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A Study on Renewable Energy Certificates as Enabling Instruments for Geothermal Energy Advancement

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Abstract. Indonesia, home to the world's second-largest geothermal reserves, holds strategic potential to accelerate the clean energy transition through expanded geothermal development. This paper examines the role of Renewable Energy Certificates (RECs) as a market-based instrument to support this agenda. Despite the introduction of geothermal RECs in Indonesia's voluntary market, their sales performance remains lower than those of hydropower and solar sources. Through a multi-phase analysis—encompassing sales trends, international price benchmarking, techno-economic simulations, and market strategy formulation—this study identifies key barriers and opportunities for improving geothermal REC utilization. Benchmarking indicates that REC prices in Indonesia are among the lowest in Asia, with limited financial impact on geothermal project economics at current levels. However, techno-economic modeling reveals that rising REC prices could significantly enhance project bankability. The study proposes a set of targeted marketing strategies, including RE100 corporate engagement, premium product positioning, and integration with ESG policy frameworks. These strategies aim to ensure full recognition and monetization of geothermal electricity via REC markets. The findings offer actionable insights for PT PLN (Persero) and stakeholders to optimize REC deployment and strengthen geothermal's role in Indonesia's renewable energy mix.

Keywords: *Renewable Energy Certificate, Geothermal Energy, REC Pricing, Energy Transition*

1 Introduction

Geothermal energy is one of the most promising renewable energy sources in Indonesia. As the country with the second-largest geothermal reserves in the world, Indonesia has a strategic opportunity to harness this resource in support of the global energy transition toward clean and sustainable energy use [1]. Indonesia, endowed with an estimated 29 GW of geothermal potential, holds a critical position in the global renewable energy landscape. As the country with the second-largest geothermal reserves in the world, Indonesia's geothermal energy has not only the capacity to meet growing domestic energy demands but also to support the achievement of its Nationally Determined Contributions (NDCs) under the Paris Agreement [6]. However, despite its high-capacity factor, low emissions, and baseload reliability, the adoption of geothermal energy remains relatively limited, with only around 10% of potential resources currently utilized [2] To bridge this gap, Indonesia's government has enacted a number of renewable energy policies, including Law No. 30/2007 on Energy and Law No. 30/2009 on Electricity, along with strategic targets to achieve a 23% renewable energy share in the national energy mix by 2025 [2]. Yet, deployment barriers persist, particularly related to financial risk and long payback periods typical of geothermal projects. One market-based instrument that has the potential to partially mitigate these barriers is the Renewable Energy Certificate (REC).

RECs represent proof that electricity was generated from a renewable source, with each certificate corresponding to one megawatt-hour (MWh) of green electricity [8]. RECs serve not only as documentation for green claims, but also as a tradable commodity that can be used by corporations to meet sustainability goals, including Scope 2 emissions reduction under international carbon accounting standards [3]. In Indonesia, RECs are offered through voluntary markets—primarily via PLN through the APX TIGRs platform—without a binding Renewable Portfolio Standard (RPS) mechanism [5].

Despite the increasing global recognition of RECs, geothermal-based REC sales in Indonesia remain significantly lower than those of hydropower or solar sources [4]. This discrepancy can be attributed to several factors, such as pricing structure, market demand concentration, and lack of regulatory support. For instance, geothermal RECs in Indonesia are priced between USD $2 to $4 per MWh—among the lowest in Asia, compared to up to $50 per MWh in Japan or $13 per MWh in India's compliance market.

This research explores the potential of RECs to improve the bankability of geothermal projects in Indonesia through a multi-phase methodology. The analysis begins with an overview of geothermal REC sales performance, followed by an international price benchmarking to understand competitive positioning. A techno-economic simulation is then applied to assess the financial impact of different REC pricing scenarios on key investment metrics, such as Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period, and Levelized Cost of Energy (LCOE). Lastly, the study proposes targeted marketing strategies to enhance REC monetization and geothermal project viability.

By providing an integrated analysis across technical, economic, and strategic dimensions, this study contributes actionable insights for PT PLN (Persero), policymakers, and renewable energy stakeholders to optimize geothermal REC deployment. The results are expected to support Indonesia's transition toward a more sustainable and diversified energy system in alignment with global climate goals.

2 Literature Review

2.1 Geothermal Energy

Geothermal energy is a renewable energy source derived from heat stored beneath the Earth's crust. Its key advantages include a stable energy supply, significantly lower carbon emissions compared to fossil fuels, and its reliability as a baseload energy source [7]. Indonesia possesses an estimated geothermal potential of 29 GW, yet only around 10% of this has been harnessed for power generation [2]. The development of geothermal energy is notonly essential for meeting domestic energy demands but also plays a strategic role in mitigating global climate change.

2.2 Renewable Energy Certificates (RECs)

Renewable Energy Certificates (RECs) are market-based mechanisms that certify the generation of electricity from renewable energy sources. One REC typically represents one megawatt-hour (MWh) of renewable electricity generated from sources such as geothermal, solar, or wind [8]. Internationally, standards like the International REC Standard (I-REC) ensure the credibility of RECs for global trade. In Indonesia, RECs have been introduced as tools to support the energy transition, particularly in industries with strong sustainability commitments [3]. RECs are a form of Energy Attribute Certificate (EAC), widely accepted as evidence of renewable electricity generation and consumption. The concept originated in the United States in 1987, with the first trade in California in 1995. In more advanced markets, RECs support renewable energy investments beyond mandatory schemes like the Renewable Portfolio Standard (RPS) in the U.S. and the Renewable Energy Target (RET) in Australia. Japan utilizes similar instruments such as Green Energy Certificates (GEC) to facilitate environmental value trading from renewable sources.

In six Southeast Asian APEC countries, REC trading began in 2015 to meet voluntary market demand, especially from commercial users. By the end of 2021, the total installed renewable generation capacity registered for RECs reached 12,883 MW, mostly from hydro and solar plants. Demand is projected to grow as commercial users seek to meet renewable energy targets. In recent literature, RECs have also been shown to offer reputational value for corporations when used to meet ESG goals, especially in voluntary markets such as Taiwan’s T-REC system [9][10]. Beyond financial benefits, RECs also deliver intangible value for companies in voluntary markets, particularly in enhancing corporate ESG profiles. A study found that companies in Taiwan purchasing RECs (especially on a sustained basis) experienced positive stock market responses, suggesting investor recognition of credible green commitments [11]. This aligns with a growing trend where RECs are marketed not only as compliance tools but also as instruments for achieving reputational, environmental, and stakeholder-driven objectives [9]

2.3 Renewable Energy Certificates in Indonesia

In 2019, Indonesia generated 294 TWh of electricity, a 4% increase from the previous year. The power sector remains coal-dependent, although renewable sources like hydro and geothermal are gradually expanding. Large-scale projects such as the 515 MW Poso hydropower plant began commercial operation in February 2022. The legal framework for energy and electricity development in Indonesia is governed by Law No. 30/2007 on Energy and Law No. 30/2009 on Electricity. Recent regulations on carbon taxation and pricing mechanisms aim to support carbon markets. However, Indonesia lacks a specific legal framework for REC markets, which remain voluntary [2].

Voluntary RECs in Indonesia are primarily traded through two online platforms: I-REC Standard and TIGRs APX. The market is unbundled, with PLN as a major REC seller via the TIGRs APX platform. RECs sold by PLN are immediately retired and non-tradeable. Customers can purchase RECs online through PLN's REC portal or offline agreements. Some non-PLN renewable generators are also registered under TIGRs APX. The I-REC Standard allows designated local issuers, though no local issuer currently exists in Indonesia. All RECs are issued by the Green Certificate Company (GCC). While PLN does not sell via I-REC, numerous renewable generators participate under I-REC, indicating broader market engagement.

As of 2022, renewable energy capacity registered under I-REC and TIGRs APX reached approximately 1.5 GW, covering hydro, solar, thermal, wind, and geothermal. PLN began selling unbundled RECs in 2020 from three plants: Lahendong (80 MW), Kamojang (140 MW), and Bakaru (130 MW). Priced at IDR 35,000/REC, the offering targets industrial clients pursuing 100% renewable energy. Beyond PLN, around 10.19 MW of solar projects are also listed. Between 2019 and September 2022, REC issuance grew from 1,187 to 502,842 RECs, peaking in 2021 at 941,969, mostly from hydropower.

2.4 REC Pricing

REC pricing varies across countries due to market dynamics and policy contexts. For instance, in Singapore, prices reach around USD 65/MWh due to high demand and limited supply. In contrast, Vietnam's REC prices hover around USD 0.70/MWh owing to surplus supply. In Indonesia, PLN's REC pricing starts at IDR 35,000 per MWh—lower than India's IDR 180,000 and Australia's IDR

300,000 per REC [5].

These differences reflect local renewable energy policies, supply-demand conditions, and production costs. Understanding these variations is crucial for stakeholders to make informed decisions in REC production, trading, and usage. In Indonesia, geothermal RECs tend to be more expensive due to higher production costs compared to solar or wind. Therefore, a thorough price analysis is necessary to ensure the competitiveness of geothermal RECs in global markets [8]. Recent evidence also indicates that the structure of REC markets voluntary vs. compliance strongly influences price levels, with countries implementing mandatory RPS mechanisms generally achieving higher and more stable REC prices [10][11].

Renewable Energy Certificates are implemented through diverse market designs globally. Countries with mandatory Renewable Portfolio Standards (RPS), such as South Korea and India, tend to generate more robust REC markets, with enforceable quotas ensuring demand and higher certificate prices. In contrast, voluntary markets like Japan or Indonesia face lower trading volumes and oversupply issues, often resulting in depressed prices [8]. In Taiwan, the government introduced the Taiwan Renewable Energy Certificate (T-REC) as a hybrid voluntary market with high transparency and reliability. Bundling certificates with verified delivery and linking them to the national carbon registry improves market credibility and investor confidence [9].

3 Methodology

This study employed a multi-phase methodology beginning with a comprehensive literature review to explore the concepts, mechanisms, and potential of Renewable Energy Certificates (RECs), geothermal energy, and renewable energy market dynamics. The review also identified key challenges in geothermal REC development in Indonesia and examined international best practices for local applicability. Case study locations were selected from geothermal assets managed by PT PLN (Persero), based on data availability and market relevance. Data collection involved document analysis, REC sales records, regulatory frameworks, and REC price data from both domestic and international markets. The collected data were organized into tables and visualizations, followed by statistical analysis to identify trends, pricing patterns, and market competitiveness. Benchmarking was conducted to compare geothermal REC prices with other countries and assess Indonesia's positioning. The analysis results served as the foundation for developing marketing strategies and policy recommendations to improve the performance and market appeal of geothermal RECs.

4 Discussion

4.1 Sales Trends of Geothermal RECs in Indonesia

Indonesia's Renewable Energy Certificate (REC) market between 2023 and 2025 reveals a significant disparity in performance across different types of renewable energy sources. Based on aggregated REC sales data, a total of 6,316,879 MWh were transacted, with contributions from six registered power plants comprising hydropower (PLTA), mini-hydro (PLTM), and geothermal (PLTP) facilities.

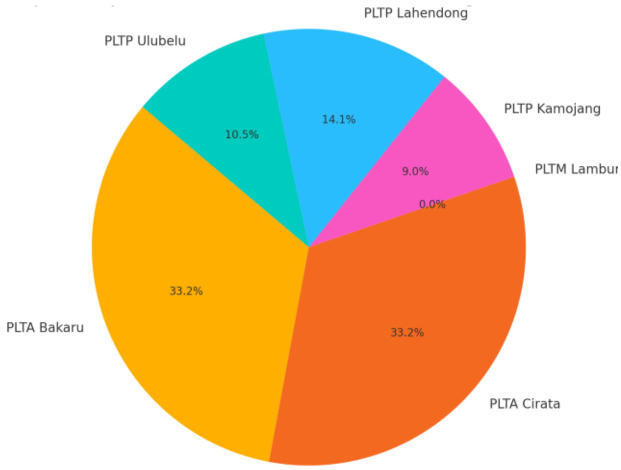

Fig 1. REC Sales Distribution by Power Plant Type in Indonesia (2023–2025)

Based on the 2023–2025 REC sales data as shown in Fig 1 and Table 1, the total number of Renewable Energy Certificates sold reached 6,316,879 MWh, with the largest contributions coming from two hydropower plants PLTA Bakaru: 1,450,009 RECs (33.2%); PLTA Cirata: 1,449,960 RECs (33.2%). Together, these two plants account for over 66% of total REC sales, highlighting the dominance of hydropower sources. Meanwhile, in the geothermal sector: PLTP Lahendong contributed 615,904 RECs (14.1%) PLTP Ulubelu contributed 460,822 RECs (10.5%) PLTP Kamojang contributed 394,223 RECs (9.0%) PLTM Lambur contributed only 392 RECs (0.006%). The total contribution from geothermal plants is approximately 1,470,949 RECs, or about 23.3% of national REC sales, significantly lower than the contribution from the two major hydro sources.

This indicates that REC sales from geothermal power plants are not yet optimal, lagging behind other renewable energy sources. Further analysis is required to determine whether this is due to production limitations, less competitive pricing, or insufficient marketing strategies.

Table 1. REC Sales and Utilization Metrics by Power Plant (2023–2025)

Power Plant	Installed Capacity (MW)	Annual Generation Potential (MWh)	Total REC Sold (MWh)	Utilization (%)
PLTA Bakaru	130	896,000	1,450,009	161.83%
PLTA Cirata	1,008	1,200,000	1,449,960	120.83%
PLTM Lambur	8	30,000	392	1.31%
PLTP Kamojang	140	993,000	394,223	39.70%
PLTP Lahendong	80	700,000	615,904	87.99%

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PLTA Bakaru: 896,000 MWh/year vs. 1,450,009 RECs → 161.8% utilization

PLTA Cirata: 1,200,000 MWh/year vs. 1,449,960 RECs → 120.8% utilization

These percentages exceeding 100% suggest that REC sales may include carry-over volumes or multi-year fulfillment commitments. It also signals the maturity of the hydropower REC market and strong buyer demand.

PLTP Lahendong achieved 87.99% utilization—an excellent performance within the geothermal segment, indicating close alignment with generation capacity. PLTP Ulubelu follows at 63.9%, reflecting a decent, though improvable, market reach. PLTP Kamojang, despite having the largest geothermal capacity (140 MW), only reached 39.7%, signaling a gap between potential and market realization. PLTM Lambur, with 1.3% utilization, is evidently underutilized. Possible causes include limited buyer awareness, its new operational status, or structural constraints in REC trading channels.

4.3 Price Benchmarking of RECs

Geothermal Renewable Energy Certificates (RECs) in Indonesia are currently traded in a voluntary market through PLN, under international registries such as APX TIGRs and I-REC. Price levels for geothermal RECs in Indonesia are notably low—ranging between IDR 35,000 and IDR 57,750 per MWh, which translates to approximately USD $2.3 to $3.8 per MWh at prevailing exchange rates. This pricing reflects the absence of a binding renewable portfolio obligation (RPO), abundant supply from legacy renewable energy plants, and a market still in its early adoption phase. While prices are low, the instrument is intended to promote green energy adoption among corporate users and potentially serve as a precursor to future carbon or energy attribute exports.

In comparison, REC prices in other Asian countries vary widely depending on regulatory frameworks, market maturity, and supply-demand dynamics:

- India operates a compliance market under the Renewable Purchase Obligation (RPO) scheme. While initial REC prices exceeded USD $120/MWh in the early 2010s due to limited supply and strong demand, the market has since stabilized, with REC prices (solar and non-solar) trading at around USD $13/MWh in 2023. Although India has no commercial geothermal plants, this price serves as a reference for non-solar renewable energy certificates.

- Japan features multiple green certificate instruments, including Non-Fossil Certificates (NFC), J-Credits, and Green Power Certificates. Voluntary certificates are priced between USD $4–5/MWh on average, though specific schemes like Green Power Certificates for premium users can reach USD $14–50/MWh. Japan's extensive feed-in tariff (FIT) coverage results in an oversupply of renewable attributes, which depresses average REC prices.

- South Korea employs a mandatory Renewable Portfolio Standard (RPS) since 2012. During the early years of implementation, REC prices reached as high as USD $120/MWh (KRW 144,000) but have gradually declined to USD $30–40/MWh in the early 2020s due to a rapid increase in solar PV capacity and subsequent REC oversupply. Although geothermal capacity in Korea is negligible, this pricing trajectory suggests that if geothermal were active, it would likely follow similar price trends.

- Thailand does not have a mandatory REC scheme but participates in the voluntary I-REC market. With significant overcapacity in solar, biomass, and hydro, REC prices in Thailand are extremely low, typically ranging from USD $0.75 to $1.45/MWh, as reported by S&P Global in 2023. If geothermal projects existed in Thailand, their REC value would likely align with this low price bracket.

Table 2. REC Price Benchmarking and Market Typology Across Asia

Country	Indicative REC Price (USD/MWh)	Market Type	Notes
Indonesia	$2 – $4	Voluntary	Low prices due to oversupply and no mandatory demand
India	~$13	Compliance (RPO)	Stabilized price after early market volatility
Japan	$4 – $5 (avg), up to $50 (premium)	Mixed: FIT-linked + Voluntary	Strong FIT influence suppresses market REC prices
South Korea	$30 – $120	Compliance (RPS)	High initial prices, declining due to PV-driven oversupply
Thailand	<$2	Voluntary (I-REC)	Severe oversupply; very low prices

This benchmarking exercise highlights the direct correlation between REC price levels and market design. Countries with mandatory procurement schemes (e.g., India, South Korea) tend to have higher REC prices, providing stronger financial incentives for renewable energy projects. Conversely, voluntary markets (e.g., Indonesia, Thailand) often suffer from price depression due to oversupply and limited buyer engagement. For geothermal developers, this implies that REC revenues in Indonesia are currently marginal contributing only ~3–5% of total project revenue at best. However, in a future scenario where REC demand increases (e.g., through export opportunities or mandatory domestic targets), the value of geothermal RECs could rise significantly, improving project economics.

The price benchmarking analysis underscores the need for strategic interventions in Indonesia's REC market to improve geothermal competitiveness, such as: Creating premium REC classes for geothermal as a baseload renewable source, Introducing minimum pricing floors or guaranteed purchase schemes. Promoting corporate procurement commitments (e.g., RE100 participation). Exploring cross-border REC trading to tap into higher-value markets.

In summary, Indonesia's geothermal REC prices are among the lowest in the region. While this currently limits their economic impact on project development, policy innovation and market expansion could unlock greater value in the near future.

4.4 The Role of Renewable Energy Certificates (RECs) in Supporting Geothermal Energy Development

While Renewable Energy Certificates (RECs) provide an additional revenue stream for renewable energy projects, their impact on the economic viability of geothermal power plants must be assessed using a structured and transparent approach. A techno-economic simulation model is employed to evaluate how varying REC price scenarios affect key financial performance indicators, namely: Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period, and Levelized Cost of Energy (LCOE). To ensure consistency in the simulation, key technical and financial parameters are summarized in Table 3.

Table 3. Summary of Key Parameters Used in Simulation

Parameter	Assumption
Plant Capacity	50 MW geothermal power plant
Capacity Factor	90%
Annual Energy Output	394,200 MWh/year
Project Lifetime	30 years
CAPEX	USD 4–6 million per MW (including drilling, EPC, infrastructure)
OPEX	USD 20 per MWh
Electricity Tariff	USD 70 per MWh (PPA/feed-in-tariff benchmark)
REC Price Scenarios	USD 0, USD 2.5, and USD 10 per MWh
Discount Rate	10%–12%, reflecting geothermal project risk profile in developing markets

The model builds a year-by-year cash flow over the 30-year project life, structured into two phases:

a. Construction Phase: Capital expenditures are allocated across pre-operational years (typically 3–4 years).
b. Operational Phase (Years 1–30): Annual cash flow is calculated using the following equations:

Electric Revenue:

$$Electricity\ Revenue = E_{annual} \times P_{elec} \tag{1}$$

REC Revenue:

$$REC\ Revenue = E_{annual} \times P_{REC} \tag{2}$$

Total Revenue:

$$Total\ Revenue = Electricity\ Revenue + REC\ Revenue \tag{3}$$

Net Cash Flow:

$$Net\ Cash\ Flow = Total\ Revenue - (E_{annual} \times OPEX) \tag{4}$$

Where:
E_{annual} = Annual energy production (MWh/year)
P_{elec} = Electricity Tariff (USD/MWh)

P_{REC} = REC price (USD/MWh)
OPEX = Operational Expenditure (USD/MWh)

Discounted cash flows are calculated to derive: NPV (Net Present Value), IRR (Internal Rate of Return), LCOE (Levelized Cost of Energy), Payback Period. Two comparative scenarios are analyzed:

a. Scenario A (Without REC): Revenue is derived exclusively from electricity sales.
b. Scenario B (With REC): REC revenues are added based on assumed price levels.

The simulation reveals that incorporating Renewable Energy Certificates (RECs) into the revenue model of geothermal power plants significantly enhances the financial attractiveness of the projects. Under Scenario A (Without REC), the financial outlook of the geothermal project remains marginal, with the Net Present Value (NPV) hovering around zero or slightly negative, making investment decisions less compelling.

Table 4. Summary of Simulation Outcomes

Indicator	Scenario A (Without REC)	Scenario B (With REC)
NPV	Marginal or negative	Positive with REC revenue
IRR	Approximately 9.0%	Improves to ~9.5% (at USD 2.5/MWh REC)
LCOE	Full cost from electricity alone	Effective reduction by 3–5%
Payback Period	Longer due to limited revenue sources	Accelerated due to additional REC income
Revenue Source	Electricity sales only	Electricity + REC sales
REC Contribution to Revenue	0%	2.8% at USD 2/MWh, up to 14% at USD 10/MWh

When Scenario B (With REC) is considered, even at a modest REC price of USD 2.5 per MWh, a noticeable improvement in financial performance is observed. The NPV transitions into positive territory, indicating enhanced long-term profitability. The Internal Rate of Return (IRR), which is approximately 9.0% in Scenario A, increases to around 9.5% with REC revenue. Although the improvement may appear marginal, it is significant in the context of high-capex, long-lifecycle projects such as geothermal plants, where small gains in IRR can shift investment viability.

As shown in Table 4, The Levelized Cost of Energy (LCOE), although not directly affected by operational costs, is effectively lowered due to the additional income from RECs. This results in a more competitive cost structure, reducing LCOE by an estimated 3–5%. Furthermore, the Payback Period—defined as the time required to recover the initial capital investment—is shortened under Scenario B. While REC income at current Indonesian market rates (~USD 2/MWh) only contributes around 2.8% of total project revenue, this share could grow to approximately 14% if REC prices rise to USD 10/MWh, substantially accelerating capital recovery.

Overall, the integration of RECs not only diversifies revenue streams but also strengthens the financial metrics critical for investment decisions in geothermal energy development. These findings support the strategic case for enhancing REC market mechanisms and pricing policies to unlock the full potential of geothermal power in Indonesia.

4.5 Strategic Recommendations to Enhance Geothermal REC Sales in Indonesia

To fully unlock the economic and environmental value of Indonesia's vast geothermal resources, a robust and targeted marketing strategy for Renewable Energy Certificates (RECs) is essential. While RECs provide a mechanism to attribute clean energy to consumers, their market performance remains suboptimal, especially for geothermal-based certificates. This section proposes integrated marketing strategies to ensure that all electricity generated from geothermal power plants (PLTP) in Indonesia is fully recognized by end-users, allowing 100% of the generated renewable electricity to be matched with sold RECs.

1. Targeted Corporate Engagement with RE100 Companies
   Engaging RE100 companies operating in or sourcing from Indonesia is a key strategy to drive geothermal REC sales. By offering customized REC packages that emphasize geothermal's baseload reliability and low emissions, PLN and REC issuers can align with the renewable procurement goals of multinational corporations. Strategic outreach should include bundled PPAs, transparent tracking, and alignment with international sustainability reporting standards.
2. Positioning Geothermal RECs as Premium Products
   Geothermal RECs can be differentiated from other renewables by highlighting their consistent energy output and environmental superiority. Marketing should promote geothermal as a "premium" renewable source, suitable for high-demand, 24/7 operations. Creating a gold-standard certification or premium REC label would attract ESG-focused buyers seeking higher-impact energy sourcing beyond basic compliance.
3. Digital Integration and Market Access Expansion
   To expand market reach, REC transactions must be digitized and accessible

to both domestic and international buyers. Enhancing PLN's online portal, enabling real-time purchases, and integrating platforms like APX or I-REC with blockchain-based tracking will build trust, simplify processes, and attract broader participation in the geothermal REC market.

4. Integration with National ESG and Decarbonization Goals
   Geothermal REC marketing should align with Indonesia's broader ESG and climate targets by mobilizing SOEs and industrial consumers through voluntary or incentivized REC procurement. Positioning geothermal RECs as part of corporate ESG strategy supports national NDCs while enhancing private sector participation in the renewable transition through transparent and measurable contributions.
5. Ensuring 100% Utilization of Geothermal RECs
   To fully monetize geothermal generation, all MWh produced by PLTPs should be matched by REC issuance and sales. This requires accurate generation tracking, automatic REC issuance, strong buyer demand, and potential policy support. Achieving full utilization ensures that Indonesia's geothermal energy receives full environmental and economic recognition in both domestic and global markets.

5 Conclusion

The analysis reveals that geothermal REC sales in Indonesia are significantly underutilized compared to hydropower, with major PLTPs only monetizing a fraction of their annual generation. Despite Lahendong achieving nearly 88% REC utilization, Kamojang and Ulubelu remain well below their sales potential. These disparities suggest that geothermal energy, despite its reliability and environmental benefits, has not yet been fully leveraged in the REC market. To improve this, better market outreach and pricing strategies are essential.

Benchmarking geothermal REC prices against regional peers confirms that Indonesia's current price level—USD $2 to $4/MWh—is among the lowest in Asia. In contrast, compliance markets like India and South Korea support higher REC valuations, reinforcing the importance of regulatory design in market value. For Indonesia to unlock meaningful REC-based revenues, policy instruments such as minimum price floors or export-linked schemes should be considered to increase competitiveness.

Techno-economic simulations show that REC revenues currently contribute only 2–3% of total project revenue at base-case pricing. However, at higher REC prices (USD $10/MWh), REC revenue can account for up to 14% of income, substantially improving Net Present Value (NPV) and Internal Rate of Return (IRR). This demonstrates that REC markets—if strategically strengthened—can shift geothermal projects from marginal to viable investments, especially in frontier or early-stage development zones.

Strategic marketing interventions are needed to align geothermal REC supply with growing ESG-driven demand. Engaging RE100 companies, positioning geothermal as a premium green energy product, and integrating digital platforms are key to unlocking corporate participation. By doing so, geothermal RECs can appeal to international buyers seeking traceable, high-quality renewable energy attributes. Moreover, tying REC procurement to national ESG and decarbonization goals can incentivize broader private sector involvement and drive sustained demand.

Achieving full REC utilization—where 100% of geothermal output is matched by REC sales—is a realistic target if paired with robust tracking, transparent issuance, and strong buyer engagement. This not only enhances geothermal's market recognition but also maximizes its contribution to climate mitigation and clean energy goals. Regulatory support and market education will be critical to ensure that every MWh of geothermal electricity receives its full environmental and financial value.

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