ECONOMIC ANALYSIS

A. Project Rationale

1. The peak demand for electricity in Bali in 2012 was 618 megawatts (MW). This demand was served by the transmission interconnection between Java and Bali, and diesel-based generators installed in Bali. The undersea transmission interconnection between Java and Bali is presently used to its full capacity, constraining the supply of low-cost power from Java–Bali power grid. The two existing undersea cables and the additional two cables being newly installed will provide a combined transfer capacity of 400 MW. The total diesel generating capacity in Bali at present is 526 MW. Therefore, once the undersea cable installation is completed in early 2014, the total installed supply capacity to Bali will be 926 MW.

2. However, the diesel generators supplementing the main power supply from Java to Bali are required to be phased out due to: (i) a policy decision by the Bali provincial government to reduce carbon dioxide emissions and minimize noise pollution in Bali; and (ii) the government's plan to phase out diesel power generation to reduce the annual subsidy being provided to the State Electricity Company (PLN).[1] Therefore, investments are required to strengthen Bali's power supply by (i) strengthening the transmission capacity from Java to Bali, and (ii) installing more economical, less polluting generating plants in Bali itself. The project is included in PLN's power supply business plan as the most technically and economically feasible option. Accordingly, PLN has completed the initial designs of a 500-kilovolt (kV) double circuit overhead transmission line from Java to Bali, which will transmit 1,500 MW of power and be operational by 2018.

B. Macroeconomic and Sectoral Context

3. Bali is an internationally renowned tourist and cultural destination, and contributes 6% of the national gross domestic product of Indonesia. Tourism generates 67% of Bali's gross regional domestic product, and about 70% of the island's residents are directly or indirectly dependent on the tourist industry. About 46% of the total electricity consumption in Bali is in the commercial sector, which includes the hotel industry and associated services. The Java–Bali transmission project addresses the imminent shortage of power supply capacity in Bali, which, if not resolved early, would cause (i) the continued use of expensive diesel generators, (ii) load shedding, and (iii) a combination of both diesel use and load shedding, thus constraining further development of the economy of the island. The energy sector strategy of the Asian Development Bank (ADB) supports the development of infrastructure required to relieve supply constraints. The project is listed in the country operations business plan, 2013–2014.[2]

C. Project Alternatives

4. The project will establish a gross transmission capacity of 3,000 MW between Java and Bali, but transfer a maximum of only 1,500 MW in normal operation to ensure any unexpected outage of one circuit will not curtail supply to Bali. However, in contingency situations where other sources of supply to Bali are constrained, the project may deliver up to 3,000 MW. The peak demand in Bali is expected to reach 1,234 MW by 2018, thus exceeding the combined capacity of the existing transmission interconnections at 150 kV and diesel generators in Bali.

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[1] PT (Persero) Perusahaan Listrik Negara.
[2] ADB. 2012. *Country Operations Business Plan: Indonesia, 2013–2014.* Manila.

When considering the need for reserve margin, this capacity limit is likely to be reached by about 2025.

D. Demand Analysis

5. PLN forecasts the demand in Bali will increase by about 9.6% per year from 2012 to 2022. The electricity demand in Bali for each year within the evaluation period was directly taken from PLN forecasts as published in its System Planning Update, May 2012. For the period 2009–2012, Bali experienced an average annual growth of 10% in foreign tourist arrivals, and the Bali tourism board targets annual growth rates above 10%. Therefore, the annual demand growth of 9.6% per year forecasted by PLN is reasonable. Since Indonesia has a policy of uniform pricing of electricity sold in Java and Bali, the proposed project or its alternatives are unlikely to make a significant incremental impact on electricity prices because the demand in Bali is only a small share (2.5%) of the total demand in the Java–Bali grid. The project is expected to significantly reduce the cost of supplying electricity to Bali and contribute toward the reduction of government subsidies to PLN.

E. Cost–Benefit Analysis

6. **Approach:** The economic analysis was conducted in accordance with ADB's Guidelines for Economic Analysis of Projects.[3] The project evaluation period is from 2014 to 2037, including 4 years of implementation period. Power transfer through the Java–Bali transmission line will exceed 1,500 MW by the 8th year of operation in 2025, beyond which the single contingency criterion cannot be fulfilled, and the supply capacity to Bali will again be constrained. For each year, the net benefit of the project was calculated. Annual economic benefits were then used to calculate the economic internal rate of return (EIRR).

7. **Capacity balance to serve Bali:** As the existing diesel-fired power plants are decommissioned or placed on reserve, the demand in Bali will be met from three sources: (i) transfers through the 150 kV submarine cables with a total capacity of 400 MW, (ii) transfer of 3,000 MW through the proposed project, and (iii) generation from small thermal power plants to be established in the future. Table 1 shows the capacity balance, gross reserve capacity, and the reserve capacity with a single circuit outage.

Table 1: Capacity Balance in Transmission Services from Java to Bali, with Project

Year	Peak demand (megawatt [MW])	Existing Cables	Proposed Project	Reserve Capacity to Serve Bali		Reserve Capacity under Single Line Outage	
		Capacity (MW)	Capacity (MW)	Reserve capacity (MW)	Reserve Margin	Reserve capacity (MW)	Reserve Margin
2018	1,234	400	3000	2,166	175%	666	54%
2020	1,394	400	3000	2,006	144%	506	36%
2022	1,619	400	3000	1,781	110%	281	17%
2024	1,876	400	3000	1,524	81%	24	1%
2025	2,020	400	3000	1,380	68%	no reserve	no reserve
2026	2,175	400	3000	1,225	56%		
2028	2,530	400	3000	870	34%		
2031	3,172	400	3000	228	7%		
2032	3,421	400	3000	no reserve	no reserve		
2033	3,689	400	3000				
2037	4,989	400	3000				

Source: Asian Development Bank estimates.

[3] ADB.1997. *Guidelines for Economic Analysis of Projects.* Manila.

8. In the economic analysis, transfers through the project were assumed to be limited to its firm capacity of 1,500 MW. As per the capacity balance in Table 1, the electricity supply shortfall in Bali can be met entirely through the new transmission line from 2018 to 2025 under single line outage conditions and reserve margin, from 2025 onwards, other means of power supply to meet the growing power demand in Bali shall be available.

9. **Energy transferred through the project:** The annual capacity factor for the Java–Bali transmission lines (both existing and new) was assumed to be 80% to account for planned and unplanned outages. In the analysis, the following loading order was assumed: (i) the existing undersea cables, and (ii) the proposed 500 kV transmission line. This assumption provides a conservative assessment of benefits of the proposed line. Table 2 provides the energy balance.

Table 2: Energy Balance in Bali with the Proposed Project

Year	Bali Energy Demand (GWh)	Energy Served through Existing Undersea Cables (GWh)	Energy Supplied by Existing Diesel Generation (GWh)	Energy to be Served through the Project (GWh)	Energy Served by New Generation (GWh)
2013	4,201	2,803	1,398		
2014	4,625	2,803	1,822		
2015	5,090	2,803	2,287		
2016	5,588	2,803	2,785		
2017	6,123	2,803	3,320		
2018	6,995	2,803	2,765	4,192	0
2019	7,297	2,803	1,843	4,494	0
2020	7,926	2,803	922	5,123	0
2021	8,560	2,803	0	5,757	0
2022	9,245	2,803	0	6,442	0
2023	9,984	2,803	0	7,181	0
2024	10,783	2,803	0	7,980	0
2025	11,646	2,803	0	8,843	0
2026	12,578	2,803	0	9,775	0
2027	13,584	2,803	0	10,512	269
2028	14,670	2,803	0	10,512	1,355
2030	17,112	2,803	0	10,512	3,797
2032	19,959	2,803	0	10,512	6,644
2036	27,154	2,803	0	10,512	13,839
2037	29,326	2,803	0	10,512	16,011

GWh = gigawatt-hour.

Note: As noted in Table 1, sufficient reserve capacity is not available from 2025 onwards. In calculating the energy to be served through the project, it was conservatively assumed that the project would transfer only 1,500 megawatts, and any additional capacity transfers will only be under short-term emergency conditions, whose benefits have not been included as project benefits.

Source: Asian Development Bank estimates.

10. **Project costs:** The costs of the project are: (i) investments in the new 500 kV transmission line and associated substations, and their operation and maintenance costs; (ii) cost of power supplied to the line from power plants in Java; and (iii) cost of incremental transmission losses owing to the transfer of power over the relatively long distance of 220 kilometers from the Paiton substation in East Java to the Antosari substation in Bali.

11. **Assumptions:** A domestic price level numeraire was used throughout the analysis. The reference point for comparison of costs and benefits was defined to be the 150 kV level bus bar in Bali. The project economic costs were calculated using estimated financial costs by (i) excluding taxes and duty, (ii) multiplying the costs of equipment, and (iii) consulting and engineering services (which are tradable) by a shadow exchange rate factor of 1.2. Other costs, excluding taxes and duty, were used without adjustment. The project annual maintenance costs were assumed to be 1.5% of the economic cost. Incremental transmission losses along the 500

kV line in each year were estimated on the basis of the forecasted peak demand on the transmission line, conductor resistance and an estimated loss load factor, and a further 0.4% loss in transformation from 500 kV to 150 kV in Bali. Estimated cost of supply from Java and diesel generation in Bali is shown in the Table 3.

Table 3: Estimated Cost of Supply from Java, and Diesel Generation in Bali

	Total Cost (Rp/kWh)	Shadow Exchange Rate Factor	Shadow Cost (Rp/kWh)
Cost of coal-fired generation in Java	668.5	1.2	802
Existing diesel generation in Bali	1,994.6	1.2	2,393

kWh = kilowatt-hour.
Source: Project preparatory consultants.

12. **Economic benefits**: The economic benefits of the project were evaluated as (i) non-incremental benefits to be the resource cost savings, and (ii) incremental benefits, as the line serves the growing demand in Bali.

(i) Non-incremental benefits from resource savings due to displacement of power from diesel generators in Bali by power supplied from power plants in Java are valued at the economic cost differential between a coal-fired power plant and a diesel generator (economic costs given in Table 3), less transmission energy loss. A key assumption was that the existing diesel generators in Bali would be mothballed for use in emergency situations. Accordingly, the non-incremental benefits end in year 2020.

(ii) Incremental benefits accrue from 2018 and were evaluated at the willingness to pay, which was estimated to be the current tariff of 937 Rp/kWh. After adjustments for distribution losses of 5%, the reference point was brought to 150 kV.

13. **Economic internal rate of return:** Results of the economic evaluation is summarized in Tables 4 and 5. The evaluation shows that the project is economically viable, with an estimated EIRR of 25.5%, which is acceptable.

Table 4: Energy Balance Used for Economic Cost Benefit Evaluation

Operating Year of the Project	Year	Bali Energy Demand (GWh)	Energy Supplied by Existing Undersea Cables (GWh)	Energy Supplied by Existing Diesel Generation (GWh)	Energy to be Served through the Project (GWh)	Energy Served through the Project (GWh)	
						Non-incremental (i.e., replacing electricity that would have been generated using diesel)	Incremental (i.e., energy in addition to the energy capability of existing diesel generation)
	2013	4,201	2,803	1,398			
	2014	4,625	2,803	1,822			
	2015	5,090	2,803	2,287			
	2016	5,588	2,803	2,785			
	2017	6,123	2,803	3,320			
1	2018	6,995	2,803	2,765	4,192	2,765	1,427
2	2019	7,297	2,803	1,843	4,494	1,843	2,651
3	2020	7,926	2,803	922	5,123	922	4,201
4	2021	8,560	2,803	0	5,757	0	5,757
5	2022	9,245	2,803	0	6,442	0	6,442
6	2023	9,984	2,803	0	7,181	0	7,181
7	2024	10,783	2,803	0	7,980	0	7,980
8	2025	11,646	2,803	0	8,843	0	8,843
9	2026	12,578	2,803	0	9,775	0	9,775
10	2027	13,584	2,803	0	10,512	0	10,512
11	2028	14,670	2,803	0	10,512	0	10,512
20	2037	29,326	2,803	0	10,512	0	10,512

GWh = gigawatt-hour.
Source: Asian Development Bank estimates.

Table 5: Economic Cost Benefit Evaluation

Operating Years of the Project	Year	Bali Energy Demand (GWh)	Non-incremental Benefit Valued at Replacement Cost of and Diesel Generation (Rp billion)	Incremental Benefit Valued at Willingness to Pay (Rp billion)	Resource Cost of Incremental Benefit Valued at Java Generation Costs (Rp billion)	Investment and Maintenance Cost of Project (Rp billion)	Net Benefit (Rp billion)
	2013	4,201					
	2014	4,625				481	(481)
	2015	5,090				1,723	(1,723)
	2016	5,588				1,789	(1,789)
	2017	6,123				1,091	(1,091)
1	2018	6,995	4,336	1,271	1,209	76	4,321
2	2019	7,297	2,861	2,360	2,198	76	2,947
3	2020	7,926	1,376	3,740	3,461	76	1,579
4	2021	8,560	0	5,125	4,730	76	319
5	2022	9,245	0	5,734	5,303	76	355
6	2023	9,984	0	6,393	5,926	76	391
7	2024	10,783	0	7,104	6,601	76	426
8	2025	11,646	0	7,872	7,299	76	496
9	2026	12,578	0	8,701	8,047	76	578
10	2027	13,584	0	9,357	8,638	76	643
11	2028	14,670	0	9,357	8,638	76	643
20	2037	29,326	0	9,357	8,638	76	643
						EIRR	**25.5%**

EIRR = economic internal rate of return, GWh = gigawatt-hour.
Source: Asian Development Bank estimates.

F. Project Risks and Sensitivity Analyses

14. **Sensitivity analyses:** The economic evaluation was tested for its sensitivity to adverse changes in key assumptions. Table 6 shows the results, indicating that the project is viable under the adverse conditions analyzed.

Table 6: Results of Sensitivity Analyses

Sensitivity Parameter	Variation	EIRR	Switching Value
Base case		25.5%	
Capital cost	20.0%	19.8%	62.0%
Cost of diesel generation in Bali	(10.0%)	21.4%	(36.0%)
Cost of coal-fired generation in Java	5.0%	19.9%	8.7%
Bali demand	(10.0%)	24.8%	(41.0%)

EIRR = economic rate of return, ( ) = negative.
Source: Asian Development Bank estimates.

15. **Project risks**: One key risk is the possible delay in project implementation owing to implementation of compensation for the lands affected by the projects. However, any delays would cause economic losses to Bali but would not affect the economic viability of the project given its substantial economic returns. With the increase in electricity demand within Java itself, the supply from Java to Bali may be restricted, compelling Bali to resort to diesel generators to meet any shortfalls. Such a contingency measure, however, is not expected to affect the project’s economic viability. Future generating capacity in Java and any new capacity to be installed in Bali in the longer term would be further strengthened by the proposed regional interconnections, including connections to Malaysia.

G. Overall Economic Assessment

16. The economic analysis confirms that the transmission line between Java and Bali is economically beneficial. The analysis yields an EIRR of 25.5%, and the sensitivity analyses show that this expected economic performance is robust.