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Delivering Power Sector Transition in Indonesia

Costs, Benefits, and Implications of Intervening the 13.8 GW Coal-fired Power Plants Project Pipeline of Indonesia's State-owned Utility

Imprint

Delivering Power Sector Transition in Indonesia:

Costs, Benefits, and Implications of Intervening the 13.8 GW Coal-fired Power Plants Project Pipeline of Indonesia's State-owned Utility

Authors:
Akbar Bagaskara
Deon Arinaldo
Fabby Tumiwa
Raden Raditya Yudha Wiranegara, PhD

Editor:
Fabby Tumiwa

Reviewers:
Ali Al-Saffar (Rockefeller Foundation)
Joseph Curtin (Rockefeller Foundation)
I Made Ro Sakya (Power System Expert)
Pramudya (Directorate General of Electricity, Ministry of Energy and Mineral Resources)

Enquiries concerning reprint of this paper should be sent to the following address:

Institute for Essential Services Reform
Jalan Tebet Timur Raya No.48 B
Jakarta Selatan 12810 | Indonesia
T: +62 21 2232 3069 | F:+62 21 8317 073

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Forewords

We are living in perilous times. As the global temperature rises to 1.1°C, the world is witnessing extreme weather events that have affected people all over the world. Climate change is happening faster than scientists predicted. "Humanity is on thin ice, and that ice is melting fast," said UN Secretary-General Ban Ki-moon at the launch of the IPCC Synthesis report in March. Only by acting quickly to reduce GHG emissions can the world avoid a climate disaster.

Coal-fired power generation accounts for the majority of global energy-related GHG emissions. One of the culprits behind the acceleration of global warming is the burning of the dirtiest energy on the planet. Reduced coal use for power generation is one of the most significant measures to take in order to meet the Paris Agreement's 1.5°C temperature goal.

Indonesia is one of the countries with the highest coal generation, ranking third after China and India. In 2022, Indonesia will add 1.2 GW and operate 40.6 GW, a 60% increase since 2015. Last year, 18.8 GW of coal plants were considered for construction. Except for India and China, this capacity exceeds that of other countries.

According to research published last year by IESR and the University of Maryland, in order to be compatible with 1.5°C, 9.2 GW of coal generation in Indonesia should be retired by 2030, bringing power sector emissions to 200 million tCO_2e, followed by more than 90 percent capacity by 2040, and the last remaining capacity by 2045 to achieve net-zero emissions.

This path is more ambitious than the target specified in Presidential Regulation 112/2022, which aims to phase out coal by 2050, and the Just Energy Transition Partnership (JETP) agreed last year between Indonesia and IPG, which aims to achieve a peak emission of 290 million tCO_2e by 2030 and a 34% renewable energy mix. To meet this target, we estimate that approximately 8.6 GW of coal capacity must be decommissioned.

The majority of this retired capacity is expected to come from PLN's old coal fleets. So far, PLN has identified 6 GW that could be retired before 2030 for a cost of approximately USD 5 billion. That is still insufficient to meet JETP's goal. Additional coal plants must be built not only to meet the demand for coal but also to reduce the cost of coal phase-out and the financial burden on the country and PLN in the near future.

This study discovered that canceling nine units of coal plants totaling 3 GW currently under construction will have no effect on reliability or cost, and that early retirement is the cheapest option in terms of investment and carbon cost when compared to achieving the 2050 net-zero goal. We are fully aware that the cancellation should not be decided unilaterally by PLN in order to avoid a legal dispute, but making it happen requires both PLN and IPPs to agree on the cancellation and compensation terms for the IPP.

Last but not least, with this study, IESR has contributed to the thinking on achieving Indonesia's energy sector's net-zero goal. It is up to the government and PLN to take action based on this analysis. We hope that other countries can use this new approach to find the most cost-effective measures for their coal pipelines.

Finally, this report begins with IESR and the Rockefeller Foundation exchanging ideas about the coal phase-out pathway last year. Ideas become actions, and the results can be found in this report. We are grateful to the Rockefeller Foundation for entrusting IESR with this research.

Jakarta, 30 May 2023

Fabby Tumiwa
Executive Director IESR

Table of Contents

Executive Summary

Meeting the Paris Agreement's goal requires phasing out the unabated coal-fired power plants by 2040 globally. This poses significant challenges for Indonesia, which has increased its coal-fired power plants development over the last two decades and is currently facing the growing energy demand. Since 2006, amidst the energy crisis and the need for economic growth, the Indonesian government has developed power plants through three acceleration programs: Fast-Track Program I (2006–2009), Fast-Track Program II (2010–2014), and 35 Gigawatt (2015–2019), with coal-fired power plants as the main power generator.

As a result, coal-fired power plant's capacity is soaring, and as of 2022, about 67%[1] of Indonesia's electricity comes from the burning of coal. By 2022, Indonesia's coal-fired power plant's (CFPP) installed capacity has reached 44.6 GW. The figure is envisaged to increase as indicated in the RUPTL 2021–2030, the state-owned utility PLN's most recent plan for expanding its electricity provision. The company proposed adding a further 13,822 MW of CFPP capacity before 2030. Unfortunately, electricity demand has been growing much slower than the forecasts of generating capacity expansion for the last five years. This condition has led to overcapacity in the Java-Bali and Sumatra systems, especially since 2020, as only small adjustments have been made to the generation capacity expansion plan.

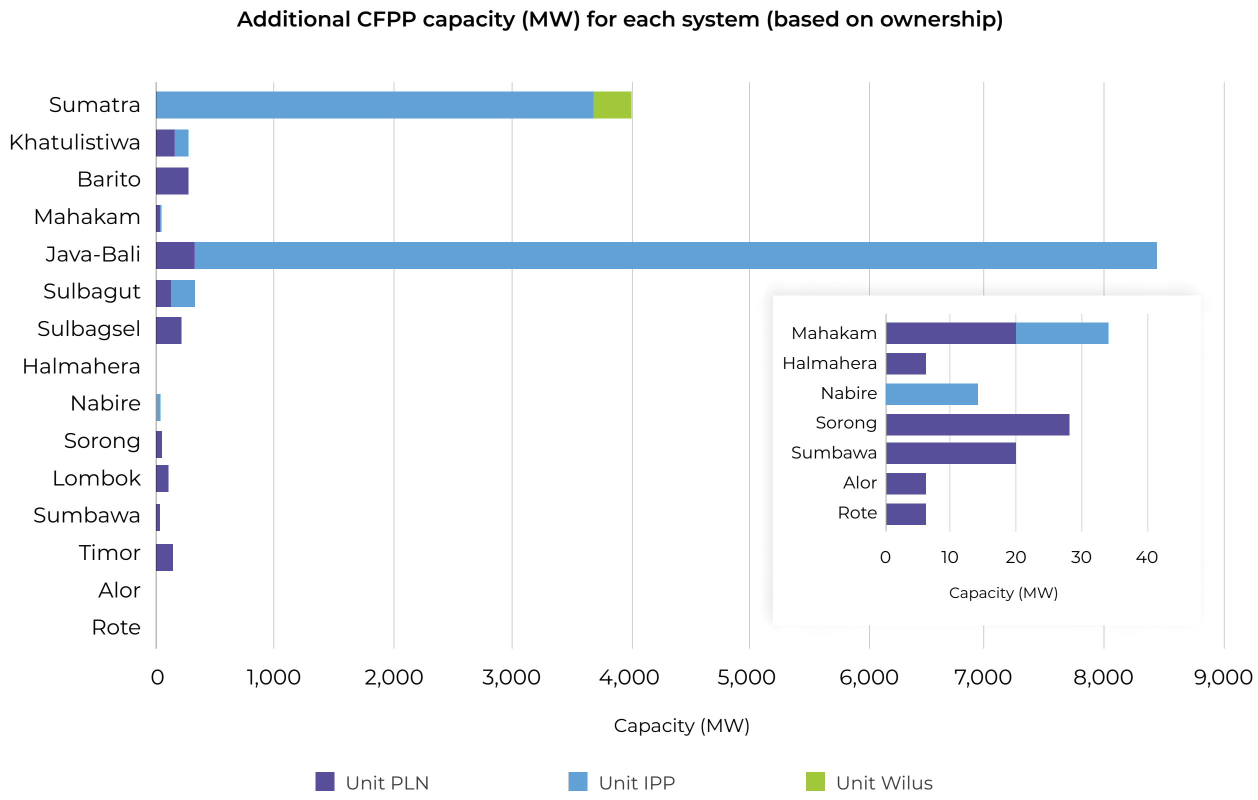


Figure ES 1. The distribution of 13.8 GW of CFPP in the pipeline in PLN's system

This is a complete opposite to the context of recent discussions on vital energy transitions, which requires a significant reduction of Indonesia's coal-fired power plants capacity. Analysis by IESR and the University of Maryland (2022) found that 9.2 GW of coal must be phased out from the state-owned utility (PLN) grid before 2030 and all unabated coal plants phased out by 2045 at the latest to put Indonesia on track to meeting the 1.5°C Paris Agreement global temperature goal[2].

[1] 2023 Q1 realisation: 67% (Source: MEMR, personal communication, 18 May 2023)

[2] The analysis of IESR and UMD (2022) only considers the power plants connected to the grid. Emissions from the captive power plants are not included in the pathway yet.

The government of Indonesia has made a commitment to phase out unabated coal gradually as a means to meet Paris Agreement's goal and has stated the need for international support to do so. In addition to Energy Transition Mechanism (ETM) launched at COP-26, during the G20 summit, Indonesia and the International Partnership Group (IPG) signed the Just Energy Transition Partnership (JETP), aimed at meeting the power sector's peak emission target of 290 million metric tons of CO_2 ($MtCO_2$) by 2030, reaching a 34% renewable energy mix by 2030, and achieving net-zero in the power sector by 2050.

Although the JETP targets are not yet aligned with the Paris Agreement's goal, it is still an important opportunity for Indonesia to accelerate energy transition and open the possibility for early coal-fired power plants decommissioning. According to one of IESR analyses,[3] meeting the JETP goals under the current power system would require slashing 8.6 GW of coal power plants capacity in the PLN grid by 2030, less than the capacity required to meet the 1.5°C pathway.

This study hence explores potential interventions in some of Indonesia's coal-fired power plant pipelines and assesses their legal, financial, system resilience, energy security, and carbon emission reduction. The idea behind this assessment is that, given the average age of coal-fired power plants in Indonesia, including those currently in the pipeline, they will operate beyond the target year of 2045 or 2050. Meanwhile, early retirement of existing power plants in operation could be very costly given their long-term contract and nature of their PPA's terms. Therefore, intervention for individual plants in the pipeline, even cancellation of existing projects whenever possible, could produce a lower-cost carbon emission abatement and might contribute to meeting the target to reach peak emission by 2030 and net-zero emission by 2050. Types of interventions considered in the study include cancellation of planned CFPP, repurposing, and early retirement.

In order to find a suitable intervention for each plant, we began with listing all CFPPs in the pipeline and acquiring their technical and financial information. Then, we developed a multi-criteria system and conducted an analysis to identify coal-fired power plants that might be suitable for each intervention by evaluating and ranking them against multiple criteria, as seen in Table ES 1, including: how far advanced the project is, commercial terms for power purchasing (where available), completion date, recent progress, project owner, and system condition. In addition, we conducted a legal and regulatory analysis to figure out the options available from a legal and regulatory perspective.

Table ES 1. Multi-Criteria Analysis (MCA) scoring system

Criteria				Score
Status of the project development	Project owner + system condition	Planned COD	Status progression update	
Procurement	PLN + oversupply[4]	>2025	Not progressing for the last 2 years	1
Financing	PLN + normal			0.75
PPA or construction progress <30%	IPP + oversupply/ normal	2023-2025	Progressing for the last 2 years	0.5
Construction progress 30-50%	PLN + undersupply[5]			0.25
Construction progress >50%	IPP + undersupply	<2023	Progressing for the last 1 year	0

[3] This is an IESR internal assessment that was carried out specifically based on the request from the MEMR within the context of coal power plants retirement plan under Presidential Regulation 112/2022. Note that this analysis also does not consider captive power plants.

[4] Oversupply for Java-Bali system: reserve margin >35%; Oversupply outside Java-Bali system: reserve margin >40% (Source: PLN, 2021)

[5] Undersupply: reserve margin <25%

The main finding of this exercise is that nine coal-fired power plants, accounting for a total of 2,928 MW of capacity, could be cancelled out of a total of 13,822 MW in the current pipeline. These are predominantly projects that are at the financing stage or have failed to secure financing. Another 220 MW of plant, particularly ones with a stoker-type boiler, was identified as having the potential for repurposing, potentially into a 100% biomass power plant, provided that the local biomass supply chain exists or is feasible to develop and that fuel can be produced sustainably.

The total direct cost of cancelling these 2,928 MW power plants is USD 238 million, based on the estimated capital spending on the projects so far. The potential avoided emissions from cancelled projects is estimated at 460 $MtCO_2$ based on the conservative assumption that these plants would have run up to 2050. This means that the cost of carbon reduction is less than USD 0.52 for every tonne of CO_2 avoided.

To understand the impact of cancellations on power system reliability, cost of electricity and affordability were analyzed through power system analysis using PLEXOS. Projects that are most likely to be cancelled would then undergo a system-level analysis to figure out the technical and economic effects of cancelling them on the power system's operation using indicators such as system costs and supply security.

Since PLN's power systems are not interconnected, we developed models for seven regions, which are Java, Sumatra, Kalimantan, Sulawesi, West Nusa Tenggara, East Nusa Tenggara, Maluku, and Papua. Each region consists of several nodes representing the general load distribution within the region. For the Java-Bali system, the modelling nodes are in accordance with PLN's distribution of control centres, while for the Sumatra, Kalimantan, and Sulawesi, three nodes are assumed. For the remaining regions, each node will represent each island because there is no interconnectivity between these islands at the moment. The MEMR projection estimates that the demand for electricity in the systems will be 303 TWh by 2022. By the end of 2050, the total electricity demand will increase to 1,026 TWh.

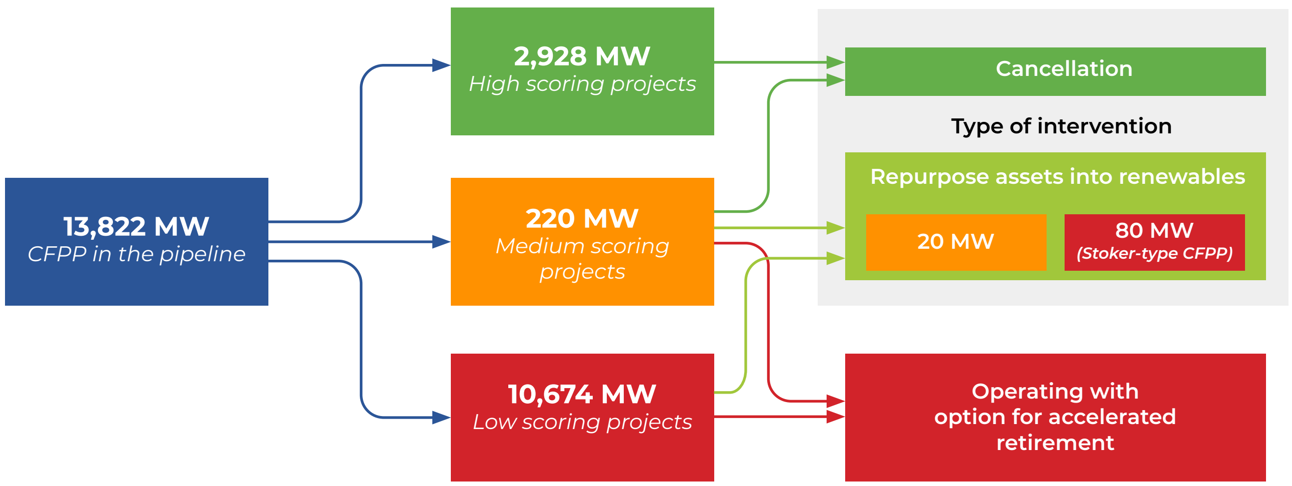


Figure ES 2. Types of intervention for CFPP in the pipeline as result of MCA outcome

To enrich the analysis, several scenarios were assessed in the power system simulation. PLN's RUPTL 2021–2030 is used as the baseline scenario, assuming that all CFPPs and other planned power plants will operate on schedule as indicated in the document. We developed two intervention scenarios: the first scenario solely considers the cancellation of 2,928 MW of CFPP in the pipeline, while the second scenario considers both the 2,928 MW CFPP cancellation and early retirement of the rest of the CFPPs in the pipeline. The early retirement of CFPPs means they can only run for 20 years. As for the rest of the CFPPs in the system, they will be retired naturally based on the MEMR projection.

By analyzing and comparing the results of the first intervention scenario (CFPP cancellation only) with the business-as-usual (BAU), the study found that natural gas power plants increased their generation to replace some of the power loss from the CFPPs. One of the reasons is because most of the cancelled CFPPs are in the Jawa-Bali grid, which is experiencing overcapacity at the moment. Thus, there are already sufficient existing power plants in the grid that could simply ramp up their output. This scenario is preferred since it incurs lower cost for the system[6] operator compared to investing in a new (renewable) power plant.

Table ES 2. Summary for cost impact of interventions

	Value (Present Value 2023)
Intervention 1 (Cancellation)	
Cancellation Cost for 2,928 MW	USD 238 million
Intervention 1: Additional System Cost	USD 2.54 billion
Total Cost	**USD 2.78 billion**
Total Cost without considering system cost	**USD 238 million**
Intervention 2 (Cancellation & Early Retirement)	
Cancellation Cost for 2,928 MW	USD 238 million
Early Retirement Cost for 10,894 MW	USD 2.2 billion
Additional System Cost	USD 3.01 billion
Total Cost	**USD 5.45 billion**
Total Cost without considering system cost	**USD 2.44 billion**

In the cancellation and early retirement scenario, there will be a higher increase in the generation of existing coal and gas power plants to maintain reliability. Moreover, since generating electricity from gas power plants is more expensive than coal, the increased utilization of gas power plants would lead to an increase in the system cost. However, after 2040, as the penetration of RE increases with a very low, even close to zero, marginal generation cost of RE, the electricity generation cost will become lower than the BAU. This will in turn also reduce the gap in the total system cost between scenarios. The NPV cumulative system cost increase until 2050 compared to BAU is USD 2.54 billion and USD 3.01 billion for the first and second scenario, respectively.

[6] The system cost consists of total cost of operation/generation as well as investment depreciation for a given time.

For both intervention scenarios, total emission reductions also differ from potential mitigated emissions due to increased coal and gas generation from the plants that are still in the system. In the first scenario, the cumulative reduction of emissions from the power system operation amounted to 295 $MtCO_2$, or 36% lower than the calculated potential of avoided emissions of around 460 $MtCO_2$. Similarly, in the second scenario, we observed a 35.5% reduction from the potential avoided emissions. However, we could see the potential of early integration of renewables to maximize the avoided emissions, therefore lowering the mitigation cost (USD/tonne CO_2). Early integration of renewables would potentially accelerate the decline in the cost of RE investment in the country (due to economy of scale and RE learning curve) and thus, resulted in a lower system cost in the long run.

Overall, the cancellation of CFPP in the pipeline still results in the lowest cost per tonne of CO_2, that is around USD 0.52-0.8/tonne CO_2 (Without system cost). However, the combination of the cancellation of 2,928 MW of coal plants in the pipeline and the early retirement of 10,894 MW of coal plants still provides considerably low mitigation costs in the range of USD 2.52-3.92/tonne CO_2. In comparison, we calculated the mitigation cost from the announced potential asset sale and early retirement of CFPP Pelabuhan Ratu of PLN and PT Bukit Asam (PT BA), which is around USD 6.57/tonne CO_2.

Table ES 3. Cost comparison for 2 scenarios with Pelabuhan Ratu

Mitigation Measures	Cost per Avoided CO_2 Emissions
Pipeline intervention: 2,9 GW cancellation (range of cost is for scenarios with calculated and realization of emission)	USD 0.52-0.8/tonne CO_2
Pipeline intervention: 2,9 GW cancellation + 10,9 GW early retirement (range of cost is for scenarios with calculated and realization of emission)	USD 2.52-3.92/tonne CO_2
Pelabuhan Ratu CFPP: 3 x 350 MW early retirement plan (calculated emission)	USD 6.57/tonne CO_2

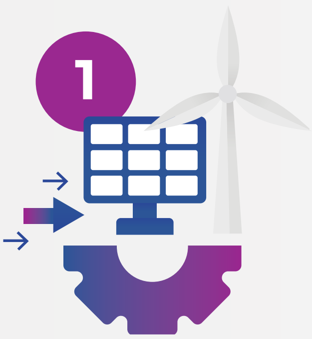
There is a potential legal risk for cancelling the project, especially for the government of Indonesia and PLN as the state-owned utility, as evidenced by a case that happened in 2020, when the Ministry of Energy and Mineral Resources (MEMR) removed the Kaltelseng-3 CFPP project from the 10-year Electricity Capacity Expansion Plan of PLN (RUPTL). As a result, the owners sued the government and won the lawsuit although no actual construction happened. This case should serve as a lesson learned prior to making any further cancellations.

This legal risk must be considered when making the decision to cancel a project pipeline. Therefore, each proposed cancellation must have strong evidence that the project could not continue due to the owner's failure to meet necessary milestones and timelines as indicated in the agreement, and prior engagement and negotiation with the project’s owner must be established to obtain their consent.

Conclusion and recommendation

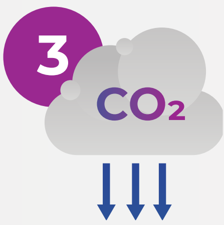
Compared to the early retirement of an operating coal plant, the option of cancelling coal plants in the pipeline is considered the least expensive. The cancellation of the existing pipeline is also beneficial to the government's goal of reaching the power sector's emission peak by 2030 and reaching net zero by 2050. For PLN, cancelling the planned CFPP could prevent more fossil infrastructure lock-in. It also allows the utility to plan more ambitious renewable energy projects toward 2030 that could accelerate the utility's business transformation away from fossil fuel assets. Adding more renewables to the energy mix could help reduce the average generation costs of utilities, especially in the long term.

However, on the other side, there are few incentives for IPP to cancel the project. IPPs would enjoy a long-term PPA with PLN, with a higher take-or-pay (ToP) and guaranteed return on investment. From PLN's side, the move to request a cancellation could be perceived as an effort to breach the contract, which should be avoided. Therefore, as an external party to the contract, the government should assist the effort of the utility to communicate the option in the first place by a series of measures:



Under a certain regulation, the government directs PLN to conduct a thorough review on the status of each IPP's project and identify the most recent status of each project. Projects that do not reach financial close should be immediately notified that they may be cancelled, and no extensions should be granted. The requirement for PLN to communicate and negotiate with the owner of the IPP project in the pipeline to cancel the project is included in this regulation. Alternatively, depending on the system's condition, PLN can provide project owners with the option of replacing coal plants with renewables that suit the needs of the system.

The government provides the public with information on the status of each coal project in the pipeline as a means of mobilizing public support for cancellation and communicating benefits offered to the public by taking such action.



Referring to Presidential Regulation No. 112/2022, the government issued a regulation that stipulated a target for reaching the power sector emission peak by 2030 and net-zero by 2050 or sooner and requested PLN and all utilities to prepare respective plans to reduce coal plant capacity. This regulation could serve as the foundation for PLN and all utilities to develop a strategy for addressing coal projects in their pipelines.

Furthermore, to make the proposed interventions discussed in this study feasible, additional research in the following topics is required:

1. Alignment with the JETP target (which is not yet considered in this study) and thus expansion of the intervention to include all power sectors (existing CFPP in operation owned by PLN, IPP, or even captive and Private Power Utility/PPU ones). MEMR is conducting a similar analysis for its roadmap; thus, combining this analysis with the other ongoing works could provide an overall view of the power sector emission pathway and evaluate this pathway against the JETP target.

2. Analysis and recommendations for CFPP mitigation options in the captive and PPU sectors.

3. The non-cancellation options considered so far were only on the repurposing into biomass power plants and early retirement. Additional options, such as biomass co-firing, flexible operation, and repurposing into thermal energy storage, should also be considered in the expansion of this study.

4. To fully understand the viability of the CFPP-to-100% biomass conversion option, investigation of potential biomass resources in the acceptable proximity of the CFPP location must be followed by a feasibility study. The study could also be expanded to include captives and PPU/Private Power Utility, which are not covered by PLN's RUPTL.

5. Detailed analysis of the condition and evolution of each power system (Java-Bali, Sumatera, Kalimantan, etc.) and, on that basis, support the development of a pipeline of renewable energy projects that would allow immediate replacement of the retired/cancelled CFPPs. The availability of ready-to-develop or even bankable renewables projects could boost the government and PLN's confidence in implementing CFPP intervention options.

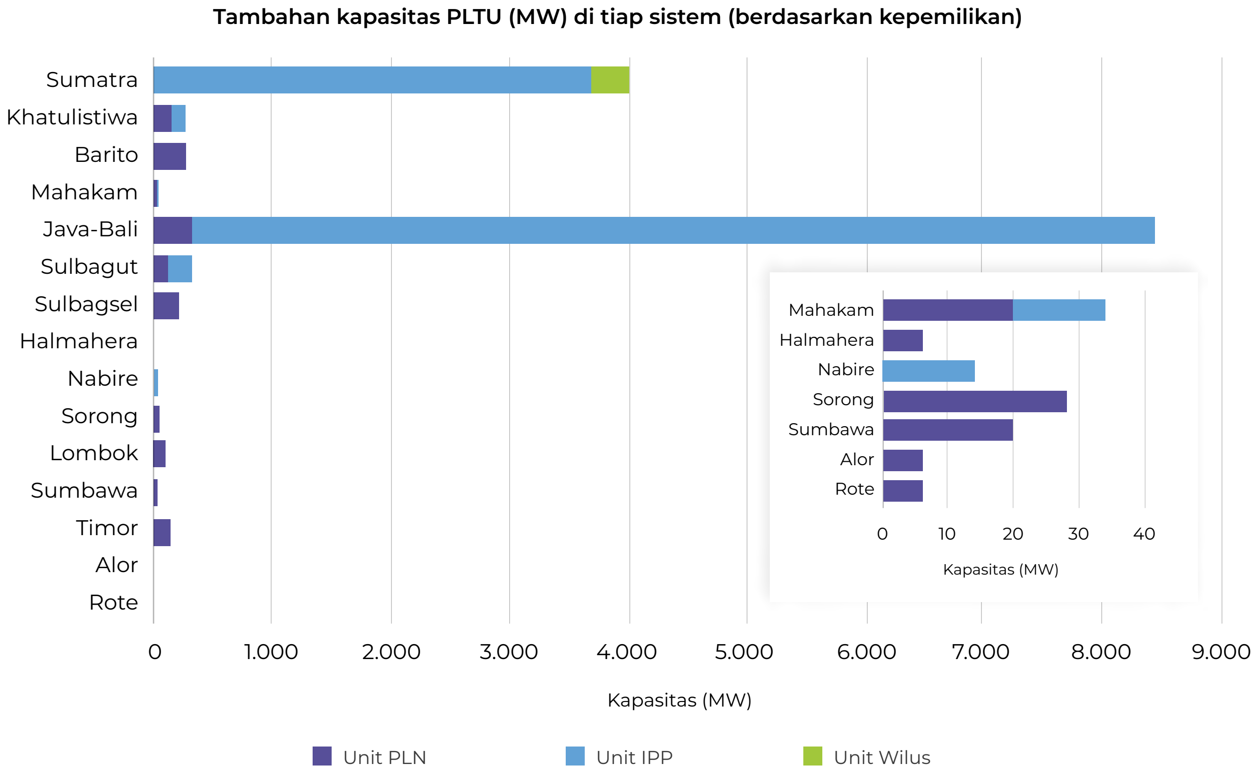
6. A grid stability analysis with decreasing dispatchable power plant capacity and increasing Variable Renewable Energy (VRE) to debunk the need for gas in the power system with increasing VRE.

7. Analysis of combined legal and financial structuring for implementing the three above-mentioned options (CFPP cancellation, 100% biomass conversion for CFPP, and early retirement).

Ringkasan Eksekutif

Untuk memenuhi target Persetujuan Paris diperlukan penghentian operasi pembangkit listrik tenaga batubara secara bertahap pada tahun 2040 secara global. Hal ini menimbulkan tantangan yang signifikan bagi Indonesia, yang telah meningkatkan pembangunan PLTU batubara selama dua dekade terakhir dan saat ini sedang menghadapi permintaan energi yang terus meningkat. Sejak tahun 2006, di tengah krisis energi dan kebutuhan pertumbuhan ekonomi, pemerintah Indonesia mengembangkan pembangkit listrik melalui tiga program percepatan: Program *Fast Track* I (2006–2009), Program *Fast Track* II (2010–2014), dan 35 Gigawatt (2015–2019), dengan PLTU batubara sebagai pembangkit listrik utama.

Akibatnya, kapasitas PLTU batubara melonjak, dan pada tahun 2022, sekitar 67%[1] listrik Indonesia berasal dari pembakaran batubara. Pada tahun 2022, kapasitas terpasang PLTU batubara Indonesia telah mencapai 44,6 GW. Angka tersebut diperkirakan akan meningkat seperti yang ditunjukkan dalam RUPTL 2021–2030, rencana terbaru PLN untuk memperluas penyediaan listriknya. PLN mengusulkan penambahan kapasitas PLTU sebesar 13.822 MW sebelum tahun 2030. Sayangnya, permintaan listrik tumbuh jauh lebih lambat dari perkiraan peningkatan kapasitas pembangkit selama lima tahun terakhir. Kondisi ini menyebabkan kelebihan kapasitas di sistem Jawa-Bali dan Sumatera, terutama sejak tahun 2020, karena hanya sedikit penyesuaian yang dilakukan pada rencana perluasan kapasitas pembangkitan.



Gambar RE 1. Distribusi 13,8 GW PLTU dalam *pipeline* di sistem PLN

Hal ini berlawanan dengan konteks transisi energi vital yang banyak didiskusikan baru-baru ini, yang membutuhkan pengurangan kapasitas PLTU batubara di Indonesia secara signifikan. Analisis oleh IESR dan University of Maryland (2022) menemukan bahwa 9,2 GW batubara harus diakhiri secara bertahap dari jaringan utilitas milik negara (PLN) sebelum tahun 2030 dan semua pembangkit batubara harus diakhiri secara bertahap paling lambat pada tahun 2045 agar Indonesia berada di jalur yang sesuai Persetujuan Paris, yaitu memenuhi target kenaikan suhu global maksimal pada level 1,5°C[2].

[1] Realisasi Q1 tahun 2023: 67% (Sumber: Kementerian ESDM, komunikasi pribadi, 18 Mei 2023)
[2] Analisis IESR dan UMD (2022) hanya mempertimbangkan pembangkit listrik yang terhubung ke jaringan listrik. Emisi dari pembangkit listrik captive belum termasuk dalam jalur tersebut.

Pemerintah Indonesia telah membuat komitmen untuk menghapus batubara secara bertahap sebagai sarana untuk mencapai tujuan Persetujuan Paris dan telah menyatakan perlunya dukungan internasional untuk melakukannya. Selain *Energy Transition Mechanism* (ETM) yang diluncurkan pada COP-26, selama KTT G20, Indonesia dan negara-negara *International Partner Group* (IPG) menandatangani kesepakatan *Just Energy Transition Partnership* (JETP), yang bertujuan untuk memenuhi target emisi puncak sektor ketenagalistrikan sebesar 290 juta metrik ton CO_2 ($MtCO_2$) pada tahun 2030, mencapai bauran energi terbarukan sebesar 34% pada tahun 2030, dan mencapai *net-zero emissions* di sektor ketenagalistrikan pada tahun 2050.

Meskipun target JETP belum selaras dengan tujuan Persetujuan Paris, hal ini masih merupakan peluang penting bagi Indonesia untuk mempercepat transisi energi dan membuka kemungkinan penghentian operasi PLTU batubara lebih awal. Menurut salah satu analisis IESR[3], untuk memenuhi target JETP di bawah sistem tenaga listrik saat ini, akan membutuhkan pengurangan 8,6 GW kapasitas PLTU batubara di jaringan PLN pada tahun 2030, lebih kecil dari kapasitas yang dibutuhkan untuk mencapai target 1,5°C.

Oleh karena itu, studi ini mengeksplorasi potensi intervensi pada beberapa PLTU batubara yang masuk dalam perencanaan pengembangan di Indonesia dan menilai dari aspek hukum, keuangan, ketahanan sistem, keamanan energi, dan pengurangan emisi karbonnya. Gagasan di balik penilaian ini adalah mengingat usia rata-rata PLTU di Indonesia, termasuk yang sedang dalam proses pengembangan, akan beroperasi melebihi target tahun 2045 atau 2050. Sementara itu, pengakhiran operasi PLTU yang sudah beroperasi bisa sangat mahal mengingat kontrak jangka panjangnya dan sifat ketentuan PPA-nya. Oleh karena itu, intervensi untuk masing-masing proyek dalam perencanaan, bahkan pembatalan proyek yang ada jika memungkinkan, dapat menghasilkan pengurangan emisi karbon dengan biaya lebih rendah dan dapat berkontribusi pada pemenuhan target untuk mencapai emisi puncak pada tahun 2030 dan emisi *net-zero* pada tahun 2050. Jenis-jenis intervensi yang dipertimbangkan dalam studi ini meliputi pembatalan PLTU yang direncanakan, pengalihan tujuan, dan pengakhiran operasional secara dini.

Untuk menemukan intervensi yang sesuai untuk setiap proyek, kami mulai dengan mendaftar semua PLTU dalam perencanaan dan memperoleh informasi teknis dan keuangannya. Kemudian, kami mengembangkan sistem multi-kriteria dan melakukan analisis untuk mengidentifikasi PLTU yang mungkin sesuai untuk setiap intervensi dengan mengevaluasi dan memberi peringkat berdasarkan beberapa kriteria, seperti yang terlihat pada Tabel RE1, termasuk: sejauh mana proyek tersebut telah berjalan, persyaratan komersial untuk pembelian daya (jika tersedia), tanggal penyelesaian, kemajuan terkini, pemilik proyek, dan kondisi sistem. Selain itu, kami melakukan analisis hukum dan regulasi untuk mengetahui opsi yang tersedia dari perspektif hukum dan regulasi.

Tabel RE 1. Sistem penilaian dengan analisis multi-kriteria

Kriteria				Skor
Status pengembangan proyek	Pemilik proyek + kondisi sistem	Rencana COD	Update perkembangan status	
Pengadaan	PLN + *oversupply*[4]	>2025	Tidak ada kemajuan selama 2 tahun	1
Pembiayaan	PLN + normal			0,75
PPA atau pembangunan <30%	IPP + *oversupply*/ normal	2023-2025	Ada kemajuan dalam 2 tahun	0,5
Pembangunan 30-50%	PLN + *undersupply*[5]			0,25
Pembangunan >50%	IPP + *undersupply*	<2023	Ada kemajuan dalam 1 tahun	0

[3] Ini adalah penilaian internal IESR yang dilakukan secara khusus berdasarkan permintaan dari Kementerian ESDM dalam konteks rencana pemensiunan pembangkit listrik tenaga batu bara di bawah Peraturan Presiden 112/2022. Perlu dicatat bahwa analisis ini juga tidak mempertimbangkan pembangkit listrik *captive*.

[4] Kelebihan pasokan untuk sistem Jawa-Bali: reserve margin >35%; Kelebihan pasokan di luar sistem Jawa-Bali: reserve margin >40% (Sumber: PLN, 2021)

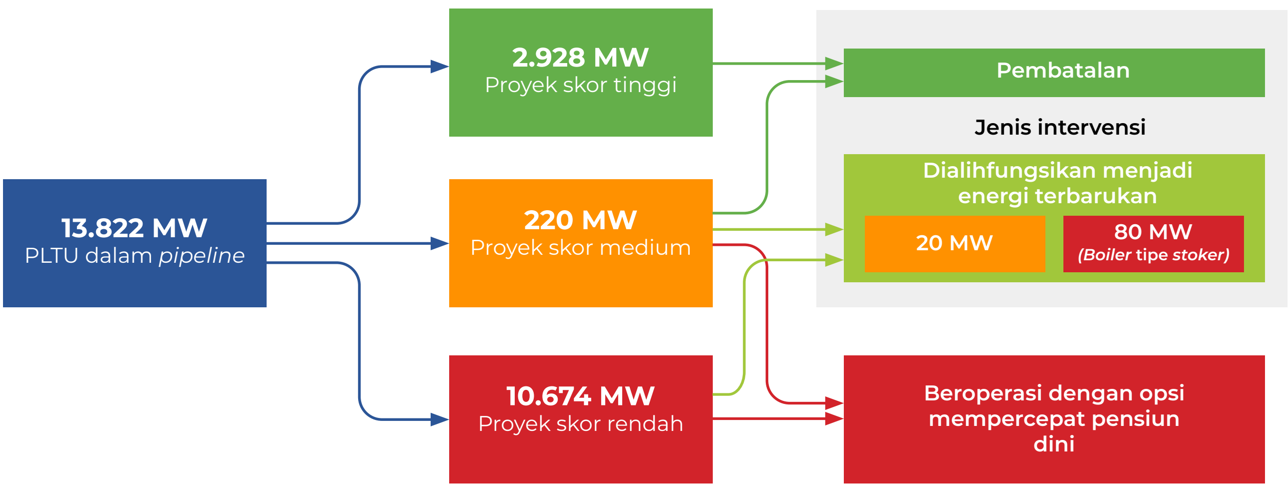
[5] Kekurangan pasokan: margin cadangan <25%

Temuan utama dari analisis ini adalah bahwa sembilan PLTU batubara, dengan total kapasitas 2.928 MW, dapat dibatalkan dari total 13.822 MW dalam perencanaan saat ini. Proyek-proyek tersebut sebagian besar adalah proyek yang berada pada tahap pembiayaan atau telah gagal mendapatkan pembiayaan. Pembangkit listrik 220 MW lainnya, terutama dengan *boiler* tipe *stoker*, diidentifikasi memiliki potensi untuk dialihfungsikan menjadi pembangkit listrik biomassa 100%, asalkan rantai pasokan biomassa lokal ada atau layak untuk dikembangkan dan bahan bakar dapat diproduksi secara berkelanjutan.

Total biaya langsung untuk membatalkan pembangkit listrik 2.928 MW ini adalah sebesar USD 238 juta, berdasarkan perkiraan belanja modal untuk proyek-proyek tersebut sejauh ini. Potensi pencegahan emisi dari proyek yang dibatalkan diperkirakan sebesar 460 $MtCO_2$ berdasarkan asumsi konservatif bahwa pembangkit listrik ini akan beroperasi hingga tahun 2050. Hal ini berarti bahwa biaya pengurangan karbon kurang dari USD 0,52 untuk setiap ton CO_2 yang dihindari.

Untuk memahami dampak pembatalan terhadap keandalan sistem ketenagalistrikan, biaya listrik dan keterjangkauan dianalisis melalui analisis sistem kelistrikan menggunakan PLEXOS. Proyek-proyek yang kemungkinan besar dibatalkan kemudian akan menjalani analisis tingkat sistem untuk mengetahui dampak teknis dan ekonomi dari pembatalan tersebut pada operasi sistem kelistrikan dengan menggunakan indikator seperti biaya sistem dan keamanan pasokan.

Karena sistem kelistrikan PLN tidak saling terhubung, kami mengembangkan model untuk tujuh wilayah, yaitu Jawa, Sumatera, Kalimantan, Sulawesi, Nusa Tenggara Barat, Nusa Tenggara Timur, Maluku, dan Papua. Setiap wilayah terdiri dari beberapa *node* yang mewakili distribusi beban secara umum di wilayah tersebut. Untuk sistem Jawa-Bali, *node* pemodelan sesuai dengan distribusi pusat kontrol PLN, sedangkan untuk wilayah Sumatera, Kalimantan, dan Sulawesi, diasumsikan ada tiga *node*. Untuk wilayah lainnya, setiap node akan mewakili setiap pulau karena saat ini belum ada interkonektivitas antar pulau. Proyeksi Kementerian ESDM memperkirakan bahwa permintaan listrik di sistem tersebut akan mencapai 303 TWh pada tahun 2022. Pada akhir tahun 2050, total permintaan listrik akan meningkat menjadi 1.026 TWh.



Gambar RE 2. Jenis Intervensi untuk PLTU Berdasarkan Hasil Analisis Multi Kriteria

Untuk memperkaya analisis, beberapa skenario dikaji dalam simulasi sistem tenaga listrik. RUPTL PLN 2021–2030 digunakan sebagai skenario dasar, dengan asumsi bahwa semua PLTU batubara dan pembangkit listrik lain yang direncanakan akan beroperasi sesuai jadwal seperti yang ditunjukkan dalam dokumen tersebut. Kami mengembangkan dua skenario intervensi: skenario pertama hanya mempertimbangkan pembatalan 2.928 MW PLTU batubara yang sudah direncanakan, sedangkan skenario kedua mempertimbangkan pembatalan 2.928 MW PLTU batubara dan penghentian operasional lebih awal bagi PLTU lainnya yang ada dalam perencanaan. Pengakhiran operasional PLTU secara dini berarti PLTU batubara hanya bisa beroperasi selama 20 tahun. Sedangkan untuk PLTU lainnya dalam sistem akan dipensiunkan secara alami berdasarkan proyeksi Kementerian ESDM.

Dengan menganalisis dan membandingkan hasil skenario intervensi pertama (pembatalan PLTU saja) dengan skenario *business-as-usual* (BAU), studi ini menemukan bahwa pembangkit listrik tenaga gas meningkatkan pembangkitnya untuk menggantikan sebagian daya yang hilang dari PLTU. Salah satu alasannya adalah karena sebagian besar PLTU yang dibatalkan berada di jaringan Jawa-Bali yang saat ini mengalami kelebihan kapasitas daya. Dengan demikian, pembangkit listrik yang ada di jaringan dapat dengan mudah meningkatkan *output*-nya. Skenario ini lebih disukai karena menimbulkan biaya yang lebih rendah bagi operator sistem[6] dibandingkan dengan berinvestasi di pembangkit listrik baru (berbasis energi terbarukan).

Tabel RE 2. Rangkuman dampak biaya dari intervensi

	Nilai (*Present Value* 2023)
Intervensi 1 (Pembatalan)	
Biaya Pembatalan 2.928 MW	USD 238 juta
Tambahan Biaya Sistem	USD 2,54 juta
Total Biaya	**USD 2,78 miliar**
Total Biaya tanpa mempertimbangkan biaya sistem	**USD 238 juta**
Intervensi 2 (Pembatalan & Pensiun Dini)	
Biaya Pembatalan 2.928 MW	USD 238 juta
Biaya pensiun dini 10.894 MW	USD 2,2 miliar
Tambahan Biaya Sistem	USD 3,01 miliar
Total Biaya	**USD 5,45 miliar**
Total Biaya tanpa mempertimbangkan biaya sistem	**USD 2,44 miliar**

Pada skenario pembatalan dan pengakhiran operasional secara dini, akan terjadi peningkatan yang lebih tinggi pada pembangkit listrik batubara dan gas yang ada untuk menjaga kehandalan. Selain itu, karena menghasilkan listrik dari pembangkit listrik tenaga gas lebih mahal daripada batubara, peningkatan pemanfaatan pembangkit listrik tenaga gas akan menyebabkan peningkatan biaya sistem. Namun, setelah tahun 2040, seiring dengan meningkatnya penetrasi energi terbarukan dengan biaya pembangkitan marjinal sangat rendah, bahkan mendekati nol, biaya pembangkitan marjinal energi terbarukan akan lebih rendah dari BAU. Hal ini, pada gilirannya juga akan mengurangi kesenjangan dalam total biaya sistem antar skenario. Kenaikan biaya sistem kumulatif NPV hingga tahun 2050 dibandingkan dengan BAU masing-masing sebesar USD 2,54 miliar dan USD 3,01 miliar untuk skenario pertama dan kedua.

[6] Biaya sistem terdiri dari total biaya operasi/pembangkitan serta penyusutan investasi untuk waktu tertentu.

Untuk kedua skenario intervensi, total pengurangan emisi juga berbeda dari potensi emisi yang dapat dimitigasi karena peningkatan pembangkit listrik tenaga batubara dan gas dari pembangkit yang masih berada dalam sistem. Pada skenario pertama, pengurangan emisi kumulatif dari pengoperasian sistem ketenagalistrikan mencapai 295 $MtCO_2$, atau 36% lebih rendah dari potensi emisi yang dapat dihindari yang diperkirakan mencapai 460 $MtCO_2$. Demikian pula, dalam skenario kedua, kami mengamati pengurangan 35,5% dari potensi emisi yang dapat dihindari. Namun, kami dapat melihat potensi integrasi awal energi terbarukan untuk memaksimalkan emisi yang dihindari, sehingga menurunkan biaya mitigasi (USD/ton CO_2). Integrasi awal energi terbarukan berpotensi mempercepat penurunan biaya investasi energi terbarukan di Indonesia (karena skala ekonomi dan kurva pembelajaran/*learning curve* energi terbarukan) dan dengan demikian menghasilkan biaya sistem yang lebih rendah dalam jangka panjang.

Secara keseluruhan, pembatalan PLTU yang telah masuk perencanaan masih menghasilkan biaya terendah per ton CO_2, yaitu sekitar USD 0,52-0,8/ton CO_2 (tanpa biaya sistem). Namun demikian, kombinasi dari pembatalan 2.928 MW PLTU dan pengakhiran operasional secara dini 10.894 MW PLTU batubara masih memberikan biaya mitigasi yang sangat rendah di kisaran USD 2,52-3,92/ton CO_2. Sebagai perbandingan, kami menghitung biaya mitigasi dari potensi penjualan aset dan pengakhiran operasional secara dini PLTU Pelabuhan Ratu PLN dan PT Bukit Asam (PT BA), yaitu sekitar USD 6,57/ton CO_2.

Tabel RE 3. Perbandingan Biaya untuk 2 Skenario di Pelabuhan Ratu

Langkah Mitigasi	Biaya per CO_2 yang Dihindari
Intervensi: Pembatalan 2,9 GW (kisaran biaya untuk skenario dengan perhitungan dan realisasi emisi)	USD 0,52-0,8/ton CO_2
Intervensi: Pembatalan 2,9 GW + penghentian operasi dini 10,9 GW (kisaran biaya untuk skenario dengan perhitungan dan realisasi emisi)	USD 2,52-3,92/ton CO_2
PLTU Pelabuhan Ratu: penghentian operasi dini 3x350 MW (emisi yang dihitung)	USD 6,57/ton CO_2

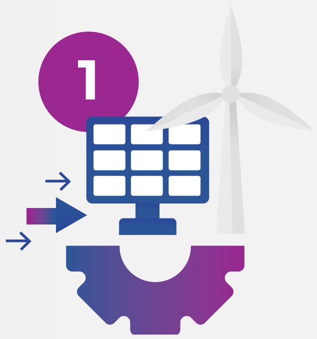
Terdapat potensi risiko hukum atas pembatalan proyek tersebut, terutama bagi Pemerintah Indonesia dan PLN sebagai BUMN, terbukti dengan kasus yang terjadi pada tahun 2020, ketika Kementerian Energi dan Sumber Daya Mineral (ESDM) mencabut Proyek PLTU Kaltelseng-3 dari RUPTL PLN. Akibatnya, pengembang menggugat pemerintah dan memenangkan gugatan meskipun sebenarnya tidak ada pembangunan yang terjadi. Kasus ini harus menjadi pelajaran sebelum melakukan pembatalan lebih lanjut.

Risiko hukum ini harus dipertimbangkan saat membuat keputusan untuk membatalkan proyek yang sudah disepakati. Oleh karena itu, setiap pembatalan yang diusulkan harus memiliki bukti kuat bahwa proyek tidak dapat dilanjutkan karena kegagalan pengembang untuk memenuhi target pekerjaan tertentu sesuai batas waktu yang disepakati dalam perjanjian kerjasama, serta komunikasi dan negosiasi dengan pemilik proyek harus dilakukan untuk mendapatkan persetujuan mereka.

Kesimpulan dan Rekomendasi

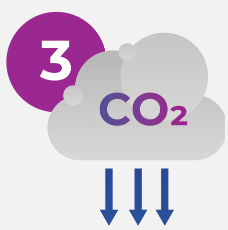
Dibandingkan dengan pengakhiran operasional secara dini pembangkit batubara yang sudah beroperasi, opsi untuk membatalkan pembangkit batubara yang masih dalam perencanaan dianggap pilihan paling murah. Pembatalan rencana pembangunan PLTU yang ada juga bermanfaat bagi tujuan pemerintah untuk mencapai puncak emisi sektor ketenagalistrikan pada tahun 2030 dan mencapai emisi nol bersih pada tahun 2050. Bagi PLN, pembatalan PLTU yang direncanakan dapat mencegah lebih banyak penguncian infrastruktur (*lock-in infrastructure*) fosil. Hal ini juga memungkinkan PLN untuk merencanakan proyek energi terbarukan yang lebih ambisius menuju tahun 2030 yang dapat mempercepat transformasi bisnisnya dari aset bahan bakar fosil. Menambahkan lebih banyak energi terbarukan ke dalam bauran energi dapat membantu mengurangi biaya pembangkitan rata-rata PLN, terutama dalam jangka panjang.

Namun di sisi lain, hanya ada sedikit insentif bagi IPP untuk membatalkan proyek tersebut. IPP akan menikmati PPA jangka panjang dengan PLN, dengan skema *take-or-pay* (ToP) yang lebih tinggi dan pengembalian investasi yang terjamin. Dari sisi PLN, langkah meminta pembatalan bisa dimaknai sebagai upaya wanprestasi yang harus dihindari. Oleh karena itu, sebagai pihak eksternal dalam kontrak, pemerintah harus membantu upaya PLN untuk mengomunikasikan opsi tersebut pertama-tama dengan serangkaian tindakan:



Di bawah peraturan tertentu, pemerintah mengarahkan PLN untuk melakukan kajian menyeluruh terhadap status setiap proyek IPP dan mengidentifikasi status terbaru dari setiap proyek. Proyek yang tidak mencapai *financial close* harus segera diberitahukan bahwa proyek tersebut dapat dibatalkan, dan tidak ada perpanjangan yang diberikan. Kewajiban PLN untuk berkomunikasi dan bernegosiasi dengan pemilik proyek IPP yang sedang dalam proses untuk membatalkan proyek tersebut, sudah termasuk dalam peraturan ini. Sebagai alternatif, tergantung pada kondisi sistem, PLN dapat memberikan opsi kepada pemilik proyek untuk mengganti pembangkit batubara dengan energi terbarukan yang sesuai dengan kebutuhan sistem.

Pemerintah memberikan informasi kepada publik tentang status setiap proyek PLTU batubara yang sedang direncanakan sebagai sarana untuk memobilisasi dukungan publik untuk pembatalan dan mengomunikasikan manfaat yang ditawarkan kepada publik dengan mengambil tindakan tersebut.



Mengacu pada Peraturan Presiden No. 112/2022, pemerintah mengeluarkan peraturan yang menetapkan target untuk mencapai puncak emisi sektor ketenagalistrikan pada tahun 2030 dan *net-zero* pada tahun 2050 atau lebih cepat, serta meminta PLN dan semua utilitas untuk menyiapkan rencana masing-masing untuk mengurangi kapasitas PLTU batubara. Peraturan ini dapat menjadi landasan bagi PLN dan semua perusahaan utilitas untuk mengembangkan strategi dalam menangani proyek batubara yang telah mereka rencanakan.

Selanjutnya, agar usulan intervensi yang dibahas dalam studi ini dapat dilaksanakan, diperlukan penelitian tambahan pada topik berikut:

1. Penyelarasan dengan target JETP (yang belum dipertimbangkan dalam studi ini) dan dengan demikian perluasan intervensi untuk mencakup semua sektor listrik (PLTU yang sudah beroperasi baik yang dimiliki PLN, IPP, atau bahkan perusahaan *captive* dan Pembangkit Listrik Swasta Terintegrasi/*Private Power Utility*, PPU). Kementerian ESDM sedang melakukan analisis serupa untuk peta jalannya; dengan demikian, menggabungkan analisis ini dengan pekerjaan lain yang sedang berlangsung dapat memberikan gambaran keseluruhan tentang jalur emisi sektor ketenagalistrikan dan mengevaluasi skenario ini terhadap target JETP.

2. Analisis dan rekomendasi opsi mitigasi PLTU di sektor *captive* dan PPU.

3. Opsi non-pembatalan yang dipertimbangkan sejauh ini hanya pada pengalihan tujuan (*repurposing*) menjadi pembangkit listrik tenaga biomassa dan pengakhiran operasional PLTU secara dini. Opsi tambahan, seperti *co-firing* biomassa, pengoperasian secara fleksibel, dan pengalihan fungsi menjadi penyimpanan energi panas, juga harus dipertimbangkan dalam perluasan studi ini.

4. Untuk memahami sepenuhnya kelayakan opsi konversi PLTU menjadi 100% biomassa, investigasi sumber daya biomassa potensial di dekat lokasi PLTU harus diikuti dengan studi kelayakan. Studi ini juga dapat diperluas untuk mencakup *captive* dan PPU/Pembangkit Listrik Swasta Terintegrasi, yang tidak tercakup dalam RUPTL PLN.

5. Analisis terperinci tentang kondisi dan evolusi masing-masing sistem kelistrikan (Jawa-Bali, Sumatera, Kalimantan, dan lainnya.) dan, atas dasar itu, mendukung pengembangan jalur proyek energi terbarukan yang memungkinkan penggantian segera PLTU yang dihentikan/dibatalkan. Ketersediaan proyek energi terbarukan yang siap dikembangkan atau bahkan *bankable* dapat meningkatkan kepercayaan pemerintah dan PLN dalam menerapkan opsi intervensi PLTU.

6. Analisis stabilitas jaringan dengan penurunan kapasitas pembangkit listrik yang dapat disalurkan dan peningkatan Variabel Energi Terbarukan (V*ariable Renewable Energy* - VRE) untuk menyanggah kebutuhan gas dalam sistem dengan peningkatan VRE.

7. Analisis kombinasi penataan hukum dan keuangan untuk menerapkan tiga opsi yang disebutkan di atas (pembatalan PLTU, konversi biomassa 100% untuk PLTU, dan pengakhiran operasional secara dini).

1 Background

In the latest enhanced NDC, Indonesia has updated its pledge on GHG emission reductions to 31.2% (unconditional) and 43.2% (conditional), relative to business as usual (BAU) by 2030. Being the second-largest contributor of GHG emissions in Indonesia, the energy sector, in particular, would see a reduction of 12.5% (unconditional) and 15.5% (conditional). The sector itself consists of several sub-sectors, including power generation, transportation, and energy use in industry and buildings. According to the latest Ministry of Environment and Forestry (MoEF) GHG inventory report, the power generation sub-sector contributes to 47.8% of GHG emissions in the energy sector (MoEF, 2022). Such a large contribution is understandably driven by the country's reliance on coal-fired power plants (CFPP), known to be the highest among fossil-based generation technologies in terms of CO_2 emissions[7] and covering almost 67% of Indonesia's energy generation mix in 2022 (MEMR, 2023). Hence, it comes as no surprise that the country's power generation sub-sector is constantly being scrutinized for decarbonization measures to achieve the predetermined emission reduction goals.

In line with this, the Ministry of Energy and Mineral Resources (MEMR) has developed a series of scenarios to reach net-zero emissions (NZE) in the power generation sector by 2060. In the scenario favored by the agency, CO_2 emissions are projected to peak at 488 $MtCO_2$ in 2030[8]. By 2045, a significant downfall in CO_2 emissions is propelled by the retirement of a large fleet of CFPP and combined-cycle gas turbines (CCGT), before being completely phased out in 2056, mainly due to the end of their natural operational lifetime.

Far from being ambitious, the scenario is still incompatible with the globally orchestrated pathways to maintain the average temperature below 1.5°C. A joint study by IESR and the University of Maryland shows that under a 1.5°C compatibility scenario, CO_2 emissions must already decline and peak before 2021 (Cui et al., 2022). CFPP, in particular, should be completely phased out by 2045. This includes accelerating the retirement of multiple CFPPs, thereby reducing the lifespan of CFPPs to just 20 years from the previous 30 years. It is rather an ambitious proposition, yet necessary, that consequently requires enormous mobilization of financing to carry out the accelerated retirement and expansion of renewable energy (RE) capacity, as well as the supporting infrastructure, such as transmission and distribution lines and energy storage.

During the G20 event, developed countries assembled under the International Partners Group (IPG) agreed upon a commitment to mobilize USD 20 billion over the next three to five years to support Indonesia's energy transition. The Indonesia JETP was then launched, announcing a joint commitment to peak Indonesia's power sector[9] emissions at 290 $MtCO_2$ by 2030, down from its baseline of 357 $MtCO_2$ and immediately declining to achieve the NZE by 2050, 10 years ahead of the government's plan. Another target to achieve through the partnership is to accelerate the deployment of RE, increasing its power generation share to at least 34% by 2030. A number of actions are formulated in accordance with these targets. Of particular relevance to the CFPP include the following:

1. CFPP early retirement with candidate units as prioritized and identified by the Government of Indonesia.
2. Restricting the development of captive CFPPs by offering zero-emission and RE-based alternative solutions, given the utter importance of balancing Indonesia's industrial development and economic growth and its commitment to net zero.
3. Freezing CFPPs in the existing pipeline, as stipulated in PLN's business plan, RUPTL 2021-2030.

[7] Emission factor for fossil-based power plants (Source: JCM, 2017),
- Coal: 795 tCO_2/kWh (for plant efficiency: 42%)
- Gas: 320 tCO_2/kWh (for plant efficiency: 61%)
- Diesel: 533 tCO_2/kWh (for plant efficiency: 49%)

[8] The emission figure has already included those coming from captive coal-fired power plants. (Source: MEMR, personal communication, 18 May 2023)

[9] The power sector includes: on-grid power, which refers to PLN business areas and off-grid power, which refers to captive/PPU powers, non-PLN business areas.

While being carried out, all of these actions must adhere to the Presidential Regulation (Perpres) No. 112/2022.

To date, the total installed capacity of CFPP in Indonesia is 44.6 GW[10]. According to the RUPTL 2021–2030, there will be an addition of 13.8 GW, which is currently in the pipeline, despite the large surplus of capacity, particularly in the Java–Bali system. It is estimated that without any intervention, an additional 87 $MtCO_2$ will be emitted into the atmosphere each year by 2030. Apart from being incompatible with the 1.5°C pathway, the addition would indeed put a burden on efforts to curb emissions toward achieving NZE in 2060 or earlier. In addition, it could also hold back the massive expansion of RE capacity in Indonesia.

With these concerns in mind, coupled with the need to implement actions consistent with JETP's joint commitment, this report examines CFPPs in the existing pipeline, i.e. RUPTL 2021-2030, in-depth, and serves as a basis for suitable interventions. The analysis carried out in this report will attempt to answer the following research questions:

1. What is the status of each unit in the project pipeline?
2. What is the appropriate intervention for each unit?
3. What are the costs and risks associated with the intervention from a legal point of view?
4. How will the intervention affect the power system, in terms of emissions, generation mix, and, most importantly, cost?
5. What sort of assistance is required from developed countries, e.g., G7 countries, in ensuring the success of intervening the project pipeline?

As the JETP is in the process of developing the Comprehensive Investment Plan (CIP), the work in this report comes with a hope that it could enrich and strengthen the analysis required to solidify the commitment mentioned earlier and therefore jumpstarting the energy transition in Indonesia.

[10] The figure includes installed capacity for captive usage, i.e. outside PLN business area. (Source: MEMR, personal communication, 18 May 2023)

2 Coal power plants in Indonesia

2.1. Coal development in the country's power system

Perceived as being cheap, mainly due to the abundance of the country's coal reserves[11] and the price capping policy that was introduced in 2018, it is not surprising to see that 67% of Indonesia's electricity comes from coal-fired power plants (CFPPs) (MEMR, 2023). Indonesia's CFPPs' installed capacity is also estimated to be 44.6 GW. The figure puts the country in sixth place in the global coal power ranking (GEM, 2022). The development itself has been carried out through three government-backed programs, namely Fast Track Programs 1 and 2 (FTP-1 and 2) in 2006–2014 and the 35,000 MW program, starting in 2015 as one of President Jokowi's infrastructure agenda. Cumulatively, these programs have catapulted the state-owned utility (PLN)'s generating capacity from 33,793 MW in 2014 to 48,346 MW in 2016, as depicted in Figure 1. It should be noted that the peak demand shown is a non-coincident one as it comes from the summation of the peak loads across a varying degree of power systems in Indonesia, each bearing its own characteristics[12].

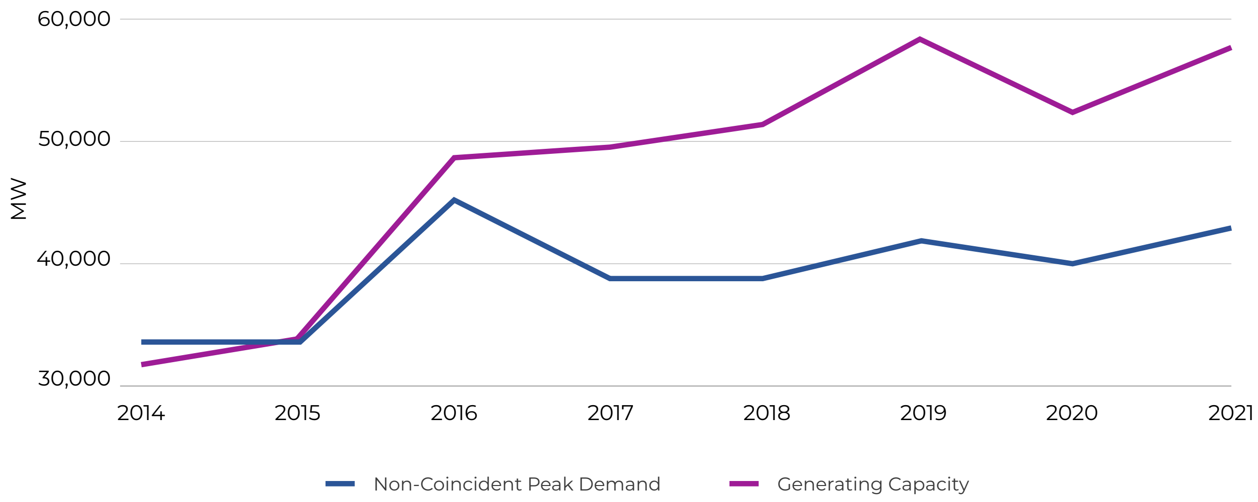


Figure 1. Comparison between the national generating capacity and non-coincident peak demand between 2014 and 2021 (Source: PLN Statistics Reports)

During the course of these programs, some CFPP projects, particularly those in the first two programs, faced significant delays, leading some of them to be terminated and replaced with renewables or other forms of power generation. Despite the measures, some of those plants still made their way into the 35,000 MW program. Nevertheless, in the latest state-owned utility company's business plan, PLN RUPTL 2021-2030, a few of these projects are included along with other units, giving the country's additional generating capacity from coal power plants of up to 13,822 MW (PLN, 2021). The addition is significantly less than the one planned in the RUPTL 2019–2028, which amounts to 27,063 MW.

Figure 1 also shows that the peak demand has averaged-annual growth of 4.6% since 2014. The gap between generating capacity, which has averaged-annual growth of 10%, and peak demand tends to widen toward 2021, suggesting a striking difference in the growth rates of the two. Even without considering the economic activity restrictions during the COVID-19 pandemic, the discrepancy between planning and

[11] Indonesia's coal reserves account for about 3.2% of total global reserves (BP, 2021).

[12] Hence, the calculation of the reserve margin cannot be done on the national scale, rather it should be quantified for each power system.

realization had been apparent. In more granular detail, the electricity supply within Indonesia's power systems reveals an alarming condition. Some of them experience supply beyond their ideal reserve margin[13]. An example of such a condition can be seen in the Java-Bali grid (Figure 2). The grid is currently oversupplied, with a reserve margin estimated at 49.99%, far higher than the normal reserve margin of 30%. PLN estimates that the oversupply condition could remain in place until 2028, with a potential increase of up to 61% (Bisnis, 2021).

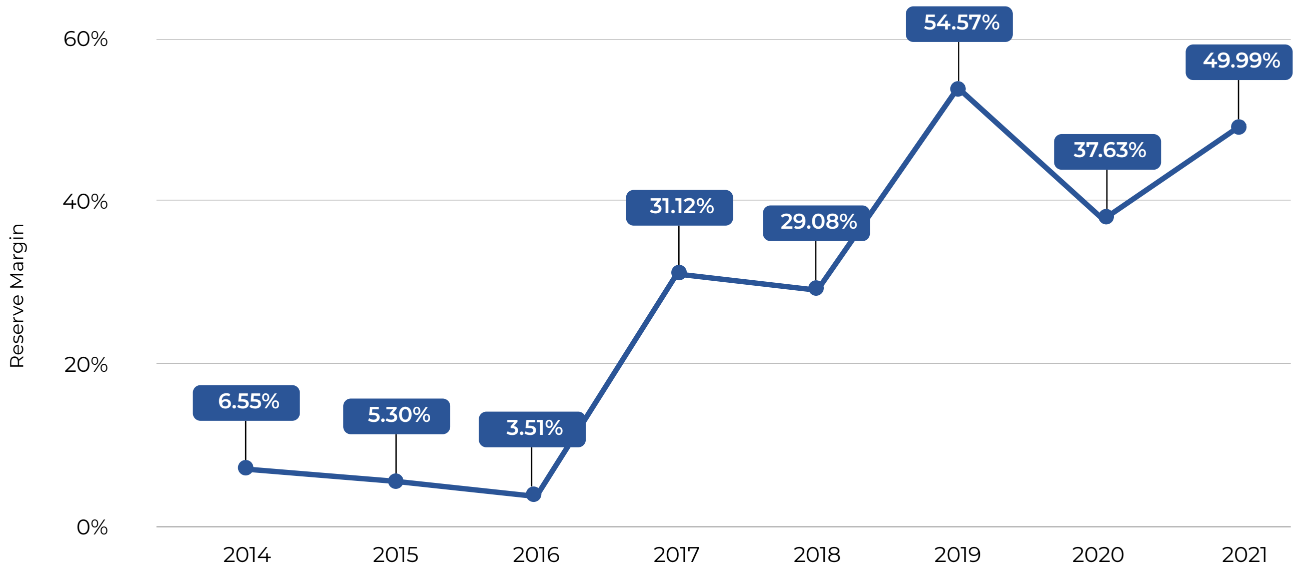


Figure 2. Historical trend of Java-Bali grid's reserve margin (Source: PLN Statistics Report)

The root cause lies in the assumptions made in the expansion plan. The recent 35,000 MW program was designed under optimistic projections assuming national economic growth of 7% and electricity demand growth of 8.7% (Deloitte, 2016; Guild, 2020). These exaggerations are in fact the Jokowi government's response to the previous administration's chronic power supply shortages, which has hampered investment, particularly in the manufacturing industries. Unfortunately, economic growth has not taken off from 5% since 2015. Contracted by the pandemic, economic growth instead declined sharply to -2.07% in 2020, before bouncing back to 3.69% in 2021 (Bappenas, 2022). Although the recovery has been positive, with the latest one reaching 5.31% in 2022 (BPS, 2023), the assumed economic growth for the 35,000 MW program remains unmet.

2.2. Reevaluating the generation expansion planning

Between 2019 and 2021, PLN made adjustments to the planned CFPP capacity. In RUPTL 2019, the CFPP generation capacity to build was 27.1 GW, but in RUPTL 2021 the capacity was reduced to 13.8 GW. About 8.6 GW was removed from the previous pipeline, with the remaining 4.7 GW confirmed to be operational at the time of writing. The decision to cancel some pipeline projects was mainly driven by the realization that CFPP's share of the generation mix had exceeded the maximum share stipulated in MEMR's National Electricity Planning, RUKN 2019-2038. The ministry then specifically requested PLN to reduce the CFPP additional capacity in its latest RUPTL by taking out projects listed as 'in planning'[14].

[13] 35% for the Java-Bali system and 40% for the remaining systems (Source: PLN, 2021)

[14] In the actual document, a few of the cancelled projects are listed as 'financing', 'procurement', 'in construction', and 'PPA'.

However, with the outbreak of the COVID-19 pandemic, PLN experienced a massive overcapacity, particularly in the Java-Bali grid, which caused trouble for PLN. As the contract with IPPs is based on take-or-pay with a high capacity factor, PLN has to absorb most of the demand growth risk. PLN has to pay IDR 3 trillion (USD 195.1 million) for each unutilized GW (CNBC, 2023). To prevent further losses due to unfulfilled targets in both the economic and electricity demand growths, intervening some of the projects in the pipeline seems to be a reasonable approach. Hence, intervention in the 13,822 MW of CFPPs in the country's project pipeline should be carefully considered by the government and PLN. Rather than facing the financial and socio-economic risks of significant stranded assets in the future, it may be a better option to stop the CFPP projects in the pipeline immediately and/or repurpose the already-built assets into renewable-based power generation.

Reducing the planned coal plants could also be seen as an effort to be in line with the 1.5°C pathway to reach the NZE goal earlier and, more importantly, to meet the nearest goal set by the Just Energy Transition Partnership (JETP), which is toreach power sector emission peak of 290 $MtCO_2$ by 2030 and increase the share of renewable energy to 34%. In another study, it was found that the key to meeting the 23% renewable energy mix goal set by the 2014 National Energy Policy at a lower cost is to quickly increase solar capacity while reducing coal plant generation (or at least running the coal plants more flexibly) (IEA, 2022).

The goal of this study was to figure out which CFPP project to intervene and what kind of intervention to make. To achieve this purpose, the study applied a few criteria and metrics related to the development of a typical CFPP project to evaluate each project. Then, the results of the assessment were used to estimate the cost to intervene in each project and the amount of potential emissions to avoid. In addition, a high-level legal analysis was conducted to see the legal opportunities from existing regulations as well as the legal challenges to either cancel or repurpose an ongoing project.

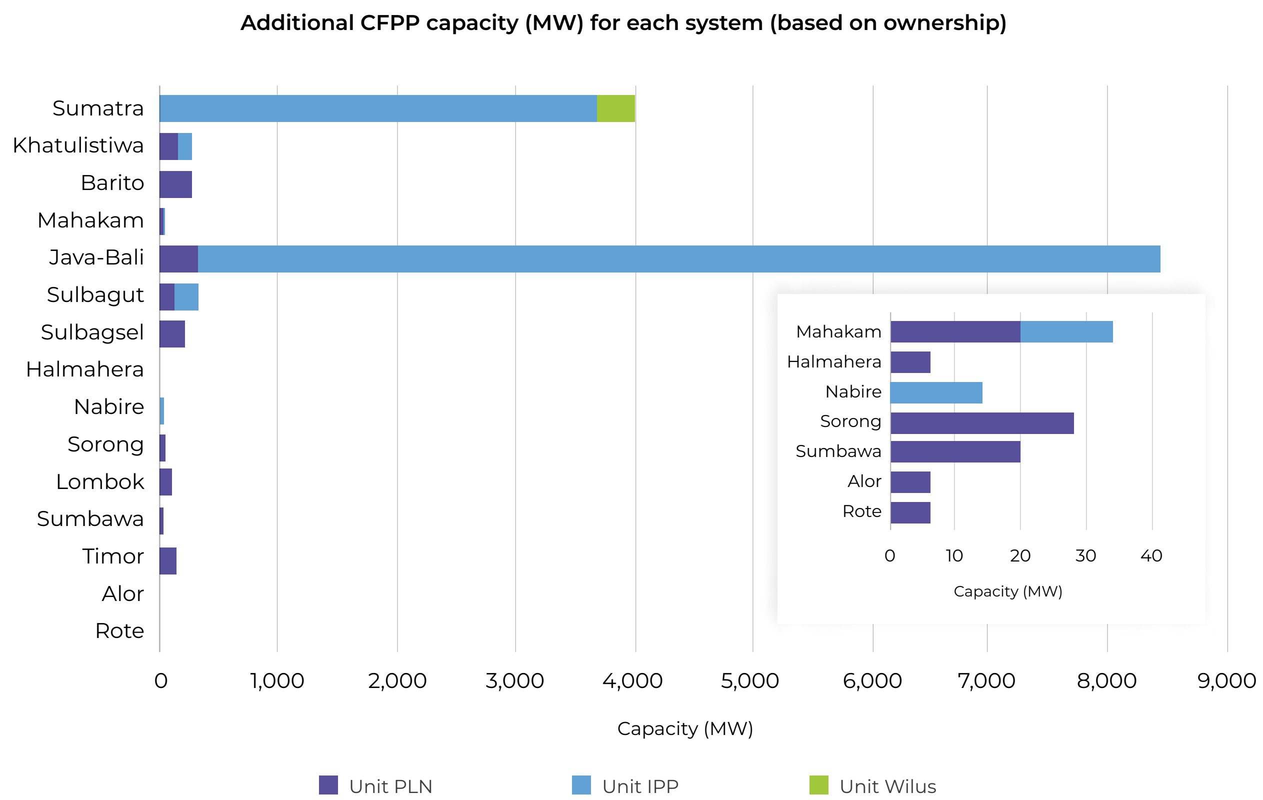
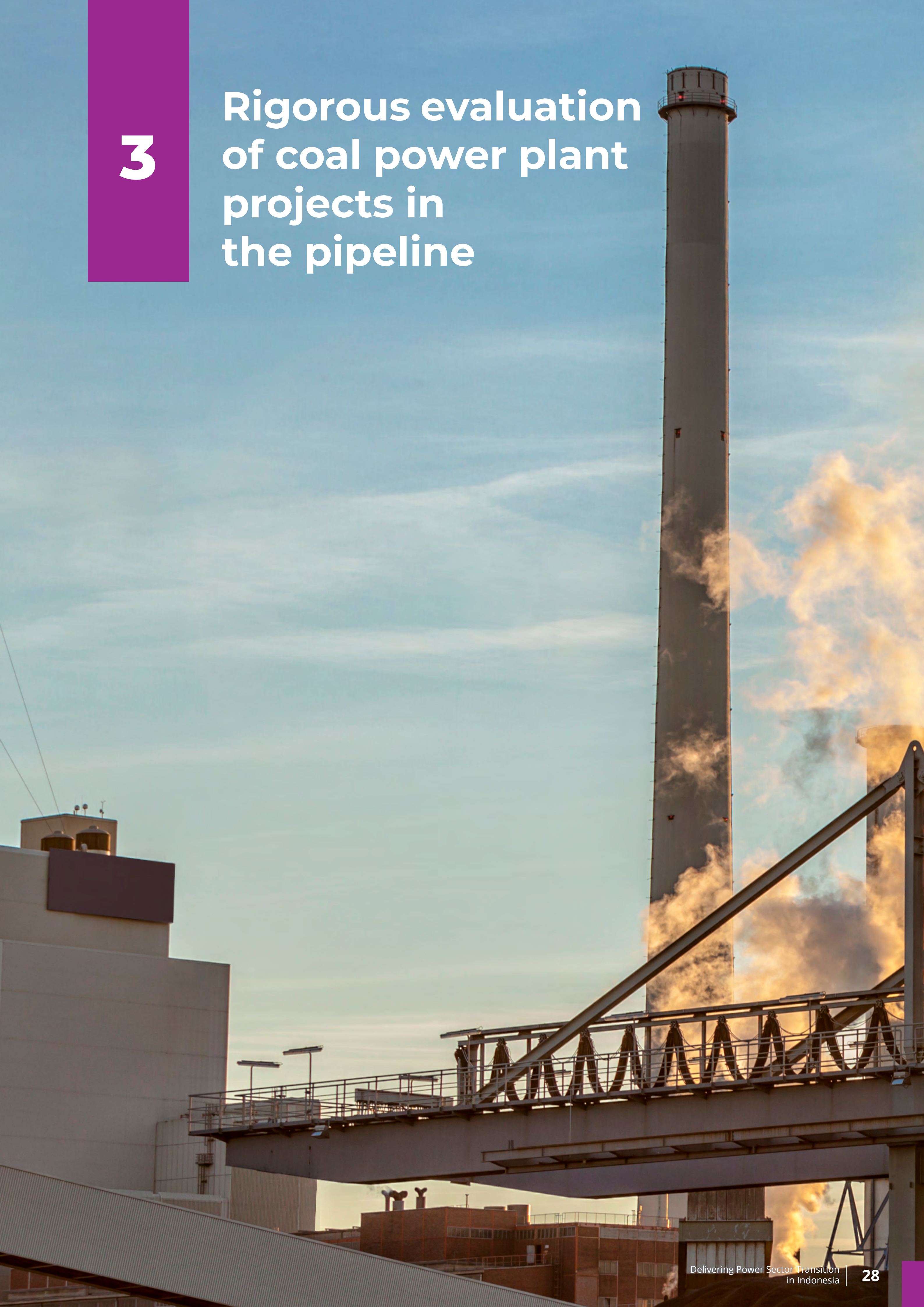


Figure 3. CFPP Pipeline 2021 - 2030 (inset: systems with total capacity addition below 50 MW)

The intervention was also analyzed from the perspective of the power system, quantifying its impact on system costs and potential emission reductions at the system level. Therefore, included in the analysis was the effect of the intervention on the generation cost and the share of renewables that could be introduced to the power system as a replacement for intervened projects. Lastly, from all the outcomes, this study formulated several recommendations required to ensure the success of intervening the CFPP pipeline projects.

3 Rigorous evaluation of coal power plant projects in the pipeline



By looking at each project in the pipeline, it was found that these projects are not all the same, depending on where they are in the development process and how they will affect the power system in which they are located. This report looked at how much the intervention might cost and whether it would affect how the system works if implemented. To begin, projects eligible for intervention are identified. Each CFPP project listed in the PLN's most recent RUPTL was given an initial score using a Multi-Criteria Analysis (MCA) scoring system that showed how likely it is to be intervened. Once the projects were scored, they would be ranked and put into groups based on the options for intervention, such as cancelling or reusing assets. To complete the analysis, CO_2 emissions, costs, and legal consequences at the plant level were also looked at.

3.1. Assessing decarbonization options for coal power plant projects in the pipeline

3.1.1. Identifying each project in the pipeline

Populating background information, such as power plant technical specifications (capacity, steam-cycle technology, boiler-type, COD, etc.), asset shareholders, investment cost, and source of financing of each project, served as the first activity of this step. Complete information about each project is provided in Appendix C. The study also looked into the status of each project to see if there are ways to cancel one or more projects at the best cost or even use the asset for something else, especially if the project was already well along in the construction process.

For this step, information was gathered from public sources like PLN's RUPTL 2021–2030, PLN and its subsidiaries' financial and especially annual reports, research repositories at other institutions, and news stories in mainstream media. Also, satellite imagery was used to estimate the most recent physical progress of a project, especially for those that had already started building.

This approach is especially crucial for projects that may not have visible signs of progress that the public can see. A sampling of the patterns can be observed in Figure 4. Professionals were asked about the physical steps needed to build a power plant, and the results are shown in Table 1. So, putting together the two, i.e., the structural and physical construction milestones, would help figure out how far along the project is right now, which is how the scoring for MCA works. All satellite images are available in Appendix D.

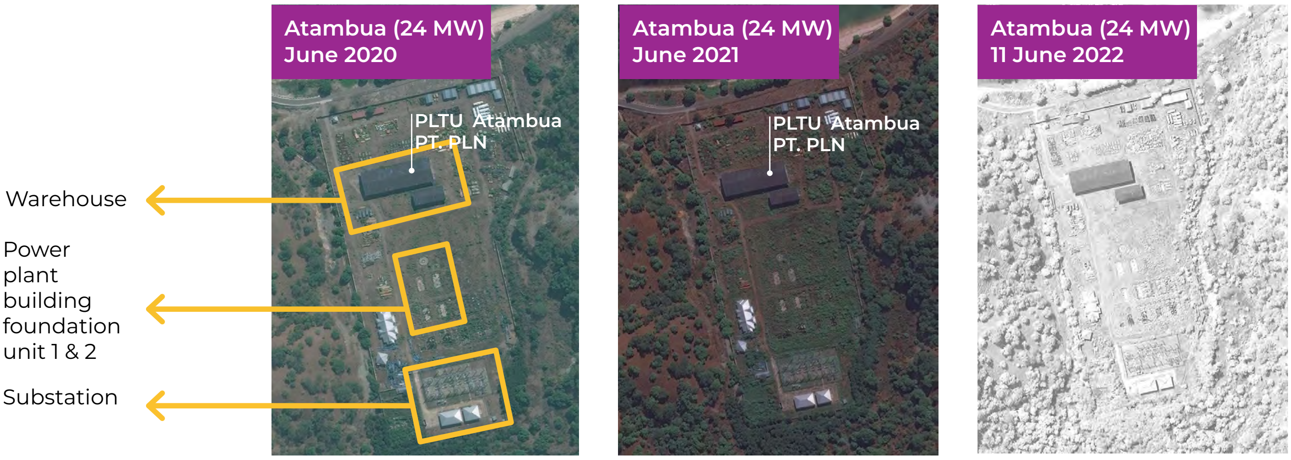


Figure 4. Atambua 24 MW CFPP satellite imageries

Table 1. Reference on construction physical milestones

Construction Progress Range	Physical Milestones
<30%	land clearing, power plant buildings foundation
30% - 50%	stack, buildings steel structure, coal yard and processing area
51% - 70%	building construction complete to house large types of machinery, e.g. steam turbine, boiler, generator, installation
>70%	back feeding, flushing, commissions

3.1.2. MCA scoring system

The next part of this step is to assess and then score each project in terms of intervention possibility based on four criteria: the status of the project's development, project ownership and system condition, planned COD, and status progression update. Each criterion has been given a different set of metrics, as observed in Table 2.

Table 2. The MCA scoring system

Criteria				Score
Status of the project development	Project owner + system condition	Planned COD	Status progression update	
Procurement	PLN + oversupply[15]	>2025	Not progressing for the last 2 years	1
Financing	PLN + normal			0.75
PPA or construction progress <30%	IPP + oversupply/ normal	2023-2025	Progressing for the last 2 years	0.5
Construction progress 30-50%	PLN + undersupply[16]			0.25
Construction progress >50%	IPP + undersupply	<2023	Progressing for the last 1 year	0

Each metric bears a different score, ranging from 0 to 1. A metric score of 1 indicates that the project has a high probability for intervention, while a metric score of 0 indicates the opposite. A project with a "procurement" status, for instance, would score 1 for the corresponding criterion, as it is considered still in the early phases of project development. Thus, the intervention would be relatively straightforward. Correspondingly, a project with a "planned COD" of 2026 would also score 1 due to the relatively sufficient time to process any possible ramifications from the intervention. The status of the project was also considered in the scoring assessment. A project with no notable change, in terms of status or construction stage[17], for the last two years would then score 1. In one criterion, the project owner (PLN or IPP) is weighted by the current power system's condition (see Appendix F). Since the CFPP project pipeline is a natural part of PLN's RUPTL, any interference with PLN-owned projects is more likely to happen than with IPP projects. Hence, a project falling under the "PLN + oversupply" metric would then score 1.

[15] Oversupply for Java-Bali grid: reserve margin >35%; Oversupply outside Java-Bali grid: reserve margin >40%
[16] Undersupply: reserve margin <25%
[17] Satellite images from at least three consecutive years were extracted to assess the progress of the construction stage.

The composite score for each project was then obtained by taking the average of these criteria. The score was further normalized, resulting in the final score that ranges between 0 and 1. Based on the normalized score, projects were then ranked and grouped based on the probability of intervention, namely high, medium, and low. Sensitivity analysis was also conducted by applying a different amount of weighting factors to each criterion to see how well the ranking and grouping of the projects match up. The outcome of the sensitivity analysis is presented in Appendix E.

3.1.3. Plant-level analyses

Intervention options

This study proposed several intervention options. Depending on how each project's score adds up, the options would be either to cancel the project or change the project to generate power from renewable sources. In terms of renewable resources, the technical potential of renewables in the area where the project is located is taken into account when repurposing the project. The assessment was further complemented with other information, such as the boiler technology[18] planned to be used in the project, obtained from the exercise performed earlier. Lastly, projects that are already well underway in the construction process would not be considered for intervention, with a few exceptions that will be explained in the analysis of the results. Nevertheless, this study mainly proposed an early retirement for non-cancellable projects.

Cost estimation

In general terms, Figure 5 depicts how power plant projects are financed and the major steps in the development and construction phases. During the development phase, activities carried out are assumed to be financed by the equity of the project owner. In more advanced stages, the financing would come from the debt owed to lenders. Usually, this would be the case once the project reaches the construction phase. It is also safe to assume that some of the early construction phase milestones (such as land clearing, storage space, and support buildings) still rely on equity financing in a project with a high share of equity. It is important to know the most up-to-date status of the project's financing (or how far along it is in construction), as projects that have not involved lenders might have a better chance of being stopped or cancelled, since only the parties in the PPA contract would be involved in the negotiation.

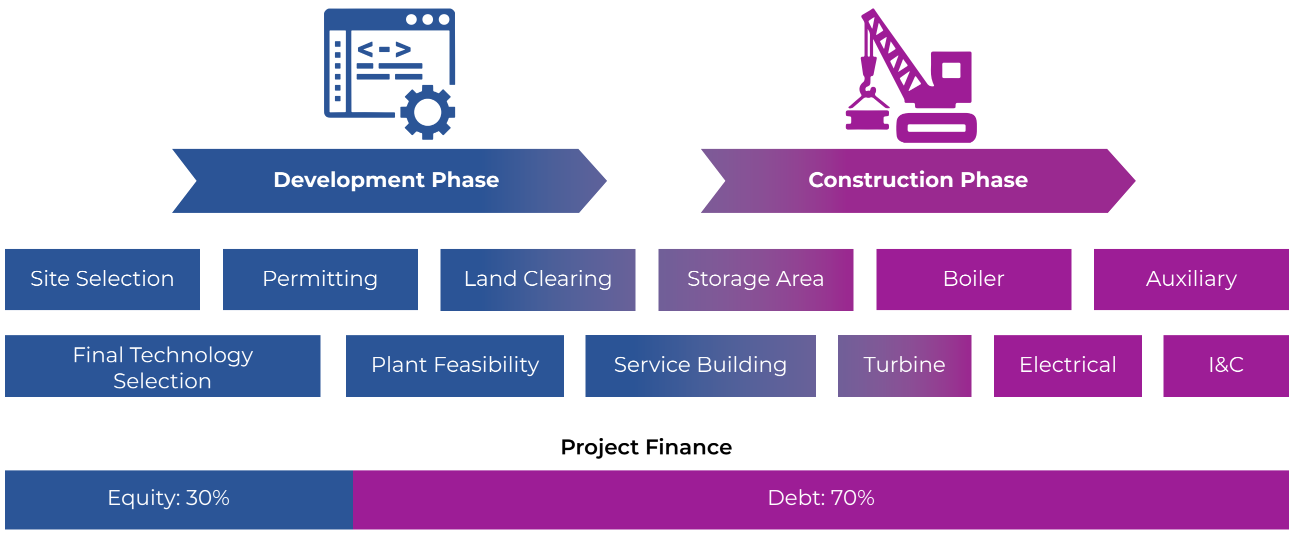


Figure 5. Assumed project financing structure supplemented by key milestones

[18] Pulverized coal (PC), circulating fluidized bed (CFB), and stoker boilers.

Plant-level cost estimation figures out how much capital is needed to compensate for the intervened projects. The estimate was formulated by looking at the amount of CAPEX, equity, and/or debt that has been spent on the project so far and comparing it to the project's latest progress. This study assumed that the CAPEX spending follows the S-curve profile according to the project management rule of thumb as illustrated in Figure 6. Nevertheless, some adjustments were made to the CAPEX spending profile to accommodate some of the spending remarks based on construction progress as presented in Table 3. The remarks were developed based on the physical milestones, as seen in Table 1, formulated from interviews with professionals in the power plant project development.

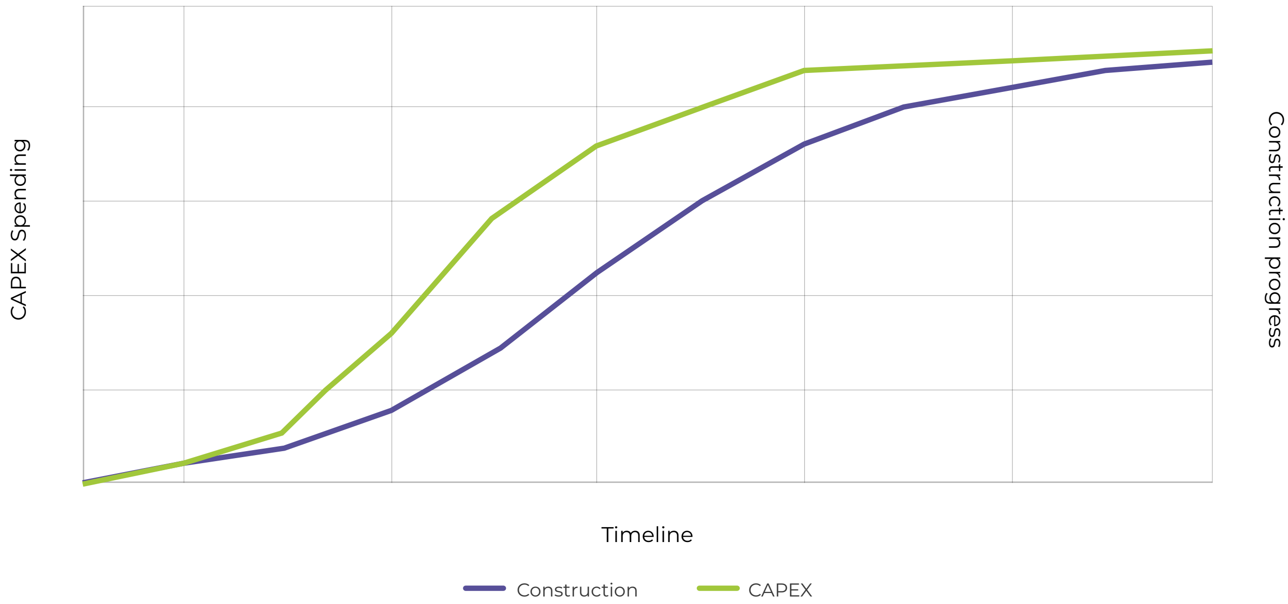


Figure 6. CAPEX spending and construction progress assumed profiles

Table 3. Assumed CAPEX spending remarks

Construction Progress Range	CAPEX Spending Remarks
<30%	CAPEX spending rate may still be linear with the rate of the construction progress
30% - 50%	As large machinery will start to be installed after 50% of progress, the procurement could have started within this stage of construction; cash outflow could be large
51% - 70%	Large machinery will start coming to the construction site, hence the spending rate is slowing down
>70%	CAPEX is spent on the remaining construction of supporting facilities, such as plant road or access road

Additional costs for early retirement were also estimated, especially for the non-cancellable projects. Their calculation was performed by taking the difference between the natural and early retirement NPV of each asset's depreciation (assuming linear depreciation). In this case, the natural retirement was set to match the asset's designed lifetime, which is 30 years, while the minimum guaranteed lifetime for early retirement was set to 20 years (Cui et al., 2022). The difference was then presented as today's present value. To carry out the NPV calculation, the initial investment is indispensable. Since this information was not available for some projects, the initial investment was estimated using a nominal investment figure from MEMR's Technology Data Catalogue (2021).

Legal analysis

Furthermore, the study also conducted an analysis of the current legal and regulatory framework on the implementation of the above-mentioned intervention options, with the support of a legal expert. The goal is to find out if the proposed options can fit into the current legal and regulatory framework and, if they cannot, to make high-level recommendations about the legal and regulatory framework. After carefully reviewing the legal and regulatory framework and the status of the on-going coal projects, options and cost estimates for cancelling or repurposing the project can be made.

Avoided CO_2 emissions

In order to perform the analysis, CO_2 emissions of the project that was intervened were first estimated. As the projects were not yet built or in operation, some of the technical parameters were assumed. These include the availability factor (AF), plant efficiency, carbon content, and gross calorific value. The formulas used in the calculation of power plant emissions are shown below. The order indicates the step in the calculation.

$$\text{Plant yearly generation } (MWh_{el}) = 8760 \text{ (hours)} * AF * \text{Plant capacity } (MW) \quad \textbf{Equation 1}$$

$$\text{Plant yearly thermal input } (MWh_{th}) = \frac{\text{Plant yearly generation } (MWh_{el})}{\text{Plant efficiency } (\%)} \quad \textbf{Equation 2}$$

$$CO_2 \text{ emissions factor } \left(\frac{\text{gram } CO_2}{kWh_{th}}\right) = \frac{\text{Carbon content } (\%) * \frac{44}{12} * 1000 \left(\frac{\text{gram } CO_2}{\text{gram coal}}\right) * 1.162 \times 10^{-3} \left(\frac{kcal}{kWh_{th}}\right)}{GCV\left(\frac{kcal}{\text{gram coal}}\right)} \quad \textbf{Equation 3}$$

$$\text{Plant yearly } CO_2 \text{ emissions (mil. tonnes)} = \frac{\text{Plant yearly thermal input } (MWh_{th}) * CO_2 \text{ emissions factor } \left(\frac{\text{gram } CO_2}{kWh_{th}}\right)}{10^9 \left(\frac{\text{gram } CO_2 MWh_{th}}{\text{mil.tonnes } kWh_{th}}\right)} \quad \textbf{Equation 4}$$

The next part of the emission analysis quantified the potential amount of emissions being avoided. Two scenarios were developed, each assigned to the cancellable and non-cancellable projects, respectively. Both scenarios were imposed on the mandate of adhering to 2050 as the deadline for all operating CFPPs, as stipulated in Article 3 of Perpres 112/2022. Similarly, another scenario was made for projects that could be stopped from being built and projects that could not be stopped from being built but were to operate for no more than 20 years. In this case, the avoided emissions were the sum of each project's emissions for the remaining years after its supposed COD year or accelerated retirement year, 2050. These projects were probably allowed to go forward, and the total amount of pollution they would cause over their guaranteed lifespans was also measured.

3.2. Overview of the coal power plant projects in the pipeline

A few characteristics of the CFPP project can be summarized from the background information (see Appendix C for details). Most of the installed capacity and approximately 88% of the projects in the pipeline were developed by IPP (see Figure 3). The remaining 9.8% and 2.2% are shared between PLN and another electricity business concession holder (Wilayah Usaha or Wilus), respectively[19]. As most PLN's projects are small units with a capacity below 60 MW, with the highest being 315 MW, its aggregate capacity is lower than IPP's. On the other hand, the IPP is mostly building units that can produce between 300 MW and 1000 MW. In terms of system allocation, a lot of CFPP capacity is being added to the Sumatra and Java-Bali systems, which make up 28.9% and 61.2%, respectively, of the total planned capacity in the pipeline. The remaining systems only see a miniscule CFPP capacity increase.

Based on the share of built capacity, Indonesian companies like PLN have the most, followed by Japanese and Chinese companies, as presented in Figure 7. Japan and China have played an important role in the development of the CFPP in Indonesia.

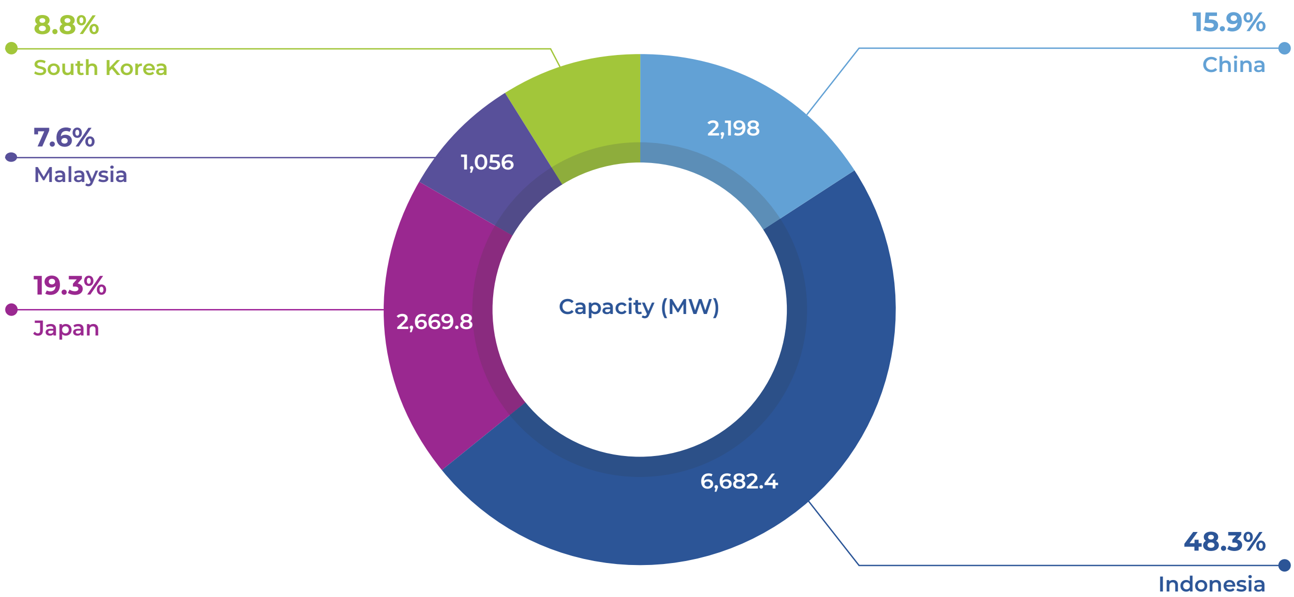


Figure 7. Share of additional CFPP capacity by project shareholders' country

Many coal plant projects are currently in the construction phase at different stages, as visualized in Figure 8. Some units are marked as "delayed" for several reasons. These units are mostly still being built or have just started to sell electricity beyond their initial COD year stated in PLN RUPTL 2021–2030. In some projects, the delay was intentional due to several reasons, for example, due to the oversupply of the system in which these units are planned to be commissioned, as in the case of the 2x950 MW Batang CFPP and 2x1000 MW Jawa-4 CFPPs. Having completed their construction, these power plants operations were intentionally delayed due to the overcapacity that lingers in the Java-Bali grid, reaching as high as 49.9% (see Figure 2). Delay in the arrival of the transmission line is another reason for such a decision for other units, as in the case of the 14 MW Tanjung Selor power plant. At the time of the completion of the power plant, Tanjung Selor - Tanjung Redep 150 kV transmission line was still being built. The line finally reached its completion in mid-2022.

[19] A private electricity company contracted to allow some of its electricity to be utilized on PLN's grid.

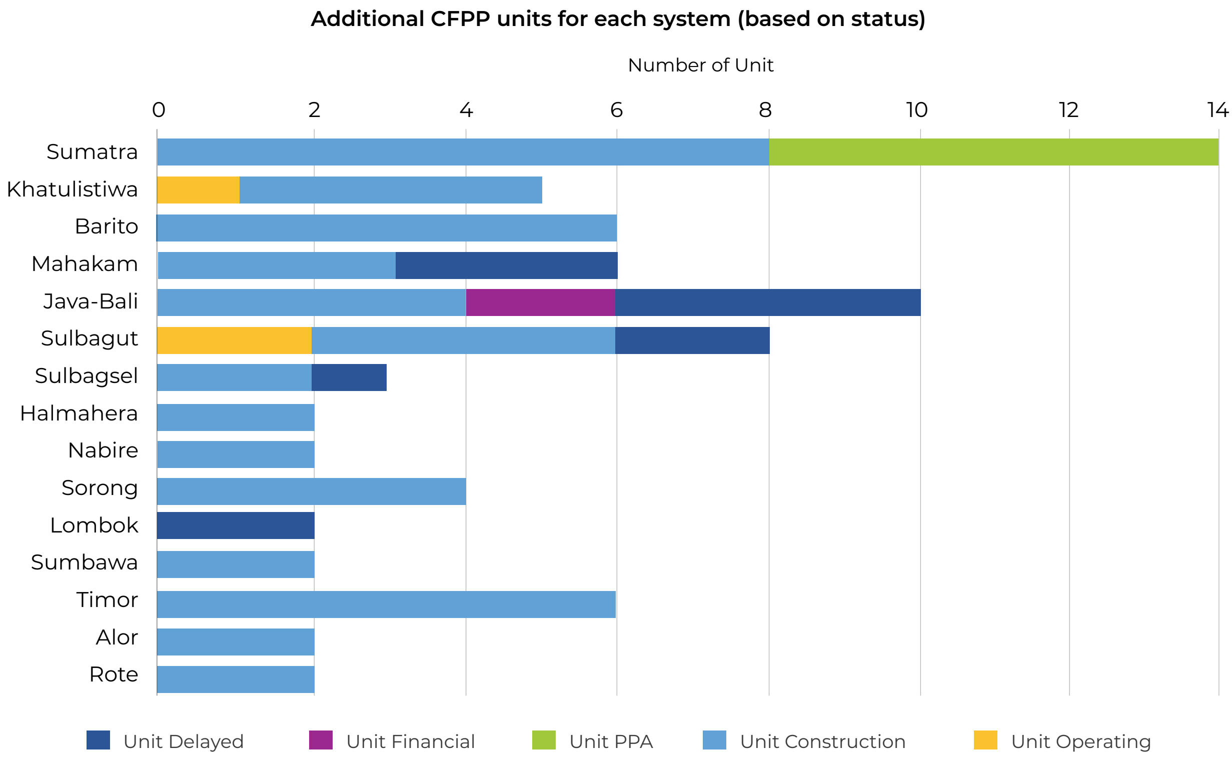


Figure 8. Current status of the additional units in Indonesia's power systems according to RUPTL 2021-2030

3.3. Analysis results and proposed list of interventions: cost and CO_2 emissions avoided/reduction)

Through rigorous data collection and MCA scoring, the result is categorized into three groups: low, medium, and high. The scores range from 0 to 1, with 0 meaning that there is a low chance of intervention and 1 meaning the opposite. Figure 9 shows the aforementioned score grouping. A complete list of the projects along with their MCA scoring is available in Appendix D.

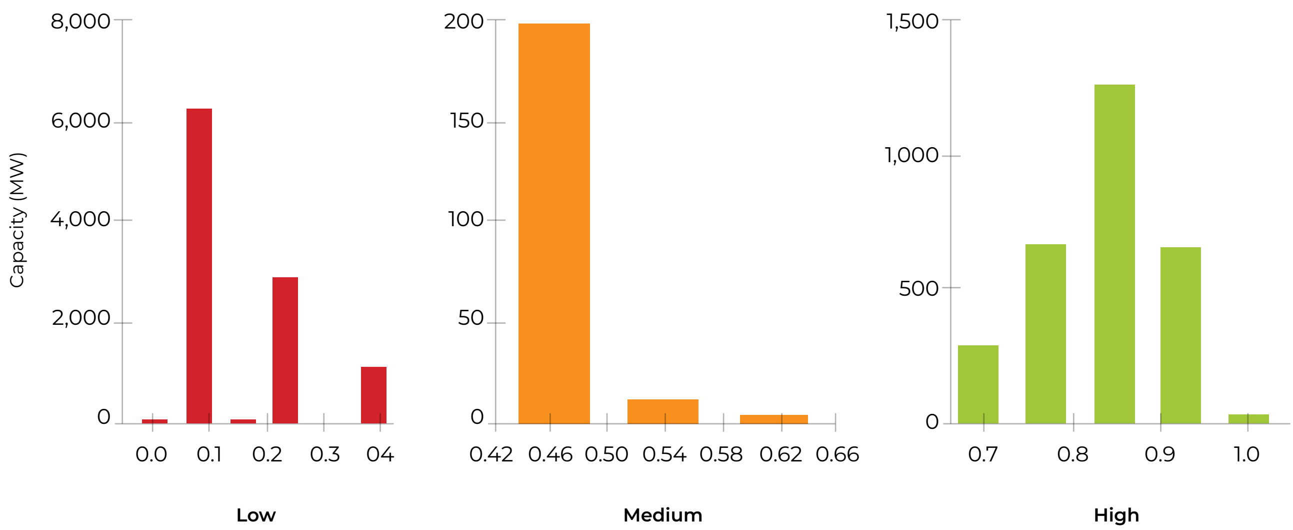


Figure 9. Grouping of the MCA scoring outcome: low (red), medium (orange), and high (green)

The analysis has identified approximately 10,674 MW of pipeline projects that are unfeasible to intervene in and are grouped in the low group. Cancellation of these projects will incur high costs and be a lengthy process that involves many parties, not only developers but also project sponsors and financiers. Therefore, this study suggests that these plants be built and operated, but there should be a way to early retire them 20 years later.

Projects included in this group scored low during the MCA scoring with various causes. The majority of them are already in an advanced construction stage, i.e., above 50% of the construction process. Some have even already been operating, with a few of them starting the plants after receiving the green light from the higher-ups in PLN[20].

On the other hand, projects indicated as having difficulty securing the funding required for its construction are grouped in the high category. The construction progress of the remaining high-scoring projects is less than 30%, and no significant progress has been observed for some projects from the satellite imagery of the past 2 to 3 years.

Among the projects that have been evaluated, a few are in the medium group and add up to 220 MW. These projects could be intervened in or run with an option for early retirement. From satellite images taken over the past few years, we can see that the construction progress of some projects is between slightly lower than 30% and slightly higher than 30%, and that important physical milestones have been reached. Because of this, even if these projects are in the medium group, they are less likely to be intervened. The rest of the projects in the group might be able to be intervened in, either because the progress of their construction stage is unclear or because they have not moved forward in the last two years. This study recommends the regulating authority to look at the progress of projects' construction and PLN to make sure that construction or COD deadlines don't get pushed back too far.

3.3.1. Proposed options for the pipeline projects: intervention and/or to operate with an option for early retirement

Based on the scoring laid out earlier, this study suggests three options for each group of clustered projects to be considered for the pipeline projects, as presented in Figure 10. The high-scoring projects could be immediately considered for cancellation. Even though projects with medium and low scores have a few options, such as repurposing and operating with the early retirement option, a few of these projects could also be cancelled, especially if legal issues can be resolved and the cost is manageable.

[20] Consequently, the project will not be included in the upcoming RUPTL, which is expected to launch in late 2023.

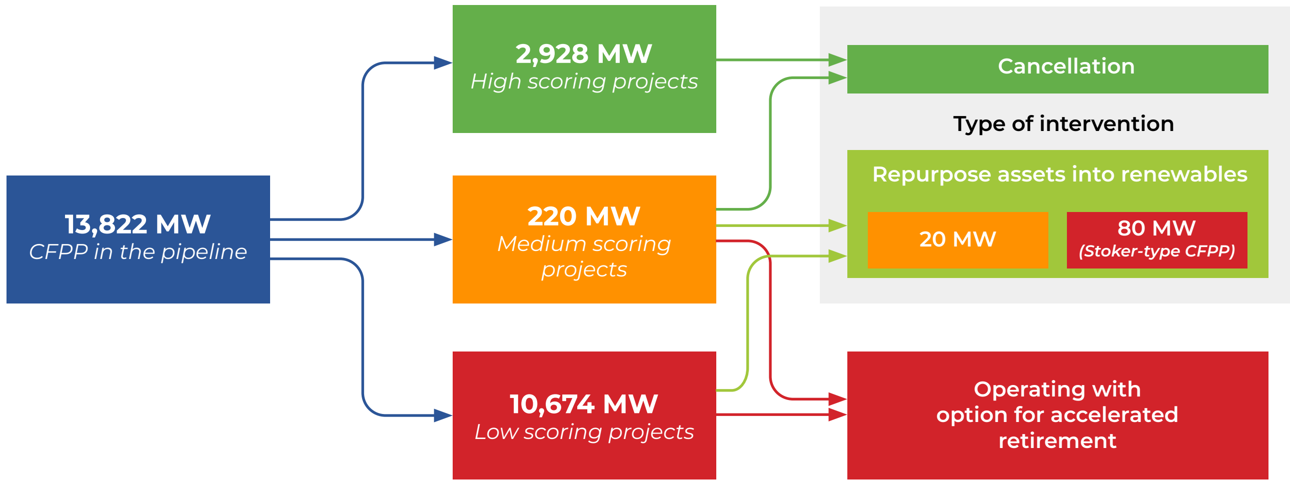


Figure 10. Options proposed based on the score of pipeline projects

Cancellation

Close to 3 GW of pipeline projects could be considered for cancellation. The Atambua CFPP project in Timor Leste is at the top of the list, as tabulated in Table 5. The 24 MW power plant was targeted for operation in 2012. However, the developer failed to meet the deadline, and its contract, which was signed by both parties in 2008, was then severed by PLN. Following the event, the project has been left stranded with no clear timeline for its completion. In 2021, PLN decided to continue the project by including it in the RUPTL 2021–2030. However, satellite images show that although the project is in the works, there has not been notable progress as depicted in Figure 4.

This situation is not unique to Atambua. There are other projects, including the 20 MW Bima/Bonto CFPP (see Figure 11), Sampit, and Tanah Grogot/Janju CFPPs, which are in advanced stages of construction with no sign of being near completion. One project, Sumbagsel-1, is marked in the RUPTL as 'PPA', meaning the power purchase agreement between PLN and the IPP has been signed, with a planned COD in 2024. The project has so far only appointed a developer, which took place in October 2022 (PT D&C Engineering, 2022). Given its progress, it will be difficult for the project to meet the COD timeline and will likely be delayed. The remaining projects, namely Jawa-3, Jambi-1, and Jambi-2 CFPPs, are currently in the process of being cancelled, with Jawa-3 already being considered for a moratorium.

Table 5. List of CFPP recommendations for cancellation

Plant	Plant Capacity (MW)	Note
Atambua	24	Available satellite imagery dated June 2021 shows no sign of construction at this time
Jawa-3 Unit 1	660	In the process of being cancelled
Bima/Bonto	20	30.03% in progress by May 2021 (Satellite imagery dated November 2022 still show similar built structure with no further additions
Jambi-1 (mine mouth)	600	In the process of being cancelled
Jambi-2 (mine mouth)	600	In the process of being cancelled - Source: PLN 2021 Financial Report (Audited)
Sampit	50	Available satellite imagery dated September 2021 shows cleared land area
Jawa-3 Unit 2	660	In the process of being cancelled
Tanah Grogot	14	Satellite imageries from August 2018 to January 2020 show no notable progress
Sumbagsel-1 (mine mouth)	300	12 % in progress. Based on the PJB annual report, the location of the unit is in Kecamatan Semidang Aji, South Sumatra. However, the report does not provide any further detail. Source: MEMR

Some medium-scoring projects can be considered for cancellation. These include the Alor and Nabire-Kalibobo CFPP projects, with a total capacity of 20 MW. Due to its lack of progress, the Alor CFPP project is a suitable candidate for cancellation. However, the system was identified as having a need for additional generating capacity. This could be a chance to switch to utility-scale solar PV or wind power generation with energy storage as a replacement. The project site happens to be in an area where these renewable energy sources have a lot of technical potential.

The Nabire-Kalibobo CFPP project could actually be considered for straight cancellation as the project was unable to secure its required funding. According to information from PLN[21], its former financier was discouraged as it intends to move away from financing another coal-based power generation. Nevertheless, the financier hinted there would be interest if the project considered switching fuel to biomass instead of coal.

Figure 11. Bima/Bonto CFPP project satellite imageries for the last 2 year

[21] The information was obtained during the FGD set up by IESR with the Ministry of Energy and Mineral Resources (MEMR), the Coordinating Ministry of Maritime and Investment, and PLN.

Repurposing into biomass power plant

Some projects in the low-scoring group could be considered for the repurposing of the built assets. Smaller CFPP projects under construction, especially those using stoker boiler technology, could be turned into 100% biomass power plants if local biomass resources are available. PLN has implemented this method at Tembilahan CFPP, which has a total capacity of 14 MW, without making any modifications to the equipment. The challenge is to make sure that there is a sustainable supply of biomass. In this study, the average production capacity of certain crops, such as palm, coconut, and paddy, in each province where the candidate for repurposing is located was used to estimate the technical potential of a biomass source.

Table 6 shows that relying solely on the closest available feedstock may not be enough for most of these projects. Therefore, they may need feedstock from other provinces. Even so, the amount is still not enough for the extent of this analysis, as in the case of Sorong. Further analysis of other biomass sources with an estimate of their technical capacity is required. Also, it is worth noting that the difference in calorific value between biomass and coal will have an impact on the cost of electricity generation. In addition, alteration to the original contract, especially about the fuel supply, needs to be discussed at the Business-to-Business (B2B) level.

Table 6. Estimated technical potential of biomass within the region of each repurposing plant candidate

Unit	Total Capacity (MW)	Province	Local Biomass Potential	Utilised Waste	Averaged Production (tonne/year)[22]	Calorific Value (MJ/kg)	Waste Percentage (%)	Technical Biomass Capacity (MW)
Kotabaru	14	South Kalimantan	Palm	Fibre	592,325	14.5	11.50%	6.58
				Kernel		23.6	40%	37.26
Sofifi	6	North Maluku	Coconut (island)	Shell	144,784,000	22.89	15%	3,312.97
Sorong	28	West Papua	Paddy	Husk	6,562	12.98	20%	0.11
			Paddy (province)	Husk	27,665	12.98	20%	0.48
Malinau	6	East Kalimantan	Palm (province)	Fibre	347,689	14.5	11.50%	3.86
				Kernel		23.6	40%	21.87
Tanjung Selor	14	East Kalimantan	Palm (province)	Fibre	347,689	14.5	11.50%	3.86
				Kernel		23.6	40%	21.87
Talaud (Tarun)	6	North Sulawesi	Coconut	Shell	19,310	22.89	15%	0.44
			Coconut (province)	Shell	272,184	22.89	15%	6.23
Rote Ndao	6	East Nusa Tenggara	Paddy	Husk	26,306	12.98	20%	0.46
			Paddy (province)	Husk	731,878	12.98	20%	12.66

[22] Source: Statistics Indonesia (BPS).

Early retirement

The option is recommended for the majority of the low-scoring projects, which make up 65% of pipeline projects. Candidate projects for this option have a total capacity of 10,674 MW, including the 80 MW with stoker boiler technology and potential repurposing into biomass power plants. There is a likely addition of 200 MW from the medium-scoring projects, subject to further analysis and updates on progress. According to Presidential Regulation No. 112/2022, the option took into account a minimum guaranteed lifespan of 20 years for each CFPP, with the end of the lifespan set for 2050. The guaranteed lifetime is selected to comply with the Paris Agreement's 1.5°C pathway and is assumed to have fulfilled the debt obligations (Cui et al., 2022). Examples of these power plants and their current progress[23]:

- Nagan Raya Unit 3-4 (400 MW): construction progress at 70%
- Sumsel-8 Mine Mouth (1200 MW): construction progress at 97%
- Sumsel-1 Mine Mouth (600 MW): construction progress at 70%
- Kalbar-1 Unit 2 (100 MW): already operating
- Jawa-9 & Jawa-10 (2000 MW): construction progress at 73%
- Lombok (100 MW): construction progress at 90%

3.3.2. The estimated cost of intervention and early retirement, and corresponding legal analysis

Cancellation

This study estimates the total investment required to compensate the 2,928 MW CFPP at around USD 235-238 million or USD 80,000 per MW. Nevertheless, the actual amount may be higher than the current estimated capital spent, taking into account project development costs, committed procurement, inflation, and possibly legal costs incurred due to the cancellation of the project. Table 7 provides the estimated bail for each project that should be cancelled. The table also shows possible sources of financing, considering the current progress. This should indicate the complexity of the negotiation and the appropriate strategy.

Table 7. Estimated bailout spending for each project

Plant	Plant Capacity (MW)	Status	Source of Financing	Nom. Investment (million USD/MW)	Est. Investment (million USD)	Est. Capital Spent (million USD)
Atambua	24	Construction - <30%	Equity	1.06[24]	25.39	7.36
Bima/Bonto	20	Construction - 30.3%	Equity+Debt	1.06	21	6.41
Jambi-1	600	PPA	Equity	1.05[25]	630	31.5[26]
Jambi-2	600	PPA	Equity	1.05	630	31.5
Jawa-3 Unit 1	660	Financing	Equity	1.4[27]	924	46.2[28]
Jawa-3 Unit 2	660	Financing	Equity	1.4	924	46.2
Sampit	50	Construction - <30%	Equity	1.06	52.90	15.34
Sumbagsel-1	300	Construction - 12%	Equity	1.65[29]	495	59.4
Tanah Grogot/ Janju	14	Construction - 30-50%	Equity+Debt	1.06	15	4.44-7.41

[23] Per September/October 2022.
[24] Source: (Chakravarty & Somanathan, 2021)
[25] Source: (MEMR & Danish Energy Agency, 2021)
[26] Initial spending to cover feasibility studies and AMDAL, assumed to be around 5% of the investment
[27] Source: (MEMR & Danish Energy Agency, 2021)
[28] Initial spending to cover feasibility studies and AMDAL, assumed to be around 5% of the investment
[29] Source: (MEMR & Danish Energy Agency, 2021

However, there is a legal risk, especially for the government of Indonesia and PLN for cancelling any project in the pipeline. This has been the case when the RUPTL 2021–2030 was published under the MEMR decree T-373/TL.03/MEM.L/2021. The decree has officially excluded 8,770 MW of CFPP that were in the pipeline under the previous RUPTL 2019–2028. A project owned by PT Energi Katingan Prima, a 2x100 MW mine mouth CFPP located in Central Kalimantan, namely Kalselteng-3, has filed a lawsuit against MEMR in court and asked for the rescission of the decree. In June 2022, PT Katingan Energi Prima won the lawsuit, and the court ordered MEMR to publish a decree to reinclude the Kalselteng project in the RUPTL 2021-2030.

The court's decision was based on two things. First, there is a procedural defect from MEMR, which has not properly consulted the decree with potentially impacted stakeholder/public. The court deemed that the process of stipulating the decree has infringed the Law on Government Administration that mandates the government to conduct a socialization to the impacted stakeholder as well as the principle of accuracy and appropriateness, where the government failed to take into account the plaintiff effort and resources spent in preparing the project for years. Second, the decree has also violated the principle of reasonable expectations and the principle of legal standing, where the plaintiff has worked on the project for years and reached "committed" status in the RUPTL, but the decree one-sidedly cancelled the project for the sake of fulfilling the government's commitment in developing clean energy[30] (see Appendix A for the summary of the case study).

Learning from what happened with PT Katingan Energi Prima shows that developers need to be aware of project cancellations and should be informed in a crystal clear manner. MEMR and PLN might have to start the discussion with project owners, especially if they were listed as committed projects in the previous RUPTL document. Vice versa, MEMR and PLN could push the CFPP project that lacks in its development stage, as identified in the analysis above, to be taken off the pipeline on the basis that the developer failed to fulfil its obligations or meet its operation's date as stipulated in the RUPTL or in the contract. In the second case, a notification might be enough to make the decision official before putting it into regulation.

Early Retirement

For the 10,674 MW that will keep running because the construction is underway, early retirement could be a way to reduce the amount of greenhouse gas emissions (GHGs) over time. The difference between accelerated depreciation (for PLN-owned projects) and refinancing (for the IPP-owned project) for the plants affected by the intervention gives an estimate of how much this intervention will cost. Putting the difference in net present value, it is estimated that the cost of accelerated retirement 10 years earlier is around USD 2.2 billion. The cost figure would change, especially considering the additional cost potential coming from the legal process, the financing process, and even the negotiations.

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[30] Putusan PTUN JAKARTA Nomor 297/G/2021/PTUN.JKT

Table 8. Estimated cost of early retirement for several plants calculated using the difference between present value of CAPEX depreciation cost of natural and early retirement

Plant	Total Capacity (MW)	Investment Cost	COD	Year of natural retire-ment	Year of early retire-ment	Estimated PV of CAPEX depreciation at COD year		Estimated PV in 2023
						Natural retirement	Early retirement	
Nagan Raya Unit 3 & 4	400	USD 540 mil (Source: Link)	2023	2053	2043	USD 169,684,460	USD 229,866,220	USD 60,181,760
Sumut-1	300	USD 500 mil (Source: Link)	2023	2053	2043	USD 157,115,241	USD 212,839,093	USD 55,723,852
Sumsel-8 (mine mouth)	1,200	USD 1.68 bil (Source: Link)	2022	2052	2042	USD 527,907,210	USD 715,139,352	USD 187,232,142
Sumsel-1 (mine mouth)	600	USD 750 mil (Source: Link)	2023	2053	2043	USD 235,672,862	USD 319,258,639	USD 83,585,778
Pantai Kura-kura (Bengkayang)	55	USD 52.9 mil	2025	2055	2045	USD 16,622,793	USD 22,518,376	USD 4,872,383
Parit Baru (Jungkat)	100	USD 114.2 mil	2025	2055	2045	USD 35,885,121	USD 48,612,449	USD 10,518,453
Kalselteng-2	200	USD 388.2 mil (December 2021); USD 444.3 mil	2022	2052	2042	USD 139,298,373	USD 188,703,140	USD 49,404,767
Kotabaru	14		2025	2055	2045	USD 7,258,724	USD 9,833,166	USD 2,127,638

There are indirect ways for pushing the early retirement of CFPP based on the current laws and regulations as briefly described below (a more detailed explanation can be found in Appendix B:

- For PLN-owned CFPP plants

  Based on current regulation, PLN could write-off the CFPP value after going through several procedures. However, there are numerous financial and economic considerations for these options, which are not discussed in this section. This also includes the risk or potential of state losses from implementing this option, which could be investigated by the Supreme Audit Board of the Republic of Indonesia (BPK).

  From a legal perspective, based on the MSoE regulation PER-03/MBU/03/2021 regarding the Transfers of Fixed Assets of SoE, the sales of fixed assets could be triggered by certain conditions, e.g., being lost or destroyed, being dismantled to be rebuilt as another form of fixed assets, being forced by binding court decisions, or other conditions determined by the Minister of SoE. In the event of any condition being triggered, the process still needs to be approved by the Supervisory Board or even the General Meeting of Shareholders and the PPA will continue to apply.

- For IPP-owned CFPP plants

  Early retirement of IPP-owned CFPPs is generally implemented by terminating the PPA that could be triggered by the Political Force Majeure. In general, this will be followed by a negotiation between parties involved in the PPA. All conditions of the termination would be agreed upon through negotiations. However, if no agreement is reached, the terms of the PPA will continue to apply.

3.3.3. CO_2 emissions analysis: avoided and lifetime

Using equations in Section 3.1.3, the potential avoided emissions from the 2,928 MW cancelled projects were estimated to be up to 460.33 $MtCO_2$. As required by Presidential Regulation No. 112/2022, the calculation is based on a situation in which these projects can be built and run until 2050 according to their COD. Table 9 presents the estimated avoided emissions for each cancelled project.

Table 9. Estimated of the avoided emissions from the cancelled projects

Plant	Plant Capacity (MW)	% AF (assumed)	% Efficiency (assumed)	Est. CO_2 emission per Year ($MtCO_2$)	COD	Remaining Lifetime (limited to 2050)	Avoided emission ($MtCO_2$)
Atambua	24	80%	21%	0.27	2027	23	6.14
Bima/Bonto	20	80%	29%	0.16	2029	21	3.37
Jambi-1	600	80%	37%	3.76	2027	23	86.51
Jambi-2	600	80%	37%	3.76	2026	24	90.27
Jawa-3 Unit 1	660	86%	37%	4.35	2026	24	104.40
Jawa-3 Unit 2	660	86%	37%	4.35	2026	24	104.40
Sampit	50	80%	29%	0.31	2025	25	7.83
Sumbagsel-1	300	80%	34%	2.05	2024	26	53.21
Tanah Grogot	14	80%	21%	0.16	2023	27	4.20

For the 10,674 MW considered for early retirement, it is estimated that letting these CFPPs run for 20 years will add 1,332 $MtCO_2$ emissions. This means that up to 505.91 $MtCO_2$ could be avoided. Figure 12 shows how these projects will be retired, showing how emissions and capacity will change each year. It is expected that by 2046, there will be no operating CFPPs in the pipeline.

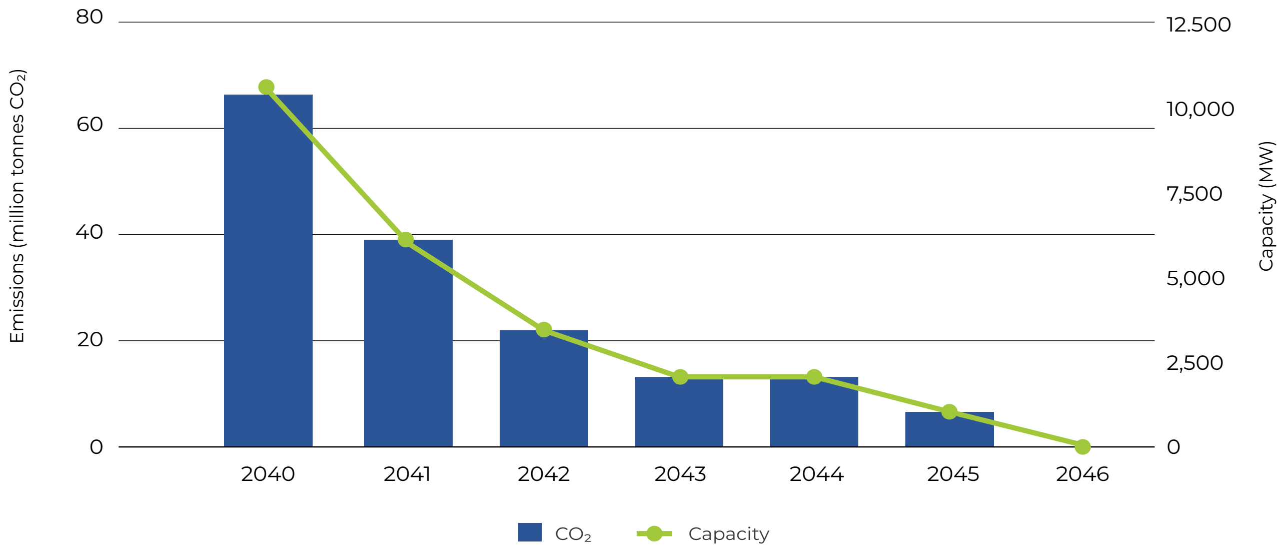


Figure 12. Estimated profile of lifetime emissions of the projects considered for early retirement up until the last retirement year

4 Assessing the implications of the interventions from a system-wide perspective

This chapter provides a techno-economic assessment of the implications of cancellation and early retirement of CFPP projects assessed in the previous chapter. The analysis provides a system-level perspective, overlooking three key sustainability pillars of the Indonesian energy transition policy, better known as Triple A: **A**vailability (security of supply), **A**ffordability (least cost), and **A**cceptability (environmental sustainability). Several metrics were employed to quantify the system's costs and benefits, including generation mix, CO_2 emissions, and total system cost. The value of the reserve margin used in PLN's expansion planning was employed as one of the constraints in the analysis. The assessment in this chapter was performed through a power system analysis using PLEXOS, a software for electric power system modelling.

4.1. Methodology

4.1.1. Modelling Indonesia's power systems

To better understand the impact of the interventions, a model of Indonesia's power system was developed using publicly available data and information. As a starting point, this study uses existing and planned infrastructure data from the latest RUPTL, showing Indonesia's planned expansion of the power system until 2030. Furthermore, it assumes that the construction of these infrastructures will be finished on time.

Since the horizon of the planning document is limited to 2030, several key inputs from other sources are also used to further develop the expansion model beyond 2030. These inputs include the techno-economic properties of the power plant candidates, transmission network constraints, VRE generation profiles, demand profiles, and the MEMR's forecasted demand growth until 2050. On the demand profile, this study utilizes the profile of the Java-Bali system in 2019 and uses it as the base profile for the remaining systems along with the growth projection from MEMR. By 2022, the demand for electricity in the systems is estimated to be 303 TWh. From the MEMR projection, the electricity demand will increase to 1,026 TWh by the end of 2050.

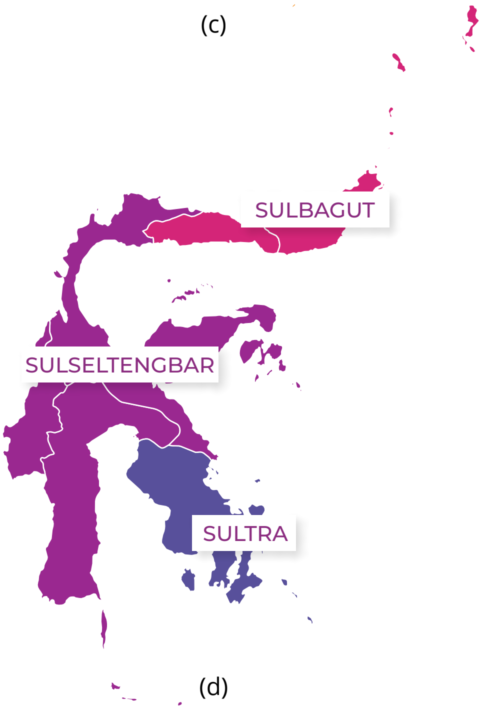
The Indonesian power system is modelled by decomposing it into seven regions, i.e.Java, Sumatra, Kalimantan, Sulawesi, West Nusa Tenggara, East Nusa Tenggara, Maluku, and Papua as illustrated in Figure 13. Each region consists of several nodes.

- Java-Bali system nodes: West, Central, and East (based on control regions of PLN)
- Sumatra system nodes: North, Central, and South (assumed)
- Kalimantan system nodes: North, Central-South-East, and West (assumed)
- Sulawesi system nodes: North, Central-South-West, and Southeast (assumed)
- The remaining regions will have each node to represent each island due to the unavailability of island interconnections at the moment.

(a)

(b)

(c)



(d)

Figure 13. Power system representations: (a) Java-Bali, (b) Sumatra, (c) Kalimantan, and (d) Sulawesi

One important feature in the power system that should be considered in its expansion planning is reliability. To put it into perspective, the reliability criteria should be imposed on the model as a constraint. The main reliability criteria that Indonesia has set out in its electricity policy is to maintain a reserve margin of at least 35%, which is based on a loss of load probability (LOLP) of one day per year or less than 0.274% (PLN, 2021). The number was derived from the Study of the Development of Service Level Agreement for PLN by the Ministry of Finance (MoF), assisted by McKinsey & Company. The breakdown of the value is detailed in Table 10.

Table 10. PLN's reserve margin breakdown (PLN, 2021)

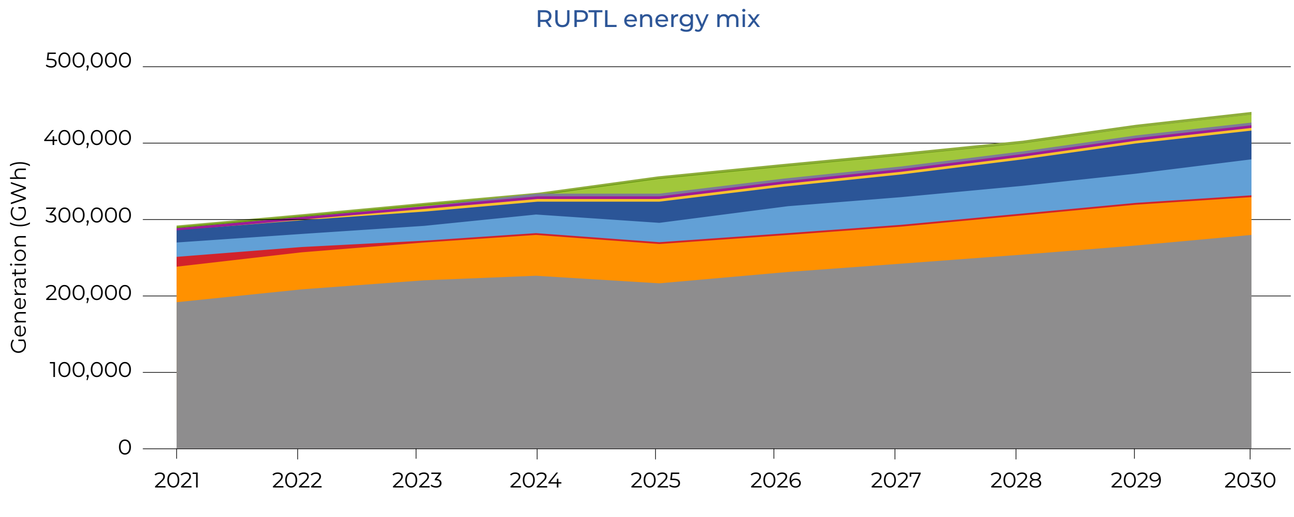
Item	Reserve Margin Contribution (%)	Explanation
Optimal reserve margin with LOLP of 1 day/year	25	Probabilistic model with input Loss of Load Probability (LOLP) of 1 day per year generates 25% net dependable capacity reserve margin
De-ratings and auxiliary power	5	De-ratings of existing plants as well as power used by the power plant
General delay buffer	5	Based on probability of delay of PLN and IPP projects in the pipeline
Total	**35**	

The capacity expansion, compounded by the projected growth of electricity demand by at least threefold as shown earlier, necessitates building new power plants beyond what has been planned in the RUPTL. Key assumptions for the candidates of these new power plants are based on the MEMR's Technology Data for the Indonesian Power Sector[31]. There are, however, some limitations to be considered, particularly on the allowable candidates for the new power plants. The recently enacted Presidential Regulation No. 112/2022 prohibits the construction of new coal-fired power plants with the exception of those already included in the existing pipeline. Consequently, the model will not consider coal-fired power plants as candidates beyond 2030. Gas power plants[32], are also excluded from the model's future expansions to further limit the emissions of the power sector.

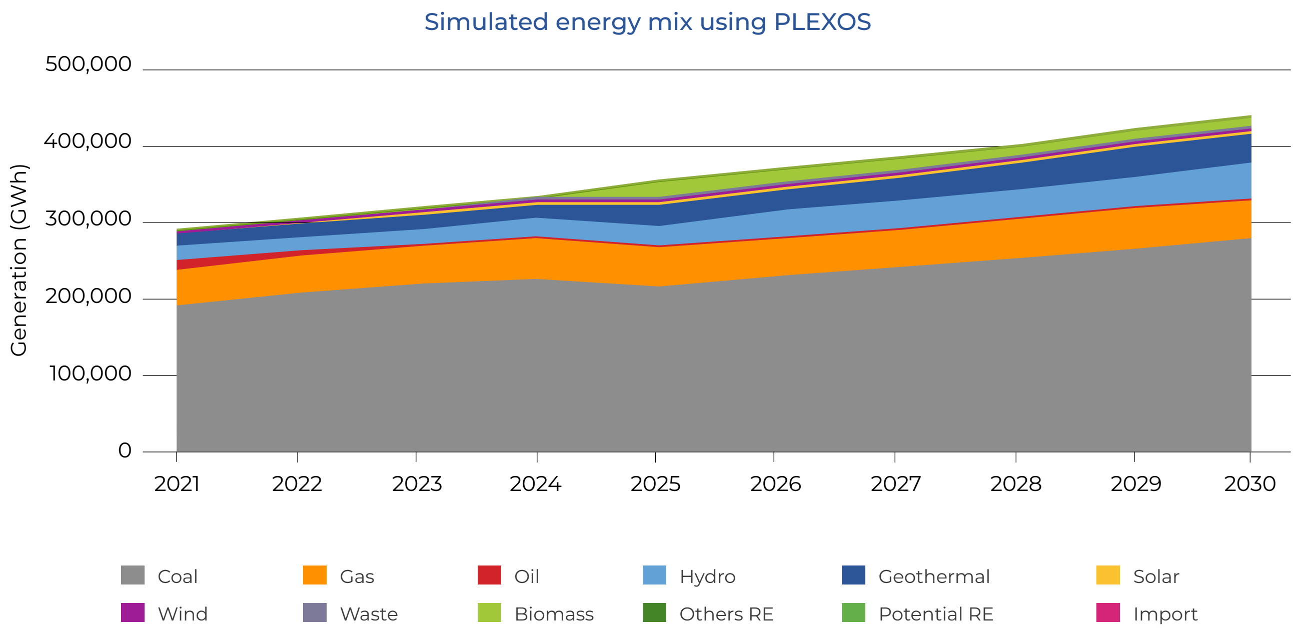
Renewable energy technologies considered in this study are solar PV, onshore wind, biomass, mini-micro hydropower, large-scale hydropower, and geothermal. The first four renewable energy sources' technical potentials are based on IESR[33] estimates in each province. According to the estimate, solar has a potential of up to 7,714.6 GW, onshore wind power is up to 106 GW, biomass is up to 30.73 GW, and mini-micro hydropower is up to 28.1 GW. Geothermal and large-scale hydropower candidates, including pump storage, are considered as candidates in this study only if sufficient information on their development plans is available from PLN. Hence, this study only uses geothermal and large-scale hydropower projects that PLN has listed as "possible" in the most recent RUPTL. The technical, economic, financial, and socio-environmental viability of a geothermal or large-hydropower candidate, as well as its indicative developer are crucial for such a candidate to be regarded as "ready" and included in this study. Based on these terms, the potential capacity of geothermal and large-scale hydropower considered in this study is 8.6 GW and 9.3 GW, respectively.

[31] Source: (MEMR & Danish Energy Agency, 2021)
[32] Including gas turbine power plant (OCGT & CCGT) and gas engine power plant
[33] Source: (IESR, 2021)

Prior to carrying out expansion planning calculations, validating the model is necessary to make sure whether it is reflecting the real condition or not. Since this study uses PLN's RUPTL 2021–2030 as a baseline, the model's result should reflect the planning document projections, in this case, the energy mix projection. From the comparison, a minor discrepancy is observed between the RUPTL and the PLEXOS result (this study), as observed in Figure 14(a) and (b), respectively. The difference occurs in the thermal power generation, i.e. coal and gas, as this study does not possess any factual information on the contracts for each power plant. The difference also slightly influences the generation from other types of energy sources, including renewables.



(a)



(b)

Figure 14. Energy mix projection of a) RUPTL 2021-2030 b) Using PLEXOS simulation

4.1.2. Power system impact assessment

The next stage of the assessment is understanding the supply-side (generation) resources needed to meet the assumed demand projection, with several developed scenarios. The scenarios are listed in Table 11.

Table 11. List of considered scenarios

Scenario	Baseline	CFPP in the pipeline	Existing CFPP
Business-as-Usual (BAU)	RUPTL 2021-2030	Built on time	Natural retirement
Cancellation of CFPP projects		Cancellation of 2.9 GW + remaining is built on time	
Cancellation + Early retirement of CFPP projects		Cancellation of 2.9 GW + Accelerated retirement for 10.8 GW	

The model uses PLN's RUPTL 2021–2030 as a baseline, or BAU, with the assumption that all planned project constructions will be finished on time. All CFPPs in the system will be retired naturally based on the MEMR projection. Based on the previous multi-criteria analysis, we added CFPP cancelation to the intervention scenarios, namely the second and third scenarios (see Table 11). The rest of the coal plants that cannot be cancelled will still be retired naturally in the second scenario and put into the accelerated retirement in the third scenario, with guaranteed operational time of 20 years.

The objective function used in the analysis is aimed at achieving the least Net Present Value (NPV) of construction, O&M, and generation costs while ensuring supply and demand balance. The setup in PLEXOS maintains affordability and security of supply as key points of interest for stakeholders. Through this analysis, the implications of cancelling certain CFPPs on the system cost, supply and demand balance, GHG emission reduction, and additional investment (if required) could be understood.

4.2. How the power system reacts to the interventions

4.2.1. The conundrum in the projected generation mix

As previously stated, the BAU scenario does not require any intervention in the planning process. The capacity of the CFPP is reduced based on the natural retirement scheme. Consequently, by the end of 2050, the installed capacity of CFPP will reach 17.7 GW, still accounting for 12% of the power sector's energy share.

Figure 15 shows that there is a difference in the CFPP power generation share between the intervention scenario and the BAU due to the cancellation of almost 3 GW of CFPP. Since most of these projects are located in the Java-Bali grid, the electricity generation from the cancelled pipeline project will most likely be replaced by other power plants, mainly the fossil-based ones, especially until 2030. During this period, it is cheaper to increase the utilization of existing power plants than to invest in new renewable power plants. It can also be observed that the utilization of these coal power plants has increased by 8% relative to the BAU by the end of 2030.

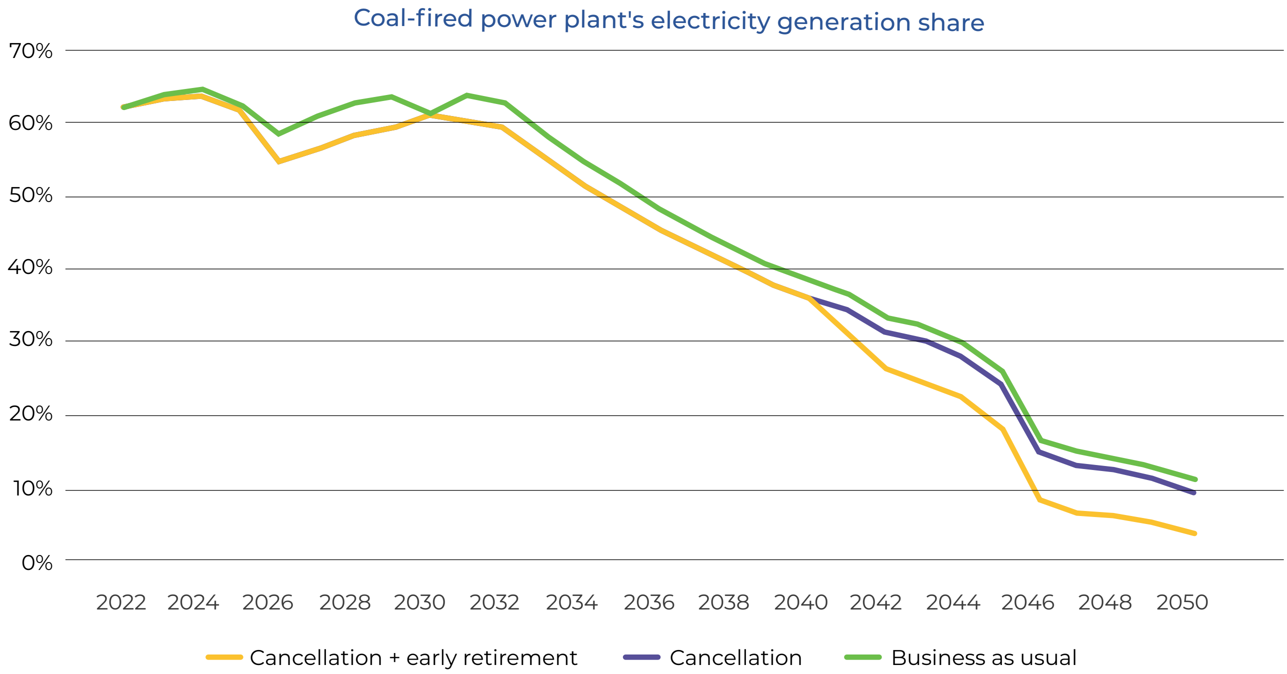


Figure 15. CFPP's share in the electricity mix

As a result, renewables' share in the intervention scenarios could only reach 30% at best by 2030, a 4% increase compared to the BAU of the same year as depicted in Figure 16. This could jeopardize the efforts to reach JETP's 34%. Due to the increasing electricity demand and the constraint to also meet the reserve margin from dispatchable generation, renewables' share (including VRE and storage) can start to accelerate after 2030, as observed in Table 12.

Considerable differences in RE shares between scenarios are observed between 2045 and 2050, as CFPPs in the pipeline that cannot be cancelled are undergoing accelerated retirement. The power system still maintains existing gas power plants to meet reserve margin constraints, and even increases their utilization, while investing in new renewable power plants and storage. After 2050, there will still be some gas power plants in the system, while coal-fired power plants will be reduced to zero.

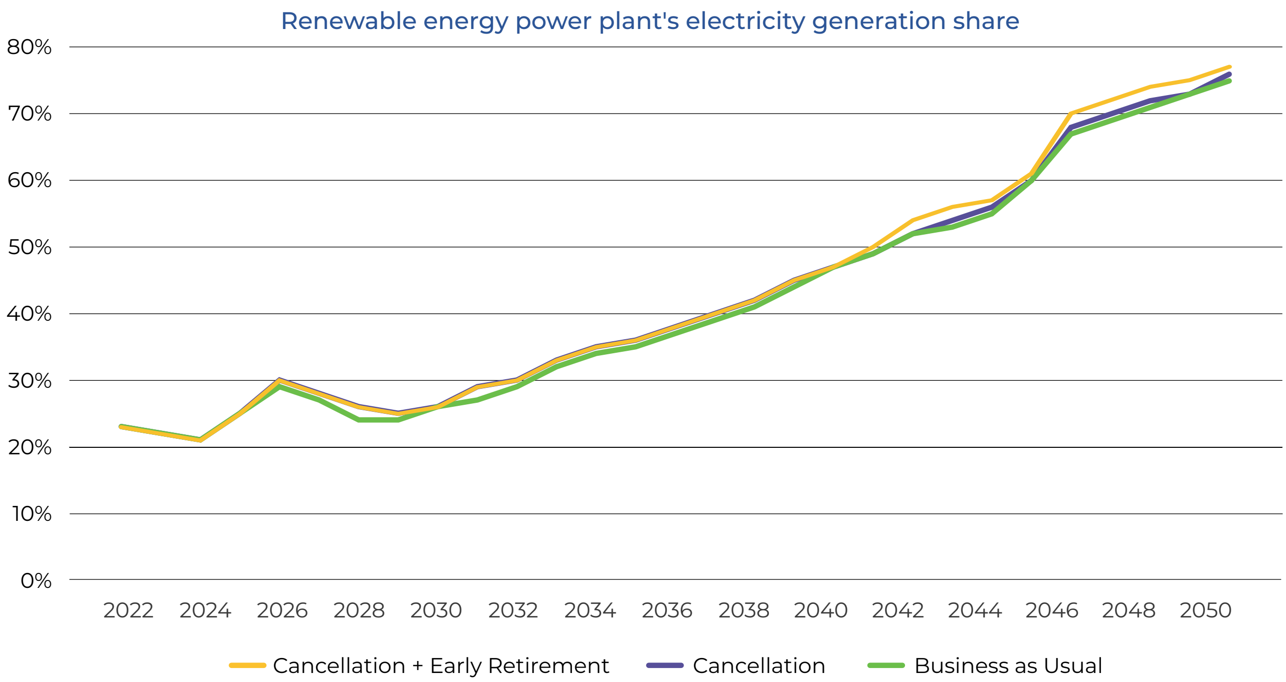


Figure 16. Renewable energy's share in the power generation mix

Table 12. Installed capacity of coal and RE power plants in all scenarios

Scenario	2022 (GW)		2030 (GW)		2040 (GW)		2050 (GW)	
	CFPP	RE	CFPP	RE	CFPP	RE	CFPP	RE
Business as Usual			42	23.8	40	71.4	17.7	161
Cancelled CFPP projects	33	10.8	39.1	26.3	37.1	79.9	14.8	168.4
Cancelled + shortening lifetime CFPP projects								184.7

4.2.2. Changes in system-level CO_2 emissions

Cancellation of CFPP projects may lead to CO_2 emission reductions. Given that existing gas power plants and other CFPPs in the system are replacing electricity generation from the intervened CFPPs, the mitigated emissions will not be as high as the potential calculated from the plant-level analysis. Table 13 provides a comparison of the potential and realized avoided emissions. Cancellation and early retirement of CFPPs in the pipeline could potentially avoid emissions of up to 966 $MtCO_2$ over the period 2022-2050. On the other hand, the realization of the avoided emissions figure considers the changes in the system's generation mix. Due to the cancellation of some projects, the system chooses to increase the utilization of existing coal and gas power plants to maintain the system's reliability, which is constrained by a predetermined reserve margin, along with the increasing electricity demand. Consequently, such a condition results in lower avoided emissions of around 622 $MtCO_2$ within the same period.

Table 13. Comparison between calculated potential & simulated avoided emissions

Model	Cancelled projects	Cancelled projects + accelerated retirement
Potential	460 $MtCO_2$	966 $MtCO_2$
Realization (based on simulation)	295 $MtCO_2$	622 Mt CO_2

According to the simulation, cancellation of CFPPs in the pipeline could help to achieve the JETP target of 290 $MtCO_2$ as observed in Figure 17. However, this figure only considers emissions in the PLN grid, and has not considered emissions from off-grid and captive plants. Furthermore, this study estimates[34] that an additional 5.6 GW of CFPP should be retired before 2030 on top of the cancelled project. Further mitigation measures, such as high penetration of renewable energy, switching to gas-fired power plants, and integrating storage systems, should be taken to ensure that emissions decline after 2030, as stated in the JETP target.

[34] Performed using PLEXOS optimization with the JETP emission target (290 MtCO2) as one of the simulation's objective and set all CFPPs as options of early retirement (with different cost for each plant).

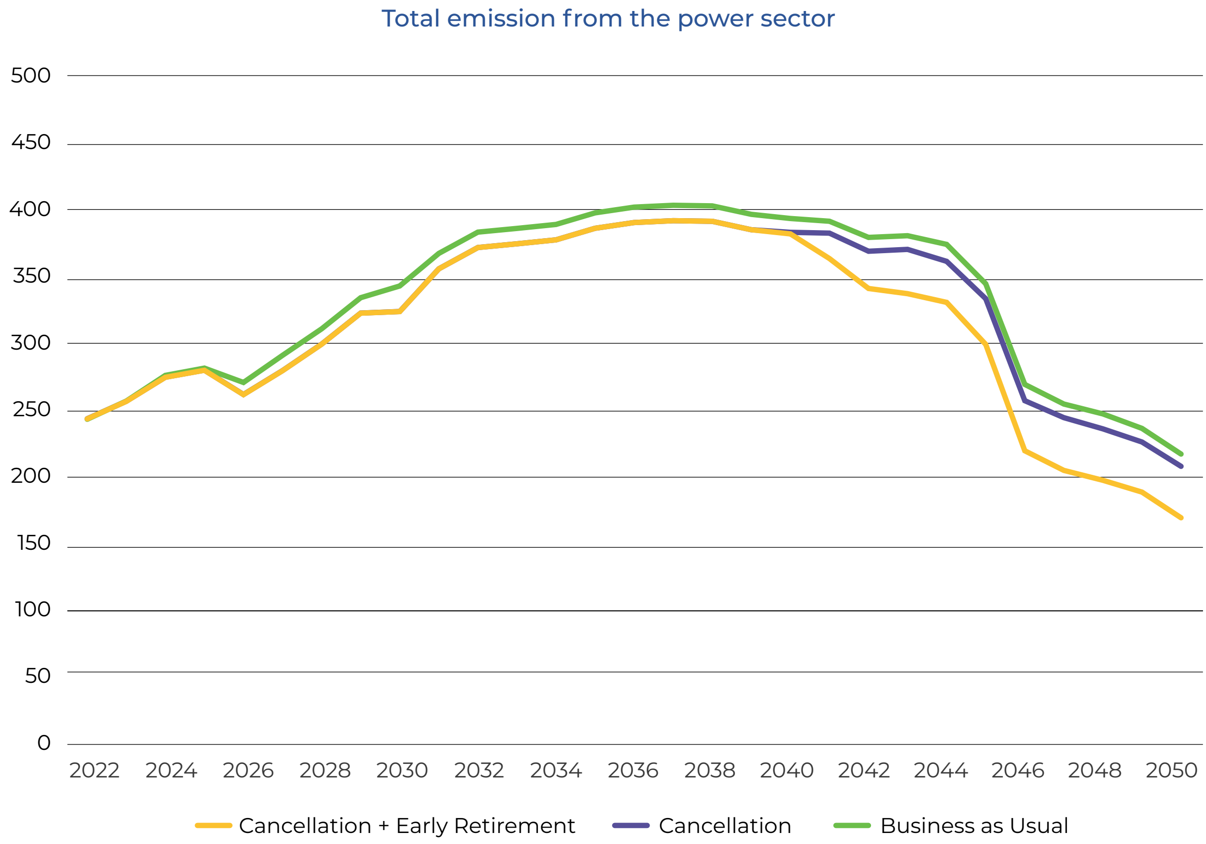


Figure 17. Power system emissions under different scenarios.

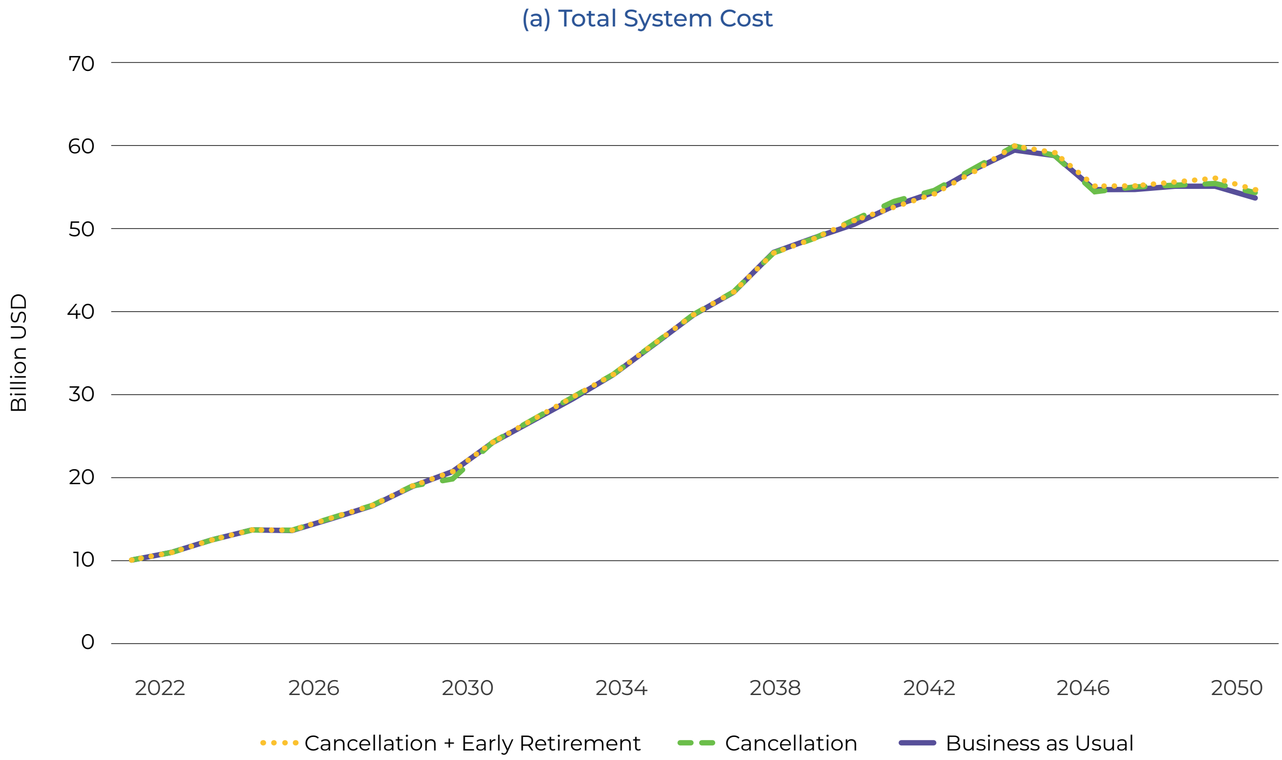
Existing CFPPs (42.1 GW) are undergoing natural retirement, and most will retire between 2050 and 2056. Therefore, existing CFPPs' emissions account for the majority of system emissions in all scenarios.

4.2.3. Incurred generation and investment costs

The increased share of gas power plants results in an increase in the generation/operational cost[35]. However, after 2040, due to the increased penetration of RE, with RE's typical marginal generation cost close to zero, the cost of electricity generation becomes lower than the BAU. This in turn reduces the gap in total system cost[36] between scenarios observed in Figure 18. Changes in the system costs, which have already been calculated as net-present value, show that the two intervened scenarios, pipeline cancellation and pipeline cancellation plus additional early retirement, have a cumulative total system cost of about USD 2.54 billion and USD 3.01 billion higher than the BAU scenario until 2050, respectively.

The difference in system cost is mainly due to the increase in the generation of gas power plants to replace cancelled coal plants before 2030. Furthermore, RE and storage are not yet competitive during this period, leading to a further increase in the power generation share of gas power plants. However, we could also see the potential to reduce mitigation costs (USD/tonne CO_2) by integrating renewables early on to maximize avoided emissions. Early integration of renewables would also accelerate the decline of RE investment costs in the country (due to economies of scale and the RE learning curve), resulting in lower system costs in the long run.

[35] Generation costs only consider the marginal generation cost. Therefore, for RE this number would be close to zero, while for fossil plants this would come from the fuel cost.
[36] System costs include the total cost of operation/generation as well as the depreciation of the investment over a given period



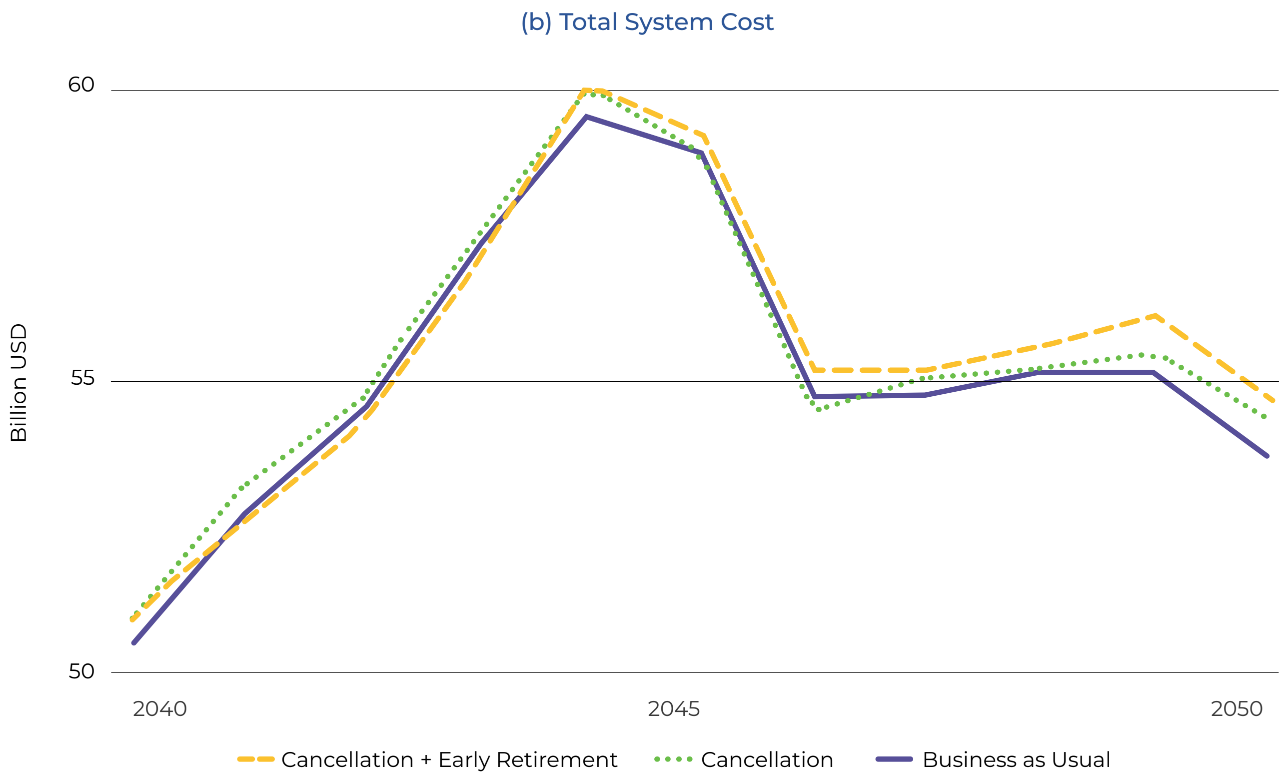


Figure 18. Total system cost comparison over time projection

The required cumulative investment in renewables and other generation to replace the cancelled and early retired CFPPs is higher between 2041 and 2045, or in the period where CFPPs with accelerated retirement are being decommissioned. However, total investment by the end of 2050 will grow even higher due to the early decommissioning of a large number of CFPPs. Compared to BAU, the total differences for two scenarios are USD 20.5 and 30.1 billion, respectively, most of which occurs between 2041 and 2050. The comparison of total investment between scenarios is depicted in Figure 19.

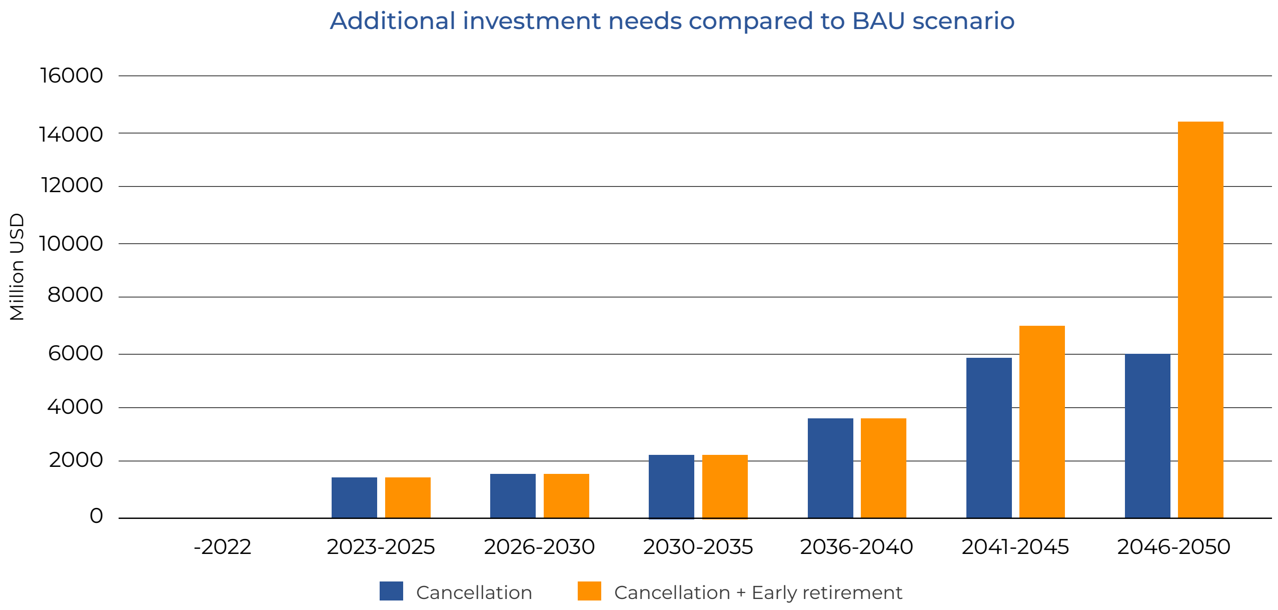


Figure 19. Investment cost comparison over time projection

4.3. Key takeaways from system-wide analysis

Based on the previous analysis, this study has come up with an estimate of how much it would cost to implement certain interventions for all 13.8 GW. These interventions include stopping the development of the CFPP and putting into place an accelerated retirement plan for the CFPPs that are non-cancellable. The estimated cost excludes the biomass option, as it has not yet been analyzed and requires further study. Table 14 provides a summary of the intervention cost and the breakdown for each intervention scenario.

Other findings from power system analysis suggest that additional costs are also incurred from power system operation to keep it running under existing reliability and operational constraint criteria, e.g., reserve margin of each system, as well as to maintain affordability, which would increase the utilization of existing plants such as gas and coal to lower the total cost of the system. However, it should be noted that depending on the agreed PPA, costs may vary as legal, transactional, and even negotiation costs increase.

From the calculation of avoided emissions, this study has estimated that cancelling 2,928 MW would result in cumulative avoided emissions of up to 460.33 $MtCO_2$, which is the total emitted by CFPPs from their stated COD year to 2050. Additionally, early retirement of 10,894 MW of CFPPs could potentially avoid emissions of up to 505.91 $MtCO_2$, bringing the total cumulative avoided emissions to 966 $MtCO_2$. However, the simulation shows that the actual avoided emissions is around 622 $MtCO_2$. The number is lower because existing gas plants and CFPPs are still used to meet the electricity demand.

Table 14. Summary of estimated intervention costs

Cost	Value (Present Value 2023)
Intervention 1 (Cancellation)	
Cancellation Cost for 2,928 MW	238 million USD
Additional System Cost	2.54 billion USD
Total Cost	**2.78 billion USD**
Total Cost without considering system cost	**238 million USD**
Intervention 2 (Cancellation & Early Retirement)	
Cancellation Cost for 2,928 MW	USD 238 million
Early Retirement Cost for 10,894 MW	USD 2.2 billion
Additional System Cost	USD 3.01 billion
Total Cost	**USD 5.45 billion**
Total Cost without considering system cost	**USD 2.44 billion**

Taking into consideration the total cumulative avoided emissions of 966 MtCO_2, the cost of not releasing CO_2 could be estimated at around USD 2.53/tonne CO_2. When the extra cost of running the power system is added, the emission abatement cost is around USD 5.64/tonne CO_2. However, if we consider the realization of the avoided emissions from the system perspective (total avoided emissions of 622 MtCO_2), the cost per avoided emissions will increase further to USD 8.76/tonne CO_2.

Having a closer look at the impacts of each intervention on emissions and incurred costs, the study found that cancellation of 2,928 MW of coal-fired power plants will result in 295 MtCO_2 of actual cumulative emission reduction from the power system operation, 36% lower than the calculated potential of avoided emissions (around 460 MtCO_2). Similarly, early retirement of 10,894 MW of CFPPs will result in actual cumulative emission reduction that is 35.5% lower than the calculated potential avoided emissions.

Overall, the cancellation of CFPP in the pipeline still results in the lowest cost per tonne of CO_2, which is around USD 0.52-0.8/tonne CO_2. However, the combination of the cancellation of 2,928 MW of coal plants in the pipeline and the early retirement of 10,894 MW of coal plants still provides considerably low mitigation costs in the range of USD 2.52-3.92/tonne CO_2. The additional system cost comes mostly from running gas generators to keep the system stable, which increases the cost of reducing emissions. However, we could see the potential of early integration of renewables to maximize the avoided emissions, therefore lowering the mitigation cost (USD/tonne CO_2). Early integration of renewables would potentially accelerate the decline in the cost of RE investment in the country (due to economies of scale and RE learning curve) and thus, resulted in a lower system cost in the long run.

As a comparison, PLN and PT Bukit Asam, a state-owned coal mining company, signed a Principal Framework Agreement (PFA) during the G20 event last year regarding the sale of Pelabuhan Ratu CFPP. They both agreed that spin-off and blended financing mechanisms could be used to shorten the remaining life or to early retire PLN's coal power plants, Pelabuhan Ratu (3 x 350 MW). It was also expected that the plant, recently valued at USD 400 million, could have its remaining operational lifetime reduced by nine years, from 24 to 15 years, which could potentially result in avoiding 60.91 $MtCO_2$. Even though the cost per avoided CO_2 emissions is similar (at USD 6.57/tonne CO_2), note that the cost of retiring Pelabuhan Ratu does not include potential changes in system cost, so the actual cost could be much higher.

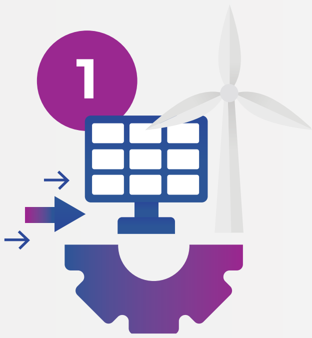
Table 15. Comparison of mitigation costs in the pipeline and early retirement plan of existing plants

Mitigation Measures	Cost per Avoided CO_2 Emissions
Pipeline intervention: 2,9 GW cancellation (range of cost is for scenarios with calculated and realization of emission)	USD 0.52-0.8/tonne CO_2
Pipeline intervention: 2,9 GW cancellation + 10,9 GW early retirement (range of cost is for scenarios with calculated and realization of emission)	USD 2.52-3.92/tonne CO_2
Pelabuhan Ratu CFPP: 3x350 MW early retirement plan (calculated emission)	USD 6.57/tonne CO_2

5 Conclusion and further works

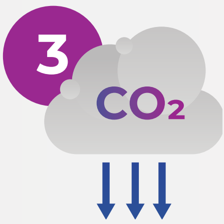
Compared to early retiring operating coal plants, cancelling existing coal plants in the pipeline is considered less expensive. The cancellation of existing pipeline projects is also beneficial to the government's goal of reaching the power sector's emission peak by 2030 and net zero by 2050. For PLN, cancelling planned coal plants could serve as a momentum for the utility company to increase its power systems flexibility to address the demand risk. It also allows the company to plan more ambitious renewable energy projects toward 2030, which could help reduce average generation costs in the near future and accelerate the company's business transformation away from fossil fuel assets.

However, on the other side, there are few incentives for IPPs to cancel the project. IPPs enjoy a long-term PPA with PLN, with a higher take-or-pay and guaranteed return on investment. From PLN's side, the requesting cancellation could be perceived as an attempt to breach the contract, which should be avoided. Therefore, as an external party to the contract, the government should assist the utility company to communicate the options in the first place by a series of measures:



Under a certain regulation, the government should mandate PLN to identify and conduct a thorough review on the most recent status of each IPP's project. Projects that do not reach financial close should be immediately notified that they will be cancelled, and no extensions should be granted. The requirement for PLN to communicate and negotiate with the owner of the IPP project in the pipeline prior to project cancellation must be included in the regulation. Alternatively, depending on system availability, PLN can offer project owners the option to replace coal plants with renewables.

The government provides the public with information on the status of each coal project in the pipeline as a means of mobilizing public support for cancellation and communicating benefits offered to the public by taking such action.



Referring to Presidential Regulation No. 112/2022, the government issued a regulation that stipulated a target for reaching the power sector emission peak by 2030 and net-zero by 2050 or sooner and requested PLN and all utilities to prepare respective plans to reduce coal plant capacity. This regulation could serve as the foundation for PLN and all utilities to develop a strategy for addressing coal projects in their pipelines.

Furthermore, we suggest the following additional research to apply the findings to other projects and implement the discussed intervention options in Indonesia.

1. Alignment with the JETP target (which is not yet considered in this study) and thus expansion of the intervention to include all power sectors (existing CFPP in operation owned by PLN, IPP, or even captive and Private Power Utility/PPU ones). MEMR is conducting a similar analysis for its roadmap; thus, combining this analysis with the other ongoing works could provide an overall view of the power sector emission pathway and evaluate this pathway against the JETP target. The additional analysis should include the roadmap for the phase-out of fossil gas power plants to reach net-zero state in 2050.

2. Analysis and recommendations for CFPP mitigation options in the captive and PPU sectors.

3. The non-cancellation options considered so far were only on the repurposing into biomass power plants and early retirement. Additional options, such as biomass co-firing, flexible operation, and repurposing into thermal energy storage, should also be considered in the expansion of this study.

4. To fully understand the viability of the CFPP-to-100% biomass conversion option, investigation of potential biomass resources near the CFPP location must be followed by a feasibility study. The study could also be expanded to include captives and PPU/Private Power Utility, which are not covered by PLN's RUPTL.

5. Detailed analysis of the condition and evolution of each power system (Java-Bali, Sumatera, Kalimantan, etc.) and, on that basis, support the development of a pipeline of renewable energy projects that would allow immediate replacement of the retired/cancelled CFPPs. The availability of ready-to-develop or even bankable renewables projects could boost the government and PLN's confidence in implementing CFPP intervention options.

6. A grid stability analysis with decreasing dispatchable power plant capacity and increasing Variable Renewable Energy (VRE) to debunk the need for gas in the power system with increasing VRE.

7. Analysis of combined legal and financial structuring for implementing the three above-mentioned options (CFPP cancellation, 100% biomass conversion for CFPP, and early retirement).

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Appendix

Appendix A - Case Study of the Kalselteng-3 CFPP Cancellation

Project Details:

Gross Capacity	: 2x100 MW
Type	: Minemouth CFPP
Technology	: Subcritical
Initial COD	: 2024 (unit 1), 2025 (unit2)
Sponsor	: Pembangkitan Jawa Bali (PLN Subsidiary)
Status	: Cancelled based on RUPTL 2021-2030. MEMR decree T-373/TL.03/MEM.L/2021

Figure A1. Kalselteng-3 CFPP Project Informations

The latest RUPTL 2021-2030 has excluded 8,570 MW of CFPPs compared to the previous RUPTL 2019-2028. The exclusion of these CFPPs is to compensate for the misprojection of electricity demand (and 35,000 MW program) as well as the slowing demand growth due to COVID-19 pandemic.

PT Energi Katingan Prima, owner of the Kalselteng 3 CFPP project, has fought back against the decision in a legal case brought to the Indonesian Supreme Court. The basis of PT Energi Katingan Prima's legal standing is summarized below:

- The plaintiff is a private institution based in Indonesia, legally approved under Indonesian law.
- The CFPP project is part of the Government of Indonesia's 35,000 MW project that is stipulated by the Presidential Regulation No. 4/2016 jo. 14/2017 on the acceleration of electricity infrastructure development.
- The plaintiff owned a coal mining license, in which the operation will also be impacted by the cancellation of the CFPP project.
- The project has been listed since RUPTL 2016 and the previous RUPTL 2019-2028 stated the CFPP project as a "committed" project.
- There has been investment commitment from China National Machinery Import and Export Corporation (CMC) and approval from PLN for partnership between PJB and CMC. The project is on the verge of reaching the "financial closing" stage.
- There is an alleged unfair treatment, as there are other projects that have not reached the "committed" status in RUPTL 2019 and still in the "PPA" stage (e.g. Jambi 1 and Jambi 2, Sumbagsel 1), but unaffected by the minister decree.
- No communication or discussion between the minister and project owner prior to the stipulation of the decree.

It is important to note that all CFPP projects mentioned in the legal standing of PT Energi Katingan Prima (see unfair treatment bullet point) are listed in this analysis as highly potential projects to be cancelled. In June 2022, PT Energi Katingan Prima won the lawsuits, and the supreme court ordered the MEMR to revise the regulation (RUPTL 2021-2030) to include the mentioned project and cover the legal cost.

The court's decision was based on two things. First, there is a procedural defect from MEMR, which has not properly consulted the decree with potentially impacted stakeholder/public. The court deemed that the process of stipulating the decree has infringed the Law on Government Administration that mandates the government to conduct a socialization to the impacted stakeholder as well as the principle of accuracy and appropriateness, where the government failed to take into account the plaintiff effort and resources spent in preparing the project for years. Second, the decree has also violated the principle of reasonable expectations and the principle of legal standing, where the plaintiff has worked on the project for years and reached "committed" status in the RUPTL, but the decree one-sidedly cancelled the project for the sake of fulfilling the government's commitment in developing clean energy.

Appendix B - Existing Regulatory and Legal Framework for CFPP Early Retirement

B.1. Indonesian Law in the Power Sector

Indonesia Electricity Law has been changed several times. However, there has not been any significant changes on how the power market is structured. As a state-owned enterprise, PLN is responsible for most of Indonesia's electricity supply by having priority rights over the transmission, distribution, sales, and supply of electricity to the public. The basis is Article 33 of the Constitution, which states that the State has power over productive sectors and natural resources that may affect people's lives, and has a responsibility to bring greater benefits to the people.

Under Article 66 of Law No. 19 of 2003 on State-Owned Enterprises (as amended by 2020 Omnibus Law and further amended by Law no. 6 of 2023), the Indonesian government has the power to assign state-owned enterprises to carry out public services obligations in accordance with the SoE's aim and objectives, business activities and capabilities. If the government's assignment is not financially feasible, the government must provide compensation for all costs that have been incurred by the SoE, including the expected margin, so long as it is in accordance with the reasonable level pursuant to the assignment given. However, PLN as an SoE is also tasked to generate profits.

The implication of the above laws and regulations is that SoE, as a business entity, is entitled to generate profits to meet its performance obligations, as stipulated by the MSoE. However, electricity price is regulated by the government and any changes in the price would also need approval from the Parliament. Therefore, when the government assigns a project to PLN, it also provides support to PLN to complete the task, e.g., providing subsidy/compensation and state equity investment.

B.2. Legal basis for CFPP early retirement

Current laws and regulations do not specifically regulate the early retirement mechanism for CFPP, either for CFPPs owned by PLN or Independent Power Producer (including CFPPs that are still under construction and commission stages). However, in September 2022, President of the Republic of Indonesia issued a new regulation, namely Presidential Regulation No. 112 of 2022 on the Acceleration of Renewable Energy Development for the Provision of Electric Power, which aims to increase investment and accelerate the development of renewable energy. Article three of the mentioned regulation is addressed towards the CFPP. Key summary of the regulations is as follows:

a. Prohibition of New CFPP Development (article 3 clause 4)

The development of new CFPPs is prohibited, unless the CFPP meets the following criteria:

- The CFPP has been determined under *Rencana Usaha Penyediaan Tenaga Listrik*/RUPTL (electricity supply business plan) before the enactment of this regulation; or
- CFPP that meets the following three requirements:
    - ◊ CFPP is integrated with industries that are developed to increase the added value of natural resources, or included in the National Strategic Projects that have a major contribution to job creation and/or national economic growth.

◊ In the 10 years since its operation, the CFPP has reduced GHG emissions by at least 35% compared to CFPP's average emissions in Indonesia in 2021 through technology development, carbon offsetting, and/or renewable energy mix; and

◊ CFPPs only operate at most until 2050.

b. CFPP Early Retirement (article 3 clause 5-11)

PR No. 112/2022 can be the legal basis for PLN to conduct early termination for its CFPP and/or CFPP based on PPAs of IPPs. PR No. 112 also stipulates that CFPPs early termination shall fulfill the following provisions:

- The list of CFPPs to be terminated or retired must be first determined by MEMR following receipt of written approvals from MoF and MSoE;
- The approved CFPPs shall then be included in PLN's RUPTL.

Therefore, the early retirement of CFPP will only be targeted to CFPPs included in the list that is determined by MEMR and approved by MSoE and MoF. The MEMR has not finalized the list of CFPPs to this date, and with the JETP joint statement coming into effect in November 2022, the MEMR is adjusting the list to also comply with the JETP target.

B.3. Early retirement of CFPP under existing laws and regulations (outside PR 112/2022)

There is a possibility for an early retirement of CFPPs under the current regulation. However, many considerations must be taken into account. The option for early retirement of CFPP can be split into PLN's plant and IPP's plant as follow:

a. PLN's plant: early retirement through asset write-off

Asset write-off is previously regulated under Article 3 of Ministry of State-Owned Enterprises Regulation (MSoE) No. PER-02/MBU/2010 regarding Procedures for Write-off and Transfer of Fixed Assets of State-Owned Enterprises as last amended by Ministry of State-Owned Enterprises No. PER-03/MBU/03/2021. The regulations have recently been replaced with the Minister of SOE Regulation No. Per-2/MBU/03/2023 on Procedures for Governance and SOE Significant Corporate Activities. Articles 162-179 of the MSOE Reg 2/2023 stated that asset write-off can be carried out through transfer and/or certain conditions (see figure B1).

Note that the Minister of SoE is also able to determine other types of specific conditions. Under its purview and/or if there are statutes mandating early termination of the CFPP, the Minister of SOE may determine the condition and/or enforce the early termination of the CFPP under such statutes.

The board of directors shall be the one to submit the proposal for the write-off and/or transfer of assets. Afterward, when the conditions are met, the asset write-off will need to go through an approval process by the Board of Commissioners or the Supervisory Board of SoE, or granted through a general meeting of shareholders or by the minister of SoE himself.

Approval must be granted by the Board of Commissioners or the Board of Supervisor of SoE

a. Loss;
b. Destroyed;
c. Total loss that cannot be transfered (total lost);
d. The transfer cost is higher than the economic value generated from the transfer;
e. Dismantled to be rebuilt into other fixed assets, the budget of which has been determined by the General Meeting of Shareholders (GMS)/ministers appointed and/or authorized to represent the government as shareholder (Minister) through the approval of RKAP;
f. Dismantled but not to be built in connection with other program that have been planned in the RKAP;

Approval must be granted through General Meeting of Shareholders (GMS)/by the ministers of SoE

g. Demolished to be rebuilt in connection with a government program;
h. Based on regulations and/or court decisions with binding legal force, such fixed assets can no longer be owned of possessed by an SOE.

Figure B1. Conditions that could trigger the assets write-off

In addition to the above regulations, due diligence must be conducted on PLN's global bonds, loan agreements, indentures, and local bonds to check if there are any restrictions for early retirement of PLN's CFPP, e.g., lenders' approval may be required.

b. IPP's plant: Political Force Majeure (PFM)

The early retirement of IPP-owned CFPPs is generally implemented through the termination of the Power Purchase Agreement ("PPA"). If a regulation is issued to mandate the retirement of the CFPP ahead of time, it may lead to the government/political force majeure ("PFM") clause being triggered (**first scenario**), or the early retirement of the CFPP would be initiated by simply terminating the PPA (**no PFM clause/second scenario**). In all scenarios, the plant shall be deemed dispatched in accordance with the terms and conditions of the PPA, and generally, PLN shall continue to be obligated to make payments for net dependable capacity. Afterward, the two scenarios could go in the following manner:

- First scenario: a plant with PFM clause

  PLN and the seller will discuss the subject matter of Notice of Force Majeure. Throughout the discussion, various decisions can be made depending on the agreement between the seller and PLN. Another possible way is for the seller to send a written notice to PLN, which shall serve as a Notice of Force Majeure, and if PLN delivers written notice to the seller confirming that event within 30 days, then the seller may terminate the Agreement.

  As a consequence of the termination, there will be an obligation to purchase the project and the price may vary depending on the stage of the project. Purchasing the project may also include taking over all obligations and loans originally owned by the project.

- Second scenario: a plant with no PFM clause

  Negotiations must be conducted between the seller and PLN. The result of the negotiation may include the amendment to the time limit of the PPA (reducing the applicable years of the PPA), while also considering the appropriate compensation granted to the seller. If the shortened life span of the CFPP is agreed upon and consented to by both parties, the termination will be on the due date.

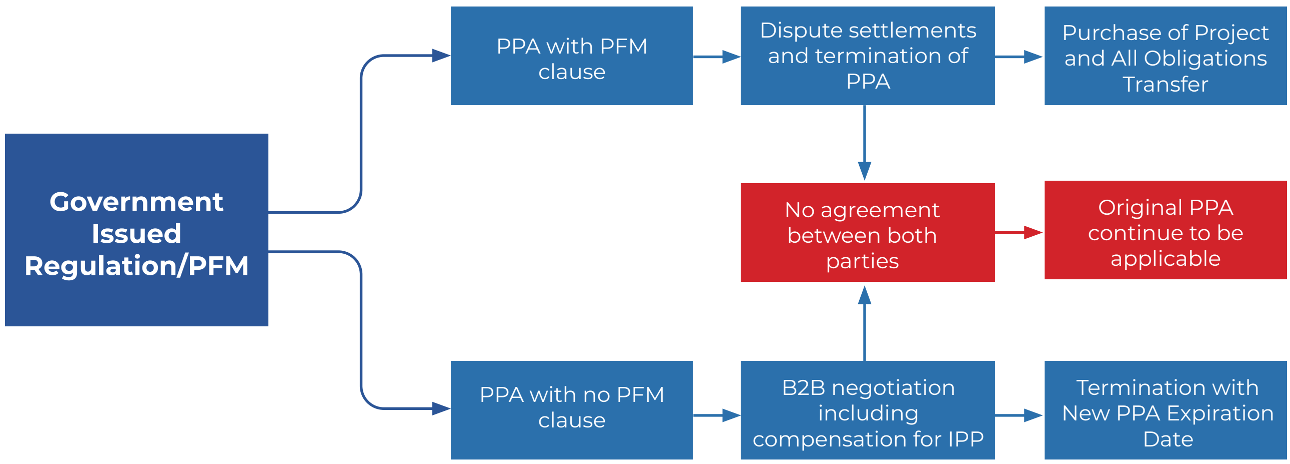


Figure B2. Possible scenarios after triggering the PFM clause in the PPA

Aside from the PPA document, there will still be the need to conduct due diligence on the IPP's project documents (e.g. coal supply agreement, O&M agreement, loan agreement, etc.) to check if there are any restrictions for early retirement of the CFPP.

Note that both scenarios may lead to disagreement between both parties. In this case, the terms of the PPA will continue to apply, and PLN as the buyer must continue purchasing the electricity as if the power plants have dispatched electricity to PLN, and the seller in general can renegotiate the purchase price of electricity.

B.4. Key considerations in the early retirement of CFPP

For the write-off of state assets, there is a consideration that the SoE may involve state finances. PLN will have to pay attention to the amount of compensation that must be paid by PLN to relevant lenders or other third parties under the agreement, which may cause state losses to occur or findings that can be assessed or questioned by the authorities due to CFPP's early retirement. If there is any concern about potential state losses with the implementation of the write-off, PLN may consider obtaining legal advice from the Board of Auditors of the Republic of Indonesia (Badan Pemeriksa Keuangan "BPK") or the Prosecutor's Office (Kejaksaan).

For the government of Indonesia, there are at least three considerations that must be taken with early retirement under the current legal and regulatory framework for the IPP plants:

- Judicial Review

  There is a potential risk in which a judicial review request is filed to the Supreme Court by IPPs to the Government of Indonesia regarding the new regulation (which triggers the PFM). This is still subject to the decisions made by the Supreme Court in relation to the judicial review requested by the relevant party. If the new regulation is issued in the form of a Ministerial/Directorate General/ etc. Decree (that meets the criteria of a State Administrative Decree), aside from the decision of the administrative court to annul or declare the decision to be void, the relevant IPP also has grounds for compensation to be claimed in relation to the Decree.

- Increase in Subsidy & Compensation

  Under MoF Regulation No. 174/PMK.02/2019, as amended by MoF Regulation No. 178/ PMK.02/2021, there will be an increase in subsidies if the electricity system cost increases. This may happen due to the negotiations and additional costs to compensate the IPP/seller. The Government of Indonesia would need to provide this subsidy.

  In addition, the MoF Regulation No. 159/PMK.02/2021 on Procedures for Provision, Disbursement, and Accountability of Compensation Funds for Lack of Revenue of Business Entities due to Policies Determining The Retail Price of Oil and Electricity Tariff, as amended by MoF Regulation No. 159/ PMK.02/2022 regulates electricity tariff compensation funds that business entities receiving assignments to generate electricity may receive. The electricity tariff compensation fund is paid by the government based on the revenue deficit suffered by the business entity due to the net difference between the non-subsidized electricity tariff calculated based on the tariff adjustment formula pursuant to regulations and the non-subsidized electricity tariff determined by the government.

- Government Guarantees

  There is Business Viability Guarantee Letter (BVGL) given to the IPP based on article 15 MoF Regulation No. 130/PMK.08/2016, as amended by MoF Regulation No. 135/PMK.08/2019. The BVGL covers the electricity purchase payment obligations as well as the non-electricity purchase payment obligations. The PFM clause is considered a political risk, which is still guaranteed by BVGL. Therefore, any changes that would affect the BVGL would require the consent of the MoF.

  Moreover, there is also Government Guarantee provided for the direct lending that the SoE received from international financing institutions with certain requirements (regulated under Presidential Regulation No. 82 of 2015 on Government Guarantee for Infrastructure Provision through Direct Lending from International Financial Institution to SOE (PR 82/2015) and its implementing regulation, Minister of Finance Regulation No. 189/PMK.08/2015 on Procedures for Provisions and Implementation of Government Guarantee for Infrastructure Financing through Direct Lending from International Financing Institution to SOE (MOF Reg 189/2015). Another guarantee is given through the Infrastructure Guarantee Business Entities for power plant projects using the KPBU scheme (regulated under Presidential Regulation No. 78 of 2010 on Infrastructure Guarantee in Cooperation between the Government and Business Entities). Therefore, further analysis of the status of the guarantee must be carried out if the power plant will be terminated early.

Appendix C - List of Projects in the Pipeline

C.1. Map of Projects in the Pipeline

Due to the lack of information, some projects are not included in the map. These are:

- Sumatra: Jambi-1 (MM), Jambi-2 (MM), and Sumbagsel-1 (MM)
- Papua: Nabire-Kalibobo

C.2. Project Status and PPA

Unit	# of unit	Capacity per unit (MW)	Total capacity (MW)	COD	Project Status						PPA Condition		Note
					Operation	Construction	Contract/ PPA	Financing	Procurement	Planning	Tenor (Years)	AF (%)	
Nagan Raya Unit 3 & 4	2	200	400	2023		X					25	80	30% in progress - Source: Link; As per September 2022, a video footage (from Google Map) taken from the project site shows incomplete stack and housing for the boiler - Source: Link; 70% in progress - Source: FGD Working Group Coal Early Retirement MEMR
Sumut-1	2	150	300	2023		X							Completed stack and building structure is already seen in the area of the project, as seen from the estimated progress based on satellite imagery dated back May 30th, 2021 is 30%-50%
Jambi-2 (mine mouth)	2	300	600	2026			X						In the process of being cancelled - Source: Link
Jambi-1 (mine mouth)	2	300	600	2027			X						In the process of being cancelled - Source: PLN 2021 Financial Report (Audited)
Sumsel-8 (mine mouth)	2	600	1,200	2022		X					25	80	96% in progress, however PLN could not take the electricty due to lack of transmission infrastructure - Source: Link; 97% in progress - Source: FGD Working Group Coal Early Retirement MEMR

Unit	# of unit	Capacity per unit (MW)	Total capacity (MW)	COD	Project Status						PPA Condition		Note
					Operation	Construction	Contract/ PPA	Financing	Procurement	Planning	Tenor (Years)	AF (%)	
Sumsel-1 (mine mouth)	2	300	600	2023		X					30	80	Ongoing construction on the stack and building structure is seen from the project area as seen from estimated progress based on satellite imagery dated back July 30th, 2021 is ~30%; 70% in progress - Source: FGD Working Group Coal Early Retirement MEMR
Sumbagsel-1 (mine mouth)	2	150	300	2024			X						Based on PJB annual report, the location of the unit will be in Kecamatan Semidang Aji, South Sumatra. However, the report does not provide any further detail; 12% in progress - Source: FGD Working Group Coal Early Retirement MEMR
Kalbar-1 Unit 2	1	100	100	2021	X	X (RUPTL)					25	80	Already operating - Source: Link
Pantai Kura-kura (Bengkayang)	2	27.5	55	2025		X							86% in progress December 2021- Source: PLN 2021 Financial Report (Audited); 86% in progress July 2022 - Source: PLN 2022 Financial Report (Unaudited)

Unit	# of unit	Capacity per unit (MW)	Total capacity (MW)	COD	Project Status						PPA Condition		Note
					Operation	Construction	Contract/ PPA	Financing	Procurement	Planning	Tenor (Years)	AF (%)	
Parit Baru (Jungkat)	2	50	100	2025		X							86% in progress December 2021- Source: PLN 2021 Financial Report (Audited); 86% in progress July 2022 - Source: PLN 2022 Financial Report (Unaudited)
Kalselteng-2	2	100	200	2022		X					25	80	78% in progress December 2021 - Source: PLN 2021 Financial Report (Audited); 85% in progress July 2022 - Source: PLN 2022 Financial Report (Unaudited)
Kotabaru	2	7	14	2025		X							Satellite imagery dated back to 9 April 2019 shows a completed construction of the civil structure. Hence, it could be estimated that the progress is between 30%-50%. However, from the planned COD, there could also be a possibility that the construction has already completed, i.e. 100%, and due to the system condition the operational date is intentionally delayed

Unit	# of unit	Capacity per unit (MW)	Total capacity (MW)	COD	Project Status						PPA Condition		Note
					Operation	Construction	Contract/ PPA	Financing	Procurement	Planning	Tenor (Years)	AF (%)	
Sampit	2	25	50	2025		X							Available satellite imagery dated June 2016 shows cleared land area within estimated location of the project. In terms of progress, the condition is estimated to be below 30%
Tanah Grogot/ Janju	2	7	14	2023		X							Local interview by IESR colleague said that the project has not been started. The area of the project has been long abandoned, with long grasses covering it
Tanjung Selor	2	7	14	2021		X (RUPTL)							97% progress, COD is delayed due to adequate supply in the Bulungan region. However, the unit might have to come online once the 150 kV transmission line between Tanjung Redep and Tanjung Selor is developed - Source: Link
Malinau	2	3	6	2021		X (RUPTL)							1 unit is already in operation; another unit is still in construction with planned COD in 2021; Satellite imagery dated 1 February 2022 shows filled coal yard; Just undergone performance test - Source: Link

Unit	# of unit	Capacity per unit (MW)	Total capacity (MW)	COD	Project Status						PPA Condition		Note
					Operation	Construction	Contract/ PPA	Financing	Procurement	Planning	Tenor (Years)	AF (%)	
Lontar Expansion	1	315	315	2022		X							First firing was carried out on 28 July 2022 with expected COD in December 2022 - Source: Link; 99% in progress July 2022 - Source: PLN 2022 Financial Report (Unaudited)
Jawa-9	1	1000	1,000	2025		X					25	86	50% in progress - Source: Link; 73% in progress - Source: FGD Working Group Coal Early Retirement MEMR
Jawa-10	1	1000	1,000	2026		X					25	86	50% in progress - Source: Link; 73% in progress - Source: FGD Working Group Coal Early Retirement MEMR
Jawa-1 (Cirebon 2)	1	924	924	2022		X					25	86	99% in progress, target COD October/ November 2022 - Source: Link
Jawa-3 Unit 1 (Tanjung Jati A)	1	660	660	2025				X					In the process of being cancelled - Source: Link; Failed securing financing
Jawa-3 Unit 2 (Tanjung Jati A)	1	660	660	2026				X					In the process of being cancelled - Source: Link; Failed securing financing
Jawa Tengah (PPP/Batang)	2	950	1,900	2021	Delayed	X (RUPTL)					25	86	Delayed due to oversupply in system - Source: Link; Operating - Source: Link
Jawa-4 (Tanjung Jati B)	2	1000	2,000	2021	Delayed	X (RUPTL)					25	86	99% in progress - Source: Link; Operating - Source: Link

Unit	# of unit	Capacity per unit (MW)	Total capacity (MW)	COD	Project Status						PPA Condition		Note
					Operation	Construction	Contract/ PPA	Financing	Procurement	Planning	Tenor (Years)	AF (%)	
Sulut-3	2	50	100	2021	X	X (RUPTL)					25	80	Unit 1 of the Sulut-3 power station began commercial operation in February 2021. In May 2021, it was reported that construction on the Sulut-3 power station had reached 97%.Unit 2 was commissioned in July 2021. Already supplying - Source: Link
Talaud (Tarun)	2	3	6	2022		X							85% in progress in 2017 - Source: Link; Operation with biomass - Source: Link
Sulut-1	2	50	100	2023		X							15% in progress December 2021 - Source: PLN 2021 Financial Report (Audited); 37% in progress July 2022 - Source: PLN 2022 Financial Report (Unaudited)
Sulbagut-1	2	50	100	2021	Delayed	X (RUPTL)					25	80	Uji coba/comissioning - Source: PLN 2021 Financial Report (Audited) - already operating since 13 April 2022

Unit	# of unit	Capacity per unit (MW)	Total capacity (MW)	COD	Project Status						PPA Condition		Note
					Operation	Construction	Contract/ PPA	Financing	Procurement	Planning	Tenor (Years)	AF (%)	
Palu-3	2	50	100	2023		X							20% in progress December 2021 - Source: PLN 2021 Financial Report (Audited); 29% in progress July 2022 - Source: PLN 2022 Financial Report (Unaudited)
Sulsel Barru-2	1	100	100	2021		X (RUPTL)							95% in progress December 2021, first synchronization 11 April 2022 - Source: Link; 97% in progress July 2022 - Source: PLN 2022 Financial Report (Unaudited)
Sofifi	2	3	6	2023		X							3 years postponed, 80% in progress may 17th, 2021 - Source: Link; Satellite imagery dated November 2022 shows complete construction
Nabire-Kalibobo	2	7	14	2022		X							Location of the project can't be identified. Available satellite imagery does not reveal any cleared area within Nabire-Kalibobo regency; construction has not even started due to difficulty to secure financing

Unit	# of unit	Capacity per unit (MW)	Total capacity (MW)	COD	Project Status						PPA Condition		Note
					Operation	Construction	Contract/ PPA	Financing	Procurement	Planning	Tenor (Years)	AF (%)	
Sorong (Ex Timika)	4	7	28	2023		X							As of March 2021, construction was 41.7% complete; Satellite imagery dated 3 June 2022 only shows cleared land area, contradicting the previously stated construction progress
Lombok	2	50	100	2021		X (RUPTL)							70.84% in progress 20 Aug 2021- Source: Link; Already carried out backfeeding from 150 kV system in April 2022 - Source: Link
Bima/Bonto	2	10	20	2029		X							30.3% in progress May 2021- Source: Link; Satellite imagery dated 9 October 2022 still shows no progress
Timor-1	2	50	100	2022		X							Land clearing and preparation for blasting hole in June 2020 - Source: Link; Available photos dated July 2022 from Google maps show an almost complete building structure of the boiller house - Source: Link
Atambua	4	6	24	2027		X							Available satellite imagery shows no sign of any construction is currently taking place

Unit	# of unit	Capacity per unit (MW)	Total capacity (MW)	COD	Project Status						PPA Condition		Note
					Operation	Construction	Contract/ PPA	Financing	Procurement	Planning	Tenor (Years)	AF (%)	
Alor	2	3	6	2025		X							Colocated with gas engine power plant, construction progress below 20% with unfinished civil structure - Source: Link; Satellite imagery dated May 2022 shows incomplete civil structure; Similar condition as in May 2022, according to 10 August 2022 satellite imagery
Rote Ndao/ Onatali	2	3	6	2025		X							Although construction is complete, the power plant is not currently operating or is running on another type of fuel, i.e. diesel oil.

C.3. Ownership and Finance

Unit	Ownership Type	Involved Parties			Investment Cost	Source of Financing	
		Developer	Owner	Parent Companies		Equity	Loan
Nagan Raya Unit 3 & 4	IPP		PT Meulaboh Power Generation	China Datang Overseas (62%), PT Pembangunan Perumahan Energi (34%) and PT Sumberdaya Sewatama (4%)	USD 597.56 mil (Source: refinitv)		
Sumut-1	Kerjasama Wilus		PT Mabar Elektrindo	China Ocean-wide International Financial Management Co Ltd (60%), Shanghai Electric Power (20%) and Garda Sayap Garuda (20%)	USD 580.5 mil (Source: refinitiv)		Syndicated loan
Jambi-2 (mine mouth)	IPP	PT Pembangkitan Perkasa Daya (BOOT)		China Huadian (95%) and PT PP Energi (5%)			
Jambi-1 (mine mouth)	IPP		PT Jambi Power	Indonesia Power, PT Sumber Segara Primadaya, and other SOEs	USD 1 bil (Source: Link)		
Sumsel-8 (mine mouth)	IPP		PT Huadian Bukit Asam Power	China Huadian (55%) and PT Bukit Asam (45%)	USD 1.68 bil (Source: Link)	USD 420 million from China Huadian and PT Bukit Asam equity (Source: Link)	USD 1.26 million from CEXIM and USD 420 million,from China Huadian and PT Bukit Asam equity (Source: Link)
Sumsel-1 (mine mouth)	IPP		PT Shenhua Guohua Lion Power Indonesia	Shenhua Group Corporation Limited (75%) and PT Lion Power Energy (25%)	USD 750 mil (Source: Link)		USD 528.6 million received so far from China Construction Bank, Bank of China, and Industrial and Commercial Bank of China (Source: Link)

Unit	Ownership Type	Involved Parties			Investment Cost	Source of Financing	
		Developer	Owner	Parent Companies		Equity	Loan
Sumbagsel-1 (mine mouth)	IPP	PT Total Bangun Persada	PT Sumbagsel Energi (Sakti) Pewali	PT Sumber Energi Sakti Prima (55%), PT Adimas Puspita Serasi (25%), PT D&C Engineering (10%) and PT PJB Investasi (10%)		Capital investment from each sponsor (Source: Link)	
Kalbar-1 Unit 2	IPP	SEPCO	PT GCL Indo Tenaga	Taichang Harbour Golden Co,. Ltd (65%) and PT Putra Indotenaga (35%) - PT Indonesia Power	USD 533.3 mil	Equity from Perusahaan Listrik Negara (PLN) and Golden Concord Holdings	Loan from China Construction Bank
Pantai Kura-kura (Beng-kayang)	PLN		PT PLN Persero		USD 50.4 mil (December 2021); USD 50.4 mil		
Parit Baru (Jungkat)	PLN	Gezhouba Group and PT Praba Indopersada	PT PLN Persero		USD 114.2 mil		Loan from Export-Import Bank of China
Kalselteng-2	PLN		PT PLN Persero		USD 388.2 mil (December 2021); USD 443.3 mil		USD 89 mil loan from Japan Bank for International Cooperation - Source: PLN 2021 Financial Report (Audited)
Kotabaru	PLN		PT PLN Persero				
Sampit	PLN		PT PLN Persero				
Tanah Grogot/Janju	IPP		PT Mahajaya Arya Satya				
Tanjung Selor	PLN		PT PLN Persero				
Malinau	PLN		PT PLN Persero				
Lontar Expansion	PLN		PT PLN Persero		USD 550 mil (December 2021); USD 557 mil		USD 108 mil loan from JBIC & USD 72 mil loan from Sumitomo - Source: PLN 2021 Financial Report (Audited)

Unit	Ownership Type	Involved Parties			Investment Cost	Source of Financing	
		Developer	Owner	Parent Companies		Equity	Loan
Jawa-9	IPP	Doosan Heady and Korea Midland Power	PT Indonesia Power (JV)	PT Indonesia Power (51%), Barito Pacific (34%) and Korea Electric Power Corporation (KEPCO) (15%)	USD 3.5 bil		Funding from private sector and loan from international Project Financing
Jawa-10	IPP	Doosan Heady and Korea Midland Power	PT Indonesia Power (JV)	PT Indonesia Power (51%), Barito Pacific (34%) and Korea Electric Power Corporation (KEPCO) (15%)			
Jawa-1 (Cirebon 2)	IPP		PT Cirebon Energi Prasarana (CEPR)	Marubeni (35%), Komipo (25%), Samtan (20%), Indika Energy (10%) and JERA (10%)	USD 2.175 bil	USD 435 million in equity from the project sponsors	Loan from Japan Bank for International Cooperation (JBIC), the Export-Import Bank of Korea (Kexim), ING, Mitsubishi UFJ Financial Group, Mizuho and Sumitomo Mitsui Banking Corporation.
Jawa-3 Unit 1 (Tanjung Jati A)	IPP		PT Tanjung Jati Power	YTL Group (80%) and Bakrie Power (20%)	USD 2.2 bil		Funding would come from "external companies" (need to be specified)
Jawa-3 Unit 2 (Tanjung Jati A)	IPP		PT Tanjung Jati Power	YTL Group (80%) and Bakrie Power (20%)			
Jawa Tengah (PPP/ Batang)	IPP		PT Bhimasena Power Indonesia (BPI)	J-Power (34%), Adaro Power (34%) and ITOCHU (32%)	USD 33.9 mil + USD 3.4 bil + USD 879 mil	USD 879 million in equity from Adaro Energy, Itochu and J-Power	USD 33.9 million government guarantee from the World Bank; USUSD 3.4 billion in loan from Japan Bank for International Cooperation (JBIC), MUFG Bank, Mizuho Financial Group, Mitsubishi UFJ Trust and Banking, Norinchukin Bank, Shinsei Bank, Sumitomo Mitsui Trust Holdings, Sumitomo Mitsui Banking Corporation, DBS Bank and Oversea-Chinese Banking Corporation

Unit	Ownership Type	Involved Parties			Investment Cost	Source of Financing	
		Developer	Owner	Parent Companies		Equity	Loan
Jawa-4 (Tanjung Jati B)	IPP		PT Bhumi Jati Power	Sumi Energy Venture LLC (50%), KP Power Development (25%) and PT Unitra Persada Energia - Astra Group (25%)	USD 3.3 bil + USD 838.81 mil	USD 838.81 million in equity from Sumitomo Corporation, Kansai Electric power, and PT United Tractors.	USD 3,355 million in loan from Japan Bank for International Cooperation (JBIC) and co-financing MUFG Bank, Mizuho Bank, Mitsubishi UFJ Financial Group, OCBC Bank, Sumitomo Mitsui Banking Corporation, Sumitomo Mitsui Trust Holdings, and Norinchukin Bank
Sulut-3	IPP		PT Minahasa Cahaya Lestari	PT Toba Bara Energi (90%) and Sinohydro Corporation Ltd (10%)	USD 209.17 mil (Source: refinitiv)		USD 157 mil loan from Bank Mandiri and Sarana Multi Infrastructure (SMI) (Source: Link)
Talaud (Tarun)	PLN	PT Bousted Maxiterm Industries	PT PLN Persero				
Sulut-1	PLN	PT PP, PT IKPT, Itochu Corp and Sumitomo Heavy Industries	PT PLN Persero		USD 70 mil (December 2021); Rp USD 107.5 mil		Loan from Bank Mandiri and Sarana Multi Infrastructure (SMI)
Sulbagut-1	IPP		PT Gorontalo Listrik Perdana	PT TBS Energi Utama Tbk (TOBA) (60%), PT Toba Sejahtera (20%) and Shanghai Electric Power Construction Comp Ltd (20%)	USD 225.39 mil (Source: refinitiv)		USD 171.77 mil loan from Bank Mandiri (Source: Link)
Palu-3	PLN	PT WIJAYA KARYA (Persero) Tbk. (WIKA) - Doosan Heavy Industries and Construction Co., Ltd - Korea South-East Power (KOEN) Co., Ltd	PT PLN Persero		USD 80.6 mil (December 2021); USD 100.7 mil		

Unit	Ownership Type	Involved Parties			Investment Cost	Source of Financing	
		Developer	Owner	Parent Companies		Equity	Loan
Sulsel Barru-2	PLN	PT Wijaya Karya (Persero) Tbk and Mitsubishi Corporation	PT PLN Persero		USD 234 mil (December 2021); USD 252 mil		
Sofifi	PLN	PT Rekadaya Elektrika	PT PLN Persero		USD 6.9 mil (new contract); USD 8.8 mil (old contract) (Source: Link)	PLN	
Nabire-Kalibobo	IPP						
Sorong (Ex Timika)	PLN		PT PLN Persero				
Lombok	PLN	PT. Rekayasa Industri & Rafaco (Poland)	PT PLN Persero		USD 201.5 mil		€81 mil loan from BGK (Poland) - Source: PLN 2021 Financial Report (Audited)
Bima/Bonto	PLN		PT PLN Persero				
Timor-1	PLN	Medco Power, PT Inti Karya Persada Tehnik, PT PP Persero Tbk, ITOCHU Corporation, and Sumitomo Heavy Industries	PT PLN Persero				
Atambua	PLN		PT PLN Persero				
Alor	PLN		PT PLN Persero				
Rote Ndao/Onatali	PLN		PT PLN Persero				

Appendix D - Priority Ranking of Projects in the Pipeline with Latest Satellite Imageries

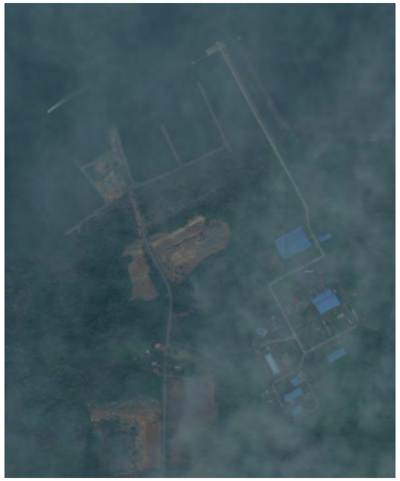
Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Atambua	0.5	1	1	1	0.8750	1.0000	 Date: June 2022
Jawa-3 Unit 2 (Tanjung Jati A)	0.75	0.5	1	1	0.8125	0.9231	N/A - not yet starting

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Bima/Bonto	0.25	0.75	1	1	0.7500	0.8462	 Date: October 2022
Jambi-1 (mine mouth)	0.5	0.5	1	1	0.7500	0.8462	N/A - not yet starting
Jambi-2 (mine mouth)	0.5	0.5	1	1	0.7500	0.8462	N/A - not yet starting

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Sampit	0.5	1	0.5	1	0.7500	0.8462	 Date: September 2021
Jawa-3 Unit 1 (Tanjung Jati A)	0.75	0.5	0.5	1	0.6875	0.7692	N/A - not yet starting
Tanah Grogot	0.25	1	0.5	1	0.6875	0.7692	 Date: September 2019

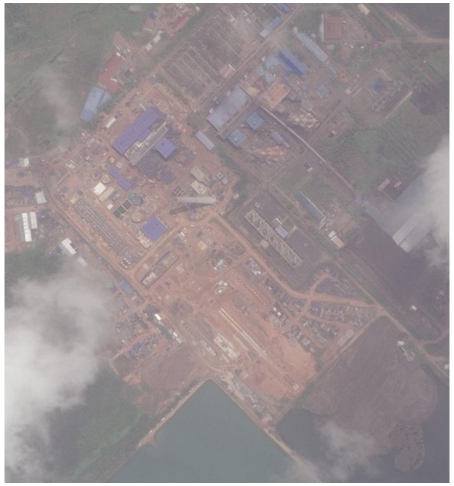
Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Sumbagsel-1 (mine mouth)	0.5	0.5	0.5	1	0.6250	0.6923	N/A - project site untraceable
Alor	0.5	0.25	0.5	1	0.5625	0.6154	 Date: January 2023
Nabire-Kali-bobo	0.5	0.5	0	1	0.5000	0.5385	N/A - project site untraceable

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Palu-3	0.5	0.75	0.5	0	0.4375	0.4615	 Date: September 2022
Sulut-1	0.25	1	0.5	0	0.4375	0.4615	 Date: May 2021 - Google Earth

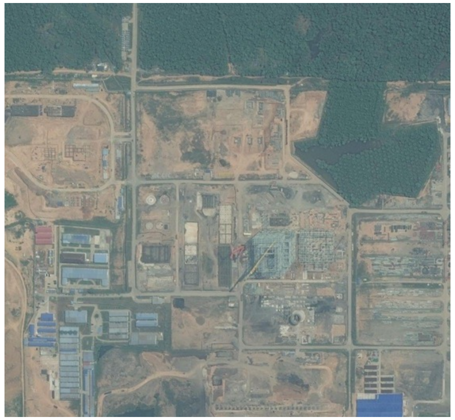
Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Jawa-10	0	0.5	1	0	0.3750	0.3846	 Date: September 2022
Kotabaru	0	1	0.5	0	0.3750	0.3846	 Date: January 2022

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Pantai Kura-kura (Beng-kayang)	0	1	0.5	0	0.3750	0.3846	 Date: January 2023
Parit Baru (Jungkat)	0	1	0.5	0	0.3750	0.3846	 Date: January 2023

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Sofifi	0	1	0.5	0	0.3750	0.3846	 Date: October 2022
Sorong (Ex Timika)	0.5	0.25	0.5	0	0.3125	0.3077	 Date: October 2022

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Jawa-9	0	0.5	0.5	0	0.2500	0.2308	 Date: September 2022
Kalselteng-2	0	1	0	0	0.2500	0.2308	 Date: March 2022

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Lontar Expansion	0	1	0	0	0.2500	0.2308	 Date: January 2023
Malinau	0	1	0	0	0.2500	0.2308	 Date: January 2023

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Nagan Raya Unit 3 & 4	0	0.5	0.5	0	0.2500	0.2308	 Date: January 2023
Sumsel-1 (mine mouth)	0	0.5	0.5	0	0.2500	0.2308	 Date: July 2021

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Sumut-1	0	0.5	0.5	0	0.2500	0.2308	 Date: January 2023
Talaud (Tarun)	0	1	0	0	0.2500	0.2308	 Date: November 2022

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Tanjung Selor	0	1	0	0	0.2500	0.2308	 Date: November 2018
Timor-1	0	1	0	0	0.2500	0.2308	 Date: January 2023

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Rote Ndao/ Onatali	0	0.25	0.5	0	0.1875	0.1538	 Date: August 2022
Sulsel Barru-2	0	0.75	0	0	0.1875	0.1538	 Date: May 2022

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Jawa Tengah (PPP/Batang)	0	0.5	0	0	0.1250	0.0769	 Date: September 2022
Jawa-1 (Cire-bon 2)	0	0.5	0	0	0.1250	0.0769	 Date: September 2022

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Jawa-4 (Tanjung Jati B)	0	0.5	0	0	0.1250	0.0769	 Date: July 2022
Kalbar-1 Unit 2	0	0.5	0	0	0.1250	0.0769	 Date: December 2020

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Sulbagut-1	0	0.5	0	0	0.1250	0.0769	 Date: August 2022
Sulut-3	0	0.5	0	0	0.1250	0.0769	 Date: August 2022

Unit	Project Status	Ownership + system condition	COD	Progression Rate	Combined Score	Norm. Combined Score	Latest Satellite Imageries
Sumsel-8 (mine mouth)	0	0.5	0	0	0.1250	0.0769	 Date: July 2022
Lombok	0	0.25	0	0	0.0625	0	 Date: September 2022

Appendix E - Sensitivity Analysis on the MCA Scoring

A sensitivity analysis was carried out to assess the consistency of the priority ranking through applying different Weighting Factor (WF) for each criteria prior to the averaging and normalisation. The calculation was done by employing Equation E1. In the analysis, three scenarios were considered, as presented in Table E1. The 'Project Status' and 'Ownership + System Condition' are given higher WF than the rest of the criteria due to the importance in determining the possibility for the intervention.

$$\text{Averaged Combine Score} = \sum_{n=1}^{4} (WF * Criteria_n) \qquad \textbf{Equation E1}$$

Table E2. WF scenario for each criteria

Scenario	WF			
	Project Status	Ownership + System Condition	COD	Progression Rate
1	40%	30%	15%	15%
2	40%	40%	10%	10%
3	50%	30%	10%	10%

From applying the weighting factors, the list for each scenario was then rearranged and compared to. This is shown in Table E2, in which the high-scoring projects are consistently placed at the top rank positions, albeit the differences in the WF. In a similar fashion, the low-scoring project are also consistently place at the bottom of the list.

Table E2. Comparison of the ranking from the WF scenarios considered

No Weighting Factors	Scenario 1	Scenario 2	Scenario 3
Atambua	Atambua	Atambua	Atambua
Jawa-3 Unit 1	Jawa-3 Unit 1	Sampit	Jawa-3 Unit 1
Bima/Bonto	Sampit	Jawa-3 Unit 1	Sampit
Jambi-1 (mine mouth)	Jawa-3 Unit 2	Jawa-3 Unit 2	Jawa-3 Unit 2
Jambi-2 (mine mouth)	Jambi-1 (mine mouth)	Tanah Grogot	Jambi-1 (mine mouth)
Sampit	Jambi-2 (mine mouth)	Bima/Bonto	Jambi-2 (mine mouth)
Jawa-3 Unit 2	Bima/Bonto	Jambi-1 (mine mouth)	Tanah Grogot
Tanah Grogot/Janju	Tanah Grogot	Jambi-2 (mine mouth)	Sumbagsel-1 (mine mouth)
Sumbagsel-1 (mine mouth)	Sumbagsel-1 (mine mouth)	Palu-3	Bima/Bonto
Alor	Alor	Sulut-1	Palu-3
Nabire-Kalibobo	Nabire-Kalibobo	Sumbagsel-1 (mine mouth)	Nabire-Kalibobo
Palu-3	Palu-3	Nabire-Kalibobo	Alor
Sulut-1	Sulut-1	Alor	Sulut-1
Jawa-10	Kotabaru	Kotabaru	Sorong (Ex Timika)
Kotabaru	Pantai Kura-kura (Bengkayang)	Pantai Kura-kura (Bengkayang)	Kotabaru
Pantai Kura-kura (Bengkayang)	Parit Baru (Jungkat)	Parit Baru (Jungkat)	Pantai Kura-kura (Bengkayang)
Parit Baru (Jungkat)	Sofifi	Sofifi	Parit Baru (Jungkat)
Sofifi	Sorong (Ex Timika)	Kalselteng-2	Sofifi
Sorong (Ex Timika)	Jawa-10	Lontar Expansion	Kalselteng-2
Jawa-9	Kalselteng-2	Malinau	Lontar Expansion
Kalselteng-2	Lontar Expansion	Talaud (Tarun)	Malinau
Lontar Expansion	Malinau	Tanjung Selor	Talaud (Tarun)
Malinau	Talaud (Tarun)	Timor-1	Tanjung Selor
Nagan Raya Unit 3 & 4	Tanjung Selor	Sorong (Ex Timika)	Timor-1
Sumsel-1 (mine mouth)	Timor-1	Jawa-10	Jawa-10
Sumut-1	Jawa-9	Sulsel Barru-2	Sulsel Barru-2
Talaud (Tarun)	Nagan Raya Unit 3 & 4	Jawa-9	Jawa-9
Tanjung Selor	Sulsel Barru-2	Nagan Raya Unit 3 & 4	Nagan Raya Unit 3 & 4
Timor-1	Sumsel-1 (mine mouth)	Sumsel-1 (mine mouth)	Sumsel-1 (mine mouth)
Rote Ndao/Onatali	Sumut-1	Sumut-1	Sumut-1
Sulsel Barru-2	Jawa Tengah (PPP/Batang)	Jawa Tengah (PPP/Batang)	Jawa Tengah (PPP/Batang)
Jawa Tengah (PPP/Batang)	Jawa-1 (Cirebon 2)	Jawa-1 (Cirebon 2)	Jawa-1 (Cirebon 2)
Jawa-1 (Cirebon 2)	Jawa-4 (Tanjung Jati B)	Jawa-4 (Tanjung Jati B)	Jawa-4 (Tanjung Jati B)
Jawa-4 (Tanjung Jati B)	Kalbar-1 Unit 2	Kalbar-1 Unit 2	Kalbar-1 Unit 2
Kalbar-1 Unit 2	Rote Ndao/Onatali	Sulbagut-1	Sulbagut-1
Sulbagut-1	Sulbagut-1	Sulut-3	Sulut-3
Sulut-3	Sulut-3	Sumsel-8 (mine mouth)	Sumsel-8 (mine mouth)
Sumsel-8 (mine mouth)	Sumsel-8 (mine mouth)	Rote Ndao/Onatali	Rote Ndao/Onatali
Lombok	Lombok	Lombok	Lombok

Appendix F - Power System Reserve Margin

Island	Power System	System Condition
Sumatra	Sumatra Interconnection	35% (July 2022) - Source: Link
Kalimantan	Khatulistiwa	49% (June 2021) - Source: Link
Kalimantan	Barito-Mahakam Interconnection	207% (August 2022) - Source: Link
Java, Madura, and Bali	Java-Bali	39% (May 2021) - Source: Link
Sulawesi	Sulbagut	55% (February 2022) - Source: Link
Sulawesi	Sulbagsel	39% (March 2022) - Source: Link
Halmahera	Halmahera	90% (October 2021) - Source: Link
Lombok	Lombok	4.8% (June 2022) - Source: Link
Rote	Rote	Assumed: undersupply; so far the island electricity has only been supplied by two diesel power plants and a solar PV (inoperational)
Alor	Alor	Assumed: undersupply; so far the island electricity has only been supplied by two diesel power plants
Papua	Sorong	22% (April 2022) - Source: Link
Papua	Nabire	59% (May 2021) - Source: Link
Sumbawa	Sumbawa	43% (August 2022) - Source: Link
Timor	Timor	110% (March 2022) - Source: Link

IESR
Institute for Essential Services Reform

Jalan Tebet Timur Raya No 48 B
Jakarta Selatan 12810 | Indonesia
T: +62 21 2232 3069
F:+62 21 8317 073

iesr.id iesr
www.iesr.or.id