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Assessing the Impact of Carbon Trading to Indonesia Geothermal Project Economic

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ABSTRACT

Indonesia possesses abundant geothermal potential, ranking among the world's leading countries with total reserve of 23.36 Gigawatts; however, only 2.29 Gigawatts are currently exploited. Unfortunately, geothermal projects in Indonesia frequently encounter difficulties in reaching the production phase due to a complex interplay of economic, technical, and social factors. To address the economic challenges associated with the projects, maximizing the revenue potential of geothermal derivative products, such as carbon trading, alongside electricity sales has emerged as potential approach. This paper aims to assess the implications of carbon trading on geothermal power plant projects in Indonesia. The research draws upon literature review related to economic components of geothermal projects, carbon trading schemes, and case studies of carbon trading. Through scenario analysis, the study compares the economic returns of geothermal projects with and without carbon trading. Additionally, the paper identifies the challenges and opportunities that carbon trading presents for geothermal power plants in Indonesia. Preliminary results indicate that carbon trading has a positive impact on enhancing the returns of geothermal projects. Furthermore, the integration of carbon trading offers additional benefits, including generating supplementary state revenue, improving the environmental perception of geothermal power plants, and fostering sustainable development. By embracing carbon trading, Indonesia's geothermal sector can potentially overcome economic hurdles and create a more favorable investment environment, unlocking the full potential of its geothermal resources.

1. INTRODUCTION

1.1 Background information on carbon trading

Climate change is one of the concerns for every country that has destructive impacts on various sectors and able to threatens the economic stability worldwide. The phenomenon itself is caused by the rise in the average temperature on earth's surface leads to heat waves, adversely affecting the human capacity to work, resulting in reduced productivity. According to the Swiss Re Institute (2021), climate change can cause a global Gross Domestic Product (GDP) decline of 11-18%, equivalent to approximately US$ 23 trillion by the year 2050, if the global temperature increases by 3.2°C.

Based on World Bank (2021), Indonesia ranks 97th out of 181 countries facing climate change impacts. This assessment is based on the Notre Dame Global Adaptation Initiative (ND-GAIN) index, which considers a country's vulnerability to climate change through political, geographical, and social factors. Indonesia is highly vulnerable to rising sea levels, which can threaten the country's food security in the agricultural sector, water availability, disaster risk management, development level, health and nutrition, and their implications for poverty and inequality.

The risk of climate change has driven various stakeholders in many countries to carry out environmental-related conventions and agreements, with the Kyoto Protocol and the Paris Agreement serving as references for taking steps to mitigate the impacts of climate change. Both Kyoto Protocol and Paris Agreement have encompassed commitments from all nations to reduce emissions and to collaborate on climate change mitigation. The Kyoto Protocol set a target of reducing emissions by 5% from the 1990 levels, and the Clean Development Mechanism (CDM) was used to achieve this goal. The Paris Agreement aims to reduce global greenhouse gas emissions to limit the average temperature increase to 2°C, aiming to reach net-zero emissions. The Paris Agreement established a new carbon trading platform called the Sustainable Development Mechanism (SDM).

One of the steps to reduce carbon emissions is using renewable energy sources like geothermal energy. Geothermal energy is produced within the Earth's crust and can be used directly, such as for hot water baths and building heating, or indirectly, like generating electricity. However, in the development of geothermal power in Indonesia, there are challenges, particularly financial ones when building geothermal power plants. To address this issue, carbon trading is being used as one of the solutions.

Based on Indonesia Carbon Trading Handbook (2022), carbon trading is market-based mechanism and one of the important financing models, both in terms of the potential for reducing greenhouse gas emissions and for cost savings. By utilizing carbon trading, renewable energy projects (in this paper is focused on geothermal projects) can boost their income by selling additional carbon credits in addition to the revenue generated from electricity sales. It can provide economic support to make geothermal projects more appealing to investors and governments. Implementing carbon trading in geothermal projects in Indonesia can yield dual benefits. Firstly, it has the potential to significantly increase income generated from these projects, diversifying revenue streams beyond traditional sources such as electricity sales. Secondly, carbon trading aligns with global commitments to mitigate the impacts of climate change. By reducing carbon emissions through such initiatives, Indonesia can play a role in international efforts to achieve carbon emission reduction targets and combat climate change. This paper will solely focus on the economic aspects of implementing carbon trading in geothermal projects in Indonesia.

1.2 Overview of Indonesia's geothermal potential and challenges

Indonesia possesses abundant geothermal potential, ranking among the world's leading countries with total reserve of 23.36 Gigawatts. However, only 2.29 Gigawatts are currently exploited from sixteen (16) projects. Unfortunately, geothermal projects in Indonesia frequently encounter difficulties in reaching the production phase due to a complex interplay of economic, technical, and social factors. Setiawan (2014) divides Indonesia's geothermal challenges into three parts, namely upstream side problems, downstream side problems, and supporting side problems.

1.2.1 Upstream side problems

Geothermal development faces challenges due to a lack of information on available reserves during auctions, causing uncertainty for investors and leading to uneconomical prices for geothermal power. The high initial investment of approximately US$25 million and the risk of exploration failure make the projects not bankable and challenging when securing the financing . Additionally, about 41.6% of the geothermal potential overlaps with protected forests or conservation areas, hindering development due to regulations prohibiting mining activities in those locations.

1.2.2 Downstream side problems

The downstream side problems in geothermal development are unattractive geothermal electricity price, with fixed tariffs set by the government, especially for remote areas. Additionally, the market structure characterized by a single buyer (monopsony market), which weakens the bargaining position of sellers also becomes a problem for the development.

1.2.3 Supporting side problems

The supporting side problems in geothermal development are the complex bureaucracy system in Indonesia, which hinders the ease of doing business and leads to lengthy licensing processes, particularly due to the authority delegation to local governments. Additionally, there has been a lack of national commitment and strong leadership to promote geothermal development in the past, both at the central and local government levels. Furthermore, consumers and society lack awareness about the importance of renewable (green) energy development, including geothermal.

One potential approach to address the challenges, particularly in the economic aspect, is to maximize the revenue potential of geothermal derivative products, such as carbon trading and electricity sales. Engaging in carbon trading alongside selling electricity allows geothermal projects to access an extra income stream. This approach leverages the reduction of greenhouse gas emissions associated with geothermal energy production, providing them with an additional source of revenue. Geothermal projects have a promising opportunity to enhance their financial returns by exploring carbon trading alongside electricity sales. Not only does this approach offer economic incentives for investing in geothermal energy, but it also contributes to combat the climate change by reducing carbon emissions.

1.3 Purpose and significance of the study

The purpose of this study is to evaluate the potential impacts of integrating carbon trading mechanisms into geothermal projects in Indonesia. Specifically, the study aims to assess the implications of carbon trading on geothermal power plant projects in Indonesia. The study will delve into the various aspects and consequences of incorporating carbon trading within the context of geothermal energy development in the country. It will investigate the potential benefits, challenges, and opportunities that will arise from participating in carbon markets alongside traditional electricity sales in geothermal power plants. The findings of this study could potentially guide decision-makers, investors, and policymakers in understanding the feasibility and significance of adopting carbon trading as a part of geothermal energy development strategies in Indonesia.

1.4 Research design and approach, Data collection methods, Scenario analysis for economic comparison

The data collection methods draw upon a literature review of the economic components of geothermal projects, carbon trading schemes, and case studies of carbon trading. Through scenario analysis, the study compares the economic returns of geothermal projects with and without carbon trading. Additionally, the paper identifies the challenges and opportunities carbon trading presents for geothermal power plants development in Indonesia.

2. CARBON TRADING SIGNIFICANCE IN GEOTHERMAL ENERGY

2.1 Geothermal projects in Indonesia: Economic challenges and opporunities

The economic aspect poses a significant challenge for geothermal projects in Indonesia, encompassing several key issues such as:

2.1.1 High initial investment

In the early stages of geothermal exploration, high initial investment refers to a substantial amount of funds needed to initiate exploration activities. This includes the costs of conducting various studies and surveys to assess the geothermal potential in the target area. The high level of uncertainty is related to the inherent uncertainty or risks associated with the geothermal exploration phase. The high risks in geothermal exploration stem from the lack of direct confirmation that the project will successfully discover economically viable geothermal sources for further development. All these studies require significant costs as they involve expensive equipment, expert teams, and in-depth analysis. Moreover, the high risks in geothermal exploration require companies and investors to carefully consider the risks and potential returns before deciding to proceed with further project development (Umam et al, 2018).

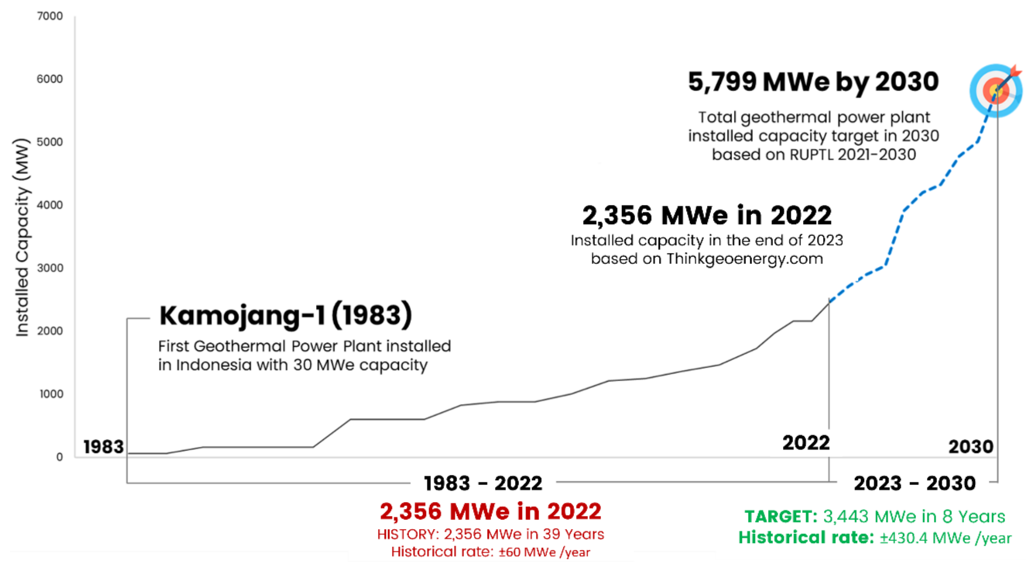

Figure 1: Current and target of Indonesia's geothermal power plant installed capacity (updated data from Thinkgeoenergy, 2023; EBTKE, 2022; PLN 2021; Purba et al,2020).

2.1.2 Long payback period

In the Geothermal energy sector, the road to profitability often stretches over a long payback period, typically spanning 5 to 10 years before reaching the critical Commercial Operation Date (COD) stage. This extended timeline is influenced by several factors, including the unique challenges posed by geothermal energy development and the reliance on a single buyer-based electricity purchase policy. While geothermal power generation offers numerous environmental benefits and long-term sustainability, its initial investment and resource exploration demands can be substantial (Umam et al, 2018).

2.1.3 Market price volatility

According to Pambudi (2017), the prices of geothermal energy vary among regions due to higher production costs in remote areas. Area 1, which includes Sumatera, Java, and Bali, has the most readily available geothermal energy and boasts the lowest benchmark selling price. In 2015, this price stood at 11.8 US cents per kilowatt-hour (kWh), and it was projected to increase to 12.2 in 2016. By 2019, the benchmark was expected to reach 13.4 US cents/kWh, and in 2021, it was anticipated to be 14.2. By 2025, it was projected to nearly reach 16 US cents/kWh. On the other hand, Area 2, consisting of Sulawesi, NTB, NTT, Halmahera, Maluku, Papua, and Kalimantan, maintains a benchmark price about 6 cents higher than that of Area 1. Area 2 started at 17 US cents/kWh in 2015 and was set to rise to 17.6 in 2016, 20 cents/kWh by 2020, and 23.3 cents/kWh by 2025. Meanwhile, Area 3 comprises areas within Regions I and II that rely on isolated transmission systems, necessitating their electricity supply from oil-fuelled power plants. Consequently, the benchmark selling price for energy in this area is the highest of the three regions. It commenced at 25.4 US cents/kWh in 2015 and gradually increased by less than a cent over the next two years—reaching 25.8 cents in 2016 and 26.2 in 2017, followed by 26.6 in 2018. By 2025, the benchmark price in Region III was projected to be 29.6 cents/kWh. Because there are price differences in each area, it will affect the geothermal field development process in each area (Pambudi,2017).

2.1.4 Regulatory and policy uncertainty

The regulations and policies in place involve a lengthy process that encompasses multiple stages and numerous prerequisites that developers must navigate to obtain the necessary approvals for their geothermal projects. This often includes strict adherence to environmental regulations, acquiring land use permits, and engaging with relevant government agencies. Moreover, approximately 40% of Indonesia's geothermal potential lies within forest conservation areas, which introduces additional layers of regulatory and environmental considerations. As a result, the development of geothermal energy projects in Indonesia becomes a protracted and complex endeavour, requiring a delicate balance between energy development objectives and environmental preservation (Pambudi,2017).

2.2 Carbon trading schemes

The carbon trading scheme involves a quota and allowance system. Each entity is given a specific quota for carbon emissions. If carbon emissions exceed the allocated quota, the entity can purchase credits from another entity that still has available quotas. This agreement was established in both the Kyoto Protocol and the Paris Agreement, granting nations the privilege of participating in tradable emission rights. The Kyoto Protocol aims to establish a reduction target of 5% from the 1990 emission levels, utilizing the Clean Development Mechanism (CDM). On the other hand, the Paris Agreement aims to reduce global greenhouse gas emissions to limit the average Earth's temperature increase to 2°C, employing the Sustainable Development Mechanism (SDM). Carbon trading, carries several significant implications. Carbon trading can impact economies by influencing investments in clean technologies and renewable energy, potentially affecting the profitability of carbon-intensive industries, fostering global cooperation in addressing climate change, and many more (Indonesia Carbon Trading Handbook, 2022).

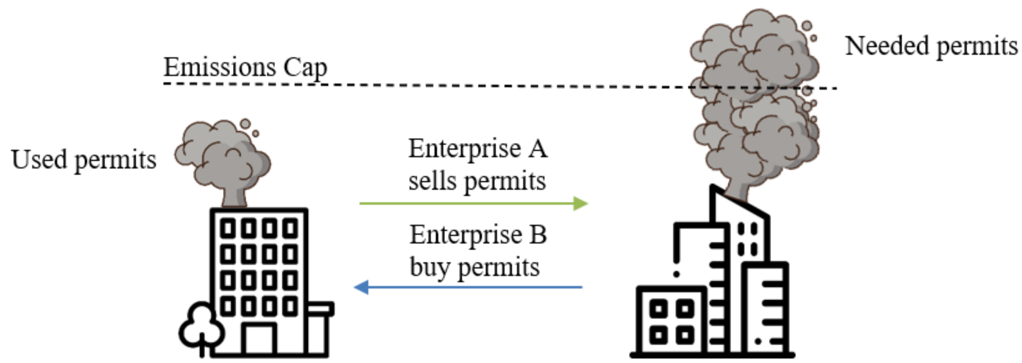

Figure 2: Carbon trading scheme (Indonesia Carbon Trading Handbook,2022).

The difference between Clean Development Mechanism (CDM) and Sustainable Development (SDM) can be seen in Table 1. In general, CDM places more emphasis on emission reduction, while SDM focuses on sustainable development

<u>2.3.1 European Union Emissions Trading System</u>

Uncertain revenue streams refer to the uncertainty related to geothermal projects' income or cash flow. This uncertainty is caused by fluctuating electricity prices, regulatory changes, weather and climate variability, and unstable energy demand. As a result, geothermal projects need to assess risks and conduct careful financial analysis to ensure profitability and sustainability amidst economic uncertainty.

Table 1: The difference between CDM and SDM (Indonesia Carbon Trading Handbook, 2022).

CDM	SDM
Balancing offset mechanism rather than emission reduction.	Contribute to overall emission mitigation/reduction.
Developing countries do not have reduction targets and do not factor climate commitments in the future.	Considering the mitigation targets of all countries, including their development.
Providing poor incentives for businesses to continue operating business as usual (BAU) and even increase emissions.	Promoting ambition and fostering the implementation of climate policies.
Questions have arisen regarding the commitment to sustainable development, including fossil fuels.	Contribute to sustainable development by switching from the use of fossil fuels.

2.3 Case studies of carbon trading in the energy sector

According to Indonesia Carbon Trading Handbook (2022), carbon trading in the energy sector was already gaining momentum as a market-based approach to mitigate greenhouse gas emissions. Some case studies of carbon trading in the energy sector are described below.

<u>2.3.1 European Union Emissions Trading System</u>

In 2005, the European Union Emissions Trading System (ETS) was established as the world's first emissions trading system involving electricity generation, intensive industries like cement, and aviation sectors. The ETS underwent four developmental phases. Phase 1 (2005-2007) served as a pilot phase, covering electricity generation and energy-intensive industries, where a significant portion of emission allowances was given free to businesses with a penalty of €40 per ton for non-compliance. Despite an increase in carbon trading volume, incomplete emission data resulted in a surplus of allowances, causing the price to drop to zero in 2007. Phase 2 (2008-2012) coincided with the commitment period of EU countries under the Kyoto Protocol, leading to reduced allowance caps and higher penalties for non-compliance. During Phase 3 (2013-2020), the ETS underwent reforms, introducing auctioning as the method for allocating allowances and expanding its coverage to more sectors. In Phase 4 (2021-2030), the ETS faced a proposed revision to the EU Climate Law, targeting a 43% emissions reduction compared to 2005, with an annual allowance reduction of 2.2% starting in 2021.

<u>2.3.2 China Emissions Trading System</u>

The China Emissions Trading System (ETS) was established in 2013 as a regional pilot to incentivize investors and market participants to support China's decarbonization and energy transition efforts. The ETS covers a significant portion of emissions from the energy sector.

In July 2021, the national ETS was launched, involving 2,225 power generation companies required to submit quotas to offset emissions from 2019 and 2020. The national carbon market serves as a tool to drive China's commitment to achieve a carbon peak before 2030 and carbon neutrality before 2060. This ETS is expected to become the world's largest carbon market, covering approximately 4.5 billion tons of CO2 annually, or around 40% of China's total emissions.

2.3.3 South Korea’s Emission Trading Scheme (KETS)

The Korean government signed and ratified the UNFCCC and Kyoto Protocol to address climate change and incorporated the goal of reducing national greenhouse gas emissions by 30% from the BAU projection in 2020 into the Framework Act on Low Carbon, Green Growth. The Act established the Target Management System (TMS) to regulate emissions and energy efficiency in various sectors, including energy. The TMS operates command and control, setting reduction targets for controlled entities. In parallel, the Act on the Allocation and Trading of Greenhouse Gas Emission Allowances (ETS Act) was implemented, establishing the Emission Trading Scheme (ETS) starting in 2015. The ETS targets compliance entities based on their emission levels. Both TMS and ETS will work together from 2015 onwards. However, some issues remain unresolved, including allowance allocation, market stabilization measures, the role of the power sector, and offset programs. The government aims to cover seven sectors in the ETS, targeting a reduction of 233MtCO2e by 2020 (Park and Hong, 2014).

3. ECONOMIC ASSESSMENT OF CARBON TRADING ON GEOTHERMAL POWER PLANT PROJECTS IN INDONESIA

3.1 Geothermal projects with and without carbon trading

Geothermal projects can experience a positive impact on producing renewable energy with low greenhouse gas emissions when engaging in carbon trading. By selling carbon credits, geothermal developers can generate additional revenue, enhancing the financial viability of their projects. Moreover, carbon trading drives higher demand for renewable energy, particularly geothermal, as companies strive to meet emission reduction targets. This increased demand may result in more favorable power purchase agreements (PPAs) or feed-in tariffs for geothermal electricity, creating a stable and appealing revenue stream for project developers. Carbon trading's impact can also be harnessed for public relations and branding efforts, attracting potential investors and customers who prioritize sustainability and eco-friendly initiatives (Indonesia Carbon Trading Handbook, 2022).

Carbon trading is one of geothermal derivative products from economic aspect to maximizing the revenue potential. The lack of additional revenue from carbon credits can make the project economics less attractive, especially when compared to fossil fuel-based power generation sources that do not incur carbon costs. Geothermal projects without carbon pricing incentives may heavily rely on government support like subsidies or tax incentives to compete with conventional energy sources, which can vary in availability and stability across regions, affecting project feasibility. The absence of carbon pricing could also reduce pressure on conventional energy producers to cut emissions, making it challenging for geothermal projects to compete on equal footing. In contrast, carbon trading can offer crucial financial support and market demand, making geothermal projects economically more viable and encouraging renewable energy investment to combat climate change (Indonesia Carbon Trading Handbook, 2022).

One of the primary challenges in carbon trading lies in determining the price of carbon, highlighting the importance of establishing robust regulations and mechanisms and implementing effective carbon pricing. These measures are essential to achieving the Nationally Determined Contributions (NDC) target and ensuring that the income generated from carbon trading is directed towards sustainable emission reduction programs, fostering Indonesia's commitment to combat climate change (Saputra et al, 2022).

Implementing an effective carbon pricing mechanism is crucial for reducing greenhouse gas emissions and achieving the NDC target. Price regulation and a well-designed carbon trading mechanism can encourage stakeholders to actively participate in emission reduction efforts and ensure that revenues from carbon trading are invested in sustainable programs. Before designing the carbon trading mechanism, it is essential to determine the specific (Green House Gas) GHG reduction target. This involves calculating the emissions to be reduced and identifying the sectors that contribute the most to these emissions. Understanding the abatement cost allows for calculating an ideal floor price, enabling effective carbon pricing and successful emission reduction strategies (Saputra et al, 2022).

Carbon trading through the commodity exchange has several benefits, namely transparency, buyers and sellers can see prices transparently and there is also direct access so there is no confusion in finding sellers or buyers of carbon credits. In addition, trading through the stock exchange can also provide the best price, because carbon trading through the carbon exchange will use an auction system, where buyers and sellers can bid and ask according to the wishes of each party (Saputra et al, 2022).

3.2 Case study in ABC geothermal project

The authors develop a hypothetical case to understand the impact of carbon trading on a geothermal project by providing two scenarios. The first scenario (baseline) represents the condition in which the geothermal project relies solely on a single revenue stream sourced from electricity sales to PLN, under a ceiling with a staggering tariff scheme. The second scenario (optimized case) represents the project's condition when it has already implemented carbon trading as an additional revenue stream. In the optimized case, project revenue is derived from electricity sales to PLN and carbon trading. The explanation of the assumptions used for the hypothetical project is provided below.

The hypothetical case, known as Project ABC, is a 55 MW project located in the Java area. Project ABC is assumed to have a capital cost of $4.3 million per MW, totaling $243 million. This capital cost falls within the range of typical optimistic geothermal project costs in Indonesia, as indicated by EBTKE (2021), which can vary among projects. Project ABC is projected to incur operation and maintenance costs of $18 per MWh during the operational period, with major plant overhauls occurring every 5 years. This assumption is consistent with the research of Quinlivan (2015) and Fadhillah (2023). Furthermore, the project has obligations to pay non-tax government fees related to royalty, production bonuses, and fixed fees, as specified in EBTKE (2021; 2022).

Table 2: Input parameter for ABC project.

Parameter	ABC project (Base and optimize case)	References
Operation and maintenance	18 USD/MWh	Quinlivan (2015)
Major overhaul cost	2 MUSD/activity	Quinlivan (2015)
Major overhaul period	5 years	Quinlivan (2015)
Non tax government payment		
Royalty	2.5% of revenue	EBTKE (2021; 2022)
Production bonus	0.5% of revenue	EBTKE (2021; 2022)
Fixed fee	4 USD/Ha/Yr	EBTKE (2021; 2022)

The project employs a mixed financing strategy, combining equity and commercial loans to fund the exploration and development capital. According to EBTKE (2021), Quinlivan (2015), Winofa (2020), and Lesmana (2020), the typical equity-to-debt ratio is 30:70. Equity is commonly used to fund capital from the survey phase until the appraisal phase, while the loan becomes available after the appraisal phase with confirmed resources. The equity accounts for 30% of the total construction costs, offering an expected return of 13.5%, while the commercial loan supports 70% of the total construction cost, with a 7% interest rate assumed during both construction and operation. These assumptions are consistent with those applied by EBTKE (2021), Quinlivan (2015), Winofa (2020), and Lesmana (2020). Table 3 summarizes the financing aspects for both scenarios of the ABC project.

Table 3: Input parameter for ABC project of equity and debt.

Parameter	ABC project (Base and optimize case)	References
Equity		
Equity ratio	30%	EBTKE (2021); Quinlivan (2015)
Cost of equity	13.5%	EBTKE (2021)
Debt		
Debt ratio	70%	EBTKE (2021); Quinlivan (2015)
Interest during construction	7%	EBTKE (2021)
Cost of debt	7%	EBTKE (2021); Quinlivan (2015)
Grace period	3 yrs	GT Management (2020)
Principal repayment period	15 yrs	EBTKE (2021)
WACC	7.42%	Calculated from Damodaran (2011)

The revenue is divided into two cases. Case 1 (baseline) primarily relies on revenue generated from electricity sales to Perusahaan Listrik Negara (PLN). The electricity is generated through a power plant with a 90% capacity factor and fully absorbed by PLN (EBTKE, 2021). In contrast, Case 2 (optimized case) includes additional revenue from carbon trading. The carbon trading scheme is referenced from GT Management (2020). The geothermal power plant is assumed to have a reduction of about 0.6-0.76 tCO_2 per MWh (Cahyono, 2010; GT Management, 2020). The emission reduction in this scenario will align with carbon crediting based on several CDM benchmark projects. Table XX summarizes the revenue aspects for the ABC project.

Table 4: Input parameter for ABC project with stages.

Parameter	ABC project Base case	ABC project Optimize case	References
Power plant capacity	55 Mw		Author discussion
Capacity factor	90%		EBTKE (2021); Quinlivan (2015); (Boston, Prieto, and Patzek, 2022)
Off-take absorption	100%		Author discussion
Tariff scheme	Ceiling with staging		Perpres 112/2022
Escalation portion	0.375		ADB (2014)
Stage 1 tariff			
Base tariff	86.4 USD/MWh		Perpres 112/2022
Location factor	1		Perpres 112/2022
End price	86.4 USD/MWh		Perpres 112/2022
Stage 2 tariff			
Base tariff	73.5 USD/MWh		Perpres 112/2022
Carbon trading			
Carbon conversion factor	Not applicable	0.75tCO_2/MWh	Predicted emissions from project trend in Cahyono (2010) and PT Pertamina Geothermal Energy (2020)
Carbon price	Not applicable	0.75tCO_2/MWh	The World Bank, 2022

The Both scenarios for the ABC geothermal project utilize the straight-line depreciation method with an 8-year depreciation period and no salvage value, following the approach described by Nur et al. (2023) and common industry practices from 2005. Additionally, the corporate income tax stands at 22%.

The project's economic assessment involves a comparison of project revenue, net present value (NPV), and internal rate of return (IRR) for both scenarios. According to financial modeling, the base case, characterized by a single revenue stream, results in a cumulative revenue of 1.088 million USD over a 30-year operational period. Unfortunately, the base case demonstrates negative NPV values for both the project (approximately -31 million USD) and equity (-43 million USD). The IRR also falls below expected levels, with the project's IRR (6.24%) being lower than the weighted average cost of capital (WACC) (7.73%), and the equity's IRR (6.47%) being lower than the cost of equity (13.5%).

The optimized scenario, which includes an extra income source from carbon trading to supplement electricity sales, demonstrates greater cumulative revenue, totaling 1.122 million USD over a 30-year operational period. However, the NPV and IRR metrics for both the project and equity still do not offer favorable conditions for potential investors. Both NPV values remain in the negative, with NPV for the project at -24 million USD and NPV for equity at -40 million USD. The project IRR (6,59%) and equity IRR (7,00%) still falls below the desired rate. Furthermore, the IRR for both the project and equity still falls short of the desired rate.

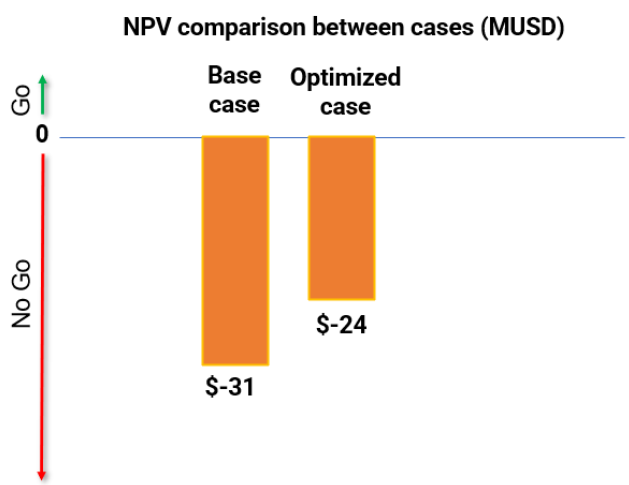

Figure 4: NPV projection of each case.

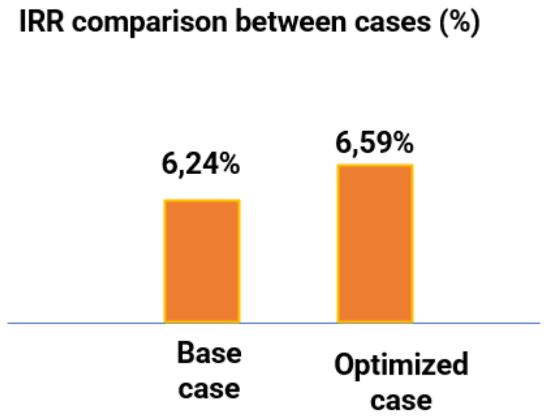

Figure 5: IRR proejction of each case.

Even though the project does not yet meet the criteria for a favorable investment, the inclusion of carbon trading has a beneficial effect on the project, leading to increased revenue and improved NPV-IRR. However, it is essential to give special consideration to the pricing mechanism for carbon trading due to the fluctuating nature of carbon prices in response to market conditions.

4. CONCLUSION

Carbon trading has a positive impact on enhancing the returns of geothermal projects. The integration of carbon trading offers additional benefits, including generating supplementary state revenue, improving the environmental perception of geothermal power plants, and fostering sustainable development. By embracing carbon trading, Indonesia's geothermal sector can potentially overcome economic hurdles and create a more favorable investment environment, unlocking the full potential of its geothermal resources. However, challenges lie in determining the price of carbon and establishing effective regulations and mechanisms to achieve the Nationally Determined Contributions (NDC) target and direct income from carbon trading towards sustainable emission reduction programs.

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