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Report No: ICR00004546

IMPLEMENTATION COMPLETION AND RESULTS REPORT

(IBRD-8082, TF-010407, TF-011854)

ON AN

IBRD LOAN

IN THE AMOUNT OF US$175 MILLION

AND A

LOAN FROM THE CLEAN TECHNOLOGY FUND

IN THE AMOUNT OF US$125 MILLION

AND A

GRANT FROM THE GOVERNMENT OF NEW ZEALAND

IN THE AMOUNT OF US$6.95 MILLION

TO THE

REPUBLIC OF INDONESIA

FOR THE

GEOTHERMAL CLEAN ENERGY INVESTMENT PROJECT

June 14, 2019

Energy and Extractives Global Practice
East Asia And Pacific Region

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CURRENCY EQUIVALENTS

(Exchange Rate Effective December 31, 2018)

Currency Unit =	Indonesian Rupiah (IDR)
IDR 14,380.00 =	US$1
US$0.00007 =	IDR 1

FISCAL YEAR
July 1 - June 30

ABBREVIATIONS AND ACRONYMS

BAPPENAS	Indonesian Ministry of National Development Planning
CPF	Country Partnership Framework
CPS	Country Partnership Strategy
CSR	Corporate Social Responsibility
CTF	Clean Technology Fund
DIPA	Budget Authorization Document (*Daftar Isian Pelaksanaan Anggaran*)
EAP	East Asia and Pacific
EIRR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
EPC	Engineering, Procurement, and Construction
ESIA	Environmental and Social Impact Assessment
FEED	Front-end Engineering Design
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
FTP I	First Fast Track Program
FTP II	Second Fast Track Program
GHG	Greenhouse Gas
GoI	Government of Indonesia
GoNZ	Government of New Zealand
GoTN	Government of the Netherlands
ICR	Implementation Completion and Results Report
IRR	Internal Rate of Return
ISR	Implementation Status and Results Report
M&E	Monitoring and Evaluation
MEMR	Ministry of Energy and Mineral Resources
MoF	Ministry of Finance
NO_x	Nitrogen Oxide
NPV	Net Present Value
PAD	Project Appraisal Document
PDO	Project Development Objective

PGE	PT. Pertamina Geothermal Energy
PLN	PT. Perusahaan Listrik Negara
PM	Particulate Matter
PPA	Power Purchase Agreement
PVC	Present Value of the Cost
QPR	Quarterly Progress Report
SAGS	Steamfield Above-Ground System
SLA	Subsidiary Loan Agreement
SO_2	Sulfur Dioxide
TA	Technical Assistance
TCP	Technical Collaboration Partnership
TSP	Total Suspended Particulate
WACC	Weighted Average Cost of Capital

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DATA SHEET

BASIC INFORMATION

Product Information

Project ID	Project Name
P113078	Geothermal Clean Energy Investment Project
Country	**Financing Instrument**
Indonesia	Investment Project Financing
Original EA Category	**Revised EA Category**
Full Assessment (A)	Full Assessment (A)

Organizations

Borrower	Implementing Agency
Republic of Indonesia	Pertamina Geothermal Energy

Project Development Objective (PDO)

Original PDO

The development objective of the proposed project is to increase power generation from renewable geothermal resources, and reduce local and global environmental impacts.

FINANCING

	Original Amount (US$)	Revised Amount (US$)	Actual Disbursed (US$)
World Bank Financing			
IBRD-80820	175,000,000	129,044,476	129,044,476
TF-10407	125,000,000	124,311,085	124,311,085
TF-11854	6,950,000	6,915,948	6,915,948
Total	**306,950,000**	**260,271,509**	**260,271,509**
Non-World Bank Financing			
Borrower/Recipient	274,700,000	274,700,000	369,304,000
Total	**274,700,000**	**274,700,000**	**369,304,000**
Total Project Cost	**581,650,000**	**534,971,509**	**629,575,509**

KEY DATES

Approval	Effectiveness	MTR Review	Original Closing	Actual Closing
26-Jul-2011	24-May-2012	13-Oct-2014	31-Mar-2015	31-Dec-2018

RESTRUCTURING AND/OR ADDITIONAL FINANCING

Date(s)	Amount Disbursed (US$M)	Key Revisions
09-Dec-2011	0	Change in Results Framework Change in Components and Cost Change in Financing Plan
26-Mar-2015	28.71	Change in Results Framework Change in Loan Closing Date(s) Change in Implementation Schedule

KEY RATINGS

Outcome	Bank Performance	M&E Quality
Satisfactory	Satisfactory	Substantial

RATINGS OF PROJECT PERFORMANCE IN ISRs

No.	Date ISR Archived	DO Rating	IP Rating	Actual Disbursements (US$M)
01	31-Mar-2012	Satisfactory	Satisfactory	0
02	09-Apr-2013	Satisfactory	Moderately Satisfactory	.46
03	17-Nov-2013	Moderately Satisfactory	Moderately Satisfactory	1.79
04	27-Jun-2014	Moderately Satisfactory	Moderately Unsatisfactory	2.66
05	31-Dec-2014	Moderately Satisfactory	Moderately Unsatisfactory	20.89
06	17-Jun-2015	Satisfactory	Moderately Satisfactory	30.69
07	09-Nov-2015	Satisfactory	Moderately Satisfactory	32.58
08	07-Jun-2016	Satisfactory	Moderately Satisfactory	91.89
09	06-Dec-2016	Satisfactory	Satisfactory	187.85
10	27-Mar-2017	Satisfactory	Satisfactory	210.09
11	05-Nov-2017	Satisfactory	Satisfactory	247.44
12	24-May-2018	Satisfactory	Satisfactory	259.47
13	28-Sep-2018	Satisfactory	Satisfactory	259.73

SECTORS AND THEMES

Sectors

Major Sector/Sector	(%)
Energy and Extractives	**100**
Renewable Energy Geothermal	100

Themes

Major Theme/ Theme (Level 2)/ Theme (Level 3)	(%)
Environment and Natural Resource Management	**0**
Climate change	100
Mitigation	100

ADM STAFF

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I. PROJECT CONTEXT AND DEVELOPMENT OBJECTIVES

A. CONTEXT AT APPRAISAL

Context

1. **Country context**. Indonesia had rebounded from the Asian Financial Crisis of 1997 and was showing strong economic growth at the time of appraisal. This sustained economic growth resulted in improved living standards and a marked decline in the poverty level. During 2001–2011, Indonesia's Gross Domestic Product grew 5.32 percent annually on average,[1] and remained positive even during the global economic downturn in 2008–2009, when many economies contracted. In 2010, economic momentum was forecast to continue to grow around 6 percent over the next couple of years and was predicted to rise to 7 percent on a sustained basis by mid-decade.[2]

2. Although infrastructure investment was considered a critical component in maintaining Indonesia's economic prospects, infrastructure for public services remained inadequate for a middle-income economy, and the country perennially lagged behind in infrastructure investments. Therefore, it was essential for Indonesia to invest in infrastructure to maintain the economic growth and sustain development outcomes.

3. **Sector context**. Due to the lack of investments in infrastructure, Indonesia's power sector struggled to keep up with high electricity demand that had accompanied the economic growth. Although there was an initial surplus of power generation capacity immediately following the Asian Financial Crisis, the demand rapidly caught up and surpassed the supply. PT. Perusahaan Listrik Negara (PLN), the national power company, struggled to mobilize investments because of its weakened financial position after the crisis and the dramatic increase in oil prices on the international market from 2002 to 2008. Private sector investments came to a halt under the combined effect of capital flight from emerging markets and the institutional turmoil that followed the repeal of the 2002 Electricity Law by the Constitutional Court in Indonesia.[3]

4. In 2006, the Government of Indonesia (GoI) responded to the capacity shortfall by announcing a first Fast Track Program (FTP I) designed to rapidly develop 10,000 MW of coal-based power generation capacity which was 32 percent of total 30,958 MW installed capacity in 2006.[4] Coal resources were abundant, readily available, and relatively inexpensive. It was expected to displace high-cost oil-fired generation and increase supply at an affordable price. However, coal power generation results in local and global environmental impacts and increased dependence on fossil fuels for power generation. About 35 percent of the electricity generation in Indonesia was based on coal,[5] emitting 0.03 million tons of $PM_{2.5}$(particulate matter with diameters that are generally 2.5 micrometers and smaller), 0.29 MT of

[1] World Bank Data Bank (data updated on November 14, 2018). https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?contextual=default&end=2011&locations=ID&start=2001.
[2] World Economic Outlook April 2010 Rebalancing Growth, International Monetary Fund.
[3] In 2004, the Constitutional Court ruled the 2002 Electricity Law to be unconstitutional largely in light of electricity's status as a social necessity and the constitutional requirement for its delivery to remain exclusively with a state-owned agency. As a result, the court effectively reinstalled the previous 1985 law and from 1999–2004 there was very little investment of any sort in new power projects (PWC 2013).
[4] Latif Adama, Maxensius Tri Sambodoa 2015.
[5] MEMR 2011.

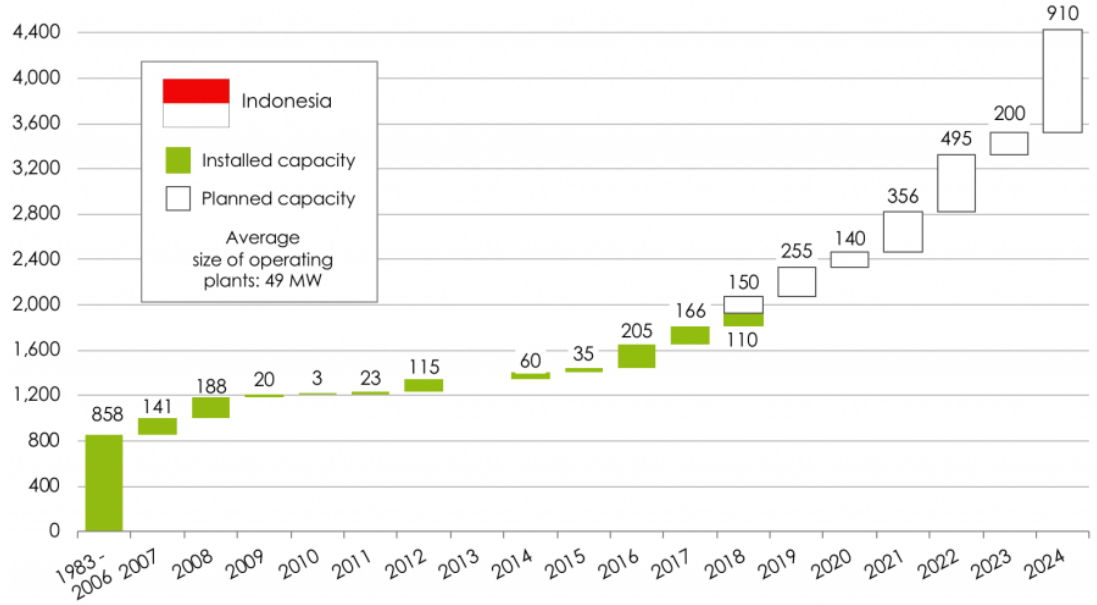
sulphur dioxide (SO_2), and 0.29 MT of nitrogen oxide (NO_x) from coal-fired power plants in 2011.[6] Environmental conditions were expected to further deteriorate when the additional 10,000 MW of coal-based capacity was fully commissioned under FTP I.

5. The GoI was seeking a more sustainable development path to supply electricity while avoiding negative environmental impacts, which led to geothermal development becoming a key development priority and a vital part of the country's Low Carbon Growth Strategy. In 2010 the GoI announced the second 10,000 MW Fast Track Program (FTP II) that was predominantly made up of renewable energy, with geothermal making up 40 percent of the target in 2020. Geothermal power is a suitable baseload substitute for coal-fired generation in many areas with much lower emissions of air pollutants and greenhouse gases (GHGs). Geothermal power is not subject to the intermittency and variability associated with most renewable electricity sources. Geothermal resources in Indonesia were also ideally located on islands with major population centers where electricity demands were high and continued to grow. Furthermore, as an indigenous and non-tradable energy source, it can also contribute to enhancing the country's energy security and serve as a natural hedge against the volatility of fossil fuel prices. For a scale-up of geothermal capacity, Pertamina Geothermal Energy (PGE), a subsidiary of the state-owned oil and gas company Pertamina, was mandated by the GoI to develop 1,000 MW of geothermal capacity, which would be the largest expansion in the world by a single company.

6. Indonesia had difficulties in mobilizing financing for the ambitious geothermal development target both globally and within the country, given the challenging investment climate at the time of appraisal. The barriers to investments in geothermal developments included (a) insufficient policy and regulatory support, (b) inadequate incentives and pricing mechanisms that fail to enable investors to secure a return commensurate with higher risks in developing unexplored geothermal fields (that is, green fields), (c) limited institutional capability, and (d) weak domestic capacity in geothermal resource monitoring and assessment and equipment manufacturing. Consequently, geothermal generation capacity was only 1,189 MW at the time of appraisal which was well below the 4,000 MW short-term FTP II target. Figure 1 shows that geothermal generation capacity expanded only marginally at appraisal.

[6] Mandvi Singh, and Shruti Issar 2017.

Figure 1. Geothermal Power Generation Capacity Additions by Year (MW) 2008–2018 and Planned to 2024



Source: ThinkGeoEnergy.[7]

7. **Rationale for World Bank support**. To tackle the barriers identified in geothermal development, the World Bank took a prudent two-track approach to be implemented simultaneously. One track was to enhance the investment climate in the sector, which takes time. The other one was to immediately stimulate investments that were at an advanced stage of preparation to develop generation capacity. While the ongoing Geothermal Power Generation Development Project[8] supported the Ministry of Energy and Mineral Resources (MEMR) during 2008–2013 focused on the first track, the Geothermal Clean Energy Investment Project provided immediate investments on the second track. The World Bank's support for immediate investments was crucial for three reasons. First, delays in geothermal development was going to result in further expansion of coal. Second, it was to help demonstrate an immediate scale-up in geothermal projects in the country, and therefore help revive the confidence of other developers in the sector after a decade of relative standstill. Last, the World Bank had the convening capacity to mobilize both financial resources and international expertise.

8. Financially, the IBRD loan and the Clean Technology Fund (CTF) loan were critical for the project in two aspects. First, the concessional CTF financing made the project financially viable by lowering the cost of capital. Second, the IBRD and CTF loans secured for construction of steamfield above-ground systems (SAGSs) and the power plants provided PGE with comfort and confidence in investing in the upfront production drilling stage with higher risks, knowing there was 'financial certainty' for completing the investments.

9. In addition to providing financing, the World Bank had advantages in mobilizing international expertise and experiences. The World Bank brought high caliber expertise into the project for high-quality

[7] *http://www.thinkgeoenergy.com/indonesia/* (Accessed on: March 28, 2019).
[8] The Geothermal Power Generation Development Project (P099757) was approved by the World Bank Board on May 29, 2008, for US$4 million financing from Global Environmental Facility through TF-92324 and US$5 million from the GoI to improve the investment environment for geothermal power projects and enhance the Government's capacity to support sector growth.

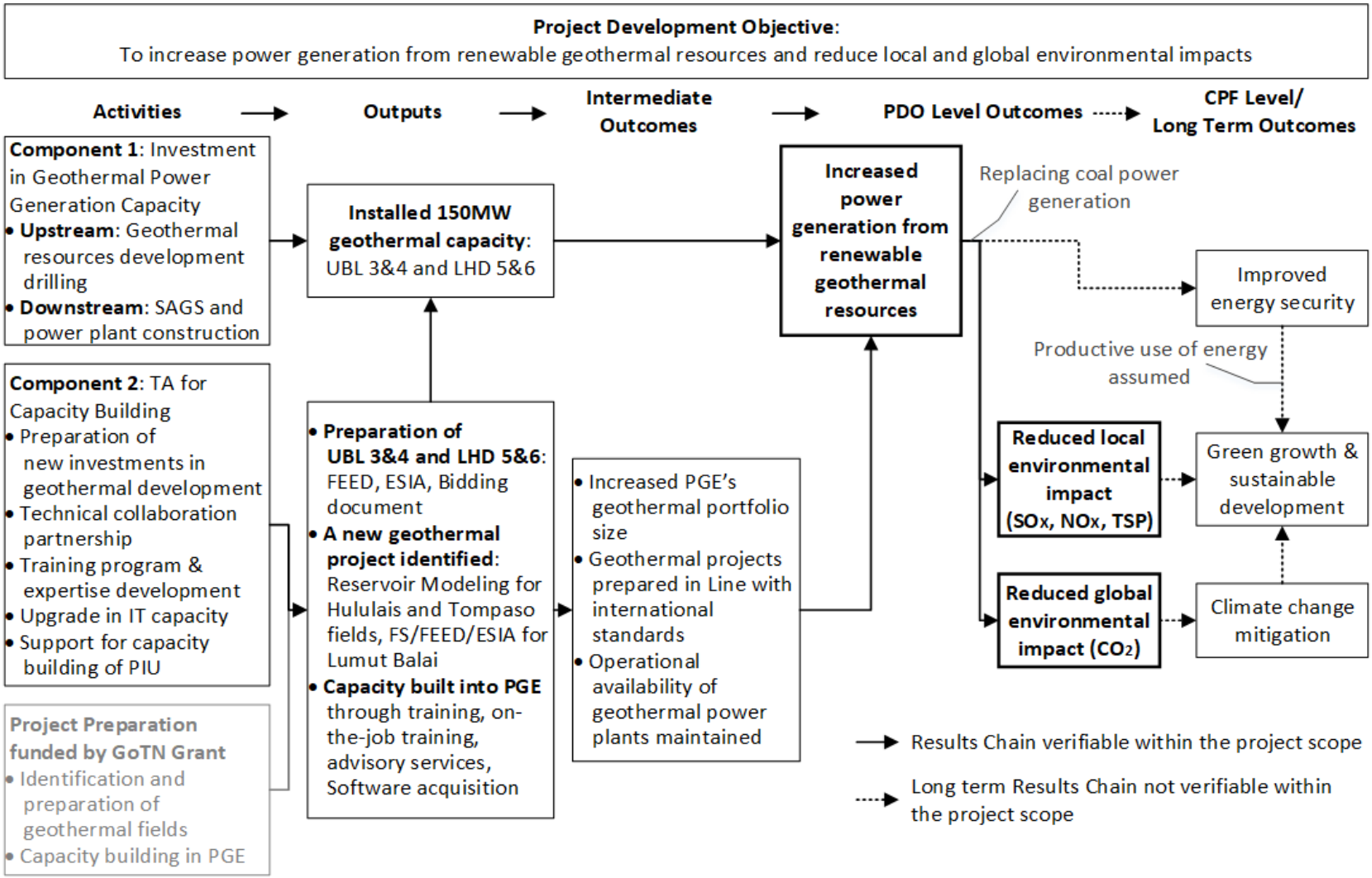
investment preparation and appraisal[9] and for capacity-building technical assistance (TA) as part of project implementation. High-quality project preparation that met industry standards was instrumental in setting up the project with a greater chance of success. By helping strengthen the capacities of the public developer, PGE, the World Bank aimed to contribute to establishing credible institutions that are independently capable of meeting international and industry standards in their current and future operations, including becoming a reliable partner for private sector investors.

Theory of Change (Results Chain)

10. The project consists of investments in geothermal development and capacity-building activities to meet its development objective of increasing geothermal generation while reducing the environmental impacts which would have occurred if coal-based generation was commissioned in the absence of geothermal generation. Investment preparation activities carried out with the Government of the Netherlands (GoTN) grant under the Geothermal Power Support Program also contributed to achievement of the development objectives. The theory of change is illustrated in Figure 2 and presents the activities envisaged under the project components, the associated outputs, and how they contribute to the achievement of the intermediate outcomes and development objectives.

[9] The preparation activity funded by the GoTN was executed under the Indonesia Geothermal Power Support Program (P115100) and the grant was channeled through TF-094705.

Figure 2. Indonesia Geothermal Clean Energy Investment Results Chain



Note: IT = Information Technology; PIU = Project Implementation Unit; FS = Feasibility Study; LHD = Lahendong; UBL = Ulubelu; CPF = Country Partnership Framework; FEED = Front-end Engineering Design; ESIA = Environmental and Social Impact Assessment.

11. Component 1 activities directly contributed to achievements of PDO-level outcomes. A total of 150 MW of geothermal power generation capacity was built after the geothermal resource drilling and construction of SAGSs and power plants. The installation of Ulubelu 3 and 4 and Lahendong 5 and 6 generation units enabled geothermal power generation, which in turn led to the avoidance of local environmental impacts arising from SO_2, NO_X, and total suspended particulates (TSPs) and reductions in global environmental impact from GHG because of avoided carbon dioxide (CO_2) emissions as a result of displacing coal power generation for electricity supply to the network.

12. Component 2 activities, funded by a grant from the Government of New Zealand (GoNZ) and investment preparation activities funded by the GoTN,[10] contributed to high-quality preparations and stable operations of Ulubelu 3 and 4 and Lahendong 5 and 6. Feasibility studies, FEEDs, ESIAs, and bidding documents were prepared under these activities for Ulubelu 3 and 4 and Lahendong 5 and 6 units to be constructed under Component 1. Other capacity-building activities, including advisory services and trainings, enabled PGE to maintain their operational availability for the enlarged portfolio size with the addition of 150 MW.

13. Feasibility studies, FEEDs, and ESIAs have additionally been carried out for other geothermal developments beyond Ulubelu 3 and 4 and Lahendong 5 and 6. A feasibility study, FEED, and ESIA were prepared for the Lumut Balai Project to be financed by different investors, and reservoir modeling has been conducted for Hululais and Tompaso fields. These outputs also led to intermediate outcomes of PGE's increased geothermal portfolio size and geothermal projects prepared in line with industry standards. Once these projects start operations, they will replace more coal power generation plants beyond the 150 MW target of Component 1 bringing larger environmental benefits. PGE's improved capacity under the TA component can be used for operation of these additional geothermal projects as well.

14. The Project Development Objective (PDO) outcomes are expected to contribute to improved energy security and climate change mitigation. In the long term, productive use of electricity from geothermal power generation will lead to green growth and sustainable development without negative environmental impacts such as air pollution and climate change. Environmentally sustainable electricity supply from geothermal resources is one of the strategies to achieve Indonesia's development goal of green growth in the CPF FY2016–2020 (Report No. 99172).

Project Development Objectives (PDOs)

15. The PDO is to increase power generation from renewable geothermal resources and reduce local and global environmental impacts.

[10] The GoTN grant was used for feasibility studies and PGE's capacity building under the Geothermal Power Support Program (P115100) before the Board approval of the project and during the early implementation period. The GoNZ grant came to take the place of the GoTN grant for completion of the remaining TA and investment preparation activities during the implementation of the project.

Key Expected Outcomes and Outcome Indicators

16. The key expected outcomes of the project are (a) increased power generation from renewable geothermal resources, (b) reduced local environmental impact, and (c) reduced global environmental impact. Achievement of each outcome is measured against a specific indicator as follows:

(a) New geothermal power generation capacity installed (MW)

(b) Avoided local air pollution (NO_X, SO_2, TSP) (tons of NOx, SO_2, TSP annually)

(c) Avoided global GHG pollution (CO_2) (tons of CO_2 annually)

Project Components

Component 1: Investment in Geothermal Power Generation Capacity (estimated total cost of US$574.7 million, of which US$175 million is IBRD loan and US$125 million is CTF loan, and US$274.7 million is PGE equity from Pertamina; actual total cost is US$622.7 million)

17. At the time of World Bank Board approval, the project included a single component of Investment in Geothermal Power Generation Capacity. Under this component, PGE financed drilling to confirm geothermal resources and steamfield development. IBRD and CTF loans funded construction of SAGSs and power plants of 110 MW and 40 MW at the Ulubelu and Lahendong geothermal fields, respectively.

Component 2: Technical Assistance for Capacity Building (estimated cost of US$6.95 million from GoNZ; actual US$6.92 million)

18. Component 2 consists of five key activities:

(a) Technical collaboration partnership (TCP) to provide just-in-time support and on-the-job training by international experts

(b) Training program and expertise development

(c) Upgrade in information technology capacity by acquisition of computer-based tools and operational methodologies required

(d) Incremental support for capacity building of project implementation unit for effective implementation of PGE projects

(e) Preparation of new investments, including feasibility studies, FEEDs, and ESIAs. The TA component grant was not included in the financing plan originally at appraisal, but was added to the project shortly after the Board approval of the investment component.

B. SIGNIFICANT CHANGES DURING IMPLEMENTATION (IF APPLICABLE)

Revised PDOs and Outcome Targets

19. The PDOs and outcome targets were not revised.

Revised PDO Indicators

20. The PDO indicators were revised through the first project restructuring for addition of the TA component on December 9, 2011. Following is the revised list of PDO indicators:

(a) To increase power generation from renewable geothermal resources

- New geothermal power generation capacity installed
- Contribute toward PGE becoming a leading geothermal developer
- Ensure technical, environmental, and social practices in line with industry standards during project preparation
- Maintain operation availability of geothermal power plants

(b) To reduce local environmental impacts

- Avoided local air pollution (NO_X, SO_2, TSP)

(c) To reduce global environmental impacts

- Avoided global GHG pollution (CO_2)

21. The last Implementation Status and Results Report (ISR) lists two PDO indicators of 'progress of EPC contract for Ulubelu SAGS + power plant' and 'progress of EPC contract for Lahendong SAGS + power plant' which were introduced in an ISR approved on November 2015 without an official restructuring, but they will not be discussed in this Implementation Completion and Results Report (ICR) as they are of activity level, not PDO level.

22. Two PDO indicators were reworded through ISRs without official restructurings. The reworded PDO indicators are 'new geothermal power generation capacity installed directly financed by the World Bank loan' and 'Ensure technical, environmental and social protection in line with industry standards during project preparation.' The ICR uses their original wordings 'new geothermal power generation capacity installed' and 'ensure technical, environmental and social practices in line with industry standards during project preparation' as the rewordings were not officially approved, and the original indicators and the revised ones measure essentially the same achievement.[11]

Revised Components

23. The TA component outlined in paragraph 18 was added to the investment project as part of the first restructuring. The TA component was originally planned as a part of the project to complement the investment component, but it was not included in the Board approval package because the grant resource

[11] In case of indicator 'new geothermal power generation capacity installed directly financed by the World Bank loan,' the term 'the World Bank loan' includes both IBRD and CTF loans. The CTF loan can be considered as a World Bank loan given that the World Bank acts as an administrator of the CTF loan and the CTF loan agreements follow the World Bank 'Standard Conditions for Loans Made by the World Bank Out of the Climate Investment Funds.'

to fund the TA component was not fully secured at the time of approval. The investment component was submitted for Board approval without including the TA component to avoid delays in project progress, which could have occurred by waiting for the grant commitment by the GoNZ. The GoNZ grant financing for the TA component was confirmed shortly after Board approval of the investment component. Upon the confirmation of the grant financing, the TA component was added to the project with necessary legal documents.

Other Changes

24. Through the second restructuring (RES 17854) on March 17, 2015, the closing dates of the IBRD loan, CTF loan, and New Zealand grant were extended. The closing dates of the former two loans were extended by 45 months from March 31, 2015, to December 31, 2018. The closing date of the New Zealand grant was extended by 21 months, from March 31, 2015, to December 31, 2016. The extensions were made to provide adequate time to complete the project activities which were delayed. Procurement of an engineering, procurement, and construction (EPC) contractor and construction and commissioning of power plants were delayed compared to the original time line at appraisal because of the insufficient geothermal steam and reinjection resources found from the first production drilling and slow progress in the second drilling campaign.

Rationale for Changes and Their Implication on the Original Theory of Change

25. Incorporation of the TA component was imperative to help strengthen the capacity of PGE so that it was better positioned to fulfill its mandate of undertaking the world's largest geothermal expansion by a single company, including the successful implementation of the two fields directly financed by the World Bank. The change strengthened the theory of change in two ways: (a) it ensured that the installed capacity translated into actual electricity generation by enhancing PGE's capacity to operate and maintain the power plant and (b) it contributed to achievement of the medium- and longer-term objectives of geothermal scaling up by contributing to placing PGE as a leading geothermal developer in the country.

26. The extension of the loan and grant closing dates did not affect the original theory of change.

II. OUTCOME

A. RELEVANCE OF PDOs

Assessment of Relevance of PDOs and Rating

Rating: High

27. The PDOs have consistently remained as country engagement priorities throughout three country engagement documents, which cover the project preparation and implementation periods. The PDOs are aligned with the second core engagement option for infrastructure development in the Country Partnership Strategy (CPS) FY2009–2012 (Report No. 44845) and contribute to the fifth core engagement of Environmental Sustainability and Disaster Mitigation. These two core engagement areas remained in the next two country engagement strategies, CPS FY2013–2015 and CPF FY2016–2020. The PDOs are directly related to Engagement Area 2, 'Sustainable Energy and Universal Access', of the World Bank

Group's CPF FY2016–2020. More specifically, geothermal energy has been identified as a technology to accelerate the promotion of renewable energy and low carbon development which is one of the four focus areas of the World Bank Group's engagement in the energy sector.

28. The objectives of the project are also fully aligned with Indonesia's priorities in the energy sector. To ensure a more environmentally sustainable development with less polluting energy supply, the GoI launched the 10,000 MW FTP II in late 2008 that was predominantly made up of renewable energy, with geothermal making up 40 percent of the target. The newly added geothermal capacity through the project directly contributed to the FTP II target as well as a total 6,000 MW of geothermal power capacity target set in the 'Blueprint for Geothermal Development in Indonesia', issued by the MEMR as a road map. This, in turn, supported the GoI's Nationally Determined Commitment target of reducing GHG emissions by 29 percent compared to the business-as-usual scenario by 2030.

B. ACHIEVEMENT OF PDOs (EFFICACY)

Rating: Substantial

29. The PDOs consist of three parts: (a) to increase power generation from renewable geothermal resources, (b) to reduce local environmental impacts, and (c) to reduce global environmental impacts. Each part will be evaluated separately against the PDO indicators in the project Results Framework. Overall, the PDO indicators are relevant and adequate to assess the project outcomes. Table 1 summarizes the achievements of the PDO indicators.

30. In addition to the project indicators in the Results Framework, electricity generation outputs will be assessed (in GWh). The electricity generation output was not included as a PDO indicator in the project Results Framework, but it has been monitored by PGE. It is crucial to assess electricity generation outputs because the generation output directly assesses the achievement of the first objective, and the achievements of the second and the third objectives are also dependent on the generation outputs. Table 2 shows the electricity generation outputs of the four units.

Table 1. Summary of Achievements of Electricity Generation Outputs and PDO-level Indicators

PDO-level Indicators/Objectives	Baseline	Target	Actual	Achievement (%)
(i) Increased power generation from renewable geothermal resources				
Ensure technical, environmental, and social practices in line with industry standards during project preparation	Feasibility studies are below industry standards	It is aimed that by 2015 feasibility studies should meet good industry practices.	Feasibility studies have been completed and could meet good industry practices	Fully achieved
New geothermal power generation capacity installed (MW)	0	150	150	100
Maintain operation availability of geothermal power plants (%)	85	85	98 (average)	116
Ulubelu 3 (55 MW) (%)	85	85	100	118
Ulubelu 4 (55 MW) (%)	85	85	98	115
Lahendong 5 (20 MW) (%)	85	85	96	113
Lahendong 6 (20 MW) (%)	85	85	100	117

PDO-level Indicators/Objectives	Baseline	Target	Actual	Achievement (%)
Contribute towards PGE becoming a leading geothermal developer (MW)	232	700	617	82% out of 468 MW planned increase
(ii) Reduced local environmental impacts				
Avoided local air pollution (ton/year)	0	10,900	10,000	92
NO_X	0	3,000	2,753	92
SO_2	0	5,400	4,923	91
TSP	0	2,500	2,324	93
(iii) Reduced global environmental impacts				
Avoided global GHG pollution (CO_2) (ton/year)	0	1,100,000	1,010,125	92

Table 2. Assessment of Electricity Generation Outputs in GWh Unit to Evaluate the Objective Increased Power Generation from Renewable Geothermal Resources

Generation Unit	Baseline	Target (GWh)	Actual (GWh)	Achievement (%)
Ulubelu 3 (55 MW)	0	887	813	92
Ulubelu 4 (55 MW)	0	776	601	78
Lahendong 5 (20 MW)	0	322	314	97
Lahendong 6 (20 MW)	0	322	325	101
Total	**0**	**2,307[a]**	**2,054**	**89**

Note: a. The target amount was calculated from January 2017 to December 2018 for Ulubelu 3, Lahendong 5, and Lahendong 6 units. For Ulubelu 4, the target was from April 2017 to December 2018 reflecting its commercial operation date in late March 2017. The calculation is based on the same assumption of 0.92 capacity factor as in the Project Appraisal Document (PAD) Results Framework while the capacity factor agreed with PLN in PPAs is 0.90.

Assessment of Achievement of Each Objective/Outcome

Outcome (i): Increased power generation from renewable geothermal resources

31. The target for indicator 'ensure technical, environmental, and social practices in line with industry standards during project preparation' has been achieved. High quality technical, environmental, and social studies are prerequisite for efficient power generation and increased possibility of achieving the PDO. The indicator gauges if the technical specifications are designed adequately with proper measures to address social and environmental impacts of the project activities. Under the TA activity 'preparation of new investments', FEEDs, supplemental ESIAs, and bidding documents were prepared for Ulubelu 3 and 4 and Lahendong 5 and 6 meeting industry standards. For future geothermal development projects, reservoir modeling was conducted for Hululais and Tompaso fields. The project activity was integral for the achievement given that the preexisting feasibility studies for the Ulubelu and Lahendong units, which were carried out before the project, were only at a prefeasibility level and were assessed as not being of international standards by international experts. The feasibility studies had to be redone under the project.

32. 'New geothermal power generation capacity installed' was fully achieved. The indicator essentially measures 150 MW total geothermal generation capacity installed under Component 1 with

IBRD and CTF financing. Two 55 MW units and two 20 MW units were designed, constructed, and commissioned for Ulubelu 3 and 4 and Lahendong 5 and 6, respectively, for the total 150 MW capacity with 8 percent budget overrun and a two-year delay in commissioning.[12] The IBRD and CTF concessional loans were critical in having the plants constructed given that negative financial return was expected without them. The financial analysis at appraisal showed that the concessional loan would offset the negative financial return, which enabled the materialization of the project. The expected risk of negative financial returns in an absence of IBRD and CTF financing is supported by the fact that PGE is currently in the tariff renegotiation process with the PLN to improve the economy of the project after having spent more for drilling than the original plan.

33. The third indicator, 'maintain operation availability of geothermal power plants', measures the availability factor of the generation units and the results exceeded the target. The result is interpreted as PGE's ability to keep plants operational reliably without unexpected plant closures. The average 98 percent of availability factor of the four units are above the typical availability factor of geothermal plants which is between 90 percent and 95 percent,[13] proving that the results surpassed both expectation in the sector and the target under the project. High plant availability is attributable to preparation of strong FEED documents for bidding among TA activities which resulted in sound plant design and selection of a good EPC contractor.

34. 'Contribute towards PGE becoming a leading geothermal developer' was met substantially at 82 percent level and is expected to be fully met in the coming years. The target of becoming the largest geothermal developer with 700 MW under operations was set based on PGE's five-year long-term business plan at the time of appraisal. The addition of 150 MW of Ulubelu 3 and 4 and Lahendong 5 and 6 directly contributed to this achievement. Improvement of PGE's capacity through the capacity-building activities to develop good quality geothermal projects that meet international standards also contributed to the expansion of PGE's geothermal portfolio. Feasibility studies, ESIAs, and FEEDs, conducted with the GoTN grant for the 110 MW Lumut Balai 1 and 2 project, were also part of the target, but could not meet the time line because of the tough topography and insufficient resource reinjection capacity. However, Lumut Balai 1 has already been commissioned. Lumut Balai 2 is expected to be commissioned in 2019. Although the site was not included in the original target of 700 MW, the project supported reservoir modeling of Hululais of which the first unit is expected to be operational in 2019 expanding PGE's portfolio beyond the target.[14]

35. The objective to increase power generation from renewable geothermal resources was achieved substantially at 89 percent. The objective is measured with electricity generation outputs in GWh unit. The cumulative generation output from January 2017 to December 2018 from Ulubelu 3 and Lahendong 5 and 6 and cumulative generation output from April 2017 to December 2018 from Ulubelu 4 is 2,054 GWh in total. This is compared to 2,307 GWh target set up retroactively at project closing for evaluation purpose with a 92 percent capacity factor assumption used at appraisal. The minor shortcoming

[12] The cost overrun and the delay is discussed in section C. Efficiency; Ulublelu 3 was commissioned on June 23, 2016, and started commercial operations on July 26, 2016. Ulubelu 4 was commissioned on March 1, 2017, and started commercial operations on March 25, 2017. Lahendong 5 was commissioned on August 4, 2016, and started commercial operations on September 15, 2016. Lahendong 6 was commissioned on November 18, 2016, and started commercial operations on December 9, 2016.

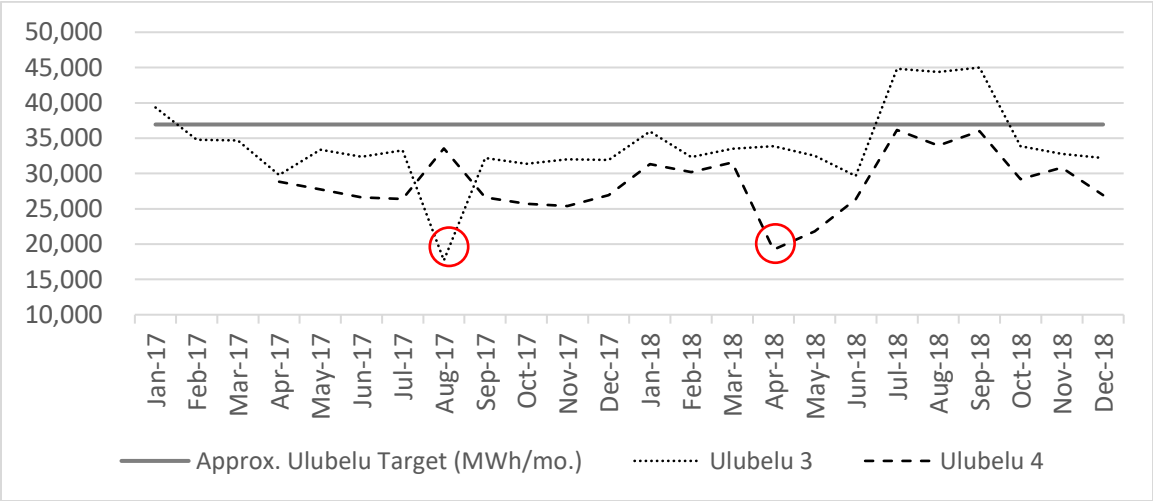
[13] United States Department of Energy 2015.

[14] *http://www.thinkgeoenergy.com/commissioning-has-started-for-55-mw-lumut-balai-unit-1-geothermal-plant-south-sumatra/.*

originated from two factors: (a) shutdown of generation units during a half-month period for first year inspections, which is a one-off event that is not expected to be recurrent and (b) temporary inability to connect additional steam resources to the power plant in Ulubelu field.

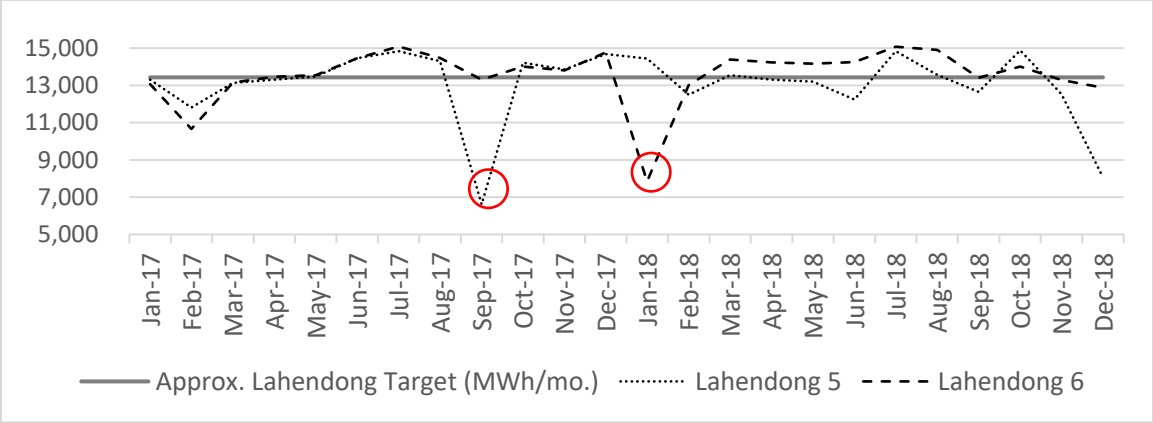
36. The impact of the first year inspections is shown in Figure 3 and Figure 4 of generation outputs of each unit. Each curve has a dip at the generation unit's first year inspection months. The first year inspections were conducted for 14 days during August 13–27, 2017, and April 24–May 8, 2018, for Ulubelu 3 and 4, respectively. The first year inspection of 14 days was carried out for Lahendong 5 during September 3–27, 2017, and 13 days of inspection for Lahendong 6 from January 6–19, 2018. The result values improved to 91 percent when the first year inspection month data and comissioning month data are excluded, which supports the expectation of higher achievements going forward. The calculation results are shown in Table 3.

Figure 3. Electricity Generation Outputs of Ulubelu 3 and 4 Units during January 2017–December 2018 (MWh)



Source: PGE.

Figure 4. Electricity Generation Outputs of Lahendong 5 and 6 Units during January 2017–December 2018 (MWh)



Source: PGE.

Table 3. Cumulative Generation Outputs without First Year Inspection month and Comissioning Month Data

Unit	Target (GWh)	Actual (GWh)	Achievement (%)
Ulubelu 3 (55 MW)	849,574	795,797	94
Ulubelu 4 (55 MW)	701,822	553,216	79
Lahendong 5 (20 MW)	308,936	307,148	99
Lahendong 6 (20 MW)	308,936	317,461	103
Total	**2,169,268**	**1,973,622**	**91**

Source: PGE.

37. The steam resource shortage in Ulubelu field is being addressed through additional drilling. The drilling of additional wells is expected to have the generation outputs exceed the target by 7 percent when the new wells are connected with pipeline in July 2019. The steam availability of Ulubelu 3 and 4 was around 97.5 MW with an assumption that 6.8 tons per hour translate into 1 MW. Two additional wells were drilled and tested with results of 39.92 MW. This will top up the original steam capacity of 97.5 MW totaling 137.42 MW, which is enough for 110 MW units. The generation projections are estimated in Table 4.

Table 4. Generation Projection after Additional Well Connection

Turbine Capacity	Target[a]	Projection	Expected Achievements (%)
Ulubelu 3 and 4	886,512 MWh	953,964 MWh[b]	108
Lahendong 5 and 6	322,368 MWh	343,392 MWh[c]	106
Total	**1,297,356 MWh**	**1,208,880 MWh**	**107**

Note: a. Targets were set with 110 MW full turbine capacity and 0.92 capacity factor.
b. The projection was made with full turbine capacity of 110 MW and average 0.99 availability factor, which were reported at project closing.
c. The projection was made with full turbine capacity of 40 MW supported by 44.6 MW steam availability and average 0.98 availability factor, which were reported at project closing.

38. The achievement of the first objective is evaluated to be **Substantial** given that targets of all the relevant PDO indicators and electricity generation output are met substantially. Moreover, the generation output is expected to improve shortly and exceed the target with the additional steam capacity from the additional drilling to be available in July 2019. Also, regular inspections require the generation units to be shut down for shorter periods than the first-year inspections did. Therefore, less impacts of inspections on electricity generation are expected in the future.

Outcome (ii): Reduced local environmental impacts

39. The achievement of reduction of the local environmental impacts was evaluated to be **Substantial** at around 92 percent with a minor shortcoming. Reductions in local and global environmental impacts are observed based on displacement of coal-based power generation, which would have happened with a high likelihood in the absence of geothermal power. The avoided local environmental impacts are estimated as the amounts of NO_x, SO_2, and TSP, which would have been released from coal-based power production for the same generation output with the project. Thus, results against this objective are dependent on the geothermal power generation outputs. The minor shortcoming in the results is due to the same factors which affected the generation outputs discussed in paragraphs 34–36. The achievement of the second objective is expected to improve as the steam availability issue will be resolved and the power generation will be less affected by plant inspections.

Outcome (iii): Reduced global environmental impacts

40. The achievement of reduction of global environmental impact is evaluated to be **Substantial** at the same 92 percent level consistently with local environmental impact reduction. It is measured as the amount of CO_2 which would have been emitted from coal power production less the CO_2 emission from geothermal generation for the same generation output. The achievement of this objective will improve over time for the same reasons stated earlier.

Justification of Overall Efficacy Rating

41. The project directly contributed to achievement of the development objectives by adding geothermal generation capacity through investments and then reducing the local and global environmental impact by substituting coal-based generation. The project investments were integral in adding the new geothermal capacity considering the low financial viability without project investment and need for capacity building. The project results exceeded the targets for some indicators and the other targets were fully or substantially met with expectations of further improvements over time. For these reasons, the overall project efficacy is rated Substantial.

C. EFFICIENCY

Assessment of Efficiency and Rating

Rating: Substantial

42. **Economic evaluation.** At appraisal, the present value of the geothermal costs was compared with the present value of the cost (PVC) for coal. When local and global externalities were factored in, the PVC for coal was found to be US$717.72 million, which is higher than the PVC for geothermal (US$657.94 million). At completion, the same comparison was made with updated cost figures (for example, monetization of global externalities according to the 2017 corporate guidelines on the Social Value of Carbon). The PVC for coal was estimated at US$749.33 million which is higher than the geothermal cost (US$ 717.08 million). The analysis confirmed the results observed at appraisal: local and global environment costs economically price out coal in relation both larger (Ulubelu-equivalent) and smaller (Lahendong-equivalent) geothermal investments.

43. **Financial evaluation**. At appraisal, the project financial internal rate of return (FIRR) and financial net present value (FNPV) were calculated. The FIRR for Ulubelu was 17.4 percent, and it was 14.6 percent for Lahendong. The FNPV for Ulubelu was US$46.8 million, and it was US$4.0 million for Lahendong. The FIRRs were found higher than the 8.03 percent weighted average cost of capital (WACC), thus confirming the financial feasibility of the project over the 30 years of their useful lives. At completion, the FIRRs and FNPVs were calculated based on updated figures (for example, actual cost of drilling and well testing, EPC, land acquisition and infrastructure, interest during construction, and so on). The FIRR for Ulubelu is 11 percent and for Lahendong 10 percent both of which are still found to be higher than the WACC but lower than PGE's hurdle rate of 14 percent. Still, the financial feasibility of the investment is reconfirmed with positive FNPVs of $89.79 million for Ulubelu and $41.24 million for Lahendong.

44. While the cost of drilling was US$94.6 million higher than the expected US$274.7 million, two factors offset the negative impact on the financial returns. The power purchase agreement (PPA) tariffs

used in the efficiency assessment were higher than the tariffs used at appraisal. In the completion analysis, US$0.084 per kWh was used for Ulubelu as it is expected to be signed with the PLN and retroactively applied over the underlying PPA-linked US$0.0753 per kWh. For Lahendong, US$0.114147 per kWh was used for the efficiency analysis as the increased rate was already renegotiated with the PLN over the original PPA value of US$0.0825 per kWh (for more details refer to annex 4). Second, an IBRD loan saving of US$46 million occurred owing to the competitive bidding among four prequalified EPC contractors for the Ulubelu units and five for the Lahendong units in the procurement of EPC contracts. Furthermore, the performance contracts enabled a net plant steam rate of about 10 percent more than the specified maximum rates.

45. The development costs for both fields stayed within the expected cost range of up to US$8 million per MW capacity in Indonesia for exploration and production drilling and plant and associated facility construction.[15] The total investment in the development of Ulubelu 3 and 4 units was estimated to be US$401 million, giving a unit investment cost of US$3.64 million per MW. The investment for Lahendong 5 and 6 units was US$221 million, giving US$5.53 million per MW. The smaller scale of Lahendong typically resulted in higher costs than Ulubelu, per MW.

46. **The project experienced delays** which resulted in the extending the loan closing date by 45 months.[16] The delay was mainly because of the uncertainties in geothermal steam resource and reinjection capacities. It took almost a year and a half from when PGE first recognized the possible need for additional drilling, in March 2012, to the resumption of drilling in October 2013 following the approvals of a revised drilling plan and needed funding by PGE. The resource uncertainty and slow process of the drilling program update caused delays in many parts of the project by holding up the procurement process and subsequently postponing the EPC contract and plant commissioning. However, the time delay caused by the resource uncertainties is not considered in the efficiency rating as the resource uncertainties are inherent risks to geothermal energy development.

D. JUSTIFICATION OF OVERALL OUTCOME RATING

47. The overall outcome is rated Satisfactory because of the high relevance of its PDO at project preparation and closing, its substantial efficacy in achieving the intended outcome with only minor shortcomings,[17] and the substantial efficiency with which the inputs and resources have translated into results.

[15] Kevin Fan, and Sang Nam 2018.

[16] The extension was requested for 45 months to accommodate almost two years of delay in project progress, contingency in time in case further delays happen in resource confirmation, and 12-month maintenance period to ensure good performance of plants. The geothermal resource uncertainties caused delays in EPC contract signing by one and half years with the last EPC contract being signed for Lahendong in December 2014 compared to June 2013, which was planned at appraisal. Consequently, plant commissioning was also delayed by almost two years with the last commissioning in March 2017 for Ulubelu 4 compared to the original plan of commissioning by March 2015.

[17] A good example ICR, rated 'High' by the Independent Evaluation Group in renewable energy sector, was used as a reference for the rating along with the ICR guidance. The ICR for Pamir Private Power Project (Report No. ICR00001513) rated the project outcome as Substantial with a lowest achievement at 82 percent for one of the PDO-level indicators. The rating of the project followed the good example ICR. It is also further justified by a recent unpublished Independent Evaluation Group analysis that renewable energy projects achieve results at around 70 percent, on average.

E. OTHER OUTCOMES AND IMPACTS (IF ANY)

Gender

48. The project included gender consideration and brought positive impacts on gender through consultations with female representatives and corporate social responsibility (CSR) investments. Female stakeholders, including representatives from Housewives Association and female local teachers, participated in ESIA consultation and disclosure events and shared their comments. When the female participants had not offered comments during the main sessions, the ESIA team requested follow-on meetings with them to ensure that female voices are heard. Also, the ESIA planned to have the local female population represented in district land acquisition committees to protect the rights of women on their assets.

49. PGE's investments in the community through its CSR program contributed to improvement of women's living conditions. Under its corporate social policy, PGE provided active support to the communities in the vicinity of the subproject areas, which included investments in water infrastructure. The presence of a local water supply saved significant amounts of time in the collection of drinking water from rivers and time spent travelling to a river to wash themselves and clothes. This had gender equality benefits as it is women who perform these activities and whose time is often most constrained by domestic chores, child rearing, agriculture, and other economic activities. In 2015, PGE was awarded the Tanggamus Award for actively conducting CSR programs.

Institutional Strengthening

50. The capacity-building activities have transformed PGE into a world-class geothermal developer. PGE expanded geothermal operations under their name by 66 percent from 232 MW at appraisal to 617 MW at project closing. In 2016, PGE was ranked as the world's 13th largest geothermal operator and the second largest in Indonesia following the PLN.[18] Through comprehensive TA support, PGE's technical capacity also improved both in preparation of new prospects and operation of the existing geothermal portfolio.

51. The project highlighted the crucial role of a fair and transparent geothermal tariff-setting mechanism. The project would not have been financially viable had it not had access to a concessional CTF loan. However, even with access to concessional funding, PGE needed to renegotiate the tariff with the PLN to reflect drilling cost overruns, which could not have been foreseen at project initiation. This was successful in the case of Lahendong but not yet for Ulubelu. This uncertainty related to tariff setting is a major deterrent for public as well as private developers and a better tariff-setting mechanism will be needed to support a scale-up in geothermal investments. In recognition of this, the World Bank continues to support the MEMR by building capacity on geothermal tariff setting. Such support was initially provided as a part of the Geothermal Power Generation Development Project and is currently being provided under the Geothermal Energy Upstream Development Project as just-in-time assistances to the MEMR.

Mobilizing Private Sector Financing

[18] World Energy Council 2016.

52. Mobilization of private sector financing was not within the project scope given that the investment in infrastructure in the country was stalled after the Asian financial crisis, and private sector investment was discouraged due to the capital flight from the emerging economies and revocation of the 2002 electricity law in 2014. After the project resumed geothermal development after a decade of relative standstill, private sector involvement has been slowly picking up. It can be presumed that the project indirectly contributed by recovering confidence in the sector and providing momentum, but the causal relationship is not supported with substantive evidences.

Poverty Reduction and Shared Prosperity

53. The project contributed to the local economy by providing employment and business opportunities. The project created jobs through local employments. For Lahendong 5 and 6 units, 1,800 people were employed for the development and 3,000 people were employed for Ulubelu 3 and 4 units.[19] Communities around the project sites have also benefited from business opportunities such as selling food for workers and providing temporary accommodations. Local content of activities funded by the IBRD and CTF loans is 41 percent with US$123 million being paid to PT. Rekayasa Industri, which is a domestic company.[20]

54. Further, the electricity supplied from Ulubelu 1–4 units to 440,000 homes and from Lahendong 1–6 units to 40,000 homes will be used for productive activities by household members, reducing poverty in the long term.

Other Unintended Outcomes and Impacts

55. Improved air quality and respiratory health benefit are positive outcomes of replacing coal power generation with geothermal power generation. The monetized value of the health benefit is estimated to be US$19.97 million per year for the generation outputs from the project. The monetized value is estimated with the benefit transfer method whereby the monetized value of health damages incurred by emissions of NO_x, SO_2, and TSP from coal-based power generation is considered a relative benefit of geothermal power generation. The coal damage costs of the three types of pollutants are estimated by using damage cost factors, which are US$0.95 per kg for NO_x, US$0.0019 per kg for SO_2, and US$0.0062 per kg for PM_{10}[21] in Indonesia.

III. KEY FACTORS THAT AFFECTED IMPLEMENTATION AND OUTCOME

A. KEY FACTORS DURING PREPARATION

56. The target of 150 MW total capacity for the four units were set realistically considering the information on resource potential from the presurveys and the typical geothermal plant sizes in Indonesia. The project design was simple with two components of investments in the post-exploration phase and capacity building TA based on a clear operational logic. The monitoring and evaluation (M&E) framework

[19] RambuEnergy News & Communities, 2016. https://www.rambuenergy.com/2016/12/president-widodo-inaugurates-lahendong-geothermal-power-plant-unit-5-and-6/.
[20] Disbursement data from World Bank Client Connection System.
[21] The damage costs are referenced from *Technical Notes: Guidelines for Economic Analysis of Power Sector Projects Volume 2* (Report No. 99506 v2) by World Bank.

was designed to monitor the progress and results of activities in spite of the weakness described in paragraph 63. An appropriate plan for monitoring the results was set up and sound methodologies were identified.

57. The implementing agency was identified appropriately. Partnering with PGE for expanding geothermal development in the country was a strategic approach given PGE's advantages. PGE is specialized in geothermal development. They were also mandated to lead the achievement of the national geothermal development goal with a number of geothermal working areas assigned to them. Also, PGE was financially credible as a subsidiary backed by the parent company, Pertamina. Readiness for development was high in that the fields had already been explored by PGE, clearing the greatest uncertainties in the geothermal development. PGE was the best partner to kick-start geothermal development when geothermal developments were stalled in the country and there was little confidence in the sector at the time of appraisal.

58. Inclusion of the capacity building TA activities funded by the GoNZ and GoTN greatly enhanced the chance of success of the project and sustainability of the project achievements. Although PGE was the best partner to develop the project with, there were weaknesses identified in PGE's capacity. To strengthen their capacity for high-quality investment, preparation, and maintenance of the operation, the World Bank team mobilized € 1,855,000 grant support from the GoTN and US$6.95 million from the GoNZ. Under these TA support, a TCP expert provided advisory services for the second drilling plan, plant specifications were well-defined in the FEEDs, ESIAs and bidding documents were prepared to meet international standards, and a high-quality EPC contractor was selected through the bid process. All of these led to a successful resource development and commissioning and operations of the plants.

B. KEY FACTORS DURING IMPLEMENTATION

59. **Factors subject to government and/or PGE control.** Indonesia has an annual budgeting process of foreign debts and grants as a part of the annual national budget planning. Spending entities of foreign debts or grants should prepare detailed budget allotment documents for the next fiscal year, within a two-month time frame, to be given to authorities for spending through the Budget Authorization Document (*Daftar Isian Pelaksanaan Anggaran*, DIPA) before the start of the spending year. If the budgeted amount is not adequate, then the spending entities submit budget realization reports and midyear budget revision for approvals by Parliament.[22] The DIPA process imposed administrative burdens on PGE and Pertamina during project implementation raising concerns on delays by the World Bank team. The budget process was further slowed down by PGE's lack of familiarity with the World Bank procedures/processes as a first-time client. Although it did not affect the implementation progress, the DIPA- Subsidiary Loan Agreement (SLA) issue and consequent slow disbursements remained one area where the World Bank team provided close supervision to avoid delays.

60. The GoI's strong ownership over the project and support from relevant government entities facilitated the project process despite their unfamiliarity with World Bank procedures. The Indonesian Ministry of National Development Planning (BAPPENAS) provided guidance on international financing procedures (which is called "Blue Book'') and project scope and facilitated discussions and agreements between PGE and PLN on transmission line construction and meeting odor standards. The Ministry of Finance (MoF) supported the loan process, including signing loan agreements, reviewing and approving

[22] Asian Development Bank 2018.

DIPA-SLA budgets, and making requests for loan closing date extensions. Most importantly, PGE's strong ownership over the project kept the project progressing toward completion. PGE was efficient in identifying the areas of ample technical capacity and where technical support from the World Bank and TCP advisers was needed. PGE used their TCP partners for various technical issues including analysis of well-testing data and review of the second drilling program, which directly contributed to high-quality preparation of the investment component. In working with TCP advisers, PGE remained aware of their primary ownership over the project.

61. **Factors outside the control of Government and/or PGE**. The uncertainties in steam resource capacities and investment risks associated with the uncertainties caused delays in the project time line. It was found that the resource capacity and the conditions from the first drilling were not adequate for the target generation capacity, and the need for additional drilling was confirmed in October 2011. Because of the need for additional drilling, bid packages for the ECP contracts could not be issued until July 2013 and May 2014 when PGE acquired enough certainty on the steam availability. Pertamina's slow approval for funding for additional drilling was a part of the delay in the project progress along with other factors including developing plans for additional drilling, land acquisition, and infrastructure preparation for new drilling clusters and procurement of drilling rigs. The slow approval by Pertamina was because they were very cautious in approving the funding given the risks associated with resource uncertainties.

IV. BANK PERFORMANCE, COMPLIANCE ISSUES, AND RISK TO DEVELOPMENT OUTCOME

A. QUALITY OF MONITORING AND EVALUATION (M&E)

M&E Design

62. The M&E framework of the project was designed based on a clear theory of change and included a set of relevant PDO-level and intermediate-level indicators to monitor the progress of activities and outcomes. Many of the indicators are well defined in terms of what they measure. For instance, reduced local environmental impact is clearly defined as avoided emissions of three representative air pollutants arising from coal power generation and an adequate indicator and a sound measurement methodology[23] were set up to assess the achievement.

63. While the overall set of indicators were relevant and useful for monitoring project progress and outcomes, some of indicators were not properly assigned to the relevant level of PDO outcomes or intermediate outcomes. For example, the first four PDO indicators linked to the first development objective in Table 5 would be more suitable for measuring outputs or intermediate-level outcomes,[24] while the last two indicators were properly placed at the PDO level to assess achievements of the second and third development objectives. Table 5 suggests how the PDO indicators in the project Results Framework can be aligned with the results chain in Figure 2. A more appropriate PDO level indicator might have been "electricity produced from geothermal generation in the project area",

[23] The methodology is described in paragraphs 66–69.

[24] In addition to the four PDO indicators, Annex I. Results framework and key outputs includes two indicators added through ISRs, 'progress of EPC contract for Ulubelu SAGS + power plant' and 'progress of EPC contract for Lahendong SAGS + power plant.' These two additional indicators were not used for efficacy evaluation in this ICR. For more explanation, see annex I.

Table 5. Alignment of PDO Indicators in Project Results Framework to the Results Chain

No.	PDO Indicators in Project Results Framework	Level in Results Chain
Objective 1: Increased power generation from renewable geothermal resources		
1	Ensure technical, environmental, and social practices in line with industry standards during project preparation	Output level
2	New geothermal power generation capacity installed directly financed by the World Bank loan	Output level
3	Contribute towards PGE becoming a leading geothermal developer	Intermediate outcome level
4	Maintain operation availability of geothermal power plants	Intermediate outcome level
Objective 2: Reduced local environmental impacts		
5	Avoided local air pollution (NO_X, SO_2, TSP)	PDO Outcome level
Objective 3: Reduced global environmental impacts		
6	Avoided global GHG pollution (CO_2)	PDO Outcome level

64. PGE prepared quarterly progress reports (QPRs) which included key information. PGE's QPRs kept good track of technical details and included data on resource status and plant operations. In particular, technical status information reported in the QPRs, such as electricity generation outputs (in GWh) and steam availabilities, were important in monitoring and evaluating the project performance. The electricity generation output is a key information to measure achievement of all three development objectives. Monitoring of steam availability was crucial as the uncertainty in steam resource was identified as a major risk inherent to geothermal development at appraisal.

M&E Implementation

65. PGE had enough capacity to monitor and report on the project status and diligently fulfilled its responsibility of collecting and reporting the progress and results of project activities. PGE started submitting QPRs to the World Bank team from October 2014 until project closing. The QPRs were not prepared before October 2014 as the EPC contracts and construction works had not started before that.

66. Reporting on the two PDO indicators to measure reduced environmental impacts followed a sound methodology, which makes the results values credible. Reduced emissions were estimated by calculating the amount of air pollutants or GHG which would have been emitted by coal-based power generation in the absence of geothermal power generation. The avoided emissions are calculated as follows:

$$\underset{(tons/year)}{\textit{Avoided Emission}} = \underset{(MWh/year)}{\textit{Electricity Generated}} \times \underset{(g/kWh)}{\textit{Net emission factor}} \div 1000$$

67. The net emission factors were calculated based on the emissions that would occur, had the same amount of electricity been generated from a coal-fired power plant rather than a geothermal power plant, less any emissions that would result from the geothermal power plant.

68. The following assumptions were made regarding the specific characteristics of coal that would have been used if a coal-fired plant was built instead of a geothermal power plant, which determine the emissions from coal that would have resulted: (a) lower heat value of 4,200 kcal per kg based on the coal proposed for the FTP I in Indonesia, which in turn was characterized as having 0.40 percent sulfur, 6

percent ash, and 40 percent carbon;[25] (b) the commonly used assumption for the average net thermal efficiency of boilers in medium-size coal-fired power plants with subcritical steam, burning somewhat higher quality coals is approximately 33 percent;[26] and (c) the pollutant removal efficiency of the control technology installed for the coal plant was assumed at 95 percent for TSP and 0 percent for SO_2 and NO_X.

69. The following assumptions were made regarding the emissions from the geothermal power plant: it does not emit TSP, SO_2, or NO_X, and its emissions of CO_2 are much lower—assumed to be about 10 percent of the emissions from a coal-fired power plant.[27]

70. Based on the abovementioned assumptions, the net emissions factors that were used in calculating the emissions from the project are as follows:

- TSP = 2.11 g/kWh
- SO_2 = 4.47 g/kWh
- NO_x = 2.5 g/kWh[28]
- CO_2 = 917 g/kWh[29]

M&E Utilization

71. The project M&E was used for monitoring project status, decision making on remedial actions, and following up. PGE used the QPRs to not only monitor and update the project status under the defined framework but also to address any issues that emerged during the implementation of the project. The regular missions were also a key to monitoring, with PGE giving thorough and open briefings on issues.

Justification of Overall Rating of Quality of M&E

72. The overall quality of M&E is rated **Substantial**. Despite the minor shortcoming, the Results Framework included sufficient indicators to monitor the progress of activities and achievement of objectives. The monitoring and reporting methodology was identified during the preparation and was applied consistently during implementation. The implementation and the utilization of the M&E framework has been satisfactory. PGE diligently submitted the QPRs, reporting key information on project status. The World Bank team also used the reporting as a means for close supervision.

B. ENVIRONMENTAL, SOCIAL, AND FIDUCIARY COMPLIANCE

73. **Environmental and social safeguards**. The project is classified as Category A with Environmental Assessment (OP/BP 4.01) and Involuntary Resettlement (OP/BP 4.12) policies triggered. Indonesia's environmental review procedures (referred to hereafter as AMDAL process)[30] were used as an initial

[25] Based on published specifications of Indonesian 4,200 GAR coal, *Indonesia Coal Index Report*, Argus/Coalindo.
[26] Based on International Energy Agency Clean Coal Center publication.
[27] Based on United States Geothermal Energy Association publication.
[28] NO_X emission is largely dependent on the boiler design and combustion technology, but not on coal characteristics. For subcritical coal-fired power plant, a generic emission factor is used.
[29] The net emission factor for CO_2 is estimated based on emissions from coal (1011 g per kWh) less emissions from geothermal (94 g per kWh)
[30] Ministerial regulation No 11 of 2006 required development of a geothermal power station greater than 55 MW to complete an AMDAL process equivalent to completion of a Full Environmental Impact Assessment with Environmental Management and Monitoring Plan for a Category A project by World Bank classification.

screening tool and then the gaps were filled for full compliance with the World Bank policies. PGE had a strong commitment to full compliance with the World Bank safeguard policies and the safeguard management was rated Satisfactory most of the time during implementation. PGE's excellence in the management of health, safety, and environment was also noted. Regarding the Land Acquisition and Resettlement Action Plan, PGE negotiated land acquisitions directly with land owners following a 'willing-seller, willing-buyer' approach. With this practice, zero complaints were received while a good grievance redress mechanism was set up.

74. The World Bank Group's Environmental, Health, and Safety Guidelines was complied with. Under the guidelines, it was required to meet the international standard of hydrogen sulfide (H_2S) emissions. Emissions modeling as part of the ESIA studies identified a possible issue at Ulubelu with the combined emissions from Ulubelu units 1, 2, 3, and 4. BAPPENAS facilitated a Joint H_2S Abatement Agreement between the PLN and PGE that would have triggered retrofitting of H_2S abatement plants if emissions reached certain levels. Potential retrofitting was built in to the EPC contracts. In practice, trigger levels were not reached, so allowance for abatement was not finally required. Still, PGE kept monitoring the fields according to the monitoring plan even after it was evident that abatement was unnecessary.

75. It is also noted that there was no gender-based violence by labor influx at both project sites.

76. **Fiduciary compliance**. Overall, PGE's financial management was Satisfactory. Although there were a couple of delays at the beginning, PGE submitted quarterly interim financial reports on time since Q1 FY2013 as they became familiar with the World Bank operation. The audit reports were also submitted on time with clean opinion. The effectiveness of the DIPA-SLA was improved over time and there was no delay in the payment of the EPC contracts. Based on transaction review results during the supervision, the internal control system was assessed to be adequate.

C. BANK PERFORMANCE

Quality at Entry

77. The project's objective was highly relevant to the CPS, the current CPF, and the FTP II. During the preparation, the World Bank team provided enough inputs and guidance on technical aspects and World Bank procedures. Due diligence was conducted on PGE's financial situation and a balance sheet check was carried out. The social safeguard was effectively complied with by complementing the gaps in the Indonesian Government land acquisition procedures set out in Presidential Regulation No. 36/2005 and its revision No. 65/06 to meet the World Bank's requirements. For environmental safeguard, the AMDAL was used and the documentation was supplemented by further analysis and measures to meet the World Bank requirements. The World Bank team also notified PGE of fiduciary requirements. The M&E framework was set up and the methodology for reporting was identified.

Quality of Supervision

78. The World Bank team carried out close supervision, including 12 official supervision missions, with key staff and frequent informal missions by the Jakarta-based team members during the seven and half years of implementation. During the early stage of implementation, the Jakarta-based team members worked with PGE almost on a daily basis. At each official mission, the World Bank checked on the progress toward achieving the development objectives. The World Bank team recorded the implementation status

and issues in Aide Memoirs and ISRs. The World Bank also provided responsive support upon emergence of issues or PGE requests. Such support included dispatching geothermal engineers or experts for technical advice, providing training on procurements, reviewing revisions on drilling programs, and others. Even when the missions were not conducted, the World Bank provided close supervision with the help of the Jakarta-based team members.

79. Candor and high-quality performance reporting contributed to effective supervision. Technical and operational issues were captured in ISRs in a candid manner with accurate analyses. Important issues were flagged for management attention in time. Measures to be taken were recorded in detail with realistic time lines in the ISRs and followed up in a systemic way.

Justification of Overall Rating of Bank Performance

80. Overall, the World Bank's performance is rated **Satisfactory**. At appraisal, the World Bank provided technical inputs and proper guidance to PGE for compliance of safeguards. During implementation, the World Bank team provided close and responsive supervision and all progresses and statuses were recorded and monitored with candor and high-quality performance reporting.

D. RISK TO DEVELOPMENT OUTCOME

81. **Production well capacity rundown** (Likelihood: high, Impact: medium). The rundown has already been observed for production wells of Ulubelu 3 and 4, which is normal in geothermal operation. Drilling program of six additional wells began in November 2017 to address it, and the steam availability reached the required level with the new wells to be connected by July 2019. Two new wells out of the six were completed with positive output test results of 18.4 MWe and 15.9 MWe each. These wells would load the station, while excessive steam capacity would leave a small reserve to account for ongoing well rundown before the next makeup drilling program. Going forward, additional makeup drilling plans will need to be prepared and implemented to mitigate the impact of the ongoing rundown, according to normal practice. The makeup drilling plans should be made and implemented on time to avoid compromising the achieved outcomes.

82. **PLN offtake issue in Lahendong 5 and 6** (Likelihood: high, Impact: low). An issue of the PLN offtake might affect the project outcome. The PLN has a contract with a Turkish mobile vessel providing heavy fuel oil generated electricity which expires in 2020 and Lahendong 5 and 6 competes with the mobile vessel to supply to the PLN. However, the impact of this issue will be limited given the 90 percent take-or-pay rate for the Lahendong 5 and 6 and the relatively short contract period of the Turkish mobile vessel plant.

V. LESSONS AND RECOMMENDATIONS

83. **While concessional financing can contribute to significantly enhance the financial feasibility of geothermal development, future support may be better directed at addressing the risks associated with the key bottleneck of resource uncertainties.** The concessional CTF loan combined with an IBRD loan made the project viable by bringing capital costs down, which reduced Pertamina's financial risk. However, the concessional financing could not mitigate the risks associated with the uncertainties in resource availability, which were fully absorbed by Pertamina as the equity provider for the drilling phase.

Because of such resource risk, more wells needed to be drilled than what was originally foreseen. Pertamina was slow in approving the additional funding needed for the additional wells, which resulted in considerable delays in project implementation, and the approval was on a conditional basis for Lahendong, where the final decision to provide funding was made dependent upon the confirmation of the first well drilling results. This experience indicates that the World Bank's support should more directly target risk mitigation at the early drilling stages for faster and effective geothermal development at scale. The loan instruments alone are not suitable to address resource risk so capital at risk instruments should be considered (such as reimbursable grants, also called contingent recovery grants). Because investing in a single project presents a large risk of an unsuccessful project, risk mitigation should be implemented adopting a portfolio approach whereby successful projects fully or partially cover the cost of unsuccessful projects through premium payments. The Indonesia Geothermal Energy Upstream Development Project, Turkey Geothermal Development Project, and the proposed Indonesia Geothermal Resource Risk Mitigation Project are examples of deploying CTF contingent recovery grants with higher risk appetite through a portfolio approach for exploration drilling, which is the biggest bottleneck in the geothermal development pathway.

84. **TA support is crucial in achieving successful results from investments and in increasing the likelihood of success of future developments in the country, especially when the client is not familiar with World Bank operations and has limited capacity to meet industry standards.** With TA support, PGE was able to prepare the investments in Ulubelu 3 and 4 and Lahendong 5 and 6 with high-quality ESIAs, feasibility studies, FEEDs, and procurement bidding packages, thus increasing the possibility of success the project. Furthermore, the capacity developed through the TA activities will remain in PGE and is now being applied to PGE's other projects. For example, an effective reinjection strategy, supported under the Ulubelu 3 and 4 investment, benefited a 110 MWe capacity associated with Ulubelu 1 and 2 as well. Also, PGE will be in a position to contract out ESIAs, feasibility studies, FEEDs, and establish the right evaluation criteria and capacity to ensure that these works are up to international standards. PGE now has a model performance contract developed from project experience, which, together with the experience acquired in contract management, which will help recognize the strengths and weaknesses of contracts under future projects.

85. **Well-managed 'willing-buyer and willing-seller' approach for land acquisition is an effective way of securing land acquisition while minimizing issues with local communities.** The approach is seen as a successful practice by PGE given that there were no major complaints recorded through the grievance mechanism that was put in place. When using this approach in other operations, it should be taken into account that the practice takes longer to complete and should be planned well ahead. Land for Cluster K was an example of protracted negotiations, where seven designs were needed for access to the site because the landowners refused to sell rice paddy lands at a reasonable price. Despite this, the 'willing-buyer willing-seller' mechanism was assessed by PGE as a faster path than compulsory acquisition and resettlement.

86. **In Indonesia, subsidiary loan arrangement increases administrational burden and time requirements for disbursements.** For disbursement of the World Bank financing, PGE had to go through multiple layers of approval process. The legal borrower was the MoF and Pertamina had an SLA with the MoF. Although PGE confirmed that the EPC contract progressed well and was not affected by delays in the DIPA-SLA budget approvals, this arrangement often raised concerns during implementation. As an alternative, an option of direct lending to state-owned enterprises with a sovereign guarantee can be considered.

ANNEX 1. RESULTS FRAMEWORK AND KEY OUTPUTS

A. RESULTS INDICATORS

A.1 PDO Indicators

Objective/Outcome: Increased power generation from renewable geothermal resources

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
New geothermal power generation capacity installed directly financed by the World Bank loan	Megawatt	0.00 26-Jul-2011	150.00 31-Mar-2015	150.00 31-Dec-2018	150.00 30-Sep-2018

Comments (achievements against targets): The target is fully achieved. The indicator is a new name of 'New geothermal power generation capacity installed' indicator which was originally approved as a part of PAD Results Framework. The re-naming has been introduced in the first ISR without an official approval.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Progress of EPC contract for UlubeluSAGS+power plant	Percentage	0.00 26-Jul-2011	100.00 31-Dec-2018	100.00 31-Dec-2018	100.00 30-Sep-2018

Comments (achievements against targets): The target is fully met. This indicator has first been adopted through ISR dated November 9, 2015

(ISR20866) without an official restructuring. While the indicator was useful for monitoring the EPC contract progress, the indicator is not used for efficacy evaluation in the ICR because it measures progress at activity level, not PDO outcome level.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Progress of EPC contract for Lahendong SAGS+power plant	Percentage	0.00 26-Jul-2011	100.00 31-Dec-2018	100.00 31-Dec-2018	100.00 30-Sep-2018

Comments (achievements against targets): The target is fully met. This indicator has first been adopted through ISR dated November 9, 2015 (ISR20866) without an official restructuring. While the indicator was useful for monitoring the EPC contract progress, the indicator is not used for efficacy evaluation in the ICR because it measures progress at activity level, not PDO outcome level.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Contribute towards PGE becoming a leading geothermal developer	Megawatt	232.00 26-Jul-2011	700.00 31-Mar-2015	700.00 31-Dec-2018	617.00 30-Sep-2018

Comments (achievements against targets): The target is substantially met at 82% level.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Ensure technical, environmental and social protection in line with	Text	Feasibility studies are under par of industry standards.	Feasibility studies meet good industry practice.	Feasibility studies meet good industry practice.	Two FS completed meeting industry standards

industry standards during project preparation.		26-Jul-2011	31-Mar-2015	31-Dec-2018	30-Sep-2018

Comments (achievements against targets): The target is fully achieved. The indicator name was originally 'ensure technical, environmental and social practices in line with industry standards during project preparation' at time of inclusion to the Results Framework through the first restructuring. The indicator was reworded through ISR dated June 17, 2015 (ISR 18126) without an official restructuring. The ICR uses the original indicator wording.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Maintain operation availability of geothermal power plants	Number	0.85 26-Jul-2011	0.85 31-Mar-2015	0.85 31-Dec-2018	0.98 30-Sep-2018

Comments (achievements against targets): The target is exceeded at 116% level. The availability factors are 0.9997 for Ulubelu 3 (55 MW), 0.9793 for Ulublelu 4 (55 MW), 0.9573 for Lahendong 5 (20 MW), and 0.9972 for Lahendong 6 (20 MW) as of December 2018. The average availability factor for the four units is 0.9834.

Objective/Outcome: Reduced local environmental impact

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Avoided local air pollution (NOX, SO2, TSP)	Text	0 tonnes of NOX 0 tonnes of SO2 0 tonnes of TSP 26-Jul-2011	3,000 tonnes of NOX 5,400 tonnes of SO2 2,500 tonnes of TSP 31-Mar-2015	3,000 tonnes of NOX 5,400 tonnes of SO2 2,500 tonnes of TSP 31-Dec-2018	2,753 tonnes of NOX, 4,923 tonnes of SO2, 2,324 tonnes of TSP 30-Sep-2018

Comments (achievements against targets): The targets are substantially met at 92% level. The results are calculated 12 months back from end of December 2018. The results for Ulubelu Units 3&4 are 1,960 tonnes of NOx, 3,505 tonnes of SO2 and 1,654 tonnes of TSP. The results for Lahendong Units 3&4 are 793 tonnes of NOx, 1,418 tonnes of SO2 and 669 tonnes of TSP.

Objective/Outcome: Reduced global environmental impact

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Avoided global GHG pollution (CO2)	Metric ton	0.00 26-Jul-2011	1100000.00 31-Mar-2015	1100000.00 31-Dec-2018	1010125.00 30-Sep-2018

Comments (achievements against targets): The targets are substantially met at 92% level. The result was calculated 12 months back from end of December 2018. The result for Ulubelu Units 3&4 is 719,212 tonnes and the result for Lahendong Units 5&6 is 290,912 tonnes.

A.2 Intermediate Results Indicators

Component: Investment in Geothermal Power Generation Capacity

Component: Technical Assistance for Capacity Building

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Minimum of 2 EPC contracts signed	Text	0 26-Dec-2011	2 31-Dec-2012	2 31-Dec-2018	2 31-Dec-2018

Comments (achievements against targets): The target is fully achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Yearly agreement reached between PGE and TCP Partner on support program	Text	Partner not procured 01-Jan-2012	Agreement reached 31-Mar-2015	Agreement reached 31-Dec-2018	Agreement reached 31-Dec-2018

Comments (achievements against targets): The target is fully achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
World Bank approval of yearly training program	Text	Training Program yet to be approved 01-Jan-2012	Training Program approved 31-Dec-2015	Training Program approved 31-Dec-2018	Training Program was fully completed 31-Dec-2018

Comments (achievements against targets): The target is fully achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Minimum of 40 staff trained in key workshops each year	Number	0.00 01-Apr-2012	120.00 31-Mar-2015	120.00 31-Dec-2018	204.00 30-Sep-2018

Comments (achievements against targets): The result exceeded the target by 70%.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
IT software purchased, installed, and being utilized by PGE staff	Text	Software not installed 01-Jan-2012	Software installed, utilized by PGE staff 31-Mar-2013	Software installed, utilized by PGE staff 31-Dec-2018	Software installed, utilized by PGE staff 31-Dec-2018

Comments (achievements against targets): The target is fully achieved.

Indicator Name	Unit of Measure	Baseline	Original Target	Formally Revised Target	Actual Achieved at Completion
Bid documents including FEED issued for one geothermal plant; Studies issued for new developments/investments	Text	Bid documents/studies not issued 01-Jan-2012	Bid documents/studies issued 31-Dec-2015	Bid documents/studies issued 31-Dec-2018	Bid documents/studies issued. 31-Dec-2018

Comments (achievements against targets): The target is fully achieved.

B. KEY OUTPUTS BY COMPONENT

Objective/Outcome 1: Increased power generation from renewable geothermal resources	
Outcome Indicators	1. New geothermal power generation capacity installed directly financed by the World Bank loan 2. Progress of EPC contract for Ulubelu SAGS + power plant 3. Progress of EPC contract for Lahendong SAGS + power plant 4. Contribute towards PGE becoming a leading geothermal developer 5. Ensure technical, environmental and social practices in line with industry standards during project preparation 6. Maintain operation availability of geothermal power plants
Intermediate Results Indicators	1. Minimum of 2 EPC contracts signed 2. Yearly agreement reached between PGE and TCP Partner on support program 3. World Bank approval of yearly training program 4. Minimum of 40 staff trained in key workshops each year 5. IT software purchased, installed, and being utilized by PGE staff 6. Bid documents including FEED issued for one geothermal plant; Studies issued for new developments/investments
Key Outputs by Component (linked to the achievement of the Objective/Outcome 1)	**Component 1: Investment in Geothermal Power Generation Capacity** • Construction of SAGS and power plants for 150MW capacity **Component 2: Technical Assistance for Capacity Building** • Supplemental ESIA issued for Ulubelu 3 and 4 and Lahendong 5 and 6 • FEEDs completed for Ulubelu 3 and 4 and Lahendong 5 and 6 • EPC contracts signed for Ulubelu 3 and 4 and Lahendong 5 and 6 • Reservoir modeling carried out for Hululais and Tompaso fields

	• 12 trainings provided to 204 PGE staff members • Software installed, utilized by PGE staff • Plant availability factors near to 1 for Ulubelu 3 and 4 and Lahendong 5 and 6 • Growth of PGE's portfolio size by 385 MW
Objective/Outcome 2 To reduce local environmental impacts	
Outcome Indicators	1. Avoided local air pollution (NOX, SO_2, TSP)
Intermediate Results Indicators	n.a.
Key Outputs by Component (linked to the achievement of the Objective/Outcome 2)	n.a.
Objective/Outcome 3 To reduce global environmental impacts	
Outcome Indicators	1. Avoided global GHG pollution (CO_2)
Intermediate Results Indicators	n.a.
Key Outputs by Component (linked to the achievement of the Objective/Outcome 2)	n.a.

ANNEX 2. BANK LENDING AND IMPLEMENTATION SUPPORT/SUPERVISION

A. TASK TEAM MEMBERS

Name	Role
Preparation	
Migara Jayawardena	Task Team Leader / Senior Infrastructure Specialist
Emil Elestianto	Development Specialist, Consultant
Ivy Chang	Financial Specialist, Consultant
Khairy Al-Jamal	Senior Infrastructure Specialist
Nouredddine Berrah	Energy/Institutional Advisor, Consultant
Pramod Agrawal	Social Development Specialist, Consultant
Shawna Fei Li	Junior Professional Associate
Thomas Walton	Environmental Specialist, Consultant
Brian Roy White	Geothermal Engineer, Consultant
Norval Stanley Peabody	Social Safeguards Specialist, Consultant
Imad Saleh	Procurement Hub Leader
Zhentu Liu	Senior Procurement Specialist
Rajat Narula	Senior Financial Management Specialist
Petrus Benjamin Gericke	Lead Specialist – Governance
Joseph Tham	Economist, Consultant
Jamil Sopher	Financial Advisor, Consultant
Yan Li	Financial Specialist, Consultant
Baher El-Hifnawi	Lead Transport Specialist/Economist
Sameena Dost	Senior Counsel
Melinda Good	Senior Counsel/Indonesia Country Lawyer
Georges Khoury-Haddad	Procurement Specialist, Consultant
Iin Arifin Takhyan	Geothermal Advisor, Consultant
Ninin Kania Dewi	Social Safeguards Specialist, Consultant
Budi Permana	Procurement Analyst

Christina I. Donna	Financial Management Specialist
Defne Gencer	Energy Specialist
Hua Du	Operational Specialist, Consultant
Heddy Suryantono	Operations Specialist, Consultant
Xiaodong Wang	Senior Energy Specialist
Gangadhar Prasad Shukla	Energy Econominist, Consultant
Moustafa Baher El-Hefnawy	Lead Transport Economist (performed financial/economic/stakeholder/risk analysis for the project)
Sri Oktorini	Program Assistant
Melissa Ortega Sanchez	Program Assistant
Cristina Hernandez	Program Assistant
Teresita G. Velilla	Program Assistant
Supervision/ICR	
Peter Johansen	Task Team Leader(s)
Yash Gupta	Procurement Specialist(s)
Christina I. Donna	Financial Management Specialist
Vilija Kostelnickiene	Senior Operations Officer
Ahsan Ali	Lead Procurement Specialist
Ninin Kania Dewi	Social Specialist
Rumiah Aritonang	Program Assistant
Tatong Permana Anggrimulja	Consultant
Brian Roy White	Geothermal Engineer, Consultant
Huong Mai Nguyen	Energy Specialist
Roberto La Rocca	Energy Specialist
Krisnan Pitradjaja Isomartana	Environmental Specialist
Muchsin Chasani Abdul Qadir	Energy Specialist
Agustina Parwitosari	Environmental Specialist

B. STAFF TIME AND COST

Stage of Project Cycle	Staff Time and Cost	
	No. of staff weeks	US$ (including travel and consultant costs)
Preparation		
FY09	13.265	69,154.42
FY10	22.276	209,407.82
FY11	37.581	185,148.16
FY12	1.260	10,125.33
Total	**74.38**	**473,835.73**
Supervision/ICR		
FY09	0	307.03
FY12	10.385	196,296.42
FY13	11.080	217,233.82
FY14	45.140	257,400.08
FY15	38.487	278,864.35
FY16	12.386	76,208.50
FY17	29.427	122,664.27
FY18	18.072	102,241.40
FY19	20.664	158,917.61
Total	**185.64**	**1,410,133.48**

ANNEX 3. PROJECT COST BY COMPONENT

Components	Amount at Approval (US$, Millions)	Actual at Project Closing (US$, Millions)	Percentage of Approval (%)
1 - Investment in Geothermal Power Generation Capacity (US$574.7 million)	**574.70**	**622.66**	**108.35**
IBRD	175.00	129.04	73.74[a]
Borrower	274.70	369.30	134.44[b]
CTF	125.00	124.31	99.45
2 - Technical Assistance for Capacity Building (US$6.95 million)[c]	**6.95**	**6.92**	**99.51**
GoNZ	6.95	6.92	99.51
Total	**581.65**	**629.58**	**108.24**

Note: a. The savings in the IBRD amount resulted from competitive bidding in EPC procurements. Planned activities have been fully delivered.
b. The cost overrun incurred from additional production drilling under the revised drilling plans because of resource uncertainties. The resource uncertainties are inherent feature of geothermal development.
c. The TA component was developed as a part of the project but was not included in the original financing plan at Board approval because the grant funding was not pledged at that time. The component was added back to the project as part of the first restructuring once the grant financing was confirmed shortly after Board approval of the investment component. Through the restructuring, necessary legal documents for the TA were added to the project package and the trust fund was added to the project financing under the same project code.

ANNEX 4. EFFICIENCY ANALYSIS

1. **Present value of geothermal and coal costs.** At appraisal, the PVC of geothermal was compared with the PVC for coal. When the local and global externalities were factored in, the PVC for coal was found higher than the PVC for geothermal. In table 4.1 the PVC for geothermal and coal (both with and without externalities) is calculated.

Table 4.1. PVC Comparison of Geothermal and Coal (US$, millions)

	Ulubelu	Lahendong	Ulubelu and Lahendong
Appraisal			
PVC for geothermal	449.31	208.62	657.94
PVC for coal without externalities	372.72	150.36	523.08
PVC for Coal with both global and local externalities	514.08	203.64	717.72
Completion			
PVC for geothermal	478.66	238.42	717.08
PVC for coal without externalities	450.14	128.61	578.75
PVC for coal with both global and local externalities	535.43	213.9	749.33

2. Table 4.2 shows that, at completion, the same cost comparison was made. The analysis was updated with modern cost figures, including the monetization of global externalities according to the 2017 corporate guidelines on the Social Value of Carbon. It confirmed the results observed at appraisal regarding the impact of local and global environment costs on economically pricing out coal in relation to geothermal.

3. **Financial feasibility and key metrics.** At appraisal, the project FIRR and FNPV were calculated for the Ulubelu and Lahendong investments. The FIRRs for both sites were found higher than the 8.03 percent WACC, thus confirming positive FNPVs and the financial feasibility of the project. This is shown in table 4.2.

Table 4.2. Financial and Economic Analysis (IRR in percentage; NPV in US$, millions)

	Ulubelu	Lahendong (Tompaso)
Appraisal		
FIRR	17.40	14.60
NPV	46.80	4.00
Completion		
FIRR	11.00	10.00
NPV	89.79	41.24

Note: IRR = Internal Rate of Return; NPV = Net Present Value.

4. At completion, the FIRRs and FNPVs were calculated based on updated figures (for example, actual cost of drilling and well testing, EPC, land acquisition and infrastructure, interest during construction, and so on). From table 4.2, despite higher-than-expected exploration drilling costs, the FIRR for both Ulubelu and Lahendong was found to still be higher than the hurdle rate, thus reconfirming the

financial feasibility of the geothermal investments over their useful life. In comparison to appraisal, the tariffs used in the financial analysis were higher. Specifically, for Lahendong, PGE negotiated and signed with the PLN an US$0.114147 per kWh PPA amendment over the original value of US$0.0825 per kWh. For Ulubelu, PGE expects to sign with the PLN and retroactively apply an US$0.084 per kWh tariff over the original PPA of US$0.0753 per kWh. Table 4.3 summarizes the tariff regime for Ulubelu and Lahendong following the higher drilling costs incurred during implementation.

Table 4.3. PPA History (US$ per kWh)

	Original PPA (2011)	Head of Agreement (2014)	PPA Amendment (2016)
Ulubelu	0.0753	0.084	0.084[a]
Lahendong	0.0825	0.116	0.114147

Note: a. Expected tariff based on negotiations with the PLN.

5. Beyond the financial feasibility of the project, the economic assessment of the Ulubelu and Lahendong investments at completion shows an economic internal rate of return (EIRR) of 17 percent and 14 percent, with economic net present values (ENPVs) of US$550 million and US$230 million, respectively. These results factor in the base case scenario for the positive global externalities of the project. Table 4.4 shows the sensitivities applied to the economic analysis based on different levels of the social value of carbon.

Table 4.4. Sensitivities (EIRR in %, NPV in US$, millions)

	Ulubelu		Lahendong	
	EIRR	ENPV	EIRR	ENPV
Low case global externalities scenario	15	422	12	163
Base case global externalities scenario	17	550	14	230
High case global externalities scenario	20	789	16	318

ANNEX 5. BORROWER, CO-FINANCIER AND OTHER PARTNER/STAKEHOLDER COMMENTS

PGE COMMENTS

The World Bank provided financing of US$175 million through an IBRD loan which complements a US$125 million concessional loan from the Clean Technology Fund (CTF) for the geothermal development of Ulubelu Unit 3&4 and Lahendong Unit 5&6. The Bank was also facilitating US$ 6.95 million technical assistance and capacity building grant to PGE from the Government of New Zealand, after the completion of the Netherland's grant for the similar purpose. The loan effectiveness date was June 29, 2012 with the closing date has extended from March 31, 2015 to December 31, 2018. The scopes of works under IBRD/CTF financing were construction of Steam field Above Ground System (SAGS) and Power Plants.
The competitively-priced IBRD and the concessional financing from CTF sources have reduced equity support from Pertamina. The IBRD/CTF loan was also able to increase the financial viability of the Ulubelu 3&4 and Lahendong 5&6 projects. A financial model simulation was carried out during appraisal and project financing without IBRD/CTF loan showed that the project had negative Financial Net Present Value and the Financial Internal Rate of Return (FIRR) was also below the hurdle rate.
While specific comments are provided to the draft of the World Bank's ICR in track changes, the general comments are provided here. In general, what have been described by the World bank team in the draft report is corresponding with PGE's views as described in our project completion report. The project was contributed to the achievement of Indonesia's renewable energy target and PGE's long-term development plan (RPJMN).

1. Achievement of PDOs

PGE confirmed the achievement of PDOs as described in the table of indicators in the report. We acknowledged that the achievement of indicator related to reducing green house gas emission was slightly below the target because of some issues that made the power plants were not operated in full capacity.

2. Key Factors During Preparation

The design of the project was simple and well-tailored to achieve the development objective of the project which was to increase power generation from renewable geothermal resources and reduce local and global environmental impacts. The Project components consisted of 2 (two) components, namely Investment in Geothermal Power Generation Capacity and supporting by Technical Assistance for Capacity Building.

The project preparation at Ulubelu Units 3&4 and Lahendong Units 5&6 (Tompaso) geothermal sites were well advanced and ready for full scale development, from steam development until power generation. PGE's equity was invested to finance the exploration, land acquisition, permits, drilling and sub-surface services to confirm the resources in each field. With the support of the US$2.5 million project preparation grant provided by the World Bank from the Government of The Netherland, PGE has secured the services of international consultants to help PGE conduct a detailed feasibility study for both fields in developing its engineering design, environmental and social impact assessment. In accordance with this, the World Bank through an independent geothermal expert conducted a review and the results concluded that each project's technical concept and design meet industry and international standards. Sequentially, the World

Bank's loan can be directly implemented to fund the development of power plants.

The project's Results Framework is clear with the simple methodology to measure the achievement of the indicators. The achievement of the objective was assessed through the successful realization of new geothermal power generation capacity, and estimated avoidance of GHG (CO_2) and local air pollutants (SO_2, NO_x, TSP), when compared with equivalent coal-based power developments.

3. Key Factors During Implementation

During the project implementation phase, there were several factors that influence the process of project completion, including internal and outside of the project.

The project experienced substantial delay due to the confirmation of geothermal resource for both Ulubelu and Lahendong sites. The initial resource development for Ulubelu Units 3&4 was completed in 2011 and for Lahendong Units 5&6 was completed in 2010. After the adjusted drilling program was approved by Pertamina at late 2012, the activity was started again for both sites. However, the result of the drilling was not reached the expected steam availability. The second-round drilling in Ulubelu was started at October 2013 and completed by April 2016. In Lahendong site, the second-round drilling was started at March 2014 and completed by July 2015. A group of experts under Technical Collaborative Program (The New Zealand Grant) was providing support for the planning and implementation of the second drilling program and had a positive influence on the drilling results.

In addition to the foregoing, the project delay was mostly associated with obtaining drilling rigs on time and land acquisition process. The difficulties in the process of land acquisition also happened. Mitigating the risk of unsuccessful negotiation with the land owners, PGE had negotiation with landowners while also considering an alternative route to accommodate pipeline modifications. A variation in the EPC contract was needed to adjust the changes in pipeline design.

On the external factor, the project did face several bureaucratic administration steps related to the loan disbursement. Each year, the project needed to submit disbursement plan and propose it to the Ministry of Finance (MoF) to be included in the DIPA budget (state budget) that would require the approval from the parliament. After that, the project could start requesting for loan disbursement through the MoF as the borrower of the loan facility. This mechanism had impacted the processing time for payments to the contractors. Another external factor is that the Power Purchase Agreement (PPA) amendment for Ulubelu Units 3&4 have not been signed with the Buyer, this is due to a very long electricity prices renegotiation process that has been going on since 2014. Price adjustments are needed to ensure sustainability of the geothermal fields and future development including additional generation capacity.

The Bank team was proactive in supporting project implementation, provided guidance on and timely approval of project documents, safeguard requirements, and contracts. Quarterly project reviews were conducted to assess project implementation and achievement of development objectives

4. PGE Performance

PGE performance during the preparation and implementation of the projects was satisfactory. PGE established PIU (Project Implementation Unit) team that had the overall responsibility for managing the

activities related to the loan and coordinating all aspects of project implementation including procurement, monitoring and evaluation, quality assurance, safeguards, and implementation of the Governance Accountability Framework (GAF).

During the project implementation with the completion of 10 million man-hours, safety was successfully implemented with zero incidents at the two project sites. To achieve this, all contractors were worked in PGE's project must be complied with regulations and PGE policy. The contractor shall also be prepared HSE Plan as part of Contractor Safety Management System (CSMS) implementation and this document is approved by PGE before the work begins. In addition, technical and safeguards teams were experience and competent to allow smooth project implementation.

5. Lessons and Recommendations

The following lessons were taken during project implementation:

- Prior to this project, PGE only had an experience on developing geothermal power plant in Kamojang Unit 4 (60 MW) commissioned at 2008. This Geothermal Clean Energy Investment project strengthened PGE's experience on developing a total geothermal project (upstream and downstream development).
- Independent international experts were useful to provide an independent review of the drilling program.
- Bureaucratic and long disbursement process which involved MoF and Parliament can be simplified by a Direct Lending mechanism between Pertamina/PGE and the World Bank for any projects in the future.
- Competitive bidding resulted project efficiency on the EPC power plant cost for each Ulubelu Units 3&4 and Lahendong Units 5&6.
- Concessional loan helped the project to be commercially and financially viable for development.
- Lesson on project disbursement process and how online system will help to expedite

6. Future Operation of The Project

The Ulubelu Units 3&4 and Lahendong Units 5&6 Geothermal Projects were completed well according to the agreed project scope including commissioning of Steam Above Gathering System facilities and Power Plants.

The Ulubelu Unit 3 has been operating commercially since 26 July 2016 and followed by Unit 4 which has been operating commercially since 25 March 2017. The Lahendong Units 5&6 has been operating commercially since 15 September 2016 and 9 December 2016, respectively. At present, the operation of the geothermal power plant is under the management area of the Ulubelu and Lahendong with the support of experienced team and has competencies in their respective fields.

Currently Ulubelu 3&4 cannot generate in full capacity (2x55 MW) due to the lack of steam availability. The steam availability Unit 3&4 from existing wells about 98.06 MW (assumption 1 MW = 6.8 ton/hour). To fulfill the steam supply, PGE has a work plan to drill 6 (six) make up wells where 4 (four) wells has been drilled and next 2 (two) wells will be drilled at the end of 2019. From 4 (four) make up wells has been obtained additional steam about 66.74 MW (Cluster J = 52.44 MW and UBL D5 = 14.30 MW). Therefore

PGE has been constructing steam pipe connection from new wells in Cluster J to existing pipeline that still on stage of construction with connection target at July 2019.

The amendment of the electricity price for Ulubelu 3&4 between PGE and PLN is still under renegotiation process. PGE has coordinated with both internal party (PT Pertamina Persero) and external party (Ministry of Energy and Mineral Resources) to request a facilitation assistance for the settlement of electricity price amendment.

The future challenges for project operations are:

- Optimizing production performance by carrying out routine and preventive maintenance so that the readiness and reliability of the power plant and production facilities are maintained.
- Steam availability has reached the expected generation capacity (MW) and waiting for steam pipe connection from the new wells by July 2019.
- Operational of Lahendong Units 5&6 at the lower capacity due to the demand issue at North Sulawesi.
- Signing of the PPA amendment for Ulubelu Units 3&4 with the support of Government Regulation on geothermal electricity pricing.

NEW ZEALAND MINISTRY OF FOREIGN AFFAIRS AND TRADE COMMENTS

New Zealand Ministry of Foreign Affairs and Trade (MFAT) is committed to supporting access to renewable energy [including through geothermal sources] in our Joint Commitment for Development with Indonesia. Our support of US$6.95m was channeled through the World Bank and sought to provide PT. Pertamina Geothermal Energy (PGE) with Technical Assistance to support two key areas in geothermal development in Indonesia a) application of internationally recognized expertise to projects and b) building capabilities of professionals within the industry.

The Technical Assistance (TA) was implemented in parallel with a World Bank investment project, Indonesia Geothermal Clean Energy Investment Project which was financed with US$ 300million loans from the World Bank (WB) and Clean Technology Fund (CTF). Our support enabled PGE to be equipped with necessary expertise to implement and manage the investment project which includes the confirmation of geothermal resources, steam field development, construction of the Steam field-Above-Ground System (SAGS) and power plants of 110 MW and 40 MW at the Ulubelu and Lahendong (Tompaso) geothermal fields located in South Sumatra and North Sulawesi respectively.

The TA has achieved most of its targets except one - installed geothermal capacity under PGE's management. The result at the time of TA completion (June 30, 2017) was 582 MW against the 700 MW target. However, PGE's installed capacity has kept on increasing, reaching 617 MW as of June 30, 2018. We expect that it will meet its target by the completion of the associated WB investment project. Furthermore, the TA brought ripple effects beyond the original TA scope, such as better reinjection strategy for Ulubelu 1&2 units and further development of Tompaso field for 40 MWe to come online in 2025, with improved expertise and confidence gained from the TA.

1. OVERALL EVALUATION

Relevance: The scope and components of the TA directly addressed Indonesia renewable energy goals and PGE's needs of building their capacity in growing as the largest geothermal developer in the country. The objectives of the TA are also well aligned with the Indonesia's national goal of scaling-up geothermal generation and the World Bank's commitment to mitigate climate change.

Efficiency: With US$6.95 million grant funding, the TA enabled PGE to implement the associated investment project and operate efficiently and safely, plants of 150 MW capacity in total. Further, the TA brought ripple effects of more efficient reinjection strategy of pre-existing plant units (Ulubelu 1&2) and further geothermal capacity development plan on one of the investment project sites (Tompaso) to come online in 2025.

Effectiveness: The project met most of its targets. Achievement in expanding PGE's capacity fell short of the target at the time of TA closing (518 MW versus 700 MW target). However, PGE's geothermal capacity has kept on increasing (617 MW as of June 2018), and expected to grow over 700 MW upon the completion of the associated investment project.

Impact: The associated investment project added new 150 MWe geothermal capacity, which will reduce about 1 million tons of CO_2, 2,555 tons of NO_X, 4,569 tons of SO_2, and 2,156 tons of TSP annually[31] during the plant lifespan. The technical capacity of PGE has grown considerably, placing it as one of the top 10 largest geothermal energy developers in the world.

Sustainability: The TA impact is expected to last well beyond the closing of the project. Pertamina's experiences of geothermal development through its long history are ring-fenced within PGE. The TA benefited the newer/ younger employees of PGE who will carry this knowledge and its benefits through into the future of the organization and the sector. PGE has been satisfied with many aspects of the TA which may lead PGE staff to repeat aspects of this work.

2. LESSONS

MFAT has had a good working relationship from both partner organizations, the World Bank and PGE. There were initial delays with the start of implementation, however these issues were quickly resolved once the project was up and running. In subsequent years, there was clear and regular communication between MFAT, the World Bank and PGE on project status.

NZ has also been able to leverage significant investments in the geothermal sector by partnering with the World Bank. In this case, NZ's provision of US$6.95million of Technical Assistance has underpinned financing of nearly US$300million in two geothermal projects worth a total exceeding US$550 million.

PGE staffs were asked about the most beneficial aspects of the overall Geothermal Clean Energy Investment Project including TA. They identified benefits coming from the discipline associated with the

[31] The presented local environmental impact results are achievements captured at June 2018, not the investment project closing in December 2018. The results at the investment project closing are reduction of 2,753 tonnes of NO_X, 4,923 tonnes of SO_2, 2,324 tonnes of TSP annually.

procurement procedures. However, one item of note was the secondment of a reservoir engineer into PGE through the Technical Collaboration Partnership under AECOM. The consultant was especially appreciated because of their mentoring role, while addressing key issues at the time. Lessons from this TA experience can be drawn on for future NZ TA support and design of capacity building activities.

MFAT is committed to addressing cross-cutting issues like gender and human rights in our development assistance, and recognizes that there is much more that is required in this space. One feature of this project has been the strong presence of women within PGE management structure represented at Mission briefings. Women have been well represented with the PIU, within environmental monitoring and management sections, in legal and accounting, and to a lesser extent within the reservoir engineering sections. A review of training courses undertaken under the TA shows about 12% of participants were women.

ANNEX 6. SUPPORTING DOCUMENTS (IF ANY)

Geothermal Clean Energy Investment Project Documents

1. PAD, Restructuring Papers, Aide Memoirs 2008-2018, Implementation Status and Results Reports, Quarterly Progress Reports.

2. PGE. 2013. Prequalification Evaluation Report: Geothermal Energy Investment Project EPC Contract for Steam Gathering System and Power Plant for Ulubelu 3&4.

3. PGE. 2013. Prequalification Evaluation Report: Geothermal Energy Investment Project EPC Contract for Steam Gathering System and Power Plant for Lahendong 5&6.

4. ESIAs

Geothermal Power Support Program Project Documents

1. TF Proposal.

2. AECOM New Zealand Limited. 2010. Draft Feasibility Study and FEED for Preparing Geothermal Fields for Lumut Balai Power Project.

3. PT AECOM Indonesia. 2010. FS and FEED for Preparing Geothermal Fields for Development Feasibility Study for Tompaso Geothermal Power Project

4. GRM

Geothermal Power Generation Development Project Documents

1. PAD.

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15. World Bank. (2008) *Investing in Indonesia's institutions International Bank for Reconstruction and Development and the International Finance Corporation Country partnership strategy FY09-12 for Republic of Indonesia*, Report No. 44845-IND.

16. World Energy Council. (2016) World Energy Resources.