FINANCIAL AND ECONOMIC ANALYSIS

I. INTRODUCTION

1. The economic and financial analysis of the proposed Golovnaya 240 Megawatt (MW) Hydropower Plant Rehabilitation Project was conducted in accordance with Asian Development Bank (ADB) guidelines,[1] and measured the projected costs and benefits at 2013 constant prices for a period of 50 years (2014–2063). Both the economic internal rate of return (EIRR) and financial internal rate of return (FIRR) were calculated by discounting the incremental annual cash flows arising from the comparison between the "with-project" and "without-project" scenarios. The economic analysis is carried out from a country perspective, while the financial analysis is undertaken from the viewpoint of Barki Tojik, the project executing agency. A sensitivity analysis was conducted to ascertain the robustness of the analysis. All financial prices have been adjusted to economic prices by applying corresponding conversion factors.

2. Golovnaya Hydropower Plant is situated 80 kilometers south of Dushanbe, Tajikistan. Its installed generation capacity is 240 MW, which makes it the fourth-largest hydropower plant in Tajikistan after the Nurek (3000 MW), Sangtuda 1 (670 MW) and Baipaza (600 MW) hydropower plants. Since being commissioned in 1962, Golovnaya hydropower plant has had no major improvements or modernization, except to one generation unit. The present condition of most of the main electro- and hydro-mechanical equipment and the switchyard is poor. It is expected that power units will fail in 5 or fewer years unless major rehabilitation work is undertaken urgently.

3. The project will increase the supply of renewable energy to national and regional power systems. The project will refurbish electrical and mechanical equipment for power generation, thereby increasing the year-round availability of clean power for domestic sales and for export to Afghanistan. The project will extend the economic life of the Golovnaya hydropower plant, increase generation capacity and improve the plant's operational efficiency.

II. METHOD AND ASSUMPTIONS

A. Seasonality and energy demand

4. The most notable feature of the Tajikistan power system is that hydropower resources produce surpluses from May to October, but cannot fully meet domestic demand from November to April. During the summer (June to August), substantial surplus water is spilled (it cannot be stored or used for electricity generation). The summer surplus could be used to generate electricity for export, if cross border transmission interconnection capacity is expanded and necessary agreements are reached power purchasing. The project is expected to contribute to reducing domestic winter shortages, and ensuring continued export of power to Afghanistan. Golovnaya generation and transmission facilities are important source of electricity in the Kunduz region of Afghanistan. The demand in northern Afghanistan is expected to grow as the Government of Afghanistan expands the transmission and distribution network, and it is expected that more electricity generated at Golovnaya hydropower plant will be exported to Afghanistan. However, to simplify the model used for the economic analysis, the export of energy from the Golovnaya hydropower plant is considered under the sensitivity analysis, but excluded from the base case scenario.

[1] ADB. 1997. *Guidelines for the Economic Analysis of Projects*. Manila; ADB. 2005. *Financial Management and Analysis of Projects*. Manila.

5. Energy demand has been estimated to increase by about 2% per year. The power shortage is acute in winter and is expected to persist for the immediate future (Table 1). Efforts are being made to increase winter generation capacity by expanding both thermal and hydropower. This project is part of the effort to reduce the power shortage in Tajikistan.

Table 1: Energy Demand and Supply Forecast

(GWh per year)

Demand/Supply	2012	2013	2014	2015	2016	2017	2018	2019	2020
Energy demand	19,635	19,918	20,007	19,909	19,810	19,970	20,129	20,307	20,484
To be met by:									
Sangtuda	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130	2,130
Existing CHPs	34	34	34	34	34	34			
Existing hydro plants	14,771	14,771	14,771	14,771	14,771	14,771	14,771	14,771	14,771
Dushanbe-2		110	329	657	876	876	876	876	876
Shurob-1							1,100	1,100	1,100
Shurob-2									1,100
Sanobod HPP									657
Deficit	2,700	2,873	2,744	2,317	1,999	2,159	1,252	1,430	0

CHPs = combined heat and power plants, GWh = gigawatt hour, HPP = hydroelectricity power plant.

Source: Sector operational performance improvement program consultant from the Ministry of Energy and Industry.[2]

B. With- or Without-Project Comparison

6. The economic analysis adopts a with- or without-project comparison. Under the without-project scenario, no action is taken with respect to plant rehabilitation, and electricity production from the Golovnaya hydropower plant eventually ceases altogether. Without rehabilitation, electricity production from the Golovnaya hydropower plant will continue in the absence of any corrective action, but at progressively deteriorating levels, until a point is reached where electricity production is no longer possible. The energy production under the without-project scenario assumes:

(i) Production will continue from the six existing units (including the new unit rehabilitated in 2012 and the five older units) until one of the older units is forced out of service in 2023.

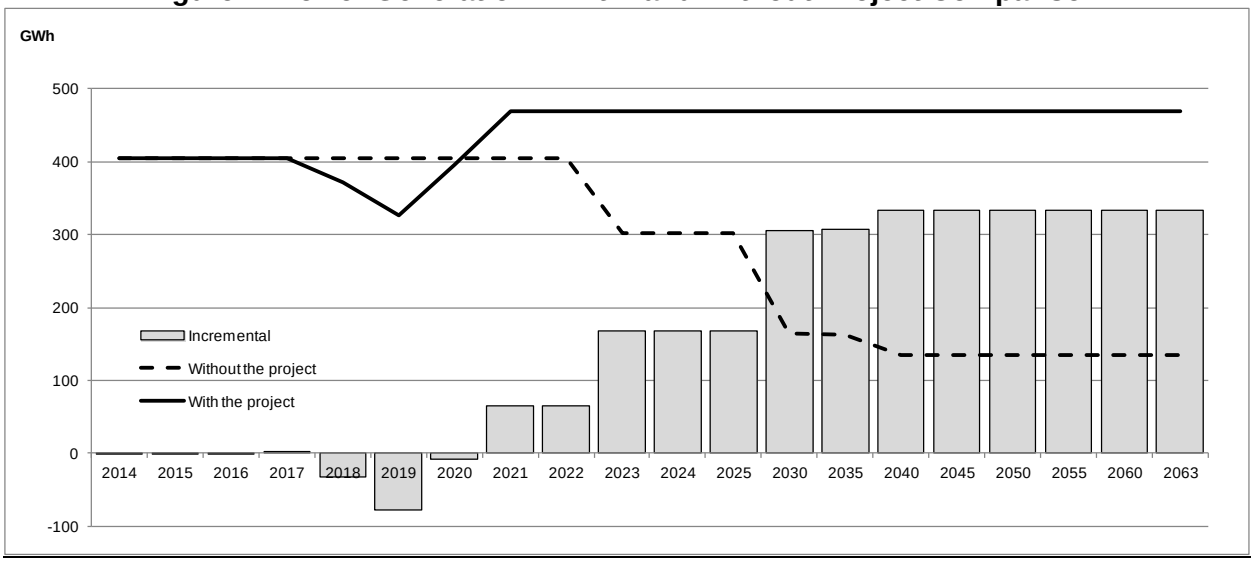
(ii) Production from the five remaining units will then continue until 2027, when an additional older unit is forced out of service in 2028.

(iii) Progressively reduced production will occur as the remaining three older units are forced out of service in 2033, 2038 and 2043, respectively.

7. The benefit of the project will be measured by subtracting the above production numbers from expected energy production for the rehabilitated Golovnaya hydropower plant. The plant's new production level will be phased in as each of the new units is rehabilitated in a sequential manner. The net increase in production is considered incremental. Under the with-project scenario—i.e., with Golovnaya hydropower plant rehabilitation—the economic life of the Golovnaya hydropower plant is assumed to be extended to 2063. No salvage value is assumed at the end of the economic life.

[2] ADB. 2010. *Report and Recommendation of the President to the Board of Directors: Proposed Grant to the Republic of Tajikistan for the Regional Power Transmission Project.* Manila.

Figure 1: Power Generation – With- and Without-Project Comparison



Power generation	GWh/ 2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060	2063
Without the project	GWh/year	404	404	404	404	404	404	404	404	404	301	301	301	164	163	135	135	135	135	135	135
With the project	GWh/year	404	404	404	404	372	326	396	470	470	470	470	470	470	470	470	470	470	470	470	470
Incremental	GWh/year	-0	-0	-0	0.01	-32	-78	-8.2	65.3	65.3	168	168	168	305	307	334	334	334	334	334	334

GWh = gigawatt-hour.
Source: Sector operational performance improvement program consultant from the Ministry of Energy and Industry (footnote 2).

C. Project Costs

8. The project financial capital costs include the estimated turnkey contract, consulting services and physical contingency, and taxes and duties. To covert the financial cost into economic cost, taxes and duties are excluded and capital costs are assumed to be 90% foreign and 10% local. Domestic prices are used for the purpose of the economic analysis. The foreign price component is adjusted upward by a shadow exchange rate factor of 1.11. Similarly, the cost of local labor is adjusted downward by a shadow wage rate factor of 0.8. As labor is estimated to comprise 50% of the total local cost, the equivalent "weighted" shadow price factor, applied to all local costs (where the shadow price for non-labor inputs is 1.00), is then 0.9.

9. The operation and maintenance (O&M) costs have been estimated by taking the difference between the with- and without-project scenarios. Under the with-project scenario, periodic maintenance is introduced: $3 million per unit for the two old units in 2020 for the initial refurbishment; $1.5 million per unit every 15 years for the two old units; and $0.5 million per unit every 20 years for the three new units. In the financial analysis, income tax of 15% was included in the cost streams during the operational period. The economic cost conversion followed the same method described for the capital costs.

D. Project Revenues and Benefits

10. The project financial revenue is the incremental sales revenue of electricity generated from the project. Average revenue per kilowatt-hour (kWh), estimated based on the financial statements, is assumed to increase from current $0.02 per kWh to $0.04 per kWh by 2024. System losses are assumed to gradually improve from the current level of 14.4% to 9.4% by 2020.

11. The incremental economic benefits are estimated by incremental electricity, taking into account seasonal differences. During the power shortage season (November to April) the incremental electricity consumed is measured based on the willingness to pay (WTP), after taking into account technical losses.

12. To estimate WTP, one of the most likely alternate energy sources considered is self-generation. Current gasoline prices in Tajikistan are about TJS6.0 per litre (l), while diesel fuel is about TJS6.5/l. The most efficient diesel units generally have specific consumption of about 0.25 l/kWh, meaning that the lowest possible cost of generation from these sources is about TJS1.6/kWh (from diesel generation). Generation from smaller generators, running on either diesel fuel or gasoline, will be more expensive, and can reasonably assumed to be 50% higher, or TJS 2.5/kWh ($0.51/kWh). In calculation, the mid-point ($0.24.5/kWh) between the WTP and the average tariff of $0.02/kWh was used.

13. The economic value of surplus summer water flow that could be used to generate electricity from the Golovnaya hydropower plant is presently zero due to limited export opportunities. However, this situation should eventually change, with growing regional energy shortages making interconnections with neighboring countries almost a necessity. The current export price to Afghanistan is $0.0364/kWh. However, additional transmission capacity will be required to export all of Tajikistan's summer electricity surplus. It is assumed that such additional transmission capacity will become available from around 2020. A recent study has estimated the export price of this energy and associated transmission to be $0.044/kWh, in addition to the then-current Afghanistan price of $0.035/kWh.[3] Therefore, a value a $0.045/kWh has been ascribed to summer energy from Golovnaya hydropower plant from 2020 onwards. However, given the possibility that the required transmission links are not available, a sensitivity test has been undertaken to determine the effect on the project economic viability.

14. The system losses considered for the economic analysis exclude non-technical losses that count as electricity delivered for the purpose of economic analysis. Considering that overall system losses are 14.4%, and based on discussions with key sector informants, it has been determined that an appropriate level of technical losses for the purpose of the economic analysis would be about 9% in 2014, falling to 7.5% by 2020 and thereafter. The loss factor is applied to the energy generated to estimate the energy consumed.

III. LEAST-COST APPROACH

15. Rehabilitation of aging hydropower stations is, by its nature, a low-cost alternative to meeting electricity demand. At a capital cost of under $0.5 million per installed MW, the project is much less expensive to build than a greenfield hydro- or thermal–based project, and relative O&M costs over a projected 50-year period are low. The rehabilitation method and project scope takes a least-cost approach. Out of five units to be rehabilitated, three units will completely replaced, and two units will be refurbished, considering the expected life of respective plant units and plant utilization.

IV. RESULTS

A. Economic analysis

16. The EIRR is estimated to be 17.3%, which is above the 12% benchmark opportunity cost (detailed cash flow in Annex 1), and the net present value at 12% discount rate is $82 million. These indicate the project is economically viable.

[3] D. Fields et al. 2012. *Tajikistan's Winter Energy Crisis: Electricity Supply and Demand Alternatives*. New York: World Bank.

17. A sensitivity analysis was carried out to examine the robustness of the economic viability of the project under adverse conditions, and the impact of expanded transmission capacity, which may allow all summer surplus energy to be exported. In addition, the EIRR is estimated for replacing four units, or five units, to check the marginal impact of expanding the scope. The result is summarized in Table 2.

Table 2: Sensitivity Tests on the Economic Internal Rate of Return

Item	3 Units	4 Units	5 Units
Base Case	**17.3%**	16.5%	15.8%
Increase in capital costs by 10%	16.5%		
Increase in O&M costs by 20%	17.3%		
Decrease in benefits by 20%	15.5%		
Export links in place by 2020	19.3%		

O&M = operation and maintenance.
Source: Sector operational performance improvement program consultant from the Ministry of Energy and Industry (footnote 2).

18. The results indicate that even under adverse conditions, the EIRR remains above the benchmark 12% opportunity cost, confirming the relative robustness of the project's economic viability. The project appears most sensitive to a decrease in benefits. The estimated EIRR assuming full export of surplus summer energy is 19.3%, or 2 percentage points above the base case. The EIRR given replacement of four or five units indicates the project would remain economically viable. However, the incremental value of full replacement of the fourth and fifth units slightly lowers the EIRR compared to the base case (replacing three units), confirming that the proposed project scope of full replacement of three units is the least-cost option.

B. Financial analysis

19. The weighted average cost of capital (WACC) is calculated based on the amounts and financing terms of the capital investment. ADB will finance the project's capital cost by grant, but because the grant proceeds are provided to Barki Tojik as a subsidiary loan from the Ministry of Finance, ADB's grant proceeds are considered debt from Barki Tojik's perspective. The subsidiary loan will have an interest rate of 5%, in US dollars. The income tax applied to Barki Tojik is 15%. The government contribution through tax and duty exemptions on capital costs. The National Bank of Tajikistan's re-financing rate of 8.15% (average for 2010–2013) is used as a proxy for the opportunity cost to the government, as there is no clear official cost announced by the government. The real WACC is 2.2% (Table 3).

Table 3: Weighted Average Cost of Capital of the Project

(%)

Item	ADB Sub Loan	Government	BT	TOTAL
Weighting	80.00	11.41	8.59	100.00
Nominal cost	5.00	8.15	8.15	
Tax rate	15.00	0.00	0.00	
Tax-adjusted nominal cost	4.25	8.15	8.15	
Inflation rate	1.80	6.50	6.50	
Real cost	2.41	1.55	1.55	
Weighted component of WACC	1.93	0.18	0.13	2.24
Weighted average cost of capital				**2.2**

ADB = Asian Development Bank, BT = Barki Tojik.
Source: Asian Development Bank estimates.

20. The FIRR is estimated at 4.3%, and exceeds the WACC of 2.2%, confirming the project's financial viability (Annex 2). The project's net present value measured at 2.2% is $76 million. These indicate the project is financially viable.

21. The sensitivity analysis confirms the robustness of the project's financial viability (Table 4). A 10% increase in capital costs, 20% increase in O&M costs, or 20% decrease in revenues will still allow the project to be financially viable. If revenue can be derived from the summer energy surplus (assuming the export transmission capacity is developed by 2020), the FIRR will increase to 9.0%, further enhancing the project's financial viability. The sensitivity analysis on the fourth and fifth unit also confirms that the project will remain financially viable if the project scope is expanded to include full replacement of the fourth and fifth units. However, the FIRR decreases slightly, supporting the partial refurbishment, (rather than full replacement) of the fourth and fifth units.

Table 4: Sensitivity Tests on Financial Internal Rate of Return

Item	3 Units	4 Units	5 Units
Base Case	**4.3%**	3.9%	3.5%
Increase in capital costs by 10%	3.8%		
Increase in O&M costs by 20%	4.3%		
Decrease in revenues by 20%	3.3%		
Export links by 2020	9.0%		

O&M = operation and maintenance.
Source: Sector operational performance improvement program consultant from the Ministry of Energy and Industry (footnote 2).

V. CONCLUSION

22. The project's EIRR is 17.3%, confirming the project's economic viability. The project will extend the economic life of Golovnaya hydropower plant, increase generation capacity, and enhance energy output. The project's cost streams (capital investment and O&M), which reflect the costs of delivering the expected benefits (power consumption and export sales) based on 2013 constant prices for the project lifetime of 50 years, were compared with the cost streams under a without-project scenario The without-project scenario assumes no significant rehabilitation takes place and the existing units fail to operate over the next 30 years, according to the expected life of each unit. The incremental benefits attributable to increased output are measured based on willingness to pay and export sales, after taking into account technical losses and summer surplus. The sensitivity analysis confirms the robustness of the project economic viability under adverse conditions, including increased capital cost, O&M cost, and reduced benefits.

23. The financial analysis confirms the financial viability of the project. The FIRR of 4.3% is higher than the WACC of 2.2%. Based on the with- or without-project comparison, the project cash flow, measured at 2013 constant prices for the project life of 50 years, reflects the costs (capital investment, operation and maintenance) and revenues (domestic sales and exports of electricity) attributable to the project, taking into account system losses and taxes, from the Barki Tojik perspective. The project remains financially viable. The sensitivity analysis confirms the project's financial sustainability under adverse conditions.

ANNEX 1

Project Economic Internal Rate of Return

($ million)

Year	Capital Cost	O&M Cost	Benefits	Net Benefits
2013	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	0.00
2015	(18.37)	0.00	(0.00)	(18.37)
2016	(19.31)	0.00	(0.00)	(19.31)
2017	(34.04)	0.00	0.00	(34.04)
2018	(25.12)	0.00	(7.31)	(32.43)
2019	(22.96)	(0.16)	(17.76)	(40.88)
2020	(11.75)	(6.69)	(1.88)	(20.32)
2021	0.00	(0.16)	14.88	14.72
2022	0.00	(0.16)	14.88	14.72
2023	0.00	(0.19)	38.34	38.15
2024	0.00	(0.19)	38.34	38.15
2025	0.00	(0.19)	38.34	38.15
2026	0.00	(0.19)	38.34	38.15
2027	0.00	(0.19)	38.34	38.15
2028	0.00	(0.21)	69.54	69.32
2029	0.00	(0.21)	69.54	69.32
2030	0.00	(0.21)	69.54	69.32
2031	0.00	(0.21)	69.54	69.32
2032	0.00	(0.21)	69.54	69.32
2033	0.00	(0.24)	69.92	69.67
2034	0.00	(0.24)	69.92	69.67
2035	0.00	(3.51)	69.92	66.41
2036	0.00	(0.24)	69.92	69.67
2037	0.00	(0.24)	69.92	69.67
2038	0.00	(0.27)	76.20	75.93
2039	0.00	(0.27)	76.20	75.93
2040	0.00	(1.90)	76.20	74.30
2041	0.00	(0.27)	76.20	75.93
2042	0.00	(0.27)	76.20	75.93
2043	0.00	(0.30)	76.20	75.91
2044	0.00	(0.30)	76.20	75.91
2045	0.00	(0.30)	76.20	75.91
2046	0.00	(0.30)	76.20	75.91
2047	0.00	(0.30)	76.20	75.91
2048	0.00	(0.30)	76.20	75.91
2049	0.00	(0.30)	76.20	75.91
2050	0.00	(3.56)	76.20	72.64
2051	0.00	(0.30)	76.20	75.91
2052	0.00	(0.30)	76.20	75.91
2053	0.00	(0.30)	76.20	75.91
2054	0.00	(0.30)	76.20	75.91
2055	0.00	(0.30)	76.20	75.91
2056	0.00	(0.30)	76.20	75.91
2057	0.00	(0.30)	76.20	75.91
2058	0.00	(0.30)	76.20	75.91
2059	0.00	(0.30)	76.20	75.91
2060	0.00	(1.93)	76.20	74.27
2061	0.00	(0.30)	76.20	75.91
2062	0.00	(0.30)	76.20	75.91
2063	0.00	(0.30)	76.20	75.91
Total	**(131.55)**	**(27.72)**	**2,872.99**	**2,713.71**
			EIRR	**17.3%**
			NPV@12%	**$81.90**

( ) = negative, EIRR = economic internal rate of return, NPV = net present value, O&M = operation and maintenance

Source: Sector operational performance improvement program consultant from the Ministry of Energy and Industry (footnote 2).

ANNEX 2

Project Financial Internal Rate of Return

($ million)

Year	Capital Cost	O&M Cost	Taxes	Revenue	Net Cashflow
2013	0.00	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	(0.00)	(0.00)
2015	(19.30)	0.00	0.00	(0.00)	(19.30)
2016	(20.21)	0.00	0.00	(0.00)	(20.21)
2017	(34.54)	0.00	0.00	0.00	(34.54)
2018	(28.27)	0.00	0.12	(0.82)	(28.96)
2019	(23.95)	(0.16)	0.49	(1.99)	(25.61)
2020	(13.94)	(6.16)	0.42	(0.21)	(19.89)
2021	0.00	(0.16)	0.28	1.85	1.97
2022	0.00	(0.16)	0.26	2.03	2.13
2023	0.00	(0.19)	(0.30)	5.76	5.28
2024	0.00	(0.19)	(0.39)	6.34	5.77
2025	0.00	(0.19)	(0.39)	6.34	5.77
2026	0.00	(0.19)	(0.39)	6.34	5.77
2027	0.00	(0.19)	(0.39)	6.34	5.77
2028	0.00	(0.21)	(1.16)	11.50	10.13
2029	0.00	(0.21)	(1.16)	11.50	10.13
2030	0.00	(0.21)	(1.16)	11.50	10.13
2031	0.00	(0.21)	(1.16)	11.50	10.13
2032	0.00	(0.21)	(1.16)	11.50	10.13
2033	0.00	(0.24)	(1.16)	11.56	10.16
2034	0.00	(0.24)	(1.16)	11.56	10.16
2035	0.00	(3.24)	(1.15)	11.56	7.17
2036	0.00	(0.24)	(1.15)	11.56	10.17
2037	0.00	(0.24)	(1.15)	11.56	10.17
2038	0.00	(0.27)	(1.30)	12.60	11.03
2039	0.00	(0.27)	(1.30)	12.60	11.03
2040	0.00	(1.77)	(1.29)	12.60	9.54
2041	0.00	(0.27)	(1.29)	12.60	11.04
2042	0.00	(0.27)	(1.29)	12.60	11.04
2043	0.00	(0.30)	(1.29)	12.60	11.02
2044	0.00	(0.30)	(1.29)	12.60	11.02
2045	0.00	(0.30)	(1.29)	12.60	11.02
2046	0.00	(0.30)	(1.29)	12.60	11.02
2047	0.00	(0.30)	(1.29)	12.60	11.02
2048	0.00	(0.30)	(1.29)	12.60	11.02
2049	0.00	(0.30)	(1.45)	12.60	10.85
2050	0.00	(3.30)	(1.64)	12.60	7.66
2051	0.00	(0.30)	(1.81)	12.60	10.49
2052	0.00	(0.30)	(1.81)	12.60	10.49
2053	0.00	(0.30)	(1.81)	12.60	10.49
2054	0.00	(0.30)	(1.81)	12.60	10.49
2055	0.00	(0.30)	(1.81)	12.60	10.49
2056	0.00	(0.30)	(1.81)	12.60	10.49
2057	0.00	(0.30)	(1.81)	12.60	10.49
2058	0.00	(0.30)	(1.81)	12.60	10.49
2059	0.00	(0.30)	(1.81)	12.60	10.49
2060	0.00	(1.80)	(1.80)	12.60	9.00
2061	0.00	(0.30)	(1.80)	12.60	10.50
2062	0.00	(0.30)	(1.80)	12.60	10.50
2063	0.00	(0.30)	(1.80)	12.60	10.50
Total	(140.20)	(26.39)	(52.54)	474.77	255.64
				FIRR	**4.3%**
				NPV@WACC	**$76.28**

( ) = negative, FIRR = financial internal rate of return, NPV = net present value, O&M = operation and maintenance.

Source: Sector operational performance improvement program consultant from the Ministry of Energy and Industry (footnote 2).