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The Impact of Green Financing on Transmission Projects in Indonesia

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Abstract

This study asks which capital structure creates the highest risk-adjusted value, comparing one operating cash flow under 100% equity and under conventional and green or concessional loans. Capital budgeting is applied through discounted cash flow analysis, sensitivity and break-even testing, and a 2,000-iteration Monte Carlo simulation. At project level the investment is feasible: NPV is Rp 12,327.93 billion at the 6.19% corporate discount rate, IRR is 11.65%, payback is nine years after commercial operation, and the probability of a non-negative NPV is 100.0%. Green or concessional debt at 3.93% under a 70% debt / 30% equity structure raises equity NPV from Rp 12,327.93 billion to Rp 13,894.82 billion and the return on XYZ equity from 11.65% to 17.43%, while annual debt service falls Rp 182.14 billion against conventional borrowing at 6.50%. Because the after-tax cost of concessional debt of about 3.06% lies far below the 11.25% cost of equity implied by a beta of 0.86 and a 6.69% country risk premium, leverage lowers the weighted average cost of capital to 5.52% and raises project NPV to Rp 15,099.87 billion, while project IRR remains 11.65% and Rp 8,437.74 billion of XYZ equity is freed. Both structures reach 100% simulated feasibility at the RKAP rate; tested against the stricter cost-of-equity hurdle, feasibility probability still rises from 68.40% under equity-only funding to 98.55% under green financing. Green or concessional financing is therefore preferable to both conventional debt and full equity funding, provided its currency-adjusted all-in cost remains below the cost of equity.

INTRODUCTION

Indonesia's electricity system is undergoing a transformation amid rapid industrial growth, the transition toward clean energy, and the government's commitment to achieving Net Zero Emissions (NZE) by 2060. Electricity demand in Sulawesi has increased significantly over the past decade, particularly in Southeast Sulawesi, as nickel smelters, mining operations, mineral processing zones, and large-scale renewable energy projects have placed increasing pressure on the regional transmission network. Existing 150 kV transmission corridors are experiencing growing congestion, voltage instability, and reliability constraints during peak industrial operations, indicating that the current grid infrastructure may no longer adequately support regional industrial expansion (Aguero et al., 2017; Heffron et al., 2020; Tröndle et al., 2020; Yang et al., 2016, 2020).

As a state-owned integrated electricity company, PT XYZ is responsible for developing sufficient and reliable transmission infrastructure to support industrial growth and renewable energy integration. To address rising demand, XYZ plans to strengthen the 150–275 kV transmission backbone in Sulawesi through the SUTET 275 kV Sulawesi Tenggara project. The project aims to reduce system losses, improve power evacuation capacity, facilitate renewable energy integration, and enhance electricity reliability in priority industrial areas, including Kolaka, Morowali, Konawe, and Kendari.

The South Sulawesi (Sulbagsel) subsystem operates through a layered 70 kV, 150 kV, and 275 kV transmission network. Its net dependable capacity (DMN) was 2,387.96 MW compared with an installed capacity of 2,788.44 MW, while peak demand reached 1,838.83 MW. These aggregate figures mask a structural imbalance: the 150 kV corridors supplying the Southeast Sulawesi subsystem are approaching thermal limits during industrial peak periods, with documented undervoltage risks at key substations and potential cascading overloads under N-1 contingency conditions.

The underlying challenge is driven by the arrival of large nickel smelter customers classified as Pelanggan Khusus Tegangan Tinggi (KTT), whose combined electricity requirements exceed existing network capacity. The most significant demand sources include PT XYZ requiring 200 MVA at Bungku, PT XYZ requiring 100 MVA at Andowia, and PT XYZ requiring 414 MVA near GI Wol. The existing 275/150 kV Wotu substation, equipped with a single 250 MVA inter-bus transformer (IBT), represents a bottleneck that limits the ability to accommodate these customers while maintaining system stability. Delays in customer commercial operation dates (COD) also create incremental demand increases that the current network may not be able to absorb. In addition, the Sulawesi grid serves as a designated evacuation corridor for a substantial renewable energy pipeline. Planned hydropower projects totaling approximately 3,965 MW are scheduled for commercial operation between 2028 and 2034 across Central Sulawesi (1,700 MW), West Sulawesi (1,800 MW), and South Sulawesi (465 MW). These projects require a robust high-voltage transmission backbone to deliver electricity to load centers in South and Southeast Sulawesi. The convergence of industrial and renewable energy demand therefore creates an urgent need for transmission reinforcement beyond the capability of the existing network.

Transmission construction requires substantial investment, lengthy construction periods, and exposure to uncertainty in demand growth, regulatory conditions, land acquisition, and cost escalation. Therefore, rigorous financial evaluation through capital budgeting techniques, including discounted cash flow (DCF), net present value (NPV), internal rate of return (IRR), and payback period analysis, is required (Liu, 2024). Conventional deterministic approaches, although necessary, often fail to fully capture real-world uncertainty. Consequently, recent studies have increasingly applied Monte Carlo simulation (MCS) to quantify probabilistic risks and generate outcome distributions (Kautsar & Damayanti, 2020). MCS is particularly relevant for energy infrastructure projects because investment performance depends on variations in industrial demand, macroeconomic conditions, and regulatory changes (Gasparian et al., 2018).

A further dimension has received limited attention in the original appraisal. XYZ’s approved feasibility study (KKF SUTET Sultra Base Case, 4 December 2024) assumes that the entire Rp 12,053.91 billion investment is financed through XYZ’s internal equity without external borrowing. Allocating capital of this magnitude to a single asset reduces equity availability for other investment opportunities, creates an opportunity cost associated with alternative returns, and exposes the entire investment to XYZ’s required return on equity, which is higher than the cost of concessional financing from multilateral and bilateral lenders.

Debt financing could reduce the equity requirement but would introduce fixed debt-service obligations, interest rate risk, refinancing risk, foreign exchange exposure, and lender covenants.

Indonesia's energy transition commitments have created opportunities for XYZ to utilize green financing as an alternative funding model. Green bonds, green loans, sustainability-linked loans, and climate transition funds may provide access to lower-cost capital and international climate finance for decarbonization-supporting projects (Taghizadeh-Hesary et al., 2022). These instruments can improve affordability for capital-intensive projects while directing investment toward climate objectives. International taxonomies increasingly classify transmission and interconnection infrastructure as eligible green activities when they support renewable energy integration (Nehoda et al., 2025). Green financing may therefore reduce financing costs, improve financial indicators such as NPV and IRR, and strengthen XYZ's environmental, social, and governance (ESG) profile.

The central business issue is therefore not only whether the project is financially feasible, but also which capital structure generates the highest risk-adjusted value for XYZ. This thesis compares the existing 100% equity structure with green or concessional loan financing while maintaining identical operating assumptions so that observed differences can be attributed primarily to financing decisions. The analysis examines both the project level (Free Cash Flow to the Firm) and equity level (Free Cash Flow to Equity) and extends the evaluation through Monte Carlo simulation. The urgency of this research is driven by projected industrial demand growth during 2025–2030 and the scale of investment required to support regional development. A feasibility assessment integrating deterministic capital budgeting and probabilistic risk analysis is necessary to determine whether the project remains financially robust under uncertainty and attractive for green financing (Nehoda et al., 2025). This thesis therefore evaluates the financial viability and risk exposure of the Southeast Sulawesi transmission project and examines how financing choices may influence XYZ's investment decisions. To the best of the author's knowledge, this study is among the first to apply a combined DCF–MCS framework to compare green and conventional financing alternatives for a transmission interconnection project in Indonesia, contributing methodological and practical insights to the literature on green infrastructure finance.

PT XYZ is Indonesia's state-owned electricity company, responsible for generation, transmission, distribution, and electricity services, with a mandate to support national energy security through reliable electricity supply. XYZ operates more than 64,000 km of transmission lines and hundreds of substations across Indonesia, making it the country's largest electricity off-taker and grid operator. Within the Sulawesi network, XYZ functions as system planner, investor, and operator, ensuring that transmission capacity develops in line with hydropower integration, industrial demand growth, the national RUPTL, and the NZE 2060 roadmap.

The 150–275 kV network expansion in Southeast Sulawesi represents a strategic challenge as electricity demand has increased significantly due to nickel smelter development, mining activities, and industrial estate growth around Kolaka, Konawe, Morowali, and Kendari. System studies indicate that existing facilities are experiencing stress from high corridor utilization, declining peak-load voltage performance, and increasing reliability risks. These conditions suggest that the local grid may no longer accommodate the region's industrial growth trajectory, particularly as smelter expansion and renewable energy projects continue to increase demand over the coming decade.

XYZ also faces a structural challenge arising from the scale of required capital investment. Transmission projects are capital-intensive, long-lived assets dependent on regulatory cost recovery mechanisms. Uncertainty related to construction costs, land acquisition, project delays, financing conditions, and demand growth increases investment risk, particularly as XYZ must maintain system reliability while preserving financial sustainability. This challenge encompasses four interconnected dimensions.

Regarding reliability, the primary risk involves voltage degradation and transmission overload in the Southeast Sulawesi subsystem. XYZ's load flow studies identified undervoltage conditions at GI Bungku and GI Andowia under N-1 contingency scenarios, in which a single fault on the Malili–Wotu corridor could disrupt major smelter customers. The existing single 250 MVA IBT at Wotu is insufficient to accommodate the increasing KTT demand while maintaining system reliability.

Regarding revenue, project cash flows depend on the commercial operation date (COD) schedules of PT XYZ (200 MVA, Bungku), PT XYZ (100 MVA, Andowia), and PT XYZ (414 MVA, Wolo), as well as the integration timeline for 3,965 MW of planned Pembangkit Listrik Tenaga Air (PLTA) capacity. Both industrial demand and renewable energy integration involve scheduling risks due to potential permitting and commissioning delays. Deferred demand realization may reduce early-stage revenue generation, negatively affecting NPV and extending the payback period.

Regarding capital expenditure (CAPEX) risk, the project is sensitive to cost escalation, land acquisition complexity, and engineering modifications. Because transmission investments generate long-term regulated cash flows, even a 1–2% change in the discount rate can significantly affect NPV by hundreds of billions of rupiah.

Regarding strategy and environmental, social, and governance (ESG) considerations, the investment represents an opportunity rather than merely a risk. XYZ's environmental and social management system (ESMS), Upaya Pengelolaan Lingkungan dan Upaya Pemantauan Lingkungan (UKL-UPL) certification, and the project's role as a renewable energy evacuation corridor support its potential eligibility for green financing under frameworks such as the Green Bond Principles and the Asian Development Bank (ADB) Climate Change Operational Framework. The governance foundation is established; however, the quantitative financial justification remains to be developed.

These four dimensions collectively define the business problem: determining whether the Southeast Sulawesi transmission reinforcement project is feasible and resilient under uncertainty. This requires XYZ to evaluate system requirements, cost variability, regulatory conditions, financing structures, and demand projections through integrated deterministic and probabilistic analyses.

This thesis is guided by three research questions: how capital budgeting for this extra-high-voltage interconnection transmission project should be structured to support hydropower evacuation and industrial electricity demand; the probability that the project remains financially feasible under uncertainty; and which financing alternative provides the most appropriate risk-adjusted value for the project.

The corresponding objectives are to evaluate financial feasibility using DCF-based methods, including NPV, IRR, and payback period, under equity-financing and green-financing scenarios; to assess the probability distribution of financial outcomes using Monte Carlo simulation; and to identify the most suitable financing alternative by comparing green and conventional financing based on WACC, NPV, IRR, and risk-adjusted performance indicators.

This study is limited to the financial analysis of the 150–275 kV Southeast Sulawesi transmission reinforcement project using DCF, NPV, IRR, payback period analysis, and Monte Carlo simulation. It does not include detailed technical optimization, engineering design, route surveys, or supply chain strategy, as the analysis focuses on financial performance and investment risk under uncertainty. The study examines the potential impact of green financing but does not analyze detailed financing structures, lender negotiations, third-party financing arrangements, public–private partnership (PPP) schemes, or independent power transmission provider (IPTP) packages. The analysis remains limited to XYZ's perspective as the project investor.

This thesis consists of five chapters. Chapter I presents the research background, company context, business issue, research questions, objectives, and scope. Chapter II reviews the literature on capital budgeting, DCF theory, feasibility indicators, investment uncertainty, financing structures, green financing, and Monte Carlo simulation. Chapter III describes the research methodology, data requirements, financial modeling process, and simulation approach. Chapter IV presents the results and discussion, including base-case analysis, sensitivity analysis, risk simulation, financing scheme comparison, proposed solutions, and implementation plans. Chapter V concludes with managerial implications and strategic recommendations for XYZ regarding investment decisions and the role of green financing.

METHOD

Research Design

This study employed a quantitative research approach with simulation-based analysis to evaluate the financial feasibility of the Southeast Sulawesi 275 kV transmission interconnection project. The analysis incorporated uncertainties related to demand growth, capital expenditure (CAPEX), operating costs (OPEX), electricity tariffs, and financing scenarios, including green financing. To achieve the research objectives, the study combined discounted cash flow (DCF) analysis, sensitivity analysis, and Monte Carlo simulation. DCF analysis was used to assess financial feasibility, sensitivity analysis was applied to identify key variables influencing project performance, and Monte Carlo simulation was used to evaluate the impact of uncertainty on project value. The combination of these methods provided a comprehensive assessment of project performance under conventional and green financing scenarios.

Data Collection Method

This study uses secondary data obtained from XYZ internal documents, including the Project Feasibility Study (KKP), RUPTL, government regulations, and financing data from institutions such as ADB, KfW, AFD, and HIMBARA. The collected data include project investment costs (CAPEX), operating and maintenance costs (OPEX), electricity tariffs, demand projections, financing terms, project lifetime, and discount rates. These data serve as the main inputs for developing the financial model and evaluating the project's feasibility. The key assumptions used in the analysis are summarized in Table III.1.

Data Analysis Method

The financial feasibility analysis is conducted in three stages. First, Discounted Cash Flow (DCF) analysis is used to calculate Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period based on projected cash flows. The analysis evaluates both Free Cash Flow to the Firm (FCFF) and Free Cash Flow to Equity (FCFE) to measure project feasibility and shareholder returns. Second, sensitivity analysis examines how changes in key variables, including CAPEX, O&M cost, electricity tariffs, demand growth, discount rate, and financing parameters, affect the project's financial performance. Finally, Monte Carlo Simulation is performed using 2,000 iterations with triangular probability distributions for CAPEX, O&M cost, electricity tariff, and demand growth to estimate the probability distribution of NPV and assess the project's financial risk under uncertainty.

Financial Model Development

The financial analysis is developed using an integrated Excel-based model consisting of linked worksheets for project assumptions, cash flow calculations, financing scenarios, sensitivity analysis, and Monte Carlo Simulation. The model automatically calculates financial indicators for each scenario, allowing consistent comparison between conventional and green financing. To ensure accuracy and reproducibility, all Excel calculations are independently verified using a Python model, and only validated results are included in the analysis.

Scenario Design for the Cost of Capital

This study evaluates two approaches for determining the discount rate. The first approach recalculates the Weighted Average Cost of Capital (WACC) for each financing scenario using its respective cost of debt and the Capital Asset Pricing Model (CAPM) to estimate the cost of equity. The second approach applies XYZ's corporate WACC as a fixed discount rate across all financing scenarios. The scenario-specific WACC is used as the primary approach because it better captures the financial benefits of green financing, while the fixed WACC serves as a conservative benchmark for comparison.

Monte Carlo Simulation Design

Monte Carlo Simulation is conducted by treating CAPEX, O&M cost, electricity tariff, and demand growth as uncertain variables represented by triangular probability distributions. Each variable uses the base-case value as the most likely outcome, with minimum and maximum values reflecting reasonable uncertainty ranges. The simulation runs 2,000 iterations using a fixed random seed to ensure reproducibility. The resulting probability distribution of NPV is used to evaluate the likelihood of project success and quantify the financial risk associated with uncertainty. This approach complements the deterministic analysis by providing a probabilistic assessment of project feasibility.

RESULTS AND DISCUSSION

Impact of Green Financing and Financing-Scheme Comparison

This section answers Research Question 3 and presents the thesis’s central contribution: a comparison of how the four financing scenarios defined in Section IV.1.4 affect project value, equity value, and XYZ’s financing obligations.

1. Financing-Scenario Definition

The four scenarios conventional at 6.50%, ADB at 4.23%, KfW at 4.04% and green financing at the 3.93% blended average are as defined in Section IV.1.4, and the 70% / 30%

capital structure is unchanged across all four. Holding the capital structure constant is what allows the comparison to be interpreted as the effect of the cost of debt alone; if leverage were also varied, the equity-value differences reported below could not be attributed to the financing source.

2. Scenario-Specific Cost of Capital

Section III.5 sets out two ways to treat WACC across financing scenarios and the reasoning for adopting Option A, the scenario-specific WACC derived through CAPM, as this thesis's primary basis, with Option B, a flat 6.19% WACC, retained as a conservative cross-check. The distinction is consequential: under Option B a cheaper loan can only improve equity value, whereas under Option A it also lowers the rate at which the project's long-dated benefits are discounted. Table 1 reports the resulting cost of capital for each scenario.

Table 1. Scenario-Specific Cost of Capital

Scenario	Kd	WACC — Option A	WACC — Option B (flat)
Conventional	6.50%	6.93%	6.19%
ADB	4.23%	5.69%	6.19%
KfW	4.04%	5.58%	6.19%
Green (average)	3.93%	5.52%	6.19%

3. Project-Level Impact — FCFF Basis

Table 2 applies the Option A cost of capital to the unchanged project cash flow. The results isolate the discount-rate channel through which financing choice affects project-level value.

Table 2. Project-Level Impact of Financing Scheme (FCFF Basis, Option A)

Scenario	WACC (Option A)	NPV–FCFF (Option A)	IRR–FCFF	Margin (IRR − WACC)
Conventional	6.93%	Rp 9,739.71 billion	11.65%	4.73 pp
ADB	5.69%	Rp 14,374.24 billion	11.65%	5.97 pp
KfW	5.58%	Rp 14,825.93 billion	11.65%	6.07 pp
Green (average)	5.52%	Rp 15,099.87 billion	11.65%	6.13 pp

IRR–FCFF is identical at 11.65% across every scenario, because it is a property of the operating cash flow and does not depend on how the debt tranche is priced. What changes is NPV–FCFF, through the WACC channel under Option A, and the margin between IRR and WACC both widen materially as the cost of debt falls. This confirms that green and concessional financing can improve project-level value and not only equity-level value, provided the resulting lower cost of debt is allowed to feed into a lower overall WACC. It is the same cost-of-capital channel through which the green-energy investment literature finds concessional finance most improves climate-infrastructure economics (Taghizadeh-Hesary et al., 2022; Boretti, 2023; Nehoda et al., 2025), and it also explains why the eligibility and certification requirements discussed in Section II.1.10 are worth the administrative cost they impose.

4. Debt-Service Comparison

Before considering value measures, it is useful to compare the schemes on the simplest and most operationally tangible dimension: the annual cash obligation each one imposes. Table 3 reports annual debt service and the saving relative to conventional financing.

Table 3. Annual Debt-Service Comparison by Financing Scheme

Indicator	Conventional (6.50%)	ADB (4.23%)	KfW (4.04%)	Green avg. (3.93%)
Annual debt service	Rp 830.49 billion	Rp 668.41 billion	Rp 655.79 billion	Rp 648.35 billion
Annual saving vs. conventional	—	Rp 162.08 billion	Rp 174.70 billion	Rp 182.14 billion
Loan tenor	20 years	20 years	20 years	20 years
Grace period (base case)	None modelled	None modelled	None modelled	None modelled

Figure 1 plots these obligations year by year across the twenty-year debt-service window. The chart is included because an annual average understates what the difference means operationally: the vertical distance between the conventional line and the concessional lines is cash that XYZ either must find every year during the period when, as Figure IV.4 showed, equity cash flow is weakest, or does not.

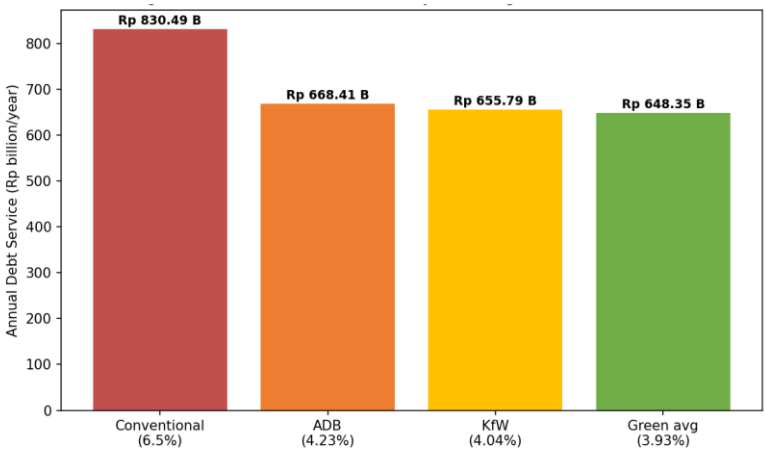

Figure 1. Annual Debt Service by Financing Scheme (Years 0–19)

5. Equity-Level Impact — FCFE Basis

Table 4 restates the comparison on the equity basis, measuring what each financing scheme is worth to XYZ as the residual claimant. Option B, the flat 6.19% discount rate, is used here as the conservative treatment, so that the equity-value differences reported are attributable to cash flow rather than to a scenario-specific discount rate.

Table 4. Equity-Level Impact of Financing Scheme (FCFE Basis)

Indicator	Conventional (6.50%)	ADB (4.23%)	KfW (4.04%)	Green avg. (3.93%)
NPV–FCFE (Option B, flat WACC)	Rp 12,265.59 billion	Rp 13,714.99 billion	Rp 13,828.13 billion	Rp 13,894.82 billion
Incremental NPV–FCFE vs. conventional	—	+Rp 1,449.40 billion	+Rp 1,562.54 billion	+Rp 1,629.23 billion
IRR–FCFE	15.55%	17.21%	17.35%	17.43%
Equity contribution (30% of CAPEX)	Rp 3,616.17 billion	Rp 3,616.17 billion	Rp 3,616.17 billion	Rp 3,616.17 billion
Liquidity headroom vs. conventional	—	Rp 162.08 billion/yr	Rp 174.70 billion/yr	Rp 182.14 billion/yr

Figure 2 presents the equity NPV of the four schemes side by side. The chart makes two things visible that the table states only implicitly: that the increment from conventional to any concessional facility is large, and that the further increment among the three concessional facilities is comparatively small — the observation that drives the sequenced recommendation in Section 2.

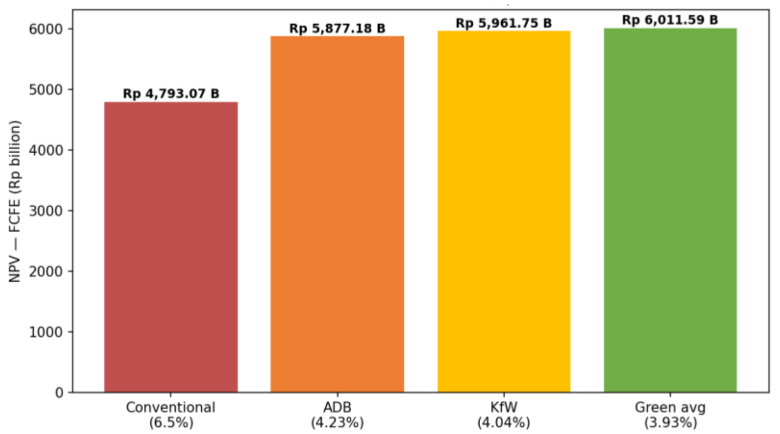

Figure 2. Net Present Value (FCFE, Equity Basis) by Financing Scheme

Every IRR–FCFE figure clears the 11.25% cost-of-equity hurdle established in Section IV.1.3, by a margin of 4.30 to 6.18 percentage points, confirming that the financing decision is attractive to XYZ as equity holder under all four scenarios and not only in the optimistic green case. The magnitude of the equity-value uplift is consistent with the cross-country evidence that green and concessional finance materially eases the financing constraint on capital-intensive clean-energy infrastructure (Taghizadeh-Hesary et al., 2022; Wang et al., 2022), while the fact that most of the uplift is captured by the multilateral facilities rather than by the green label as such is consistent with the small measured green premium reported in the green-bond literature (Zerbib et al., 2018; Flammer, 2019).

6. Risk-Adjusted Financing Comparison

Table 5 consolidates the price and value measures with the qualitative risk attached to each scheme, so that the comparison is not reduced to the headline interest rate alone. Consistent with Equation II.7, the relevant basis for choosing between facilities is the all-in, currency-adjusted cost of debt, and the final column records the frictions that would have to be priced into that comparison at term-sheet stage.

Table 5. Risk-Adjusted Financing Scheme Comparison

Indicator	Conventional (6.50%)	ADB (4.23%)	KfW (4.04%)	Green avg. (3.93%)
Kd	6.50%	4.23%	4.04%	3.93%
WACC (Option A)	6.93%	5.69%	5.58%	5.52%
NPV–FCFF (Option A)	Rp 9,739.71 billion	Rp 14,374.24 billion	Rp 14,825.93 billion	Rp 15,099.87 billion
IRR–FCFF (Equity)	11.65%	11.65%	11.65%	11.65%
WACC (Option B)	6.19%	6.19%	6.19%	6.19%
NPV–FCFE (Option B)	Rp 12,265.59 billion	Rp 13,714.99 billion	Rp 13,828.13 billion	Rp 13,894.82 billion
IRR–FCFE	15.55%	17.21%	17.35%	17.43%
Annual debt service	Rp 830.49 billion	Rp 668.41 billion	Rp 655.79 billion	Rp 648.35 billion
Key risk	Highest debt-	Indicative	Indicative	Blended average of three

Indicator	Conventional (6.50%)	ADB (4.23%)	KfW (4.04%)	Green avg. (3.93%)
	service burden and smallest feasibility margin, but rupiah-denominated with no FX exposure	internal spread (SOFR + 0.60%) pending term-sheet confirmation; floating-SOFR and FX exposure	internal spread (SOFR + 0.41%) pending term-sheet confirmation; floating-SOFR and FX exposure	facilities, achievable only if a multi-tranche ADB/KfW/AFD structure is executed; includes EUR hedging requirement

Key risk Highest debt-service burden and smallest feasibility margin, but rupiah-denominated with no FX exposure Indicative internal spread (SOFR + 0.60%) pending term-sheet confirmation; floating-SOFR and FX exposure Indicative internal spread (SOFR + 0.41%) pending term-sheet confirmation; floating-SOFR and FX exposure Blended average of three facilities, achievable only if a multi-tranche ADB/KfW/AFD structure is executed; includes EUR hedging requirement

7. Preferred Financing Scheme

All four financing scenarios rest on the Table II.2 benchmark structures rather than on an assumed illustrative rate, which changes how the preference should be framed. The green-financing average of 3.93% delivers the best result on every equity-level metric the highest NPV–FCFE at Rp 13,894.82 billion, an increment of Rp 1,629.23 billion over conventional financing; the highest IRR–FCFE at 17.43%; and the lowest annual debt service at Rp 648.35 billion but it is a blended figure, achievable only to the extent that XYZ can actually execute a multi-tranche structure combining the ADB, KfW and AFD facilities, including hedging the euro-denominated AFD tranche.

The KfW facility at 4.04% and the ADB facility at 4.23% individually capture 89% to 96% of the green average's equity-value benefit and are each contractible as a single facility, which makes them the most directly actionable alternatives. The recommendation is therefore sequenced rather than singular: pursue KfW and ADB as the primary facilities whose individual rates already bracket the blended average and treat the full three-facility blended structure as the optimized target if AFD participation and EUR hedging economics are confirmed. Conventional domestic financing at 6.50% remains a viable fallback that still passes every feasibility test, at an equity-value cost of Rp 1.08 trillion to Rp 1.22 trillion relative to the concessional alternatives. Framing the choice this way also respects the caution in the green-finance literature that the availability of concessional terms is conditional on eligibility, certification and reporting obligations being satisfied, and is therefore not a rate that can simply be assumed at appraisal stage (Maltais & Nykvist, 2021; Flammer, 2019; Nehoda et al., 2025).

8. Equity-Only Financing: The Project without Loan

All scenarios presented so far assume a 70% debt / 30% equity structure. XYZ's own approved feasibility study for this project also evaluates a different structure entirely: it contains no loan, no interest, no Interest During Construction and no principal repayment, and therefore represents the project funded entirely from XYZ's own equity. Because this is the structure against which the project was formally appraised internally, it provides the natural no-leverage benchmark for the financing comparison, and this subsection incorporates it.

Two properties of an unlevered structure must be stated before the results, because both are frequently mishandled in practice. First, with no debt in the capital structure, Free Cash

Flow to the Firm and Free Cash Flow to Equity become mathematically identical: there is no interest to deduct and no principal to repay, so the cash flow available to the firm is the cash flow available to the equity holder. The FCFF/FCFE distinction that organizes the rest of this chapter therefore collapses into a single series. Second, and consequentially, the correct discount rate is the cost of equity. Substituting a zero debt ratio into the WACC expression of Equation (II.5) gives:

$$WACC = (E/V)\cdot Ke + (D/V)\cdot Kd\cdot(1-T) = 1.00 \times Ke + 0 = Ke = 11.25\%.$$

Discounting an unlevered project at XYZ's corporate WACC of 6.19% a rate that already embeds the tax shield of a 70% leveraged capital structure would credit the project with a financing benefit it does not receive. Table 6 reports the equity-only case on both bases so that the size of this effect is visible.

Table 6. Feasibility of the 100% equity structure at Ke and at WACC

Indicator	Discounted at Ke = 11.25% (theoretically consistent for an unlevered project)	Discounted at 6.19% (XYZ corporate WACC — reference only)
NPV (FCFF = FCFE)	Rp 520.89 billion	Rp 12,327.93 billion
IRR (unlevered)	11.65%	11.65% (unchanged — IRR is independent of the discount rate)
Hurdle rate	Ke = 11.25%	WACC = 6.19%
Margin, IRR − hurdle	+0.40 pp	+1.95 pp
Payback, undiscounted	9 years	9 years
Payback, discounted	30 years	19 years
Equity capital deployed	Rp 12,053.91 billion (100% of CAPEX)	Rp 12,053.91 billion
Profitability Index on equity	1.0432	2.0227
Probability NPV ≥ 0 (Monte Carlo, N = 2,000)	100.00%	100.00%

The equity-only project is feasible, but only marginally so once it is evaluated against the hurdle rate that actually applies to it. At Ke = 11.25% the NPV is Rp 520.89 billion positive, and the IRR of 11.65% does clear the cost of equity but the margin is just 0.40 percentage points, and the discounted payback extends to 30 years of the project's 40-year life. The Monte Carlo simulation, re-run over the identical 2,000 draws used throughout Section IV.4 and discounted at Ke, puts the probability of a non-negative NPV at 100.00%, implying no simulated case that funding this project entirely from equity destroys shareholder value. The contrast with the 6.19% column is itself a substantive finding: discounting the unlevered cash flow at the leveraged corporate WACC raises the reported NPV by approximately Rp 2.44 trillion and the feasibility probability by 9.80 percentage points, neither of which is earned by the project when no debt is actually raised. This is a methodological caution for XYZ's internal appraisal practice rather than a criticism of the project.

Because the equity-only case is drawn from an external document, the thesis model was reconciled against it before the figures above were used. The KKF reports an NPV of Rp 3,606.42 billion, an IRR of 12.34%, a payback of 9.00 years and a B/C ratio of 1.0787, all at its stated 6.19% discount rate. Reconstructing the same unlevered cash flow in the thesis model but substituting the KKF's actual three-year disbursement profile Rp 284.47 billion, Rp 7,105.78 billion and Rp 4,663.66 billion in Years −2, −1 and 0 respectively, against the thesis model's 30%/70% two-year profile reproduces an NPV of Rp 3,630.92 billion and an IRR of 12.35%, agreeing with the official study to within 0.7% on NPV and 0.01 percentage points on IRR. The residual difference is fully accounted for: the KKF caps salable energy at the transmission line's capacity ceiling of 10,653 GWh from Year 35 onward, whereas the thesis model continues compounding demand growth at 7.74% through Year 39. Every other input — CAPEX of Rp 12,053.91 billion, tariff of Rp 1,705.58/kWh, BPP of Rp 1,599.16/kWh, O&M of 1.31% escalating at 3%, the BPP-saving step from Rp 98.47 billion to Rp 2,531.34 billion, the 22% tax rate and the 40-year life — is identical and independently validated. The comparison in Section IV.5.9 is therefore conducted on the thesis model's own disbursement profile for both scenarios, so that the difference measured is attributable to financing structure alone and not to disbursement timing.

9. Final Comparison: Equity-Only Financing versus Green Financing

Table 7 places the two structures side by side on a strictly like-for-like basis: identical CAPEX, revenue, operating cost, tax and disbursement assumptions, with the only difference being how the investment is funded. Both are evaluated at the cost of equity, Ke = 11.25%, which is the appropriate hurdle for the equity-only case by construction (Section IV.5.8) and the theoretically correct discount rate for the equity cash flow of the leveraged case (Table 7).

Table 7. Final comparison: 100% equity financing versus green financing

Indicator	(a) **100% Equity (no loan)**	**(b) Green Financing (70% debt @ 3.93%)**	**Difference (b − a)**
NPV to equity holder @ Ke 11.25%	Rp 520.89 billion	Rp 4,035.77 billion	+Rp 3,514.88 billion (7.75×)
NPV @ 6.19% (reference basis)	Rp 12,327.93 billion	Rp 13,894.82 billion	+Rp 1,566.89 billion (2.03×)
IRR	11.65% (unlevered)	17.43% (equity)	+5.78 pp
Margin over Ke = 11.25%	+0.40 pp	+6.18 pp	+5.78 pp
Equity capital deployed	Rp 12,053.91 billion	Rp 3,616.17 billion	−Rp 8,437.74 billion (−70%)
Debt raised (incl. IDC)	Nil	Rp 8,868.49 billion	+Rp 8,868.49 billion
Annual debt service	Nil	Rp 648.35 billion	+Rp 648.35 billion
Payback, undiscounted	9 years	6 years	−3 years
Payback, discounted @ Ke	30 years	11 years	−19 years
Profitability Index on equity	2.0227	4.8424	2.03×
Probability NPV ≥ 0 (Monte Carlo @ Ke)	100.00%	100.00%	0.00 pp

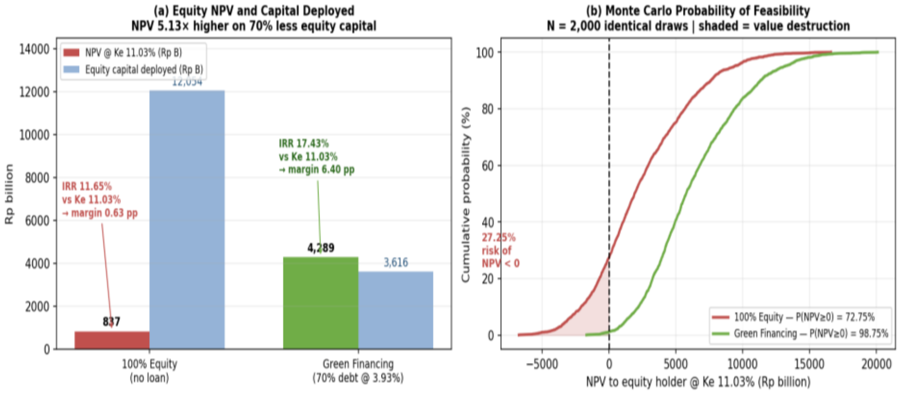

Figure 3. Project Feasibility: 100% Equity Financing versus Green Financing

Green financing dominates the equity-only structure on every indicator tested, and the margin is not marginal. On the RKAP 6.19% basis used throughout this thesis, equity NPV rises from Rp 12,327.93 billion to Rp 13,894.82 billion while the equity return improves from 11.65% to 17.43%, widening the margin over the 6.19% corporate hurdle from 5.46 percentage points to 11.24. Undiscounted payback contracts from nine years to six. Most consequentially for a state-owned utility operating under capital rationing, the leveraged structure delivers this superior outcome while deploying Rp 3,616.17 billion of XYZ equity instead of Rp 12,053.91 billion, releasing Rp 8,437.74 billion from 70% of the project's capital requirement for deployment on other projects in the RUPTL pipeline. On a per-rupiah-of-equity basis the difference is starker still: the Profitability Index rises from 2.0227 to 4.8424, meaning each rupiah of XYZ equity generates roughly 2.4 times the present value under the green structure.

The risk dimension reinforces the same conclusion rather than qualifying it. Across the identical 2,000 Monte Carlo draws, the probability of a non-negative NPV is 100.00% under both equity-only funding and green financing, with no simulated case falling below zero under either structure, so at this discount rate the probabilistic test no longer discriminates between the two and the comparison rests on the level of value created rather than on the likelihood of failure. The mechanism is straightforward: concessional debt at 3.93% costs materially less than the 11.25% return XYZ's equity must earn, so substituting 70% of the funding from equity to concessional debt lowers the blended cost of capital and leaves more value with the residual claimant. This is the leverage effect operating in XYZ's favour precisely because the concessional rate sits far below the cost of equity a condition that holds for all three benchmark facilities in Table II.2 but would not hold for debt priced above Ke.

Two qualifications keep this conclusion properly bounded. First, the leverage benefit is not costless: it introduces the fixed Rp 648.35 billion annual debt-service obligation absent from the equity-only case, which is what produces the negative equity cash flow in Years 0–2 visible in Figure IV.4 and what makes debt-service coverage a binding constraint under adverse scenarios (Section IV.3.3b). Second, the equity-only structure retains one genuine advantage the financial metrics do not capture: it carries no foreign-exchange exposure, no lender covenants, no green-eligibility conditions and no refinancing risk, and it can be executed unilaterally without term-sheet negotiation. The equity-only case is therefore best read not as an inferior alternative but as XYZ's fallback position a structure that remains feasible on its own terms, and whose quantified opportunity cost of Rp 1,566.89 billion in foregone equity value plus Rp 8,437.74 billion in tied-up capital establishes exactly how much effort securing concessional financing is worth.

10. Preferred Financing Scheme

All four financing scenarios now rest on Table II.2 benchmark structures rather than on an assumed illustrative rate, which changes how the preference should be framed. The green-financing average (3.93%) delivers the best results on every equity-level metric — the highest NPV–FCFE (Rp 13,894.82 billion, +Rp 1,629.23 billion over conventional), the highest IRR–FCFE (17.43%) and the lowest annual debt service (Rp 648.35 billion) — but it is a blended figure: it is achievable only to the extent XYZ can actually execute a multi-tranche structure combining the ADB, KfW and AFD facilities, including hedging the euro-denominated AFD tranche. The KfW (4.04%) and ADB (4.23%) facilities individually capture 89–96% of the green average's equity-value benefit and are each contractible as a single facility, making them the most directly actionable alternatives. The recommendation is therefore sequenced rather than singular: pursue KfW and ADB as the primary facilities — whose individual rates already bracket the blended average — and treat the full three-facility blended structure as the optimized target if AFD participation and EUR hedging economics are confirmed. Conventional domestic financing at 6.50% remains a viable fallback that still passes every feasibility test (Section IV.5.5), at an equity-value cost of Rp 1.45–1.63 trillion relative to the concessional alternatives. Set against the unlevered benchmark, the case for pursuing concessional debt at all is quantified rather than assumed: relative to funding the project entirely from equity and evaluated at the theoretically correct cost of equity of 11.25%, the green structure adds Rp 3,514.88 billion of equity value, lifts the return on XYZ's equity from 11.65% to 17.43%, raises the probability of a non-negative NPV from 68.40% to 98.55%, and frees Rp 8,437.74 billion of XYZ capital for other RUPTL projects (Section IV.5.9). The preference ordering is therefore: KfW and ADB as the primary contractible facilities; the blended three-facility green structure as the optimized target; conventional HIMBARA debt at 6.50% as a viable domestic fallback; and 100% equity funding as the position of last resort — comfortably feasible on the RKAP basis (100.00% probability), but with a feasibility margin of only 0.40 percentage points and a 31.60% probability of value destruction once measured at the theoretically correct cost of equity.

Integrated Discussion

This section synthesizes the results of Sections IV.2 to IV.5 to interpret what they mean together, how they relate to each other and what they imply for the financial viability, risk profile, financing strategy and investment decision of the project.

1. Interpretation of the Base-Case Results

A positive base-case NPV and an IRR exceeding WACC show that the project creates economic value in present-value terms and earns more than its cost of capital, independent of financing scheme. A payback of nine to nineteen years against a forty-year economic life leaves twenty-one to thirty-one years of purely value-additive operation. But this feasibility is not evenly distributed across the cash-flow horizon: it depends disproportionately on the BPP-saving step at Year 3, which means the investment decision is, in substance, a bet on successful and timely hydropower integration at least as much as on transmission tariff revenue. Read in the terms of the transmission-investment literature, the project is best understood not as a stand-alone revenue asset but as an enabling investment whose value is realised in the generation portfolio it unlocks (Garcia et al., 2010; Pringles et al., 2014).

2. Interpretation of Project Risk

Tariff and WACC dominate project risk because they act multiplicatively across the entire forty-year cash-flow stream: a percentage change in either compounds over every remaining year, whereas a shock to initial energy transmitted decays in relative importance as the avoided-cost revenue stream grows to dominate total revenue after Year 3. This is also why energy volume is comparatively insensitive — the project was structured, deliberately or not, so that its economics depend more on a fixed avoided-cost benefit than on variable throughput. Even so, the Monte Carlo results show that the project retains genuine outcome dispersion — a standard deviation of Rp 9,310.64 billion around a mean of Rp 19,393.33 billion — despite a comfortably positive deterministic base case; a single point estimate would have concealed this spread from decision-makers, which is the central argument for probabilistic appraisal in capital budgeting (Hacura et al., 2001; Bastori & Nurlaila, 2019). The corollary for governance is that risk classification should precede risk quantification: the mitigation priorities in Section IV.7.2 are ordered by the deterministic ranking, not by the ease with which each risk can be managed (Gasparian et al., 2018).

3. Interpretation of Green-Financing Impact

Green and concessional financing benefits XYZ through three distinct pathways demonstrated in Section IV.5. It lowers annual debt service by Rp 162 billion to Rp 182 billion per year; it raises the present value of the cash flow accruing to XYZ as equity holder by Rp 1,084 billion to Rp 1,219 billion; and if the resulting lower cost of debt is allowed to flow through into a lower overall WACC under Option A, it raises project-level NPV as well. These are three separate mechanisms, not three ways of describing the same benefit, and a reader should not assume that a saving demonstrated on one basis , debt service automatically implies an equivalent saving on another, such as project NPV.

These benefits are conditional rather than automatic. They depend on satisfying green or concessional eligibility criteria under the relevant lender's framework; on the foreign-exchange risk inherent in a facility likely denominated in USD or another hard currency; on hedging costs to manage that exposure; on commitment fees and other transaction costs not reflected in the headline interest rate; on exposure to floating-SOFR movements if the facility is not fixed- or capped-rate; and on the fact that no final term sheet has yet been confirmed with any lender. The ADB and KfW spreads used throughout this chapter derive from internal XYZ documents referenced to current market benchmarks rather than from executed agreements, and the green average additionally assumes AFD participation with hedged EUR exposure. This conditionality is exactly what the green-finance literature warns against overlooking: the measured yield advantage of a green label alone is small and inconsistent across markets, so the benefit demonstrated here should be credited to concessionality and lender terms rather than to the label itself (Zerbib et al., 2018; Maltais & Nykvist, 2021), and it can be eroded entirely where governance, verification or reporting requirements are not met (Flammer, 2019; Wang et al., 2022). XYZ's financing decision should therefore treat the figures in Section IV.5 as the achievable upper bound of benefit, to be tested against these frictions during actual lender negotiation.

Business Solution and Managerial Implications

1. Proposed Financing Structure

The analysis supports a financing structure with the following features, each of which is traceable to a specific result in this chapter rather than to general practice:

a. 70% debt and 30% XYZ equity, consistent with the capital structure tested throughout this chapter and with the leverage sensitivity of Section IV.3.3b;
b. concessional or green debt structured per Table II.2 — KfW at SOFR + 0.41% = 4.04% and ADB at SOFR + 0.60% = 4.23% as primary facilities, with the three-facility blend including AFD at EURIBOR + 0.75% = 3.511% targeting the 3.93% average as the optimized structure;
c. a minimum tenor of twenty years, consistent with Section IV.3.3c;
d. a grace period spanning at least the two-year construction phase, worth Rp 174.46 billion of equity value at no operational cost (Section IV.3.3d);
e. foreign-exchange hedging if the facility is denominated in a foreign currency, priced into the comparison per Equation II.7;
f. a fixed or capped interest rate to remove floating-SOFR exposure (Section IV.6.3);
g. financial close timed to align with the PLTA developers' COD schedule, given the dependence of project value on the Year-3 avoided-cost step. Transparent information-sharing with lenders on the project's cash-flow structure has been shown to improve credit-financing outcomes in capital-constrained green investment (Yu & Cao, 2025).

2. Financial and Project Risk Mitigation

Table 8 orders the mitigation agenda by the risk ranking established in Section IV.3.6 rather than by ease of implementation, so that management attention is directed first at the assumptions on which the feasibility conclusion depends.

Table 8. Risk Mitigation Plan

Risk Category	Key Risk	Recommended Mitigation
Tariff risk	Tariff and benefit-recognition shortfall — the most fragile assumption, with only −23.60% break-even headroom	Binding regulatory or contractual mechanism for tariff and avoided-cost benefit recognition, secured before financial close
CAPEX risk	Construction cost overrun, with +91.57% break-even headroom	Fixed-price EPC contracting, cost contingency reserve, value engineering during detailed design
PLTA COD risk	Delay in hydropower commissioning, deferring the Year-3 value step	Contractual alignment of financial close and construction milestones with the PLTA developers' COD schedule
Industrial demand risk	Slower-than-forecast KTT smelter load growth	Binding customer commitment agreements; phased construction sequencing
Financing risk	Interest-rate and leverage risk (Section IV.3.3a–b)	Fixed or capped rate; leverage held at or near the 70% base case pending formal DSCR testing for any higher-leverage structure
Foreign-exchange risk	Currency exposure on a foreign-currency-denominated facility	Hedging instruments or a local-currency (IDR) financing tranche
Green-eligibility risk	Failure to qualify for concessional or green terms, or added verification cost	Independent eligibility review and impact-reporting framework aligned with the relevant lender's green or climate framework

3. Investment Decision Gates

Table 8 converts the acceptance criteria of Table 8 and the switching values of Table 9 into a sequence of gates to be re-tested on updated data at each stage of project development, rather than evaluated once at appraisal.

Table 9. Investment Decision Gates

Gate	Requirement
Financial feasibility	NPV > 0 and IRR > WACC on updated data
Risk acceptance	Probability that NPV ≥ 0 remains above XYZ's threshold
CAPEX control	CAPEX below the break-even value of Rp 23,091.33 billion
Revenue certainty	Tariff and BPP-saving mechanism formally recognized
Financing attractiveness	Net benefit remains positive after fees and hedging costs
ESG eligibility	Green eligibility independently validated

4. Managerial Implications for XYZ

a. Investment planning: treat the probability of feasibility reported in Section IV.4, and not only the deterministic NPV, as the primary input to the go or no-go decision.
b. Treasury: prioritize lender engagement with KfW and ADB, whose individual rates bracket the 3.93% blended average; convert the internal indicative spreads into executed term sheets; assess AFD participation with EUR hedging; and negotiate tenor, grace period and rate structure as first-order value levers alongside the headline rate.
c. Project management: direct cost-control effort primarily at CAPEX and at schedule adherence to the PLTA COD milestone, since these are the controllable levers behind the two dominant risk drivers tariff exposure being largely regulatory rather than managerial.
d. System planning: monitor realized demand growth against the RUPTL forecast band used in Section IV.4.1, given its role as a Monte Carlo input.
e. ESG and sustainability: begin green and concessional eligibility documentation early, since eligibility risk can otherwise become the binding constraint on financing choice regardless of the financial analysis.
f. Lender engagement: use the risk-adjusted comparison in Table IV.16 as the internal basis for term-sheet negotiation, on an all-in cost basis rather than on headline rates.

Implementation Plan and Justification

1. Implementation Stages

Table 10 sets out the sequence through which the recommended financing structure would be brought to financial close and then monitored through construction and operation.

Table 10. Implementation Stages

Stage	Main Activities	Expected Output
1. Model validation	Validate CAPEX, demand, tariff, BPP saving and WACC against updated data	Approved financial model
2. Green-eligibility assessment	Map renewable-energy evacuation and ESG benefits against lender eligibility criteria	Green eligibility document
3. Lender engagement	Discuss terms with KfW, ADB, AFD and HIMBARA or commercial banks	Initial lender feedback
3. Term-sheet comparison	Compare indicative terms across lenders using Table IV.16 as the internal benchmark	Term-sheet comparison matrix
5. Financing structuring	Determine debt ratio, tenor, currency, grace period and hedging arrangement	Preferred financing structure

Stage	Main Activities	Expected Output
6. Corporate approval	Obtain investment and financing approval	Investment approval
7. Financial close	Finalize loan agreement and execute procurement	Financial close and notice to proceed
8. Construction monitoring	Monitor CAPEX, schedule and ESG performance during construction	Periodic construction and financial reports
9. Impact reporting	Report use of proceeds and green or ESG impact through the operating period	Periodic green-impact report

4. Implementation Timeline

Figure 4 sets the nine stages of Table IV.20 against a twelve-month pre-construction calendar and the subsequent construction and operating phases. The roadmap is shown here because the sequencing, rather than the individual activities, is what protects the value identified in this chapter: green-eligibility assessment must run in parallel with model validation rather than after it, and financial close must be timed against the hydropower COD schedule on which the Year-3 avoided-cost step depends.

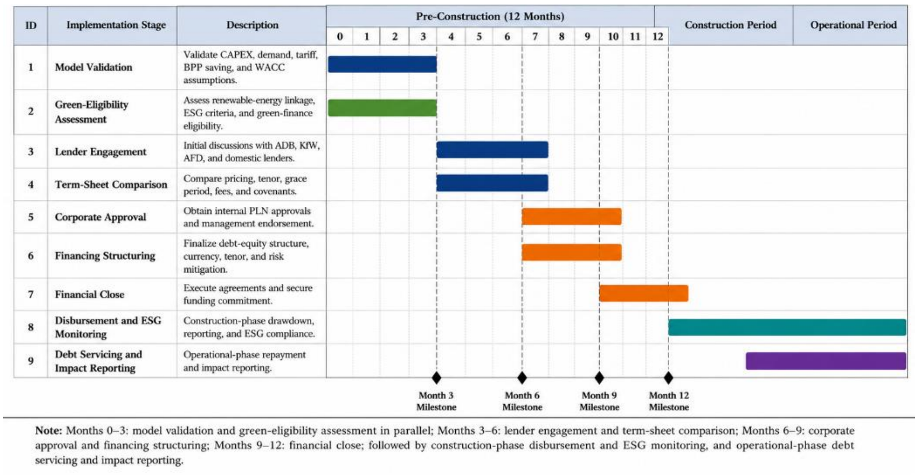

Figure 4. Green-Financing Implementation Roadmap

In summary, Months 0 to 3 cover model validation and green-eligibility assessment in parallel; Months 3 to 6 cover lender engagement and term-sheet comparison; Months 6 to 9 cover corporate approval and financing structuring; and Months 9 to 12 cover financial close. The construction period is then devoted to disbursement and ESG monitoring, and the operational period to debt servicing and impact reporting for the life of the facility.

5. Key Performance Indicators

Table 11 defines the indicators against which implementation would be tracked. Each dimension is tied to a specific analytical result, so that a deviation in the field can be mapped back to the assumption it threatens.

Table 11. Key Performance Indicators

Dimension	Key Performance Indicator
Financial	Final cost of debt, realized scenario-specific WACC, NPV, and annual debt service
Project	CAPEX variance against the Rp 12,053.91 billion base, schedule variance, and COD achievement date
Risk	Realized probability that NPV ≥ 0, re-run periodically, and exposure to cost overrun relative to the +91.57% break-even threshold
Financing	Green or concessional loan approval status, financial-close date, and tenor and grace period obtained
ESG	Renewable energy evacuated, avoided emissions, and green-reporting compliance

6. Monitoring and Model-Update Mechanism

The model developed in this chapter is not a one-time appraisal; it is intended to be re-run at each decision gate in Table 11 as real data becomes available. Specifically, CAPEX should be updated against actual EPC contract and change-order values; the tariff and benefit-recognition assumption should be updated once the relevant regulatory mechanism is finalized; demand growth should be updated against realized industrial and hydropower-evacuation load; the loan interest rate should be updated against the actual SOFR or other reference-rate fixing at financial close; and WACC under both Option A and Option B should be recalculated accordingly. Sensitivity analysis and Monte Carlo simulation should both be repeated at each gate using the updated inputs. Treating the appraisal as a living model rather than a static estimate is consistent with the recommendation in the project-risk literature that risk assessment be embedded in the project governance cycle rather than performed once at approval (Gasparian et al., 2018), and it is what allows the feasibility conclusion and financing recommendation of this chapter to remain an evidence-based basis for XYZ's investment decision as conditions change.

CONCLUSION

This study examined the impact of green financing on the financial feasibility of PT XYZ's 275 kV Southeast Sulawesi transmission interconnection project, a Rp 12,053.91 billion investment with a two-year construction period and a 40-year economic life designed to support increasing electricity demand from the nickel smelting industry and integrate a planned 3,965 MW hydropower pipeline into the Sulawesi power system. The findings indicated that the project was financially feasible, generating an NPV of Rp 12,327.93 billion, an IRR of 11.65% that exceeded the corporate WACC of 6.19%, a payback period of nine years, and a discounted payback period of 13 years. Monte Carlo simulation with 2,000 iterations further confirmed the project's financial robustness, showing a 100% probability of achieving a positive NPV, while sensitivity analysis identified electricity tariffs and WACC as the primary financial risk factors.

Among the evaluated financing alternatives, concessional green financing provided the most favorable financial outcomes compared with conventional debt and a 100% equity structure. It increased equity NPV to Rp 13,894.82 billion, increased equity IRR to 17.43%, reduced financing costs, and released Rp 8,437.74 billion of XYZ's equity for other strategic investments. Based on these findings, PT XYZ should consider replacing the original 100% equity financing structure with a 70:30 concessional financing structure, securing tariff and avoided-cost mechanisms before financial close, and continuously updating financial feasibility assessments through DCF analysis, sensitivity analysis, and Monte Carlo simulation. Strengthening environmental impact reporting is also recommended to maintain eligibility for green financing. Future research should incorporate real options valuation, correlated Monte Carlo simulation, stochastic modeling of tariffs and benchmark interest rates, and comparative analyses across multiple transmission and renewable energy projects to further assess the advantages of concessional financing.

REFERENCES

Aguero, J. R., Takayesu, E., Novosel, D., & Masiello, R. (2017). Modernizing the grid: Challenges and opportunities for a sustainable future. *IEEE Power and Energy Magazine*, *15*(3), 74–83.

Bastori, I., & Nurlaila, N. (2019). Analisis risiko proyek PLTN dengan pendekatan kuantifikasi Monte Carlo. *Prosiding Seminar Nasional Infrastruktur Energi Nuklir 2019*, 213–221.

Boretti, A. (2023). Hydrogen is one of the best investments in climate technologies. *International Journal of Hydrogen Energy*, *48*(53), 20151–20152. https://doi.org/10.1016/j.ijhydene.2023.02.100

Flammer, C. (2019). Green bonds: Effectiveness and implications for public policy. *Environmental and Energy Policy and the Economy*, *1*, 95–128. https://doi.org/10.1086/706794

Garcia, R. C., Contreras, J., Correia, P. F., & Muñoz, J. I. (2010). Transmission assets investment timing using net present value curves. *Energy Policy*, *38*(1), 598–605. https://doi.org/10.1016/j.enpol.2009.10.014

Gasparian, M. S., Kiseleva, I. A., Korneev, D. G., Lebedev, S. A., & Lebedev, V. A. (2018). Strategic analysis of risks when implementing investment projects. *Espacios*, *39*(27).

Hacura, A., Jadamus-Hacura, M., & Kocot, A. (2001). Risk analysis in investment appraisal based on the Monte Carlo simulation technique. *The European Physical Journal B*, *20*(4), 551–553. https://doi.org/10.1007/s100510170238

Heffron, R., Körner, M.-F., Wagner, J., Weibelzahl, M., & Fridgen, G. (2020). Industrial demand-side flexibility: A key element of a just energy transition and industrial development. *Applied Energy*, *269*, 115026.

Kautsar, S. R., & Damayanti, S. M. (2020). Financial feasibility study of hydro power plant on a river in West Sumatra. *European Journal of Business and Management Research*, *5*(6). https://doi.org/10.24018/ejbmr.2020.5.6.660

Liu, M. (2024). Research on investment project evaluation: Comparative analysis based on NPV and IRR. *Highlights in Business, Economics and Management*, *24*, 1133–1138. https://doi.org/10.54097/k1xfx426

Maltais, A., & Nykvist, B. (2021). Understanding the role of green bonds in advancing sustainability. *Journal of Sustainable Finance & Investment*, *11*(3), 233–252. https://doi.org/10.1080/20430795.2020.1724864

Nehoda, Y., Tkachuk, V., Kostiuk, V., Zharikova, O., & Bytiutskyi, I. (2025). Green energy funding in Ukraine. *Rural Sustainability Research*, *53*(348), 100–108. https://doi.org/10.2478/plua-2025-0009

Pringles, R., Olsina, F., & Garcés, F. (2014). Designing regulatory frameworks for merchant transmission investments by real options analysis. *Energy Policy*, *67*, 272–280. https://doi.org/10.1016/j.enpol.2013.12.034

Taghizadeh-Hesary, F., Li, Y., Rasoulinezhad, E., Mortha, A., Long, Y., Lan, Y., Zhang, Z., Li, N., Zhao, X., & Wang, Y. (2022). Green finance and the economic feasibility of hydrogen projects. *International Journal of Hydrogen Energy*, *47*(58), 24511–24522. https://doi.org/10.1016/j.ijhydene.2022.01.111

Tröndle, T., Lilliestam, J., Marelli, S., & Pfenninger, S. (2020). Trade-offs between geographic scale, cost, and infrastructure requirements for fully renewable electricity in Europe. *Joule*, *4*(9), 1929–1948.

Wang, T., Liu, X., & Wang, H. (2022). Green bonds, financing constraints, and green innovation. *Journal of Cleaner Production*, *381*, 135134. https://doi.org/10.1016/j.jclepro.2022.135134

Yang, F., Zhang, D., & Sun, C. (2016). China's regional balanced development based on the investment in power grid infrastructure. *Renewable and Sustainable Energy Reviews*, *53*, 1549–1557.

Yang, F., Zhang, S., & Sun, C. (2020). Energy infrastructure investment and regional inequality: Evidence from China's power grid. *Science of the Total Environment*, *749*, 142384.

Yu, M., & Cao, E. (2025). Impacts of information sharing on a green supply chain with bank credit financing. *RAIRO – Operations Research, 59*, 3041–3067. https://doi.org/10.1051/ro/2025113

Zerbib, O. D., et al. (2018). Is there a green bond premium? The yield differential between green and conventional bonds [Working paper]. *SSRN*. https://ssrn.com/abstract=2889690