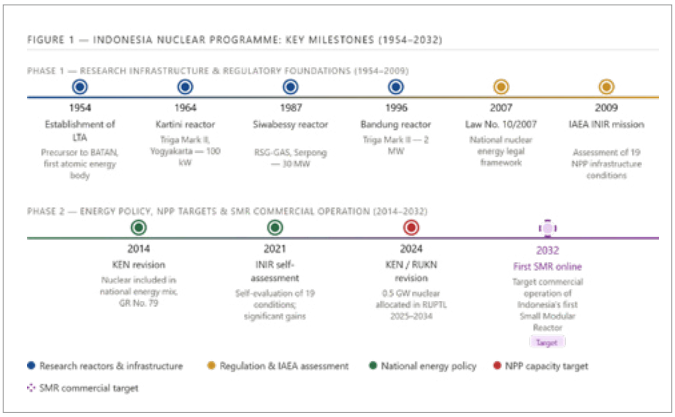
1. A 70-Year Foundation: From Research Reactors to Commercial NPP

Indonesia has a long and credible historical foundation. Indonesia's involvement with nuclear technology began with the establishment of the State Committee for the Investigation of Radioactivity in 1954, which later evolved into the Atomic Energy Institute (LTA) in 1958. Over the next few decades, Indonesia managed to build a solid technical and institutional base. This is evidenced by the track record of operating three research reactors located in Bandung, Yogyakarta, and Serpong, as well as active participation in technical cooperation programs with the IAEA.

Key Milestones

- 1954 — State Committee For Radioactivity Investigation
- 1958 — Established of LTA (Atomic Energy Institute)
- 1964 — Triga 2000 reactor, Bandung (250 kW upgrade to 2MW in 2000)
- 1979 — Kartini reactor (100MW)
- 1987 — G.A. Siwabessy reactor, Serpong (30 MW)
- 1997 — Law No.10/1997 on Nuclear Energy
- 2009 — First IAEA INIR Mission
- 2021 — IAEA Infrastructure Self-Assessment
- 2025 — KEN/RUKN revision: nuclear as strategic priority, RUPTL includes 0.5 GW nuclear target

Human resource development, technology mastery, safety and regulatory culture formation, and implementation of nuclear technology in the food and health sectors have been going very well. However, in the energy sector, the translation of nuclear competence research into the construction phase of Nuclear Power Plants (NPPs) has been repeatedly delayed. The main obstacle is not technological mastery but policy framing. For decades, nuclear power was officially categorized as a **"last resort"** in the National Energy Policy document. This creates a structural disincentive to investment and implementation, even though comprehensive feasibility studies have been repeatedly conducted in the Muria Peninsula (Jepara), the Bangka Islands, and Kalimantan.



(Figure1.) Indonesia Nuclear Programme: Key Milestones (1954-2032)

The mid-decade of the 2020s became a decisive turning point. The removal of the "last resort" clause through the revision of the National Energy Policy (KEN) and the issuance of the National General Electricity Plan (RUKN) 2024–2060 signifies a fundamental redefinition of the role of nuclear energy—from a contingency option to a strategic instrument of the state.

Decisive Turning Point: Mid-2025

The removal of the "last resort" clause through revision of the National Energy Policy (KEN) and issuance of the National General Electricity Plan (RUKN) 2024–2060 redefines nuclear energy from a contingency option to a strategic instrument of the state.

2. Nuclear as the Backbone of Industrial Downstream Energy Security

The decision to adopt nuclear energy is closely related to national macroeconomic targets. Based on the President's Vision and Mission, Indonesia targets an annual economic growth rate of 8% to realize the **"Golden Indonesia 2045".** This fundamental momentum is marked by a paradigm shift from an economic model that relies on the sale of raw natural resources to industrial downstreaming to boost national added value.

The focus on processing strategic minerals—such as nickel, tin, and bauxite—is now Indonesia's main anchor in strengthening its position in the global clean energy supply chain, particularly in the electric vehicle (EV) battery industry. This downstream industrial transformation of natural resources demands enormous energy supplies, which in turn will drastically change the national energy supply and demand profile.

The operation of smelter facilities and their derivative industries absolutely requires a sustainable, reliable, and scalable electricity supply to maintain Indonesia's commitment to clean energy. While the use of renewable energy is crucial to support decarbonization, sources such as solar and wind are intermittent and cannot guarantee a 24/7 supply for heavy industrial loads. On the other hand, hydropower plants (PLTA) and Geothermal do contribute to strong baseload capacity, but their development is often hampered by geographical constraints and distance from industrial demand centres.

It is in this landscape that nuclear power emerges as a strategic solution to encourage national economic growth while mitigating

climate change. The high-capacity factor (often exceeding 90%) and predictable energy output position nuclear power as the backbone of electrical system stability. The presence of Nuclear Power Plants (NPPs) not only increases industrial competitiveness by providing stable electricity but also allows the large-scale penetration of Variable Renewable Energies (VRE) into the grid.

3. Nuclear as the Equilibrium Solution to the Energy Trilemma

Policy Coherence
KEN + RUKN + RUPTL fully aligned — unprecedented legal certainty for nuclear investment

Industrial Urgency
Downstream mineral industries created a structural baseload demand surge unseen a decade ago

Climate Mandate
NDC and NZE commitments transformed nuclear from a political taboo to a pragmatic necessity

The Second Nationally Determined Contribution (2nd NDC) document and Indonesia's long-term commitment to achieve Net Zero Emissions (NZE) by 2060 provide strict limits on the design of the future energy mix. At the same time, the government's ambition to achieve 8% economic growth and accelerate industrial downstreaming (hilirisasi) significantly increases projected electricity demand, further tightening the constraints on energy system planning. As the largest contributor to carbon emissions, the energy sector must accelerate decarbonization while continuing to expand low-carbon generation capacity to meet this surge in electricity demand.

This combination of binding climate commitments and aggressive economic targets poses a significant energy trilemma challenge for crafting accommodative policies. Decades of heavy reliance on coal reserves risk undermining the country's climate credibility in the eyes of the international community and exposes Indonesia to the risks of the global economic transition (such as the implementation of a cross-border carbon tax). Conversely, the premature phase-out of fossil-based power plant assets without a commensurate baseload alternative could jeopardize national energy security.

It is in this context of impasse that nuclear power occupies a critical equilibrium position because of its nature, which does not produce greenhouse gas emissions, has a very high energy density, and is dispatchable (can be controlled according to load demand). Within the framework of the NZE architecture, nuclear energy should not be seen as a competitor to renewable energy but rather as a technical driver that facilitates large-scale integration of renewable energy.

Nuclear Equilibrium Position

Nuclear occupies a critical equilibrium because it produces no greenhouse gas emissions, has very high energy density, and is dispatchable. Within the NZE architecture, nuclear is not a competitor to renewables — it is a technical driver that facilitates large-scale renewable integration without destabilizing the grid.

The existence of nuclear baseload ensures that the decarbonization process can continue at scale without disrupting grid stability or hindering industrial economic growth.

4. New Rules Game: Nuclear Officially Included in the National Plan

Two to three decades ago, Indonesia actually had qualified technical capabilities in the field of nuclearization, but its implementation was always constrained by the absence of three main driving factors: policy coherence, economic urgency, and climate demands. Today, these three essential elements have been present simultaneously. Policy coherence finally reached its peak through the ratification of the Decree of the Minister of Energy and Mineral Resources No. 188.K/TL.03/MEM. L/2025 concerning the Electricity Supply Business Plan (RUPTL) 2025–2034. This document is no longer just dissemination material, but an official operational policy that provides a legal mandate for the entry of 0.5 GW of nuclear capacity into the national electricity system. This creates investment certainty that has never occurred before in Indonesia's nuclear history.

- **First,** policy coherence is finally achieved through solid alignment between the National Energy Policy (KEN), the National Electricity General Plan (RUKN), and the Electricity Supply Business Plan (RUPTL). This creates unprecedented legal certainty for stakeholders and potential investors.
- **Second,** the current scale of national downstream industries has created a structural surge in demand for low-carbon baseload power—an urgency not seen a decade ago.
- **Third,** international climate commitments and the dynamics of global decarbonization have forced nuclear to become highly relevant, transforming it from a politically avoided issue into a crucial pragmatic solution.

The convergence of these three macro factors comprehensively explains why the discourse on nuclear power plant development in Indonesia is no longer just speculation on a planning paper, but a real-world strategic agenda that has begun to be executed.

RUPTL 2025-2034: Capacity Additions & Investment Plan (USD Billion)

$188 B **Total Investment** USD Billion, 2025-2034	**22.1 GW** **Renewable Baseload** $63B - largest allocation
24.3 GW **VRE (Wind & Solar)** $34B - highest GW addition	**0.5 GW** **Nuclear (NPP/SMR)** $3.2B - first official allocation

Source. PT PLN(Persero). (2025. June 2). RUPTL 2025-2034: Beyond the Greenest RUPTL. Total planned investment across generation, grid, and financing components.

PROJECT / TECHNOLOGY	CAPACITY	USD (B)	SHARE
Renewable baseload Hydro, geothermal, pumped storage, bioenergy	**22.1 GW**	$63B	33.5%
VRE (Wind & Solar) Solar 17.1 GW, Wind 7.2 GW	**24.3 GW**	$34B	18.1%
Thermal baseload Gas 10.3 GW, Coal 6.3 GW	**16.6 GW**	$26B	13.8%
Transmission lines & substation 47,758 kms	—	$24B	12.8%
CAPEX & interest during construction	—	$17B	9.0%
Distribution lines & substation 197,998 kms	—	$11B	5.9%
Battery Storage (BESS) 6 GW / 27 GWh	**6 GW**	$4B	2.1%
End-to-end smart grid 5 regions, 38 provinces	—	$5B	2.7%
Nuclear (NPP / SMR) ★ First explicit allocation in official planning document	**0.5 GW**	$3.2B	1.7%
Total investment 2025–2034	—	$188B	100%

Source: PT PLN (Persero). RUPTL 2025–2034: Beyond the Greenest RUPTL (2025, June 2). https://www.pln.co.id

📌 RUPTL 2025–2034: USD 188 Billion Investment Plan — Nuclear Included

The ratification of RUPTL 2025–2034 (Ministerial Decree No. 188.K/TL.03/MEM.L/2025) creates unprecedented legal certainty — 0.5 GW of nuclear capacity now has a formal mandate in Indonesia's official power system plan. Three macro factors converged simultaneously to make this possible.

5. How Prepared Are We? IAEA Infrastructure Readiness Assessment

To provide security and professionalism assurance to the international community, Indonesia's nuclear readiness has been systematically assessed using the IAEA's Milestones Approach framework, which covers 19 infrastructure issues. A direct comparison between the findings of the 2009 Integrated Nuclear Infrastructure Review (INIR) Mission and the 2021 Self-Assessment document demonstrates that national infrastructure readiness has made very substantial progress.

Phase 1 Achievements: Initial Evaluation and Commitment.

Based on the results of the 2009 INIR Mission, Indonesia is considered to have successfully fulfilled most of the crucial requirements of Phase 1. Some of these foundational achievements include:

- **Legal Framework:** The availability of comprehensive nuclear energy regulations (Law No. 10/1997) as an operational basis.
- **Regulatory Framework:** The establishment of BAPETEN as an independent and competent nuclear supervisory body.
- **Human Resource Development:** Ongoing nuclear education and training programs through leading academic institutions.
- **Stakeholder Engagement:** Initiation of dialogue with the public and relevant stakeholders.

In the 2009 evaluation, three areas received a red light (requiring significant action). However, the 2021 Self-Assessment revealed that two of them have been significantly improved through improved governance and program management.

INIR 2009 vs Self-Assessment 2021: 19 Infrastructure Conditions

#	INFRASTRUCTURE CONDITION	INIR 2009	SA 2021	Trend
A — NATIONAL COMMITMENT & POSITION				
1	National position	🔴	🔴	→
2	Nuclear safety	🟢	🟢	→
B — MANAGEMENT & FINANCING				
3	Management	🔴	🟡	↑
4	Funding and financing	🟡	🟡	→
C — LEGAL & REGULATORY FRAMEWORK				
5	Legal framework	🟡	🟢	↑
6	Safeguards	🟢	🟢	→
7	Regulatory framework	🟢	🟢	→
D — SAFETY, SECURITY & EMERGENCY				
8	Radiation protection	🟢	🟢	→
14	Emergency planning	🟢	🟢	→
15	Nuclear security	🟢	🟢	→
E — GRID, SITING & ENVIRONMENT				
9	Electrical grid	🟢	🟢	→
12	Site and supporting facilities	🟡	🟢	↑
13	Environmental protection	🟢	🟢	→
F — HUMAN RESOURCES & INDUSTRIAL INVOLVEMENT				
10	Human resource development	🟢	🟢	→
11	Stakeholder involvement ★ Major improvement	🔴	🟢	↑↑
18	Industrial involvement	🟡	🟢	↑
G — FUEL CYCLE, WASTE MANAGEMENT & PROCUREMENT				
16	Nuclear fuel cycle	🟢	🟢	→
17	Radioactive waste management	🟢	🟢	→
19	Procurement	🟢	🟢	→

🔴 Red : Action needed 🟡 Yellow : In progress 🟢 Green : Ready
↑↑ Major improvement (R→G) ↑ Improvement → No change
★ Highlighted = status change

Sources: IAEA INIR Mission Report (2009) & Indonesia Nuclear Power Infrastructure Self-Assessment (2021).

Indonesia's nuclear readiness has been assessed using the IAEA's Milestones Approach framework, which covers 19 infrastructure conditions. A direct comparison of the 2009 INIR Mission and the 2021 Self-Assessment demonstrates very substantial institutional progress.

3 → 1 Red conditions reduced (2009→2021)	**10 → 14** Green conditions increased (2009→2021)
16 / 19 IAEA conditions met as of 2021	**Phase 1→ 2** Ready move to Phase 2

(Figure3.) IAEA Infrastructure Readiness matrix : INIR 2009 VS. Sellf-Assessment 2021

Transition to Phase 2 Preparations: Until the last self-assessment in 2021, almost all of the 19 infrastructure issues had moved steadily into Phase 2 or had even been resolved. Currently, only one major administrative aspect remains to be consolidated.

National Position: Although the formation of NEPIO is still in the final consolidation stage, the ratification of the 2025-2034 RUPTL by the Ministry of Energy and Mineral Resources (No. 188.K/2025) has de facto strengthened Indonesia's national position. The government is no longer at the stage of **'considering' but** has instead 'established' nuclear as part of the strategic energy infrastructure.

Apart from the NEPIO position, all other aspects of infrastructure, including financing strategy, grid readiness, site selection, supporting facilities, radiation protection, and nuclear safety, have passed Phase 1 and are now in intensive progress in Phase 2. This status puts Indonesia at a much more advanced stage of preparation than many other embarking countries, where the remaining challenges are now more institutional (governance) than technical.

6. Small Reactors (SMRs): Smart Solutions for Industry and Archipelago Regions

Recognizing the geographical complexity and network needs, Indonesia's decision to prioritize the development of Small Modular Reactors (SMRs) as a first step reflects a highly calibrated risk-management strategy. The national electricity roadmap has identified the placement of two SMR units, each with a capacity of about 250 MW, in the island areas of **Sumatra (Bangka Belitung)** and **West Kalimantan**. The selection of the site was based on three main considerations: a very high level of seismic stability, proximity to large industrial demand centres, and optimization of the regional power grid load balance.

The application of SMR technology offers a number of significant competitive advantages over large-scale conventional (Gigawatt-class) reactors, including:

- **Cost Efficiency and Flexible Financing:** The characteristics of SMRs require a much lower upfront capital cost. Its modular nature allows for a phased financing scheme, in which the first unit in operation can directly generate revenue to fund the construction of the next unit. This scheme drastically reduces financial risks for investors and eases the government's fiscal burden.
- **Accelerated Construction Period:** SMRs have a much shorter construction period because their main components are fabricated in a controlled factory facility, then transported to be assembled directly on site (plug-and-play). This deployment speed is essential to address the electricity supply deficit and support the 8% economic growth target.
- **Energy Independence and Regional Resilience:** Especially for regions like West Kalimantan, SMR is the key to unlocking energy sovereignty. The region will have a reliable, independent baseload without relying entirely on long-distance inter-island transmission infrastructure or energy imports from neighbouring countries, thereby strengthening energy security in the border area.
- **The Heart of Industrial Downstream Energy:** Bangka and West Kalimantan are the centre of gravity for the downstream industry of minerals (especially tin and bauxite). SMR is a zero-emission energy solution that can meet the massive and intensive electricity needs of smelter operations in integrated industrial estates. This ensures that Indonesia's downstream products have a low carbon footprint, thereby increasing bargaining power and competitive value in a global market that is increasingly stringent in enforcing sustainability standards.

For archipelagic, grid-based electricity systems such as Indonesia's, the modular attributes of SMRs have proven effective in lowering barriers to entry for nuclear technology adoption. The first SMR project also serves as a practical learning-by-doing facility for domestic nuclear engineers and experts before moving on to large-scale conventional reactor deployments.

7. Indonesia's Nuclear Path for Regional ASEAN & RCA Cooperation

Indonesia's openness and transparency in transforming its nuclear policy open a vast space for strategic collaboration with international partners. Technical support aligned with the IAEA's Phase 2 completion target, particularly in strengthening institutional governance, accelerating the operationalization of NEPIO, and internalizing the global safety culture, is expected to mitigate early implementation challenges and strengthen the national operational foundation.

Indonesia's active involvement in international forums opens up opportunities for mutually beneficial knowledge exchange at the regional

level. Collective support for Indonesia's nuclear program is projected to have a positive spill-over effect for the Asia-Pacific region through several key aspects:

- **ASEAN Regional Synergy:** As an economic anchor in Southeast Asia, Indonesia's bold move to integrate SMR into its national electricity grid could serve as a common technical and regulatory reference milestone for neighbouring countries considering similar moves. This effort is expected to strengthen regional aspirations set out in the ASEAN Plan of Action for Energy Cooperation (APAEC), particularly by exploring nuclear energy as a resilient decarbonization option in Southeast Asia.
- **Strengthening Regional Safety Standards:** Indonesia's unequivocal commitment to adopt the most up-to-date nuclear safety and security standards is in line with its collective goal of realizing a much safer Asia-Pacific nuclear governance. Through the practice of full transparency and absolute compliance with international regimes, Indonesia seeks to actively contribute to building public trust between countries (public trust) in the use of nuclear technology in the region.
- **Cross-Border Knowledge Exchange with RCA:** Indonesia's empirical experience in adapting SMR technology architecture to suit the unique characteristics of the archipelago and tropical climate can be a valuable discussion material for other developing countries. Through a close partnership with the Regional Cooperative Agreement Regional Office (RCARO), this experience can be leveraged to build a shared learning ecosystem that strengthens cross-border energy security in the era of the climate crisis.

8. Conclusion: Nuclear Strategies Towards Energy Independence

The transition of electricity policy from the doctrine of "last resort" to a strategic priority reflects a mature reconciliation between the ambitions of industrial economic growth (Indonesia Emas 2045), real responsibility for global climate mitigation (NZE 2060), and internationally tested domestic institutional readiness. This fundamental paradigm shift is a manifestation of Indonesia's adaptive steps to align its macro vision with the reality of baseload energy needs that must be zero-emission.

For Indonesia, nuclear power is no longer a matter of discourse or polemics but has become a real instrument being prepared to overcome the limitations of conventional electricity generation. SMR will soon become the backbone of a resilient, independent, and globally competitive low-carbon economy.

Recommendations for the RCA Community:

1. **Encouraging the Establishment of SMR Regional Task Forces:** RCARO can facilitate a dedicated working group to evaluate the challenges of SMR licensing and security standards in tropical developing countries, using Indonesia as a pilot framework.
2. **Synergy Capacity Building:** Optimize the region's nuclear education network to train aspiring engineers from Indonesia and other ASEAN countries, with a focus on the operation of SMRs and IAEA Phase 2 management framework audits.

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